Explaining Ghana's Good Cocoa Karma: A Smuggling-Incentive-Reversal Argument

Stephen E Armah[1]

Paper prepared for presentation at the Center for the Study of African Economies (CSAE) Conference on Economic Development in Africa 16th - 18th March 2008, St Catherine's College, Oxford, UK.

Abstract

The paper contends that the current boom in cocoa exports from Ghana is due to a 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, stationarity and co-integration tests, Granger causality test, single and vector error correction models (ECM and VECMs) and partial adjustment models we estimate the Ghana cocoa supply response in order to determine the most pertinent factors that explain the current 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 by Ghanaian policy-makers that of substantial productivity gains in the cocoa sector in response to good policy.

Key Words: Smuggling incentive, co-integration, VECM, supply response

JEL Classification: Q10, Q11, Q13

[1] Department of Agricultural and Consumer Economics, University of Illinois at Urbana Champaign. Room 405 Mumford Hall, 1301 West Gregory Drive, Urbana, IL 61801-3605. Phone: (217) 333-8538

Why the Good Cocoa Karma? Can the reduced incentives to smuggle Ghanaian cocoa to La Cote D I'voire sufficiently explain the current boom in Ghana's cocoa industry?

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, identifying the specific growth drivers responsible for the boom is non-trivial because economic growth is typically a complicated process that occurs along numerous dimensions. When it comes to Africa, socio-economic, cultural and military factors all come into play Ayittey (2005). That said, what is undeniable is the coincident good performance of Ghana's economy and its cocoa industry Ghana Ministry of Agriculture (2005). Given that the cocoa industry is doing so well, it is quite reasonable to surmise that the growth of the cocoa industry is the engine behind the country's current impressive growth. For this reason it is essential that the supply response of Ghana cocoa supply be appropriately modeled and analyzed to verify the suspicion. A word of caution is pertinent here with regards to Ghana cocoa supply response: almost all cocoa harvested is exported with very little used in domestic production so cocoa export trends in Ghana exactly mirror that of the supply response[2]. 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[3]. We argue that this research is important as it enables the analysis of the effect of smuggling of cocoa in or out of the country on Ghana's cocoa exports over time. This research has assumed enormous significance given political event in CIV subsequent to the time period of Bulir's analysis. Specifically Bulir although used data from 1956-1995, CIV has had a major conflict and several major up risings in the recent past and the unrest continues. This is exactly why the timing of this research makes sense. Has the underlying structure of Ghana cocoa supply changed even if we believe Bulir's model? In order words, is Bulir's model still relevant for explaining Ghana's cocoa supply response even now? As briefly mentioned earlier, the volume of Ghana's cocoa exports (the country's main cash export crop) has

[2] Supply response will typically include cocoa used at home by local processors and manufacturers, that consumed by the local population for medicinal purposes and that exported

[3] I actually model my price incentive to smuggle variable as the inverse of the Bulir variable that is price incentive to smuggle cocoa in my model is the ratio of CIV prices to Ghana price

expanded significantly in the last several years after many years of decline followed by a mediocre performance recovery ICCO (1995), IMF country report (1995). 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 COCOBOD which was 70000 cedis in 1995, topped 9000000 cedis[4] 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) (see **Fig** 1).

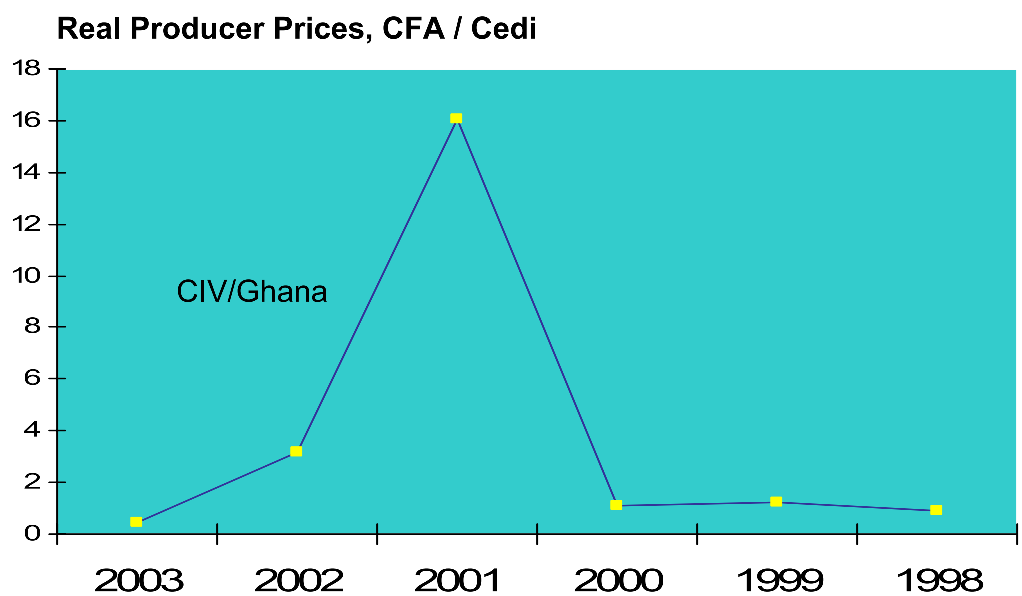
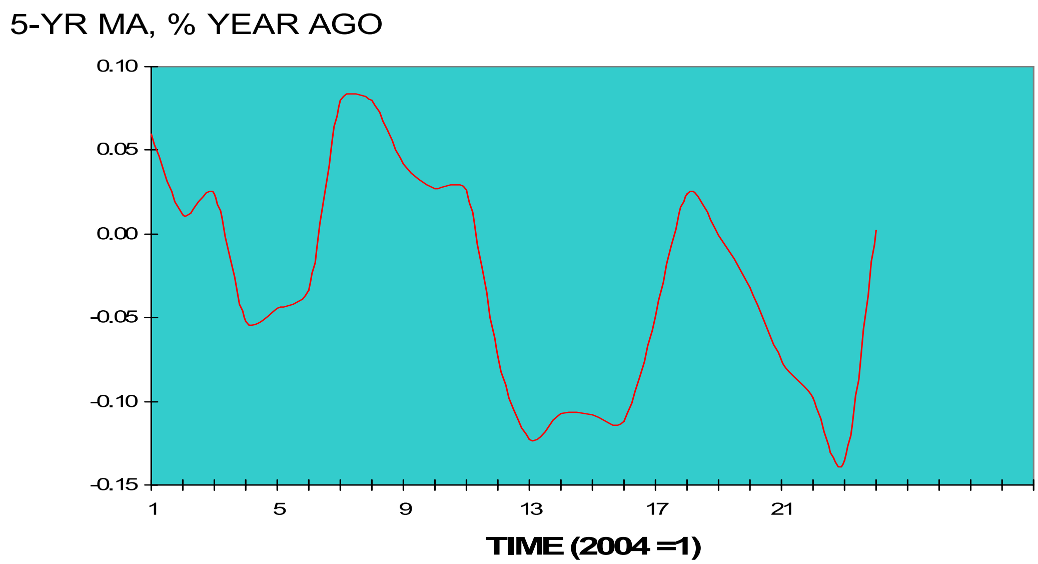


