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THE REAL EXCHANGE RATE AND GHANA'S AGRICULTURAL EXPORTS

K. YERFI FOSU

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The real exchange rate and Ghana's agricultural exports

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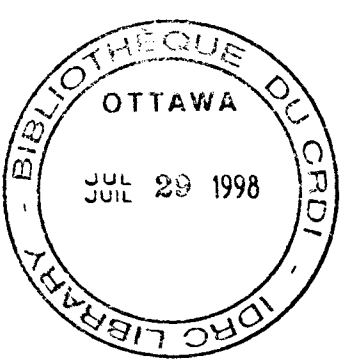

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List of abbreviations

Adj. R^2	Conventional regression adjusted coefficient of determination
Cocobod	Cocoa marketing Company of the Ghana Cocoa Board which markets Ghana's cocoa, coffee and sheanuts on the world market.
D.W.	Conventional regression Durbin-Watson test statistic
Fund-Bank	International Monetary Fund and World Bank
RER	Real exchange rate

List of variables

ASSYM	Algebraic product of the natural logarithm of the real exchange rate and a dummy variable defined to take a value of unity when the real exchange rate increases (i.e. depreciates) and zero when the real exchange rate does not change, or declines (i.e. appreciates).
b_{cc}	The share of domestic cocoa price in the domestic aggregate agricultural export price.
d_{AH}	The share of non-traded goods in domestic aggregate agricultural price.
d_{NH}	The share of non-traded goods in domestic aggregate non-agricultural price.
DUM	Dummy variable defined to take on a value of unity during 1960-83 and zero during 1983-7.
E	Nominal exchange rate (i.e. cedis per US dollar)
g_{FH}	The share of non-traded food in the aggregate food price.
g_{FX}	The share of food export in the aggregate food price.
h_F	The share of food exports in the aggregate agricultural product price.
P_A	Domestic aggregate agricultural product price.
P_{AH}	Domestic non-traded agricultural goods price.
$P_{AH(F)}$	Domestic price of non-traded food.
P_{AM}	Domestic price of agricultural import-competing goods.
$P_{AM,f}$	Foreign price of agricultural import-competing goods.
$P_{AM(F)}$	Domestic price of import-competing food.
$P_{AM(F),f}$	Foreign price of import-competing food.
$P_{AM(NF)}$	Domestic price of non-food agricultural import-competing goods.
$P_{AM(NF),f}$	Foreign price of non-food agricultural import-competing goods.

P_{AX}	Domestic price of agricultural export commodities.
$P_{AX,f}$	Foreign price of agricultural export commodities.
$P_{AX(F)}$	Domestic price of food export commodities.
$P_{AX(F),f}$	Foreign price of food export commodities.
$P_{AX(NF)}$	Domestic price of non-food agricultural export goods.
$P_{AX(NF),f}$	Foreign price of non-food agricultural export goods.
P_{cc}	Domestic price of cocoa.
P_{cf}	Domestic price of coffee.
P_F	Domestic aggregate food price.
P_f	Aggregate foreign price in the economies of Ghana's trading partners.
P_H	Domestic aggregate non-traded goods price.
P_N	Domestic aggregate non-agricultural product price.
P_{NH}	Domestic non-traded non-agricultural product price.
P_{NM}	Domestic non-agricultural import competing goods price.
$P_{NM,f}$	Foreign price of non-agricultural import-competing goods.
P_{NX}	Domestic price of non-agricultural export goods.
$P_{NX,f}$	Foreign price of non-agricultural export goods.
P_{ncc}	Domestic price of non-cocoa agricultural export commodities.
P_{sn}	Domestic price of sheanuts.
Q_{cc}	Productive capacity of the cocoa industry.
R	Real exchange rate of the cedi.
SMUG 1	Ratio of cocoa producer price in Côte d'Ivoire converted to cedis, and the cedi cocoa producer price in Ghana.
SMUG 2	Ratio of cocoa producer in Togo converted to cedis, and the cedi cocoa produce price in Ghana.
T	Trend term.
T_{AX}	Aggregate agricultural export tax rate.
$T_{AX(F)}$	Export tax rate on food exports.
$T_{AX(NF)}$	Export tax rate on non-food exports.
T_{AM}	Implicit import tariff on aggregate agricultural imports.
W	National average annual rainfall.
W_c	Average annual rainfall in the cocoa growing zone.
W_s	Average annual rainfall in the sheanut growing zone.
X_A	Real aggregate agricultural exports.
X_{cc}	Volume of exports of cocoa.

X_{cf}	Volume of exports of coffee.
X_{sn}	Volume of exports of sheanuts.
Y	Foreign trade-weighted aggregate real income of Ghana's trading partners.
ϕ_{AH}	Share of P_{AH} in P_H.
ϕ_{AM}	Share of P_{AM} in P_A.
ϕ_{AX}	Share of P_{AX} in P_A.
ϕ_{NM}	Share of P_{NM} in P_N.
ϕ_{NX}	Share of P_{NX} in P_N.

I Introduction

This study examines the effects of the real exchange rate of the cedi[1] on agricultural price incentives and agricultural exports[2] in Ghana. It is divided into six sections. The problem which motivated this study, the study's objectives and relevance, and a review of the literature are formally stated in Section II. In Section III, the time profiles of the real exchange rate of the cedi, agricultural price incentives, and Ghana's agricultural exports are described. The econometric models for analysing the linkages between the real exchange rate of the cedi, agricultural price incentives, and agricultural exports, are specified and the procedures for estimating and testing hypotheses about the relevant parameters are presented in Section IV. Empirical analyses of the effects of the real exchange rate on agricultural price incentives are undertaken in Section V. The effects of the real exchange rate on agricultural exports are studied in Section VI. Finally, conclusions are contained in Section VII.

II The purpose of the study

As will be demonstrated in greater detail in Section III, Ghana's agricultural exports have generally declined in real terms by 4.6 per cent during the period 1960-87. Various reasons have been adduced for the decline of real agricultural exports, either in the aggregate or with reference to specific export commodities (see Okyere (1989), Killick (1978), for instance). It is well known among economists that as a sector of an economy, or the economy as a whole, becomes more open (that is, as the share of tradable goods in output rises), the real exchange rate of the domestic economy's currency becomes an important determinant of sectoral or aggregate output (see Bautista (1987), Tshibaka (1986)). As will be demonstrated in Section III, Ghana's agricultural sector has been substantially open. Hence variation in the real exchange rate of the cedi is likely to explain a substantial proportion of the generally declining trend in agricultural exports. However, this has not been given adequate attention. An equally important related issues which has also not received adequate research attention concerns the effect of the real exchange rate on agricultural price incentives. The present study therefore addresses the following questions. What have been the quantitative effects of the real exchange rate of the cedi on agricultural price incentives in Ghana? To what extent has the real exchange rate of the cedi shaped Ghana's agricultural exports over the period 1960-1987?

The primary objective of the study is to undertake quantitative measurements of the effects of the real exchange rate of the cedi on agricultural price incentives and agricultural export performance in Ghana. The specific objectives are:

(a) to measure movements of the real exchange rate of the cedi for the period 1960-87;

(b) to describe the time profiles of price incentives' structure for agricultural exports;
(c) to describe the time profiles of real aggregate agricultural exports, traditional agricultural exports such as cocoa, coffee and sheanuts, and non-traditional agricultural export commodities like pineapples, banana, yam, vegetables, and seafoods;
(d) to measure the quantitative effects of real exchange rate movements on the price incentive structure for agricultural exports over the period 1960-87;
(e) to estimate the quantitative effects of the real exchange rate on agricultural exports;
(f) to make policy recommendations for improving agricultural export performance.

The theme of the present study is relevant for a number of reasons. First, domestic agriculture traditionally contributes very significantly to the external performance of the economy by generating and saving scarce foreign exchange by producing food and agro-based raw materials which would otherwise have been imported (Killick (1978), Fosu (1989b)). The recent record shows that domestic agriculture's share in total export earnings averaged slightly over 62 per cent per annum during the period 1970-87 (Fosu (1989b)). By generating foreign exchange, domestic agriculture contributes the largest share to Ghana's balance of trade and overall balance of payments.

Second, although agricultural exports are important to economic development, agricultural export performance has generally shown a downward trend over the period 1960-87. The evidence of this decline will be detailed in Section III. If the reversal of this downward trend is to be sustained over the coming decades, then the 'culprits' in the agricultural export decline issue have to be identified. It has been pointed out that the reasons for the decline comprise both domestic and external factors. The domestic factors include inadequate infrastructure and supply of inputs, smuggling of cocoa beans to border countries like Togo and Côte d'Ivoire, labour shortages on the farms producing agricultural export commodities, low and declining real domestic producer prices for agricultural export commodities, and competition from other crops (particularly staple food crops) for the use of resources (see Okyere

(1989), Robertson (1987), Ghana Cocoa Board (1974, 1987), Nyanteng (1977, 1980), Dapaah (1982), Kotey, Okali and Rourke (1974), Manu (1974), Adomako-Sarfoh (1974), Bateman (1973, 1974), La-Anyane (1972), Stern (1965) and Atsu (1965)). The external factors originate in the structure of the international commodity market. For example, external terms of trade, like those for other developing economies, have tended to limit Ghana's exports. Supply of Ghana's agricultural commodities is restricted by the low price and income elasticities of foreign markets, factors which contribute to the decline in export performance.

It is important to note that most of the factors listed above are directly or indirectly related to the real exchange rate of domestic currency. The real exchange rate is likely to be a 'major culprit' in the agricultural export decline episode, but its role in stimulating export performance has been largely neglected. This study attempts to narrow the gap by contributing empirical analysis in terms of a model of the implementation of the Fund-Bank Supported Structural Adjustment Programme as it relates to Ghana.

Third, there is increasing interest among economists in the role of the real exchange rate in agricultural performance. The real exchange rate, which is essentially the real worth of foreign exchange in terms of a given domestic currency (Bautista (1987)), is important for a number of reasons. It is an important determinant of the performance of a sector or an economy for which tradable goods constitute a significant proportion of output. Trade and macroeconomic policies could influence agriculture through their effects on the real exchange rate. As will be discussed in Section III, the share of tradables in agricultural output has traditionally been significant. Hence, the real exchange rate is likely to be very important in discussions concerning agricultural export supply response. Bautista (1987), among others, observed that a decline in the real exchange rate tends to stimulate a decline in the price of tradable goods relative to the price of non-tradable goods. This results in a movement of resources away from the production of tradable goods, including agricultural exports. A continued shift of productive resources away from the production of agricultural export commodities ultimately precipitates continued decline in agricultural export performance. The present study's focus on the role of the real exchange rate is therefore germane.

Finally, the few existing studies directly or indirectly related to this theme have tended to concentrate on one component of the linkages between the real exchange rate, agricultural price incentives and agricultural export supply response. Most of the studies have concentrated on the effects of trade and macroeconomic policies on the structure of incentives (see for instance, Krueger, Valdes and Schiff (1987), Krueger, Schiff and Valdes (1989), Bautista (1987), Tshibaka (1986), Valdes (1985)). With the exception of Bautista (1987), the studies do not provide estimates of the elasticities of agricultural price incentives with respect to changes in the real exchange rate. Such elasticities, which are useful for policy purposes, have not been computed in the case of Ghana. The present study contributes to the debate by providing elasticity estimates.

The studies mentioned above, by virtue of their chosen focus, take the agricultural exports' situation as given and only provide a cursory examination. Neither do they prove estimates of elasticities of real aggregate exports and of exports of specific agricultural commodities with respect to changes in the real exchange rate, although these elasticities represent important inputs into the policy-making process. It is worth mentioning, however, that Okyere (1989), using the ordinary least squares method, estimated a cocoa output response equation relating to Ghana. Among other variables, Okyere's response equation included the real import-weighted effective exchange rate, as well as the real producer price of cocoa. His study showed that whereas the real producer price of cocoa was statistically significant at the 5 per cent level, the real import-weighted effective exchange rate variable was not statistically significant at the 5 per cent level. In theory, one expects changes in real exchange rate to result in changes in the price incentive structure, which in turn stimulate changes in agricultural exports. If indeed the real exchange rate influences the price incentive structure (and this will be ascertained in this study), then Okyere's model encountered the econometric problems of simultaneity and multi-collinearity[3] which could have contributed to the non-significance of the real exchange rate variable.[4] The correlation matrix was not provided, so one can only speculate on this. Of course, Okyere's study[5] did not explicitly examine the possibility of a link between his real exchange rate variable and the real producer price of cocoa.

III Time profiles of the real exchange rate, agricultural price incentives, and agricultural exports

In this section, measurements are made of the real exchange rate of the cedi and the behaviour of the variable over time is described. Since the real exchange rate is held to be exogenous in the present study, we do not examine the causes of its variations. The study will also examine the behaviour of agricultural price incentives, including those for agricultural exports. Finally, the time profiles of real aggregate agricultural exports and specific traditional agricultural export commodities and aggregate non-traditional agricultural exports are described.

The real exchange rate

The real exchange rate as a concept involves adjusting a specified nominal exchange rate for relative inflation between a domestic economy and the rest of the world to determine the effect on incentives to produce, purchase and store commodities and services (Snape (1988)). Indeed, it can broadly be defined, see Bautista (1987), as the real worth of foreign exchange in terms of a given domestic currency. Bautista argues that 'since the real worth of foreign exchange (for example, the US dollar) in one year is not the same as in the next if foreign prices have changed, it is necessary to refer to a basket of goods whose price is a real dollar'. Some researchers have measured the real exchange rate as the ratio of the domestic price of tradable to non-tradable goods. However, in view of the problems associated with this approach (see, for instance, Edwards (1987), Harberger (1986), and Balassa (1987)), we do not employ it in this study. For example, Snape (1988) presents a number of

reasons why empirical economic studies employ some direct measure of real exchange rate based on equation (1) rather than the ratio of domestic tradable price to domestic non-tradable price. First, he argues that the idea of a price relation between tradable and non-tradable goods breaks down in situations where no clear distinction exists between tradable and non-tradable goods. Second, in circumstances where import-competing goods are not substitutes for imports, or where the *ad valorem* effect of subsidies and trade barriers changes, the domestic price of tradable goods is not linked to the world market price, and changes in the domestic tradable-non-tradable price ratio may not accurately be reflected in changes in a real exchange rate R as defined in (1). Finally, domestic pressures can change both the prices of tradables and non-tradables, and the terms of trade. In such a situation, importable and exportable goods prices cannot be combined to obtain an aggregate tradable goods price results.

In the present study, following Harberger (1986), Bautista (1987), and Snape (1988), the real exchange rate of the cedi, R, is defined as

$$(1) \qquad R_t = P_{h,t}^{-1} \, (E_t \, . \, P_{f,t})$$

where t denotes time (i.e. year t), Ph denotes an index of home goods price, E denotes nominal exchange rate of the cedi in cedis per US dollar, Pf denotes index of foreign prices in US dollars. In the present study, following Bautista (1987) and Harberger (1986), national wholesale prices are used as proxies for foreign goods prices. The foreign price index is measured as follows:[6]

$$(2) \qquad P_{f,t} = (n+1)^{-1} \left(WP_{us,t} + \sum_{j=1}^{n} e_{usj,t} \, . \, WP_{j,t} \right)$$

where $WP_{us,t}$ denotes the national wholesale price index for the United States in year t and $WP_{j,t}$ denotes the national wholesale price index for the jth trading partner of Ghana other than the United States in year t. Notably, n denotes the number of such trading partners. In the present study, $n = 9$. The

nine trading partners accounting for the greatest shares in Ghana's exports in each year were included. The specific trading partners employed include: West Germany, United Kingdom, USSR, Netherlands, Italy, Japan, Yugoslavia, Switzerland, and Canada, as well as Australia, Norway, Belgium, Sweden, Togo, China, France, Malaysia, and Ireland. These selected trading partners jointly account for 80.2 - 97.8 per cent of exports for each year. It is important to note that apart from 1975, 1976, 1985 and 1987 when $n = 8$, and 1977 when $n = 12$, the study uses $n = 9$. In equation (2), the symbol *eus,j* denotes an index of the nominal exchange rate (US dollar per unit of the domestic currency) of the *j*th trading partner.

The wholesale price indices and the nominal exchange rate data are obtained from various issues of the International Monetary Fund's *International Financial Statistics*. The local food component of the national consumer price index is employed as a proxy[7] for the index of home-goods price P_h. The local food CPI time series data are obtained from the *Ghana Statistical Service*. Since the index of local food price is reported with different base periods, the pieces of time series of food price indices were spliced by the standard method to a common base period (1980 = 100).