Fig 1: A Reversal in Smuggling Incentives?

A casual look at Fig1 suggests that the price incentive to smuggle Ghana cocoa series (which Bulir described) has lost steam in recent years, especially in the post 2001 period. Consequently Ghanaian production has swelled over recent period. The 5-year average (2000-2005) for total cocoa beans exported rose to 412 100 mega tones from 339 100 (1996-20000) which is almost a 22 % increase.

[4] The Ghanaian local currency is the cedi and the evidence suggest inflation has been endemic in the economy

RECENT WORLD COCOA PRICE TRENDS (FIG 2)



Interestingly world cocoa price appreciation has been muted (see **Fig** 2), a fact that may be explained by existing surplus cocoa inventory[5]. A 5–year moving average plot of nominal world cocoa prices shows that world cocoa prices increased only moderately in the recent past (See **Fig** 2). In fact, considered on a year ago basis, the seasonally adjusted data showed a growth of 5 % in 2004 after negligible growth in the last 6 years. Given the world cocoa price trends, it is obvious that the bulk of the recent gains in Ghanaian cocoa farmer producer prices is not caused by world price gains (Ghana cocoa responds to world prices in the long run not the short run) and is most probably mainly helped by the deliberate governmental policy of encouraging an "increasing percentage of the mostly stable world cocoa prices to the farmers" (Ghana Ministry of Agriculture (2005)). Rising cocoa producer prices affects the Ghana/CIV smuggling incentive and encourages or discourages smuggling depending on whether the sign of the Smuggling Incentive is negative or positive. Historically the COCOBOD pays about 50% of the international price to farmers and uses the rest to attempt to stabilize the price

[5] The major importers of cocoa beans have historically maintained a sizeable supply surplus

environment but under the Kuffour[6] administration, this percentage is on the rise which potentially bodes very well for the short term supply response of Ghana cocoa as well as long term response. Despite the thriving cocoa sector, the COCOBOD has come under fire in the past for inefficient policies.[7] To return to the question at hand, what is really behind the boom in Ghana cocoa and what does a strong cocoa sector mean for Ghana's growth? We address the latter question first[8], without dwelling too much on the now moribund import-substitution vs. export oriented policy argument. Still it is fair to say that the dominant economic ideology at the present time is that exports help promote growth Lal (2000), Smith (1776), Myint (1958) although there are valid counter arguments. Some economists add the caveat that the only contribution to growth that a primary export such as cocoa can make is a consequence of that export commodity being a component of GDP Fosu (1990), Cohen (1968), Nurse (1962) and also Adams et al (1979). Nurse (1968) argues that instability of prices in primary commodity markets make primary–export led growth self defeating. Talbot concurs emphasizing the declining terms of trade of primary commodity products as a long term hindrance to growth Talbot (2002). Fortunately, the literature does include strong support for the different ways that primary exports can contribute to LDC growth in an exogenous sense. Apart from Smith's (1776) vent for surplus argument for exports which clarifies how the opportunity to sell to foreigners can enhance growth promoting economic activities, a primary export good such as cocoa can conceivably contribute to GDP growth through *linkage effects* and positive externalities on the economy Innis (1930 and 1940), Chambers and Gordon (1966) McKinnon (1964), Chinnery and Strout (1966), Balassa (1978), Krueger (1980), Helpman and Grossman (1985). To illustrate, foreign exchange acquired from the sale of cocoa beans can boost Ghana's GDP by enabling importers of heavy duty machines needed for production and farming to continue operation. Obviously, a foreign exchange crunch will limit such market activity, pulling down GDP growth Berument and Nergiz (2004). Further support for the contribution of efforts to growth is provided by the staple theory. The staple theory of growth emphasizes the crucial role of the linkages (backward, forward and final demand) of the staple

[6] His Excellency John Kuffour is serving his second 4 year term as a democratically elected president and is the flag bearer of the New Patriotic Party. Previously Ghana was ruled for 20 years by JJ Rawlings who came into power by military intervention. He subsequently organized and won two elections as the flag bearer of the National Democratic Party. His second term ended in 2000 when Kuffour's term began.