From equation (1), it is seen that a change in the real exchange rate of the cedi, R, may be due to a change in one or more of the following variables: the nominal exchange rate of the cedi, E, the foreign price index, P_f, and the domestic goods price. Taking the total derivative of R in equation (1) with respect to time and dividing through the result by R gives equation (3) upon the appropriate rearrangement of terms.

$$(3) \qquad \frac{dR/dt}{R} = \frac{dP_f/dt}{P_f} + \frac{dE/dt}{E} - \frac{dP_h/dt}{P_h}$$

Equation (3) states that any percentage change in the real exchange rate is equal to the difference between the sum of percentage changes in the nominal exchange rate and the foreign price on the one hand, and the change in the domestic price on the other. The respective contributions of changes in the nominal exchange rate, E, foreign price index, P_f, and index of home-goods price, P_h, are given by equations (4), (5) and (6).

(4) C_E $[(dE/dt)/E]$ / $[(dR/dt)/R]$

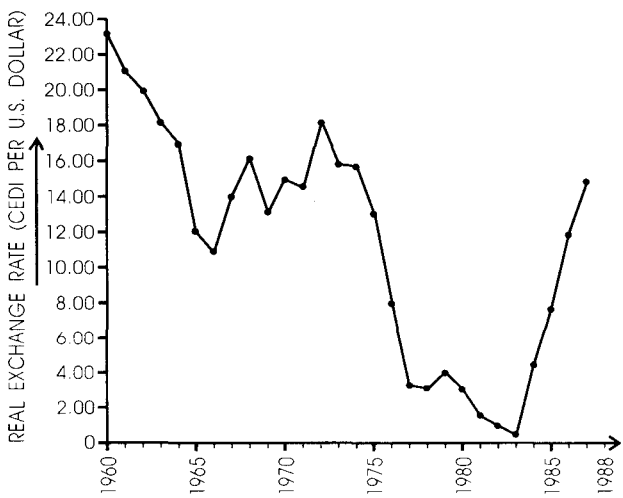
(5) $C_f = [(dP_f/dt)/P_f]$ / $[(dR/dt)/R]$

(6) $C_h = [(dP_h/dt)/P_h]$ / $[(dR/dt)/R]$

C_E, C_f and C_h denote the proportions of the change in the real exchange rate respectively accounted for by changes in E, P_f, and P_h.

The time profile of the real exchange rate of the cedi, as measured per equation (1), is depicted in Figure 1.

Figure 1 Time profile of the real exchange rate of the cedi



Over the entire period, the real exchange rate tended to decline although it moved upwards during 1983-7. Table 1 summarizes the periods during which

the real exchange rate rose (+) or fell (-). The largest average annual absolute decline in the real exchange rate is equal to cedi 2.92 and was recorded for 1968-9. This is followed by the period 1972-8 which recorded an average annual absolute decline equal to cedi 2.44. The lowest decline of cedi 0.43 is recorded for the period 1970-1. The largest rise in the real exchange rate is recorded for the period 1983-7 followed by 1971-2; the respective average annual absolute increases equal cedi 3.51 and cedi 3.27. The smallest rise is equal to cedi 0.82 and was recorded for 1978-9. The percentage increases in the real exchange during the period 1983-7 is equal to +226.62 per cent.

Table 1 Trends in the real exchange rate of the cedi

Period	Average annual absolute change (cedi per US dollar)	Percentage change
1960-6	-2.06	-11.64
1966-8	+2.66	+22.38
1968-9	-2.92	-18.23
1969-70	+1.72	+13.08
1970-1	-0.43	-2.83
1971-2	+3.27	+22.70
1972-8	-2.44	-22.56
1978-79	+0.82	+27.17
1979-83	-0.85	-40.40
1983-7	+3.51	+226.62

Source: Basic data are from the *International Financial Statistics*, IMF (various issues) and the Ghana Statistical Service.

The compound growth rates of the real exchange rate for the decades of the 1960s, 1970s, 1980s and the period 1960-87 are shown in Table 2.

Table 2 Percentage growth* and sources of growth of the real exchange rate

Period	Growth of real exchange rate	Growth of nominal exchange rate	Growth of foreign price index	Growth of domestic price index
1960s	-6.13	+4.03	+0.92	+11.85
	(-58.41)		(-13.33)	(171.74)
1970s	-18.62	+6.84	+10.04	+44.45
	(-24.91)		(-36.42)	(161.23)
1980s	+43.63	+95.97	+0.75	-37.46
	(161.95)		(1.27)	(-63.21)
1983-7	+123.18	+132.38	+6.78	+11.18
	(103.44)		(5.30)	(-8.74)
1960-87	-7.81	+16.24	+5.36	32.85
	(-144.36)		(47.64)	(292.00)

Source: Basic data are from the *International Financial Statistics*, IMF (various issues and the Ghana Statistical Service.

* Compound growth rates are employed. The figures in parentheses are the percentage shares of the corresponding variables in the growth of the real exchange rate of the cedi. See Appendix 2 for the absolute percentage shares (of absolute changes).

Although the growth rates in the 1960s and 1970s were negative, the corresponding growth rate for the 1980s was positive. Table 2 shows that the fall was faster in the 1970s than during the 1960s. This implies that the cedi appreciated in real terms at a faster rate in the 1970s than in the 1960s. The compound growth rate of the real exchange rate is equal to -7.81 per cent per annum for the period 1960-87. This implies that the real exchange rate generally declined during the period, indicating a real appreciation of the cedi. This could be explained by the fact that the sum of the growth of both the nominal exchange rate and the foreign price index was less than the growth of

the domestic goods price index during the period. The growth rate of the real exchange rate during the 1960s and the 1970s could be similarly explained. In the 1980s, on the other hand, the real exchange rate grew by 43.63 per cent per annum, indicating a real depreciation of the cedi. This is explained by the fact that the sum of the growth of the nominal exchange rate of the cedi and the foreign price index exceeded the growth in the price index of home goods (Table 2). This observation that the real exchange rate demonstrated a declining trend during 1960-87 is further borne out by the empirical linear trend regression result in equation (7): the figures in parentheses are t-ratios and T denotes trend term.[8]

$$(7) \quad R = \underset{(11.4939)}{19.8708} - \underset{(-5.8044)}{0.6046T}$$

Coefficient of determination $R^2 = 0.5644$

F-ratio = 33.6908

Hence, the value of the cedi appreciated in real terms during the period 1960-87.

It is worth mentioning that the fall in the real exchange rate of the cedi (that is, the real appreciation) at a compound growth rate of -6.31 per cent per annum in the 1960s was largely due to a rise in the domestic price which contributed approximately 171.74 per cent of the fall in the real exchange rate (Table 2). The foreign price made the least contribution to the fall during this period. During the 1970s, the real exchange rate appreciated, due largely to an increase in the domestic price which contributed approximately 161.23 per cent. The nominal exchange rate made the least contribution to the appreciation of the cedi during the period. During the 1960s and 1970s the nominal exchange rate was fixed. In the 1980s the real exchange rate depreciated by a compound growth rate of 43.63 per cent per annum. The major source of this decline was a nominal exchange rate depreciation which contributed approximately 161.95 per cent (Table 2). For most of the 1980s, Ghana experienced large nominal devaluation. During the period 1960-87, the real

exchange rate appreciated largely because of the rise in the domestic price which contributed 292 per cent of the real appreciation. Foreign prices made the least contribution to the real appreciation figures during the period. The highest real depreciation of the cedi was equal to 123.18 per cent per annum and was recorded during the structural adjustment period of 1983-7. This real depreciation was largely due to nominal exchange rate depreciation (Table 2). It appears that, in general, during periods when the real exchange rate of the cedi appreciated, this was largely due to increases in the domestic price level. During periods when the real exchange rate depreciated, on the other hand, this was largely due to depreciation of the nominal exchange rate, with foreign prices playing a minor role in real depreciation.

Agricultural price incentives

The idea that price incentives are relevant to determining the direction of intersectoral resource flows is well understood. Relative prices indicate relative profitability of production in one sector or of a commodity as against competing sectors or other commodities. Since resource flows between sectors determine sectoral economic performance, it is clear that price incentives also play a major role.