[7] For a summary of the critiques of COCOBOD practices, see Bateman (1990) who examined and questioned the efficiency of the practices of the COCOBOD.

[8] The answer to the first question is what this empirical exercise will attempt to provide.

export(s) with the rest of the economy Boame (1998). Fortunately for Ghana, cocoa's contribution has been positive Fosu (1990), Brempong Gyimah (1987) also Bamba (1987) despite the rather conflicting views in the economic literature regarding the growth enhancing power of primary exports. Cocoa, produced exclusively for export in Ghana, still continues to be a key driver for Ghana's growth. The cocoa sector employs up to one half the total agricultural labor force and is Ghana's main engine for growth (Awudu and Reider (1994)). As Brempong Gyimah succinctly put it "Ghana goes as Ghana's cocoa industry goes" (Brempong Gyimah, 1986). Given the cocoa industry's positive contribution to growth in the past, it is fair to conjecture that one of the major reasons for Ghana's recent good economic performance is good cocoa Karma. A more accurate forecast model for Ghanaian cocoa supply which accurately reproduces historical trends and can account for the recent good fortune of Ghana's cocoa sector is therefore absolutely essential given how critical cocoa revenues are to Ghana's economic growth. Evidence for the cocoa industry's robust performance is not difficult to find. The share of cocoa exports receipts in total export revenue, depressed for more than two decades is climbing again. The share fell to 11 % in 1993 but rose to 27.7% in 2003 and is still rising FAO (2005) and World development indicators (2005).[9] In addition official output which had risen to 350 000 million metric tones in the 1990-2000 period is now an impressive 700 000 million metric tones in 2005 (Ghana COCOBOD (2005)). The share of cocoa receipts in GDP which was below 5% in 1995 doubled by 2003 with no end in site. Modeling Ghanaian cocoa therefore makes even more sense now given that the country is regaining prominence in the world cocoa market. In fact Ghanaian cocoa export is currently close to apogee levels and the country is the number two exporter of cocoa beans in the world (IMF country report on Ghana (2005), ICCO (2005)). Cocoa and Ghanaian cocoa in particular, is one of the few perennials whose supply has been modeled extensively in the past Bulir (2003) but interest waned in the 70's when Ghana lost significant market share. However, following the inception of the of the 1983-1995 Economic Recovery Program (ERP) under the erstwhile PNDC and later NDC government, total Ghanaian cocoa exports grew moderately in the 1990s, albeit below maximum capacity given available tree stocks and labor Bulir (2003). Notwithstanding the current impressive performance of Ghana's cocoa industry the real cause of this once moribund industry's growth spurt has not been satisfactorily explained Zeitlin (2005). Several

[9] Numbers are from author's calculations using data from the data sources specified

authors have postulated possible reasons for the unusual expansion in cocoa exports and different models abound in the literature which not only quantify cocoa supply but also forecast Ghana's supply out into future periods. Needless to say, most of these models under-estimated recent Ghanaian cocoa supply and the explanations for the robust performance have been at best, unconvincing so the search for a "better" model continues. On the more positive side good older model exist that are theoretically sound but have to be applied to the most recent data available. The Ghanaian cocoa sector's encouraging performance is unusual given the country's cocoa sector had been producing below potential for all of the 20 years prior to 2001 Bulir, (2003) and that cocoa supply is typically inelastic (Berthelemy and Morrisson (1987) and Jaegger (1992), Stryker (1990)). One will therefore not expect a big supply response even if there is a sizeable positive domestic producer price change. Zeitlin (2005) argues that increased competition among village level licensed cocoa buying agents is challenging COCOBOD's monopoly, in cocoa purchasing, improving domestic producer prices and spurring growth of the sector. Other authors have argued that the recent boom is at best cyclical, or in line with expectations given the recent charge-free massive spraying of all cocoa trees by the Kuffuor administration. Yet others argue that, given the 6-year lag in cocoa production, at best, the cocoa export growth can be explained by the expected increase in output which is the consequence of re-planting in 1999. Some analysts credit the realization of increased output to fertilization efforts undertaken by the government in the late 1990' and more recently between 2002 and 2005. Whether this growth will last is a difficult question to answer as existing Ghanaian cocoa supply models appear to be largely out of touch with recent trends in Ghana's cocoa industry. At the one extreme, it is logical to argue that a fundamental change is occurring in the structure of the cocoa sector rendering old parameter estimates from historical data ineffective at quantifying recent trends. At the other extreme one can argue that the existing models, especially the models using the partial adjustment framework are flawed in a fundamental way Awudu and Reider, (1994); Hallam and Zanoli (1993)) and this is why they have failed to account for the current brilliant performance of the Ghanaian cocoa sector. To be fair to previous research, political conditions in the West African region is unpredictable to say the least and although the Ghanaian economy has never been de-stabilized by a major war, it is on no way immune to instability in nearby countries. The above point becomes even more pertinent when one factors in the fact that Ghana's proximal neighbor to the west is La Cote

D'Ivoire' (CIV) which retains the dominant share of the world cocoa market. Unfortunately war and unrest has led to plummeting market share for the CIV even as Ghana makes grounds in the cocoa market (a case of non-coerced business stealing.) In 2000, CIV accounted for more than half the total amount of cocoa beans exported in the world but today the country only commands 40% of the world cocoa beans market due to political instability and wars (BBC, September, 2005)). According to a recent BBC report, CIV actually halted cocoa exports in 2004 after farmers threatened to burn their cocoa farms over low domestic prices. In the light of the CIV's struggles, at least part of Ghana's recent cocoa export boom may be explained by the lull in smuggling of Ghanaian cocoa to CIV (See Sheik (1989) for a formal analysis of smuggling models). The unrest in CIV has had a significant effect on Ghana's cocoa sector both in terms of skilled and unskilled labor availability and the incentive for farmers not only to smuggle cocoa but also to increase production to meet demand for export, released by the CIV. Obviously modeling cocoa supply is a challenging process in of its self given the natural biological lag involved in production Nikolaus (2001) also French et all (1985)). For that very reason different flavors of models have been presented in the literature that tries to circumvent these modeling difficulties using different methods. According to Bulir (2003), three main flavors of models exist for Ghanaian cocoa supply; Long term technological capacity models accompanied by a short run function that accounts for weather and shocks (e.g. Bateman (1976) replicated by author (1990)), Gyimah Brempong (1987), traditional partial adjustment supply models and error correction models e.g. Awudu and Reider (1994)). The later group of models includes a typical subset that takes into account smuggling into the CIV (for example, Bulir (2003). I concentrate my research on the last flavor of models not only because they account for possible non-sationarity in the data using recently developed time series techniques but also because they are more relevant given the recent political instability in the CIV. My research is a contribution to economist's attempts to build a model that can not only reproduce Ghana cocoa historical trends but can also explain the current Ghanaian cocoa boom. I extend and modify Bulir (2003) model (which is in reality a version of Awudu and Reider (1994)) to account for more recent trends in Ghanaian cocoa supply to achieve my objectives..

Bulir argued that the severe contraction in Ghanaian cocoa supply from 1960s to the 1995s (a 60% decline) could be best explained by the distortionary effect of domestic taxes in Ghana which by widening the gap between the CIV and Ghanaian domestic prices, created incentives to smuggle Ghana cocoa to the CIV (Bulir, 2003). Bulir contended 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[10]. 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 turned price incentives on it head, and more than anything else can explain the good times in the Ghanaian cocoa industry today. This in essence is the crux of my research. I argue that because Ghana has been a relatively safer 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) as against receiving a non-random, safe domestic price from the COCOBOD[11], Ghanaian cocoa farmers should substitute for the latter. Ghanaian cocoa exports should therefore climb as more Ghanaian farmers substitute towards the latter option to take advantage of better prices. A further boost to Ghanaian cocoa exports will be the 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 own farmers. The amount of Ghana-CIV cocoa smuggling could be driven to zero and smuggling may actually go in the reverse direction following the price incentive reversal. If this is true Ghanaian cocoa exports should increase significantly both in absolute terms an relative to CIV which is what we see.

[10] Transaction costs here is understood to include bribes at the border and the disutility of having to smuggle Ghana cocoa to the CIV
[11] Ghana cocoa marketing board

After testing for, and correcting for stationarity, I test for structural break using traditional Chow Tests to verify whether the Ghanaian cocoa sector changed in a significant way because of the war in CIV. I also perform co-integration and Granger causality tests. To isolate the most important determinant of the export boom in Ghana, I begin with the error correction model formulated in the spirit of Awudu and Reider (1994) and Bulir (2002). My model is therefore a hybrid of the models used by Awudu et all and Bulir respectively. The model augments Bulir's model with significantly relevant variables. My research mirrors the work of the later authors in the sense that it uses the fundamental specification they used. The difference is that I also use a vector error correction model (apart from the single equation model) and include the incentive to smuggle term due to Bulir (2003). Even more importantly I extend my work to more recent data while testing and accounting for statonarity and structural breaks. I find that my model does a satisfactory job in explaining the supply response of Ghanaian than other postulated explanations.

Section I reviews the literature on Ghanaian cocoa supply, critiques previous supply models for Ghanaian cocoa and also provides a brief overview of the Ghanaian cocoa production process. Section II describes the data, and explains the theory and procedures used then outlines both Awudu et all and Bulir's original 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 III presents the results, Section IV discusses the results and Section V concludes. Section VI is a reference section.

Section 1: A review of previous work

Although models of cocoa supply in Ghana is found more frequently in the literature than models of other perennials in the economics literature Bulir (2003), the sum total of models of perennials in general including cocoa models remains unimpressive. The biological lag between the planting decision date and output date presents unique challenges for econometric modeling not only for cocoa but 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 in line with expectation.[12] Cocoa trees take time (specifically up to six[13] years) to yield the first harvest after planting Awudu and Reider (1995). Fortunately, subsequent to the first harvest but a healthy tree may continue to fruit for the next 40 years with significantly reduced marginal costs of care. 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 (factors that are out of the control of the farmers). To be specific, 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 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. The second and more common category of Ghana cocoa models were partial adjustment models[14]. The analysis by Bethelemy and Morrisson (1987) and Jaegger (1992) fall into this category. Partial adjustment models were sometimes used in combination with Nerlove supply models (Nerlove, 1979) although prominent economists, including

[12] 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

[13] Other perennials may take more time to bear their first fruit

[14] See model I in Section II for an example

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 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[15] 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 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 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 (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 equivalent CIV domestic producer price to deflated Ghana US dollar 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. We hope to contribute to the Ghana cocoa supply response literature by estimating Ghana cocoa supply response using a price incentive based

[15] Ghana cocoa supply response modeling is obviously an exercise in dynamics so this assumption of stationary expectations is especially problematic.

error- correction model that accounts for possible structural breaks due to Ghana-CIV price incentive reversal while using the most current data.