In this study, two partial indicators are employed to gauge the competitiveness of Ghana's agricultural sector as a whole. The first is the ratio of domestic aggregate agricultural price index to the domestic aggregate non-agricultural price index (P_A/P_N). This indicator reflects the relative profitability of producing agricultural commodities as against non-agricultural products. The second indicator is the ratio of the domestic agricultural price index to the non-agricultural home goods price index (P_A/P_H). This reflects the relative profitability of agricultural products as against non-agricultural non-tradable (home) goods. The procedure for measuring these indicators is as follows. In the case of the first indicator, time series data on the domestic agricultural price index covering the period of the study were obtained from the World Bank's *World Tables* (1987). Time series data on the domestic non-agricultural price index (P_N) were obtained[9] from Frimpong-Ansah (1989). However, the domestic agricultural price index series obtained from World

Bank (1987) was missing information for the period 1960-5 and 1986-7. To fill the gap for 1960-5, the gross domestic products of agriculture, non-agriculture and the whole economy were obtained from the Ghana Statistical Service. The shares of agriculture, $S_{A,t,}$ and non-agriculture, $S_{N,t,}$ in aggregate gross domestic product were computed for each of the years covering that period. The GDP deflator, P_t, for those years was then obtained from the *International Financial Statistics*, IMF. The agricultural price index for the missing years 1960-5 was then computed as:[10]

$$(8) \qquad P_{A,t} = S_{A,t}^{-1} \cdot P_t - S_{A,t}^{-1} \cdot S_{N,t} \cdot P_{N,t}$$

The agricultural price index and non-agricultural price index data covering 1986-7 were obtained by a linear extrapolation from the corresponding 1985 figure using the growth rates in the national wholesale price indices of agriculture and non-agricultural products, respectively, for 1986 and 1987.

With reference to the second indicator, the index of the domestic minimum wage rate was employed as proxy for the non-agricultural home goods price.[11] The time profiles P_A/P_N and P_A/P_H are depicted in Figure 2. The compound growth rates of P_A/P_N and P_A/P_H are presented in Table 3.

Over the whole period, the trend in P_A/P_N was upwards with a compound growth rate of +0.18 per cent per annum. Although P_A/P_N declined by 4.64 and 3.88 per cent, respectively, in the 1960s and 1980s, it increased by 6.13 per cent in the 1970s. In the case of P_A/P_H, the whole period, as well as the decades of the 1960s and 1970s, recorded upward trends. During the 1980s, P_A/P_H declined by 6.61 per cent per annum. The time profiles of P_A/P_N and P_A/P_H seem to show that the domestic terms of trade were generally favourable to the agricultural sector during the period 1960-87. Although the terms of trade favoured agriculture in the 1970s, they turned against it in the 1980s.

In order to delineate the agricultural export price incentive structure, three indicators were used. The first is the ratio of the domestic price index for agricultural export commodities and the domestic non-agricultural price index (P_{AX}/P_N).

Figure 2 Time profile of relative price incentive for the agricultural sector

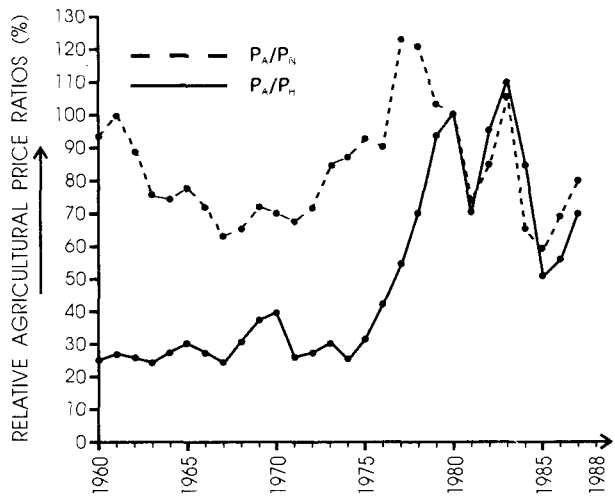


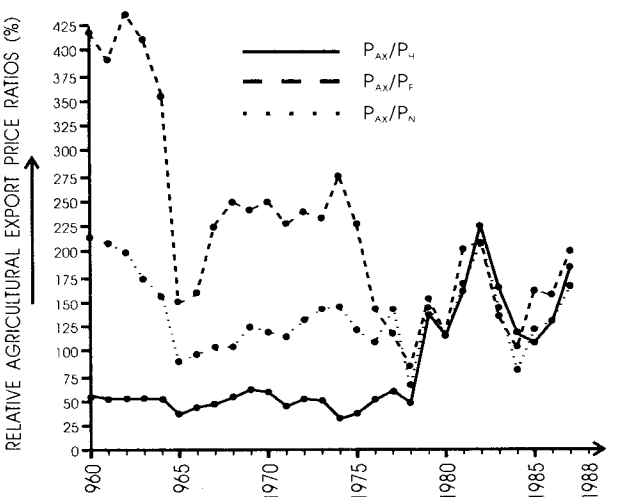
Table 3 Percentage compound growth rates of P_A/P_N and P_A/P_H

Period	P_A/P_N growth	P_A/P_H growth
1960s	-4.64	2.20
1970s	+6.13	+13.66
1980s	-3.88	-6.61
1983-7	-4.18	-12.40
1960-87	+0.18	+5.48

The second is the ratio of the domestic price index for agricultural exports and the domestic price of local food (P_{AX}/P_F). The third indicator is the ratio of the domestic agricultural export price index and the price index of non-agricultural home goods (P_{AX}/P_H). The variable P_{AX} is an index of the weighted producer prices of cocoa and coffee which constitute the bulk of agricultural exports.

Complete time series data on sheanut world prices and their share in total agricultural exports were not readily available. Non-traditional exports share in total agricultural exports was not significant and no reliable domestic non-traditional agricultural export price data were available for 1960-87. For this reason, domestic prices of sheanuts and non-traditional agricultural exports were not included in the domestic agricultural export commodity price index. The basic data for computing P_{AX} were obtained from the data files of the Policy, Planning, Monitoring and Research Department of the Ghana Cocoa Board. The domestic wholesale price index for local food was used as a proxy for the domestic food price index. Farm-gate food price index data were not readily available.

Figure 3 Time profiles of agricultural exports price incentive structure



The time profiles of P_{AX}/P_N, P_{AX}/P_F, and P_{AX}/P_H are depicted in Figure 3. The compound growth rates are presented in Table 4. This table shows that, in general, it was more profitable[12] to produce agricultural export commodities than to produce non-agricultural products in the 1980s. It was, however,

relatively less profitable to produce agricultural export commodities than to produce non-agricultural products during the 1960s, 1970s and the whole period 1960-87. The price ratio *PAX/PN* declined by 0.83 per cent during the period 1960-87. By contrast, *PAX/PH* showed a positive growth rate of 4.80 per cent during the period 1960-87, although it exhibited a negative growth rate for the 1960s. It appears that over the period 1960-87 agricultural export producers tended to receive relatively more for their produce than they paid for labour. The growth in agricultural export price-to-food producer price ratio *(PAX/PF)* was consistently negative for all the decades (except the 1980s) and for the period as a whole.[13]

Table 4 Compound growth rates (per cent) of P_{AX}/P_N, P_{AX}/P_F, P_{AX}/P_H and relative prices of cocoa (P_{CC}), coffee (P_{CF}) and sheanuts (P_{SN}).

Price ratio	1960s	1970s	1980s	1983-7	1960-87
P_{AX}/P_N	-8.33	-1.09	+1.34	+5.81	-0.83
P_{AX}/P_F	-8.40	-9.76	+2.58	+11.43	-3.81
P_{AX}/P_H	-1.59	+5.93	+1.51	+3.18	+4.80
P_{cc}/P_F	-8.48	-9.76	+2.55	+11.38	-3.79
P_{cf}/P_F	-0.53	-7.72	+10.93	+22.38	-4.46
P_{sn}/P_F	-7.54	-7.93	-16.62	-14.31	-0.01
P_{cc}/P_N	-8.41	-1.10	+1.30	5.75	-0.82
P_{cf}/P_N	+0.38	+1.14	+9.58	+16.20	-1.46
P_{sn}/P_N	-7.47	-0.22	-17.58	-18.64	+3.00

Source: Computed from basic data obtained from the Ghana Statistical Service, the Ghana Cocobod, and Frimpong-Ansah (1989).

Over the period 1960-87, the P_{AX}/P_F ratio declined by 3.81 per cent per annum (Table 4). This implies that it was more profitable[14] to produce food than agricultural export commodities during that period. A similar inference could be drawn for the 1960s and 1970s. In contrast, it has been less profitable[15] to produce food than agricultural export commodities in the 1980s. In addition to P_{AX}/P_N, P_{AX}/P_F, P_{AX}/P_H, we examine the prices of cocoa, coffee

and sheanuts relative to the food price and the non-agricultural price. The compound growth rates of these price relatives are also presented in Table 4. This table shows that for the whole period 1960-87 cocoa, coffee and sheanut prices grew at a slower rate than food prices; hence, the production of those commodities tended to be less profitable than the production of food. During the 1960s and 1970s in particular, cocoa, coffee and sheanuts were less profitable than food products, but during the 1980s, particularly in 1983-7, cocoa and coffee tended to be more profitable and sheanuts less so.