Before presenting the model, data and procedures employed a brief description of the characteristics and production procedures of cocoa beans is in order. Cocoa (Theobroma cacao) is a small tree (between 4 and 8m tall) but when shaded by taller tress (as it usually the case in Ghana, it grows up to 10 m (ICCO (1995)). For ideal production, cocoa needs between 1150 and 2500 mm of rainfall per year and hot temperatures: between 21 and 33 C. Ghana's 'Golden Pod" is the industry standard in terms of cocoa quality. Ghanaian cocoa production is a very labor intensive process (Ghana Ministry of Agriculture (2005) Farmers have to plant shade trees, plant the cocoa seedlings, clear weeds, spray the cocoa and cut out diseased branches, pluck ripe pods, split the pods open and collect the ripe pods, dry and ferment the cocoa beans, pack the beans in bags, weigh the beans and sell to COCOBOD for export (or smuggle to CIV as dictated by price incentives)

Section II: Data

The data for the project was obtained from different sources[16]. 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[17]. 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. Real 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. A step by step illumination of the data transformation process is included in the STATA code labeled STATA and included in the **Appendix.**

Structural-Break: 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). First of all the war in CIV which has dragged on since 2000 without really escalating nor dying off has resulted in a significant loss in CIV's market share for cocoa as some cocoa farms were destroyed. The CIV government inability to guarantee high producer prices likely resulted in some Ivorian farmers

[16] Summary statistics are included in the Appendix

[17] I visited Ghana in December of 2005.

smuggling their cocoa to nearby Ghana which is a historically politically stable country[18]. At the same time, Ghanaian cocoa farmers were receiving high producer prices not only to reflect the slight up-trending of world producer prices but also because effective cocoa tax rates were declining. The newly elected Kuffuor administration sought to continue the erstwhile NDC policy of returning as much money to the cocoa farmers as possible. To ensure parameter constancy we test for structural break using a dummy which is defined to take a value of 1 for the period before 1999 and 0 otherwise. We do this to avoid bias in the estimators coming from incorrectly imposing constant parameters. We employ the Chow test for structural break by interacting this dummy with all the independent variables and computing sum of square error (SSE) for the restricted and unrestricted regressions. The unrestricted regression include the dummy variable and its interactions with the Independent variables, the restricted regression does not. We employ the F –statistic given below and due to Gregory Chow (Chow, 1987).

$$Fstat = [(SSE_R - SSE_U)/J] / SSE_U / (T-K)$$

Where SSE_R is the SSE of the restricted regression, SSE_u is the SSE of the unrestricted regression. J is the number of joint hypothesis and (T-K) is the number of degrees of freedom. Ho: no structural break is rejected if Fstat < Fcritical where F critical is the critical value for the F distribution at a conventional level of confidence, typically 5%. See the results and discussion sessions respectively for the output and interpretation of the structural break test from this exercise

Theoretical Consideration[19]s:

i. Stationarity tests. The Augmented Dickey Fuller (ADF) procedure is used to verify stationarity by testing for the existence of unit roots. Obviously ADF tests are derived from the basic Dickey Fuller (DF) test. The DF test allows us to determine the order of integration or the number of times a series needs to be differenced to guarantee stationarity of that series (Awudu and Reider (1994). Regression (1) below needs to be estimated

$$\Delta X = \alpha_1 + \alpha_2 t + (\alpha_3 - 1)X_{t-1} + \varepsilon_t \quad (1)$$

Where X is the variable whose stationarity is being investigated, t is a trend and ε is the error term. A test of the null hypothesis: Ho: $\alpha_3 - 1 = 0$ (equivalently $\alpha_3 = 1$) is the standard test for unit root. The presence of a unit root is strong confirmation that the series is non-stationary. A

[18] In any case the border inhabitants of Ghana and CIV belong to the same tribe and there evidence is evidence of new CIV planting mostly around the Ghana CIV border

[19] I apologize for the abrupt change in notation but I always provide definitions for variables

very small p-value for the test statistic, indicating a rejection of Ho assures us that the series is stationary so OLS is unbiased and efficient.[20] Recall ε_t should necessarily be white noise. If X_t is 1st order autoregressive, then a single lagged X_t is sufficient to ensure stationarity as in (1). If X_t is autoregressive of order k, k additional difference terms will be added to (2) to ensure that ε_t is white noise. (2) can then be re-written as (3) for k= 3. (3) is the Augmented DF test or the ADF test.

$$\Delta X = \alpha_1 + \alpha_2 t + (\alpha_3 - 1)X_{t-1} + \lambda_1 \Delta X_{t-1} + \lambda_2 \Delta X_{t-2} + \lambda_1 3 \Delta X_{t-3} + \varepsilon_t \qquad (2)$$

The ADF procedure in STATA 9 was used to test for unit roots. The code is included in the general code in the Appendix and the results are displayed in **Table 1** in the results section and interpreted in the discussion session. 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, 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[21] so the two tests nicely complement each other.

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

[20] The power of the test has been severely criticized in the literature
[21] I do not implement KPSS because of time requirement required for me to get used to the procedure

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. Furthermore, the stationarity of the individual data series should be always be verified before any co-integration test is done and that is precisely the reason we explained the stationarity tests in the pervious section. The results from the stationarity tests are presented in **Table 2** in the results section. We also test co-integration relationships between several in a multivariate frame work. We briefly describe the theory of co-integration testing below. The regression results are of course presented in the formal results section and appropriately discussed in the discussion session.