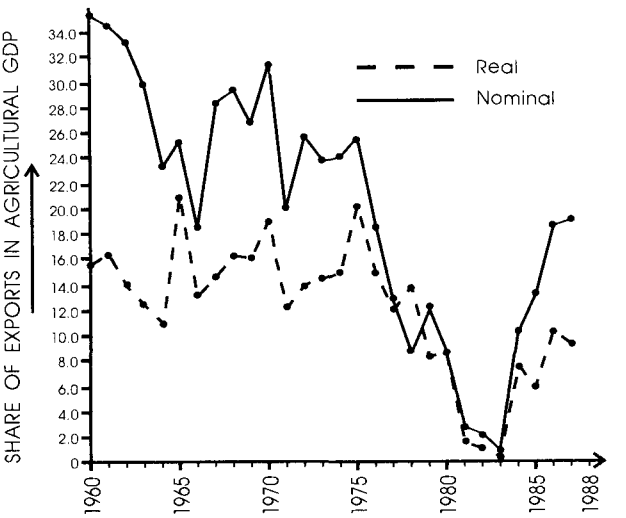
Table 4 shows that during 1960-87, when cocoa and coffee tended to be less profitable than non-agricultural products, sheanuts generally tended to be more lucrative. During the 1980s (particularly 1983-7) coffee and cocoa tended to be more profitable than non-agricultural production, and sheanut tended to be less remunerative than non-agricultural production. One of the aims of the present study is to examine the extent to which real exchange rate has influenced these relative prices.

Agricultural exports

The time profile of the share of agricultural exports in agricultural GDP is depicted in Figure 4, based on data from different sources.

The share of agricultural exports in aggregate agricultural output is computed as the ratio between the total figure for agricultural product exports and the GDP originating in the agricultural sector. Two ratios are used: one is the ratio of nominal total agricultural product exports to nominal agricultural GDP; the other is the ratio of real agricultural exports to real agricultural GDP. Real exports are obtained by dividing nominal exports by P_{AX}. Time series data on total agricultural product exports measured in nominal millions of US dollars covering 1960-87 were obtained from various issues of *Trade Yearbook* (FAO) and were converted to domestic currency units at the official exchange rate. Time series data on GDP originating in the agricultural sector during the period 1965-87 were obtained from various issues of the *Quarterly Digest of Statistics* (Ghana Statistical Service).

Figure 4 *Share of agricultural exports in agricultural GDP*



Since the corresponding data for the period 1960-4 were not readily available from the Statistical Service, they were obtained as follows. The nominal GDP originating in agriculture for 1964 was obtained from FAO Situation of Food and Agriculture. Agricultural GDP in constant 1960 prices for 1960 and 1961 were obtained from Birmingham *et al.* (1966). Since agricultural GDP data for 1962 and 1963 were not available, the following steps were employed to estimate them. First, the total GDP in constant 1960 prices for 1961 and 1964 was obtained (Ewusi (1986) and Birmingham *et al.* (1966)). The real agricultural GDP (measured in constant 1960 prices) was divided by the real total GDP to obtain agriculture's share in total output in 1961. The real agricultural GDP in constant 1960 prices for 1964 was obtained by dividing the corresponding nominal figure by the 1964 value of the aggregate agricultural price index (1960 = 100). Second, linear interpolation on using the estimated agricultural shares in 1961 and 1964 was used to obtain the agricultural shares in 1962 and 1963. This was accomplished as follows. The growth rate of the estimated shares between 1961 and 1964 was divided by three to get an average annual growth rate for 1962 and 1963. The agricultural

share in 1962 was estimated by using the estimated share in 1961 and the average annual growth rate. The share for 1963 was estimated in the same way. Third, multiplying the share of agriculture in real total output for 1962 by the total GDP in constant 1960 prices gave the estimated agricultural GDP for 1962. This was repeated for 1963. Finally, the agricultural GDP (in constant 1960 prices) data obtained, as described, for 1962 and 1963 were converted to agricultural GDP in constant 1980 prices by dividing the former by the aggregate agricultural price index (1980 = 100). Multiplying the agricultural GDP (in constant 1980 prices) for 1962 and 1963 by those years' figures for the aggregate agricultural price index (1980 = 100), gave agricultural GDP in current prices.

It can be seen from Figure 4 that the share of exports in aggregate agricultural output generally declined over the period 1960-87. It is worth noting that the share of exports has been rising due to the export drive undertaken during the structural adjustment programme which began in April 1983.

The percentage shares of exports in agricultural GDP are presented in Table 5. The data in the second and fourth columns of Table 5 are based on the ratio of agricultural exports to agricultural GDP in nominal cedis, whereas data in columns three and five are based on the ratio of real agricultural exports to real agricultural GDP. Real agricultural exports are obtained by dividing nominal agricultural exports in cedis by P_{AX}, whereas real agricultural GDP is obtained by dividing agricultural GDP in current prices by the aggregate agricultural price index, P_A.

The average annual share of exports declined from the 1960s to the early 1980s (Table 5). However, during the 1980s and particularly 1983-7, the share of exports in aggregate agricultural output increased. During the whole period 1960-87, the share of agricultural exports in aggregate agricultural output declined.[16]

Ghana's real agricultural exports fell by 4.59 per cent per annum during 1960-87 and by 4.92 per cent per annum during 1970-9. By contrast, they increased by 2.57 per cent and 20.42 per cent per annum during the 1960s and 1980s (Table 6). In particular, during the structural adjustment period of 1983-7, real agricultural exports increased by as much as 76.42 per cent per

annum. The behaviour of nominal and real[17] aggregate agricultural exports is depicted in Figures 5a and 5b.

Table 5 Percentage shares of exports in agricultural GDP

Period	Compound growth based on nominal data	Compound growth based on real data	Average annual share based on nominal data	Average annual share based on real data
1960s	-3.49	+0.54	28.41	15.13
1970s	-10.57	-4.04	20.28	14.78
1980s	+30.01	+23.33	9.51	5.71
1983-7	+98.89	+79.97	12.36	6.83
1960-87	-6.56	-5.58	20.11	12.31

Source: The basic data for the computations are from various issues of the *Quarterly Digest of Statistics* (Ghana Statistical Service), Birmingham *et al.* (1966), and *FAO Trade Yearbook* (various issues).

Ghana's agricultural exports could be disaggregated into traditional and non-traditional commodities. The traditional exports are commodities including cocoa, coffee and sheanuts which have been exported since the turn of the twentieth century. The non-traditional exports have only recently begun to be exported. The traditional commodities represent a greater proportion of total agricultural exports than do the non-traditional commodities.

The time profiles of Ghana's exports of traditional commodities are shown in Figure 6. Cocoa exports declined over the period 1960-1987, registering a negative compound growth rate of 3.82 per cent per annum. During the 1960s, 1970s and 1980s growth declined at compound rates of 3.13, 7.30 and 3.35 per cent per annum, respectively. The decline was lowest in the 1960s and greatest during the 1970s. Cocoa exports increased by 2.82 per cent per annum during 1983-7.

Figure 5a Time profiles of nominal and real total agricultural exports (in US$)

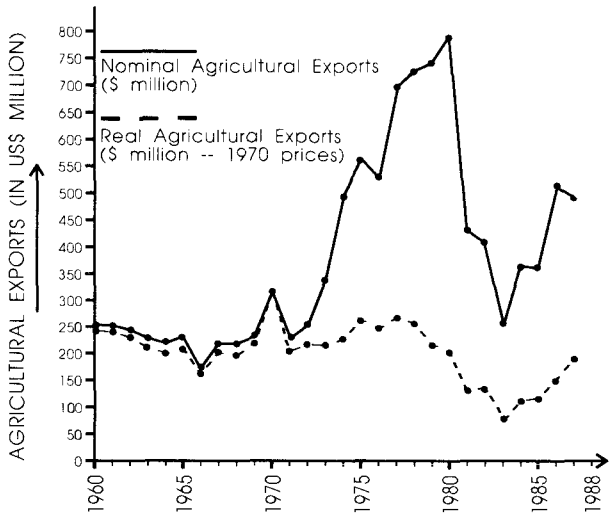


Figure 5b Time profiles of nominal and real total agricultural exports (in cedis)

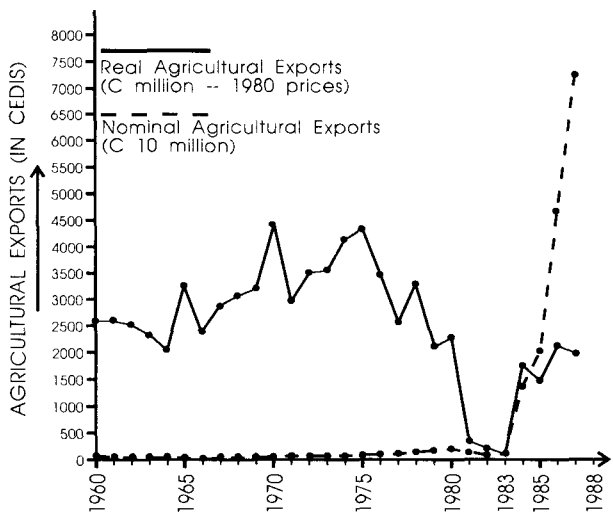


Table 6 Growth rates of real aggregate agricultural exports

Period	Compound growth rate (per cent)
1960s	+2.57
1970s	-4.92
1980s	20.42
1983-7	76.42
1960-87	-4.59

Source: Computations are based on data obtained from FAO Trade Yearbook (various issues), Ghana Statistical Service, the Ghana Cocoa Board and *International Financial Statistics* (IMF).

Table 7 shows that coffee exports generally declined by 7.34 per cent per annum during the period 1960-87. The table shows that coffee exports increased by 3.03 per cent per annum during the 1960s, and declined by 14.46 per cent and 5.72 per cent per annum during the 1970s and 1980s, respectively. The volume of coffee exports increased by 1.32 per cent per annum during 1983-7.

Although sheanut export volume increased in the 1980s, it declined during the 1960s and the 1970s. The compound growth rate of sheanut export volume was equal to +5.24 per cent per annum during 1960-87, indicating that sheanut exports generally increased over the period.

The steep increase in sheanut[18] exports during 1983-7 is explained in Section IV. In summary, it is evident that sheanut exports increased while cocoa and coffee exports declined[19] over the period 1960-87, and that the volumes of exports of the three commodities declined in the 1970s and increased during the structural adjustment[20] period 1983-7.

The export of non-traditional agricultural commodities is only a recent phenomenon. The promotion of non-traditional exports has been encouraged during the structural adjustment era, although its share in total exports continues to be relatively small (Table 8).

Figure 6 Time profiles of the volumes of Ghana's traditional export commodities

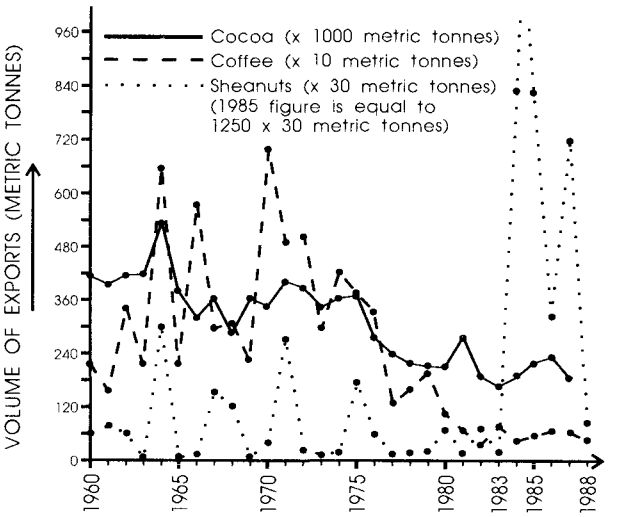


Table 7 Compound growth rates (per cent) of traditional agricultural export commodities

Period	Cocoa	Coffee	Sheanuts
1960s	-3.13	+3.03	-1.64
1970s	-7.30	-14.46	-12.02
1980s	-3.35	-5.72	+51.50
1983-7	+2.82	+1.32	+111.03
1960-87	-3.82	-7.34	+5.24

Source: The basic data are from of the Policy, Planning, Monitoring, and Research Department of the Ghana Cocoa Board, Accra.

Non-traditional commodities, 70 in number, include horticultural products like pineapples, mangoes, vegetables, kola nuts, medicinal plants, cocoa waste,

palm kernel, cotton seed, yams, tuna fish, frozen and fresh fish, lobsters, shrimps and prawns, cuttle fish, dried or smoked fish, and shark fins. Fresh pineapple exports, in particular, grew fast during 1981-6, recording an average annual growth rate of 342.3 per cent. The export volume of bran and other milling by-products grew on average by 18.03 per cent per annum. Complete time series data on these commodities covering the period 1960-87 were not readily available, so a detailed analysis is not pursued here.

Table 8 Ghana's non-traditional agricultural exports

Year	Nominal exports (US million dollars)	Percentage share in total exports
1976	10.66	1.28
1977	15.89	1.56
1978	2.25	22
1979	5.55	49
1980	3.58	0.28
1981	4.90	0.59
1982	3.72	0.49
1983	NA	NA
1984	NA	NA
1985	NA	NA
1986	13.03	1.79
1987	18.79	2.07
1988	27.06	2.66

Source: Data covering 1976-86 were obtained from the Foreign Operations Department, Bank of Ghana. Data covering 1987 and 1988 were obtained from the Ghana Export Promotion Council.

IV Econometric modelling

Econometric modelling is used to quantify the effects of the real exchange rate on the structure of agricultural price incentives and exports in this study. The theoretical foundation and structure of the econometric models are presented first, followed by the methods of estimation and tests of the relevant hypotheses.

Real exchange rate and price incentive structure

As indicated above, one of the purposes of this study is to determine the effects of the real exchange rate on the following price ratios: domestic aggregate agricultural price to domestic aggregate non-agricultural price (P_A/P_N), domestic aggregate agricultural price to domestic aggregate non-tradable or home-goods price (P_A/P_H), domestic aggregate agricultural export price to domestic aggregate non-agricultural price (P_{AX}/P_N), domestic agricultural export price to domestic aggregate non-tradable or home-goods price (P_{AX}/P_H), domestic agricultural export price to domestic aggregate food price (P_{AX}/P_F), producer price of cocoa to domestic aggregate non-agricultural price (P_{cc}/P_N), producer price of cocoa to domestic aggregate non-tradable goods price (P_{cc}/P_H), producer price of coffee to domestic aggregate food price (P_{cf}/P_F), producer price of coffee to domestic aggregate non-agricultural price (P_{cf}/P_N), producer price of coffee to domestic aggregate non-tradable goods price (P_{cf}/P_H), producer price of sheanuts to domestic aggregate food price (P_{sn}/P_F), producer price of sheanuts to domestic aggregate non-agricultural price (P_{sn}/P_N), and producer price of sheanuts to domestic aggregate non-tradable goods price (P_{sn}/P_H). The *theoretical relationships* between these relative prices and the real exchange rate are derived as follows.

Ghana's economic market may be classified into six categories, namely agricultural exports (A_X), agricultural imports (A_M), agricultural non-tradable or home goods (A_H), non-agricultural exports (N_X), non-agricultural imports (N_M), and non-agricultural home goods (N_H). The domestic prices of home goods A_H and N_H are seen to be determined solely by domestic demand and supply conditions and are not directly related to foreign prices. The exportable goods A_X and N_X are those whose prices are directly linked to corresponding foreign prices. Foreign goods whose prices are directly related to corresponding foreign prices are perceived as importable goods. In addition, the study considers a good j as a non-tradable or home good, exportable good, or importable good depending on whether $Gj = 0$, $Gj < 0$, or $0 < Gj \leq 1$, respectively, given that Gj is defined as $Gj = (Cj - Qj)/Cj$ where $Cj = Qj + Mj - Xj$ with C, Q, M, and X respectively denoting consumption, production, imports and exports.

Transport and handling costs aside,[21] the relationship between domestic prices and foreign prices of exportables (P_{iXf}) and importables (P_{iMf}) can be written respectively as

$$(9) \qquad P_{iX} = E \cdot P_{iX,f}\,(1-T_{iX}), \quad i = A, N$$

$$(10) \qquad P_{iM} = E \cdot P_{iM,f}\,(1+T_{iM}), \quad i = A,N$$

where E is the nominal exchange rate, TiX denotes implicit export tax, and TiM denotes implicit import tariff.