Testing for Co-Integration in a Multivariate Frame-work[22]

When the ECM is formulated in a multivariate framework, testing for co-integration becomes more complicated as there may be potentially more than one long run relationship. Presumably the single equation frame work can miss this (Johansen, 1993). Despite its simplicity, the single equation error correction model is limited when the ECM contains more than two dependent variables and so there is a possibility of more than one co-integrating vector (Harris, 1995). In this contest, estimating a single equation ECM will be equivalent to imposing a restriction of one co-integration vector. Imposing the wrong restriction that there is only one co-integrating vector if there is in fact more than one vector leads to biased and inefficient estimators (Johansen, 1993). So a single equation error correction mode only makes sense when there is a unique co-integrating vector or when there are only two series suspected to have a co-integration relationship. Since we do not know ex ante how many co-integrating vectors there are in the system the preferred starting point should be Johansen's MLE approach (Harris, 1995). As Harris so brilliantly illustrates in his landmark textbook, to test for co-integration in a multivariate framework, the analyst must:

1) *Test the order of integration of each variable in the multivariate model*
2) *Choose the appropriate lag length (to get WN residuals)*
3) *Determine if the system must be conditioned on any predetermined I(0) variables (including dummies to handle possible policy interventions)*
4) *Test for reduced rank: in other words should the system be estimated as an I(2) rather than as an I(1)*
5) *Should a constant and a trend be included?*
6) *Test for weak exogeneity of RHS variables*

[22] This explanation is due to Harris (1995)

7) *Test for linear hypothesis on the co-integration vectors*
8) *Test for unique co-integration vectors*
9) *Carry out joint test involving restrictions on alpha and Beta … (Harris (1995))*

We will only concern ourselves in this exercise with the theory that explains how to test for the number of co-integrating vectors in a multivariate system and briefly explain the Johansen Trace statistic (λ_{trace}) which is the preferred statistic for determining the number of co-integrating vector in a VECM

As Harris illustrates, starting from the general unrestricted VAR in the spirit of Sims (1980**)**

$Z_t = A_1 Z_{t-1} + \ldots A_k Z_{t-k} + u_t \ldots u_t \sim IN(0, \sum)$ (*)

Z_t is an (nX1) matrix of variables

A_1 is an (nXn) matrix of parameters

(*) is a reduced form system with each variable in Z_t regressed only on lagged values of both itself and all other variables in the system. OLS is efficient because RHS consists of a set of lagged and pre-determined variables. We can derive a VECM from (*)

$\Delta Z_t = \acute{\Gamma}_1 A_1 \Delta Z_{t-1} + \ldots \acute{\Gamma}_{k-1} \Delta Z_{t-K} + \Pi Z_{t-1} + ut$ (**)

Where $\acute{\Gamma}_i$ = (I-A1- -…-Ai), (i=1,2, ,k-1) and Π =(I-A1- -…-Ai)

$\acute{\Gamma}_i$ = Contains short run adjustments to changes in Z_t

Π = Contains long run adjustments to changes in Z_t

$\Pi = \alpha\beta'$ α represents the speed of adjustment to disquilibruim

Testing for co-integration in this contest, amounts to *a consideration of the rank of Π th*e reduced form matrix (Johansen, 1993). That is we must find the number of r linearly independent columns in Π. The rank tells us the number of co-integrating vectors

1) if Π has full rank (r =n) the variables in z_t are I(0) -> Estimate standard Sims type VAR in levels

2) Π has rank 0. There are no long run relationships at all. Estimate a VAR in 1st differences involving no LR terms
3) Rank r <= (n-1) so Π has reduced rank implies r co-integration relationships exist

Obviously (3) where the matrix rank is not full or reduced is the most interesting case because it indicates the possibility of testing for more than one co-integrating vector

Testing For Reduced Rank Testing For Co-Integration (Harris, 1995)

To test Ho: there are at most r co-integration vectors (and thus) n-r unit roots amounts to

Ho: $\lambda_i = 0$, i= r+1, …n

Where only the first r eigen values is non-zero.

This restriction can be imposed for different values of r and the log MLE for the restricted model contrasted with the log MLE of the unrestricted model and a standard LR test computed (albeit with a non-standard distribution. We use the trace statistic to test Ho

λtrace = -2log (Q) = -T ∑ (sum over i, i = r+1 to n) log (1-λ_i) r = 0 , 1 2, …n-2, n-1

Q = restricted MLE / unrestricted MLE

Asymptotic critical values are provided in Osterwald-Lenum (1992) but if dummies enter the deterministic part of the multivariate model then these critical values are at best indicative. Small number of observations also reduces the power of the test. In this paper we use Johansen's trace test as our main test for co-integration in the VECM

The λtrace statistic tests Ho r = q (q=1, 2,3 …n-1) against Ha: r = n. It is therefore possible to test for and accept the existence of two co-integrating vectors if the trace statistic associated with Ho: r = 1 is rejected but Ho: r = 2 is not rejected.

iii. Granger Causality

Recall that although co-integration between two variables does not specify the direction of a causal relation, if any, between the variables, economic theory guarantees that there is always Granger Causality in at least one direction (Awudu Reider (1994)). We verify the direction of Granger Causality between Ghana cocoa supply and the exogenous variables (These are the same five series for which we will also test for co-integration relationships): Smuggling Incentive, Ghana cocoa producer price, International Cocoa Price, and the Ghana Maize Wholesale Price.

Possible Co-integration and Granger Causality relationships:

i) International Price and Producer Price of Cocoa

ii) Smuggling Incentive and Cocoa Supply response

iii) Maize Price and Cocoa Supply (Substitute relationship)

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

A brief background on Granger Causality:

Consider the causal relationship between the smuggling incentive and the supply of Ghana cocoa beans (here understood to be the total export of cocoa)

Let A = Smuggling Incentive (1)

Let B = Cocoa Supply. (2)

To verify the direction of Granger causality between A and B, we must regress B on lagged values of itself and lagged values of A (Granger, 1967). Furthermore in order to unambiguously *conclude that A Granger causes B we must*:

(1) Reject **Ho**: A does not cause B or (fail to reject A causes B)

(2) We must accept (or not reject) **Ho**: B does not cause A (Pyndyck and Rubinfield, 1991.))