Let us represent the aggregate agricultural price as a Cobb-Douglas aggregation of the agricultural export price (P_{AX}), the agricultural imports price (P_{AM}), and the agricultural non-tradable or home goods price (P_{AH}):

$$(11) \qquad P_A = P_{AX}^{\phi AH} \cdot P_{AM}^{\phi AM} \cdot P_{AH}^{1-\phi AX-\phi AM}$$

where ϕ_{AX} denotes the geometric weight of P_{AX} in P_A $(O \leq \phi_{AX} \leq 1)$, and so on. The analogue of equation (11) for non-agricultural price (P_N) can be written as (12).

$$(12) \qquad P_N = P_{NX}^{\phi NM} \cdot P_{NM}^{\phi NM} \cdot P_{NH}^{1-\phi AX-\phi AM}$$

Similarly, the aggregate home-goods price (P_H) can be written as

$$(13) \qquad P_H = P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH}$$

Substituting (9) and (10) given that $i = A$ into (11) gives

$$(14) \qquad P_A = [E \cdot P_{AX_f} (1-T_{AX})]^{\phi AX} [E \cdot P_{AM_f} (1+T_{AM})]^{\phi AM} \cdot P_{AH}^{1-\phi AX-\phi AM}$$

But, by definition, the real exchange rate R as indicated in Section III, is given by

$$R = E \cdot P_f \cdot P_f^{-1}$$

where P_f denotes the aggregate foreign price of Ghana's trading partners. Upon the appropriate rearrangement of the real exchange rate equation, we can write (15)

$$(15) \qquad E = R \cdot P_H \cdot P_f^{-1}$$

Substitution (13) into (15) gives

$$(16) \qquad E = R \cdot P_{AH}^{1-\phi AH} \cdot P_f^{-1}$$

Substituting (16) into (14) gives

$$(17) \qquad P_A = \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} \cdot (P_{AX,f}) \cdot (1-T_{AX})\right]^{\phi AX}$$

$$\times \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} \cdot (P_{AM,f}/P_f) \cdot (1 + T_{AM})\right]^{\phi AM} \cdot P_{AH}^{1-\phi AX-\phi AM}$$

Similarly, substituting (9) and (10) given that $i = N$ into (12) and further substituting (16) into the result gives

$$(18) \qquad P_N = \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi-AH} \cdot (P_{NX,f}/P_f) \cdot (1-T_{NX})\right]^{\phi NX}$$

$$\times \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi-AH} \cdot (P_{NM,f}/P_f) \cdot (1+T_{NM})\right]^{\phi NM} \cdot P_{NH}^{1-\phi NX-\phi NM}$$

Dividing (17) by (18) and taking the natural logarithms of the result gives

$$(19) \qquad \ln (P_A/P_N) = (\phi_{AX}+\phi_{AM}-\phi_{NX}-\phi_{NM}) \times lnR + \phi_{AX}\ln(1-t_{AX})$$

$$+ \phi_{AM}\ln(1 + T_{AM}) + \phi_{AX}\ln(P_{AX,f}) + \phi_{AM}\ln(P_{AM,f} / P_f)$$

$$- \phi_{NX} \cdot \ln (P_{NX,f} /P_f) - \phi_{NM} \cdot \ln (P_{NM,f} / P_f) - \phi_{NX} \cdot \ln (1-T_{NX})$$

$$- \phi_{NM} \cdot \ln (1+T_{NM})$$

$$- \phi_{NM}.\ln(1+T_{NM})+\left[\phi_{AH}.(\phi_{AX}+\phi_{AM}-\phi_{NX}-\phi_{NM})+(1-\phi_{AX}-\phi_{AM})\right]$$

$$. \ lnP_{AH}+\left[(1-\phi_{AH}).(\phi_{AX}+\phi_{AM}-\phi_{NX}-\phi_{NM})-(1-\phi_{NX}-\phi_{AM})\right]$$

$$. \ lnP_{AH}+\left[(1-\phi_{AH}).(\phi_{AX}+\phi_{AM}-\phi_{NX}-\phi_{NM})-(1-\phi_{NX}-\phi_{NM})\right].\ln P_{NH}$$

Equation (19) explains the natural logarithm of (P_A/P_N) in terms of the real exchange rate, implicit agricultural export tax, the implicit agricultural imports tariff, *inter alia*. The marginal elasticity of (P_A/P_N) with respect to the real exchange rate is equal to

$$(\phi_{AX} + \phi_{AM} - \phi_{NX} - \phi_{NM}). \text{ Since } \phi_{ij} \geq 0,$$

it follows that the marginal elasticity is positive, zero or negative when

$$(\phi_{AX}+\phi_{AM})>(\phi_{NX}+\phi_{NM}), \ (\phi_{AX}+\phi_{AM})=(\phi_{NX}+\phi_{NM}),$$

or

$$(\phi_{AX}+\phi_{AM}) < (\phi_{NX}+\phi_{NM}),$$

respectively. This implies that given the share of tradables in the domestic aggregate agricultural price is greater (less) than the share of tradables in the domestic aggregate non-agricultural price, an increase in R (that is, a depreciation of the domestic currency) generates an increase (decrease) in the agricultural price-to-non-agricultural price ratio (P_A/P_N). On the other hand, given that the share of tradables in domestic agricultural price is equal to the share of tradables in domestic non-agricultural price, a depreciation of the domestic currency (namely, an increase in R) has no effect on the relative agricultural price (P_A/P_N). Similarly, a domestic currency appreciation (that is,

a decrease in R) would generate a fall (rise) in the relative agricultural price (P_A/P_N) when the share of tradables in the domestic agricultural price is greater (less) than the share of tradables in the domestic non-agricultural price. If the share of tradables in the domestic agricultural price is equal to the share of tradables in the domestic non-agricultural price, then an appreciation of the domestic currency does not have any effect on the relative agricultural price.

It is worth mentioning that $\phi_{AX} + \phi_{AM} = 1 - d_{AH}$ and $\phi_{NX} + \phi_{NM} = 1 - d_{NH}$ given that d_{AH} and d_{NH} denote the respective shares of non-tradables in the domestic agricultural price and non-agricultural price. Thus, if the share of non-tradables in the agricultural price is equal to the share of non-tradables in the non-agricultural price, then changes in the real exchange rate, R, do not have any effect on the relative agricultural price (P_A/P_N), since in this case $1 - d_{AH} = 1 - d_{NH}$, implying that $\phi_{AX} + \phi_{AM} - \phi_{NX} - \phi_{NM} = 0$. When the share of non-tradables in the agricultural price is less (greater) than the share of non-tradables in the non-agricultural price, a depreciation in the domestic currency generates a rise (fall) in the relative agricultural price P_A/P_N, since in this case

$$(1-d_{AH})>1-d_{NH} \ ((1-d_{AH})<(1-d_{NH})),$$

implying that

$$(\phi_{AX}+\phi_{AM}) > \phi_{NX}+\phi_{NM} \ ((\phi_{AX}+\phi_{AM}) < (\phi_{NX}+\phi_{NM})).$$

Notably,

$$\phi_{AX}+\phi_{AM}-\phi_{NX}-\phi_{NM} = 1 - d_{AH} - (1-d_{NH}) = d_{NH} - d_{AH}.$$

Hence,

$$-1 \leq [\phi_{AX} + \phi_{AM} - \phi_{NX} - \phi_{NM}] \leq 1,$$

since

$$-1 \leq [d_{NH} - d_{AH}] \leq 1;$$

recall that

$$0 \leq d_{AH}, d_{NH} \leq 1$$

The equation which explains the agricultural price to home goods price ratio (P_A/P_N) is derived as follows. Divide equation (17) by (13) and take the natural logarithms of the result to get equation (20).

$$\ln(P_A/P_H)=(\phi_{AX}+\phi_{AM}).\ln R+\phi_{AX}.(1-T_{AX})+\phi_{AM}.\ln(1+T_{AM})$$

$$+ \phi_{AX} \cdot \ln (P_{AX,f} /P_f) + \phi_{AM} \cdot \ln (P_{AM,f} /P_f)$$

$$+ [(1 - \phi_{AH}) \cdot (1 - \phi_{AX} - \phi_{AM})] \cdot \ln P_{AH}$$

$$+ [(1 - \phi_{AH}) (\phi_{AX} + \phi_{AM} - 1)] \cdot \ln P_{NH}$$

Equation (20) shows that the elasticity of the price ratio (P_A/P_H) with respect to the real exchange rate is equal to $\phi_{AX} + \phi_{AM}$. This elasticity is always positive since ϕ_{AX} and ϕ_{AM} are non-negative. As already indicated, $\phi_{AX} + \phi_{AM} = 1 - d_{AH}$. Hence $\phi_{AX} + \phi_{AM}$ cannot be greater then unity; so, we can specify that $0 \leq \phi_{AX} + \phi_{AM} \leq 1$. When the share of agriculture in aggregate home-goods price is equal to zero (that is, $d_{AH} = 0$), $\phi_{AX} + \phi_{AM} = 1$ implying

that a 1 per cent depreciation in the real exchange rate (that is, an increase in R) generates a 1 per cent increase in the agricultural price relative to the aggregate home-goods price, *ceteris paribus*. When the share of agriculture in aggregate home-goods price is equal to unity, $\phi_{AX} + \phi_{AM} = 0$, implying that a change in R exerts no effect on the agricultural price to home goods price ratio.