Now lets define the equation $B = \Sigma\alpha_i B_{t-1} + \Sigma\gamma_i A_{t-1}$. (3)

To prevent spurious regressions (and ensure stationarity of the series) take the first difference of (3) to obtain

$\Delta B = \Sigma\alpha_i \Delta B_{t-1} + \Sigma\gamma_i \Delta A_{t-1}$. (4) Where i= 1,2,3, …= the number of lags to be used.

It is possible to use the AIC or BIC criterion to determine the appropriate number of lags by means of the minimum (AIC/BIC) criteria. In this exercise we limit ourselves to 3 and 5 lags because of data availability problems.

Recall we must also accept (or not reject) **Ho:** B does not cause A (Pyndyck and Rubinfield, 1991.)) so specify the equation below

$\Delta A = \Sigma\alpha_i \, \Delta A_{t-1} + \Sigma\gamma_i \, \Delta B_{t-1}$. (5) The null hypothesis can be stated as **Ho**: $\gamma_i = 0$ for i=1,2,3

We must accept Ho: $\gamma = 0$ for i= 1,2,3 by means of a joint hypothesis F-test (which may be specified in terms of restricted and unrestricted regressions)

Table 2 in the results section reports the results for granger causality between the very variables for which co-integration relationships were also verified (See **Table 2**)

iv. Error Correction Models (ECMS).

ECMs explicitly account for the dynamics of short run adjustment towards long run equilibrium (Abdullah and Reider (1995)). An ECM can be executed either as a single equation or as part of a vector error correction model (VECM). To implement the former model, first, estimate the co-integration or long run relationship and compute the residual. Call this residual Z_t. Z_t actually is the error correction term in the single equation error-correction model and represents the long run correlation between the dependent variable and the RHS variables. Next, regress the dependent variable on this error correction term and the rest of the RHS variables in 1st differences. Minus Z_t, the remaining RHS variables in 1st differences capture the short run relationships between the explained variable and the explanatory variables[23]. Theoretically, the ECM can be derived from a re-parameterization of the general autoregressive distributed lag model (Abdulai and Reider (1995), Hendry et all (1984)). Hallam and Zanobi (1993) have demonstrated that in the in the context of agricultural supply response estimation ECMs are very pertinent. They point out that how ECMs circumvent the unrealistic assumption of stationary expectations that is the shortcoming of partial adjustment models. In what follows, we present the mathematical description of the evolution of the error correction model. In particular we stress our hybrid specification of the ECM (Hybrid of Abdulai et al (1995) and Bulir (2003)). We use this hybrid model to address the possible structural change and related price incentive reversal that makes the earlier models redundant. **Table** 6 in the results section presents the results from the hybrid version of the single equation error

[23] As mentioned earlier, one of the strengths of the ECMs is the ability to incorporate long run equilibrium and short run relationships in the same model

model. Of course we elaborate on what this model's results means in the discussion section. Before presenting the mathematical models however, we also briefly discuss the relevance of a vector error formulation since some advantages exist. In fact, Bulir (2003) applied both a VECM and a single equation ECM in his analysis.

<u>VECM: Extension (Harris, 2005)</u>

Variables that are weakly exogenous in the short run and insignificant in the long run can be incorporated into the VECM.

The general form of the VECM:

$$\Delta Z_t = \acute{\Gamma}_1 A_1 \Delta Z_{t-1} + \dots \acute{\Gamma}_{k-1} \Delta Z_{t-K} + \Pi Z_{t-1} + u_t \qquad (6)$$

Can be re-written as

$$\Delta Z_t = \acute{\Gamma}_1 \Delta Z_{t-1} + Z_{t-K} + \Pi Z_{t-12} + \Psi D_t + ut \qquad (7)$$

The Variables in D_t take account of short run shocks eg policy interventions and are often specified as dummies.

Including any dummy-type variables will affect the underlying distributions of the test statistics, such that the critical values of these tests will be different depending on the number of dummies included. This will mean that the published critical values provided by Johansen and Osterwald-Lennum (1992) are at best indicative. As discussed earlier at length if we wrongly impose the restriction that there is only one co-integrating vector (by limiting ourselves to the single equation ECM) we might get inefficient estimators. This is the basic reason that Johansen had argued for a multivariate VECM as explained in the theory section of the paper.

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

$$\Delta A_t^c = a_0 + a_1 \Delta P_t^c + a_1 \Delta M_t^s - \gamma\ (\mathbf{A_{t-1}^c - b_1 P_{t-1}^c - b_2 M_{t-1}^s}) + U_t$$

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

$$\Delta\ \text{Supply}_t = \alpha + \sum_{i=0}^{i=2} \beta 1i \Delta\ \text{Producer}_{t-i} + \sum_{i=0}^{i=2} \text{Smuggling Incentive}_{t-1} + \gamma\ (\text{Supply}_{t-1} - \delta_1\ \text{International price}_{t-1} - \delta_2\ \text{Smuggling incentive}_{t-1}) + \varepsilon$$

γ = 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 (but with the complete available data set)

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

$$\Delta\ \text{Supply}_t = \alpha + \sum_{i=0}^{i=2} \beta 1i \Delta\ \text{Producer}_{t-i} + \sum_{i=0}^{i=2} B_{2i}\ \text{Smuggling Incentive}_{t-1} + B_3 \Delta PM_t^s$$
$$\gamma\ (\text{Supply}_{t-1} - \delta_1\ \text{International price}_{t-1} - \delta_2\ \text{Smuggling incentive}_{t-1} - \delta_3 PM_t^s) + Dt + \varepsilon$$

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 (I need a better dummy)

Table 6c in the result section has the regression output for the hybrid specification of the model (but with the complete available data set)

Section III. Results

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

Table 1	STRUCTURAL BREAK TEST (D1=1 If 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	
Restricted	d.GSUP = l1.dGSMUG + l2.dGSMUG + l1.dGHCPL+l2.GHCPL+ l1.dINTCPL +l2.dINTCPL	
Unrestricted	d.GSUP = l1.dGSMUG + l2.dGSMUG + l1.dGHCPL+l2.GHCPL+ l1.dINTCPL + l2.dINTCPL + D1*l1.dGSMUG+	
	D1*l2.dGSMUG + D1*l1.dGHCPL+D1*L2.dGHCPL+D1* l1.dINTCPL + D2*l2.dINTCPL	

Table 2: 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: Co-integration

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: Granger Causality

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	\ccept 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	ACCEPT	Reject Ho:γi=0	-0.7
SMUG Granger Causes GHSUP YES			
GHSUP Granger Causes SMUG NO	ACCEPT	Accept Ho:γi=0	0.6
CONCLUSION **INCONCLUSIVE**			

Table 5: Partial Adjustment Model

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 Models
6a: Awudu and Reider Error Correction Model **(Vector Error Correction Model)**
6b: (Bulir (2003) Error Correction Model with Smuggling Incentive **(VEC)**
6c: 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 6.1: Stationarity Tests

6a1: Awudu and Reider Error Correction Model **(Vector Error Correction Model)**
6b1: (Bulir (2003) Error Correction Model with Smuggling Incentive **(VEC)**
6c1: HYBRID Vector Error Correction Model **(HECM)**

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

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

Table 6c1 HYBRID	***Stationarity***	***Tests***		
VARIABLES	**Test Statisitc**	**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_0:Rank=# of Co-integrating Vectors	2 Lags
Johansen's Trace	Test For # of Co-Integration Vectors	
Rank	$\lambda_{trace=}T \sum$ **(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 Model

Table 8: VECM:1977-2004 with 1 Lag VARIABLES	Unrestrictd Consant, No trend
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	

Section IV. Discussion

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. This makes sense given how we had defined the smuggling incentive variable. That is as the price mark 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. It is my guess that using an iterative procedure that tests every quarter for structural break for the 1999-2001 period will probably have identified the precise point where a structural break if any had occurred. However due to that fact that we are not familiar with a routine in STATA that executes this test I pooled the data for the rest of the exercise. 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. As outlined in the theory, 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 con-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 tests came out inconclusive. For example, we were not able to confirm that the Smuggling Incentive Granger causes Ghana cocoa supply.[24] 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

[24] This result does not make sense and is one that I intend to investigate more rigorously

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 necessary condition that has to be satisfies before a single equation error correction model can be carried out. All the models have EC 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.[25] 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.

[25] The Johansen test is the best test to use in small sample

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. Careful diagnostic testing of the residuals of the regression should be carried out. Finally the model should be evaluated based on its performance on out of sample ex post forecast.

Acknowledgement

My gratitude goes to Phil Garcia (PhD) who guided my research and to Julietta Frank who provided useful suggestions. I also want to thank Ales Bulir for making available to me his original data set. Finally thanks be to God almighty who gives me strength.

Section VI. Reference

1. Abdulai, A., and Reider, P. (1995) The Impact of Agricultural Policy on Cocoa Supply in Ghana: Error-Correction Estimation. *Journal of African Economies*, 4, pp 315-335

2. Aryeetey, E. and A.K. Fosu (2003). Economic Growth in Ghana. *African Economic Research Consortium Growth Project*

3. Ayittey, B.N. (2005) Africa Unchained: The Blueprint for Africa's Future. *Palgrave Macmillan*, NY

4. Aryeetey, E. A.K. Fosu and Mahamudu Bahamia (2001). Explaining African Economic Growth. The Case of Ghana African *Economic Research Consortium Growth Project*

5. Bart, H., Hans Frances, P., Ooms M (1998). *Econometrics Institute*. Erasmus University of Rotterdam

6. Berument, Hakan and Dincer, N. Nergiz (2004) The Effects of Exchange Rate Risk on Economic Performance: The Turkish Experience. *Applied Economics*, v. 36, iss. 21, pp. 2429-41

7. Bulir, Ales (2002). Can Price Incentive to Smuggle Explain the Contraction of the Cocoa Supply in Ghana? *Journal of African Economies*, 11 (3), pp 413-436.

8. Engle R. F. and Granger C.W.J (1987) Co-integration and Error Correction Representation, Estimation and Testing, *Econometrica,* 55 (2), pp251-276

9. Frimpong-Ansah, J. (1991). The Vampire State in Africa: The Political Economy of Decline in Ghana, *London:* James Currey.

10. Gyimah-Brempong, K. (1987). Scale Elasticities in Ghanaian Cocoa Production. *Applied Economic,* 19, pp1383-1390

11. Hallam and Zanollii, R. (1993). Error Correction Models and Agricultural Supply Response. *European Review of Agricultural Economics,* April. pp 151-166

12. Harris, R.I.D (1995). Using Co-integration Analysis in Econometric Modeling. *Prentice Hall*

13. Kwiakowski, Phillips, Schmidt and Shin (1992). "Testing the Null Hypothesis of Stationarity Against the Alternative of A Unit Root *Journal of Econometrics*, 54, 159-178

14. Lal, Deepak (2000). The Poverty of "Development Economics" *The MIT Press*. Boston, MA.

15. Smith, Adam (1776). An Inquiry into the Nature and Causes of The Wealth of Nations. *Random House, Inc*

16. Zeitlin, Andrew (2005). Market Structure and Productivity Growth in Ghanaian Cocoa Production. *ISSER /Cornell University International Conference on "Shared Growth in*

17. Zivot, E. and D Andrews (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis, *Journal of Business & Econ Statistics,* 10, 251-70.