To derive the relationship between agricultural export price-to-aggregate non-agricultural goods price (P_{AX}/P_N) and the real exchange rate (R) we proceed as follows. Substitute (16) into equation (9), given that $i = A$, and divide the result by equation (18); next, take the natural logarithm of the result to get equation (21).

$$(21)\quad \ln (P_{AX}/P_N) = (1 - \phi_{NX} - \phi_{NM}) \ln R + \ln (1 - T_{AX})$$

$$+ \ln (P_{AX,f}/P_f) + [\phi_{AH} (1 - \phi_{NX} - \phi_{NM})] \ln P_{AH}$$

$$- [\phi_{AH} (1 - \phi_{NX} - \phi_{NM})] \ln P_{NH}$$

$$- \phi_{NX} \ln (P_{NX,f}/P_f) - \phi_{NX} \ln (1 - T_{NX})$$

$$- \phi_{NM} \ln (P_{NM,f}/P_f) - \phi_{NM} \ln (1 - T_{NM})$$

It is evident from equation (21) that the elasticity of the price ratio P_{AX}/P_N with respect to the real exchange rate R is equal to $(1 - \phi_{NX} - \phi_{NM})$. Since the maximum and minimum that values $(\phi_{NX} + \phi_{NM})$ can take are unity and zero, respectively, the elasticity $(1 - \phi_{NX} - \phi_{NM})$ lies between zero and unity inclusive. When the share of tradables in the non-agricultural price is equal to zero (that is, $\phi_{NX} + \phi_{NM} = 0$) the elasticity of (P_{AX}/P_N) with respect to R is unity, implying that a 1 per cent increase (decrease) in the real exchange rate generates a 1 per cent increase (decrease) in (P_{AX}/P_N). When the share of

tradables in the non-agricultural price is equal to unity (that is $\phi_{NX} + \phi_{NM} = 1$), the elasticity of P_{AX}/P_N with respect to the real exchange rate is equal to zero; and changes in the real exchange rate do not exert any effect on P_{AX}/P_N. It could be inferred that the smaller (larger) the share of tradables in the domestic non-agricultural price, the larger (smaller) the magnitude of the effect of a change in the real exchange rate on P_{AX}/P_N. Interestingly, the smaller (larger) the share of tradables in the non-agricultural price, the larger (smaller) is the share of home goods in the non-agricultural price (that is, d_H). Hence, it could be argued that the larger (smaller) the share of home goods in the agricultural price, the larger (smaller) the magnitude of the effect of a change in real exchange rate on P_{AX}/P_N.

To derive the effect of the real exchange rate on P_{AX}/P_F, let us disaggregate the agricultural price into food export price $(P_{AX}/P_{(F)})$ and agricultural non-food export price $(P_{AX(NF)})$ with respective shares equal to hF and $(1 - h_F)$. In addition, let us disaggregate the food price P_F into its export $(PAX(F))$, and non-tradable $(P_{AH(F)})$ and import $(P_{AM(F)})$ components with respective shares g_{FX}, g_{FH}, and $(1 - g_{FX} - g_{FH})$. Furthermore, let us suppose the Cobb-Douglas aggregation of prices prevails. Given that $P_{AX(F)}$ and are respectively defined as

$$P_{AX(F)} = E \cdot P_{AX(F),f} \cdot (1 - T_{AX(F)})$$

$$P_{AX(NF)} = E \cdot P_{AX(NF),f} \cdot (1 - T_{AX(NF)})$$

where

$$E = R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{\phi NH} \cdot P_f^{-1}$$

we can write the following equations:

$$P_{AX} = R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} (P_{AX(F),f} / P_f (1-T_{AX(F)}))\Big]$$

$$\times \Big[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} (P_{AX(F),f} / P_f) (1-T_{AX(NF)})\Big]^{1-h_F}$$

$$P_F = \Big[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} (P_{AX(F),f} / P_f) (1-T_{AX(F)})\Big]^{g_{FX}} \cdot P_{AH(F)}^{g_{FH}}$$

$$\times \Big[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} \cdot (P_{AM(F),f} / P_f) (1-T_{AM(F)})\Big]^{1-g_{FX}-g_{FH}}$$

Dividing P_{AX} by P_F and taking the natural logarithms of the result gives

$$(22) \quad \ln (P_{AX}.P_F) = g_{FH} \, lnR + (h_F - g_{FX}) \ln (1-T_{AX(F)})$$

$$+ (1-h_F) \ln (1-T_{AX(NF)}) + (g_{FX}+g_{FH}-1) \ln (1-T_{AM(F)})$$

$$+ (h_F - g_{FX}) \ln (P_{AX(F),f} / P_f) + (1-h_F) \ln (P_{AX(NF)}/P_f)$$

$$+ (g_{FX}+(g_{FH}-1)) \ln (P_{AM(F),f} / P_f) + \phi_{AH} \cdot (g_{FH}-1) \ln P_{AH}$$

$$+ gFH \, (1-\phi_{AH}) \ln P_{NH} - g_{FH} \ln P_{AH(F)}$$

Since $0 \leq g_{FH} \leq 1$, it is evident from (22) that the real exchange rate elasticity of P_{AX}/P_F, which is equal to g_{FH}, lies between zero and unity. This implies that as R increases (that is, a real depreciation of the domestic currency), the price ratio P_{AX}/P_F increases. However, the magnitude of the increase depends upon the share of non-tradables in the aggregate food price. If this share is substantial (that is, close to unity), then the proportional increase in P_{AX}/P_F due

to a 1 per cent increase in R would be close to unity. If this share is equal to zero, then a change in R would exert no effect on P_{AX}/P_F. If g_{FH} is equal to unity then a 1 per cent depreciation (appreciation) of the real exchange rate would generate a 1 per cent increase (decrease) in P_{AX}/P_F).

The relationship between R and P_{AX}/P_H could be derived as follows. From the previous paragraph, P_{AX} was derived as being given by

$$P_{AX} = \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} (P_{AX(F),f}/P_f) (1-T_{AX(F)})\right]^{h_F}$$

$$\times \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} (P_{AX(F),f}/P_f) (1-T_{AX(F)})\right]^{1-h_F}$$

Dividing P_{AX} by P_H, where

$$P_H = P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH}$$

and taking the natural logarithms of the result gives

$$(23) \quad \ln (P_{AX}/P_H) = lnR + h_F \ln (1-T_{AX(F)}) + (1-h_F) \ln (1-T_{AX(NF)})$$

$$+ h_F \ln (P_{AX(NF),f}/P_f) + (1-h_F) \ln (P_{AX(NF),f}/P_f)$$

From (23) it is seen that the real exchange rate elasticity of P_{AX}/P_H is unity. This implies that a 1 per cent depreciation (appreciation) of the real exchange rate induces a 1 per cent increase (decrease) in the price ratio between agricultural exports and non-tradable goods.

In order to derive the relationship between the cocoa producer price-to-non-agricultural price ratio (P_{cc}/P_N) and the real exchange rate, let us disaggregate the agricultural export price into cocoa (P_{cc}) and non-cocoa (P_{ncc}) components with shares b_{cc} and $(1 - b_{cc})$ respectively $(0 < b_{cc} \leq 1)$. Suppose price aggregation is of the Cobb-Douglas form, then we can write

$$(24)\quad P_{cc} = P_{AX}^{b_{cc}^{-1}} \cdot P_{ncc}^{-(1-b_{cc})b_{cc}^{-1}}$$

Substituting for P_{AX} and P_{ncc} gives

$$(25)\quad P_{cc} = \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} \cdot (P_{AX,f}/P_f)(1-T_{AX})\right]^{b_{cc}^{-1}}$$

$$\times \left[R \cdot P_{AH}^{\phi AH} \cdot P_{NH}^{1-\phi AH} \cdot (P_{ncc,f}/P_f)(1-T_{ncc})\right]^{-(-b_{cc})b_{cc}^{-1}}$$

Dividing equation (25) by (18) and taking the logarithm of the result gives equation (26).

$$(26)\quad \ln (P_{cc}/P_N) = (1-\phi_{NX}-\phi_{NM})\, lnR + b_{cc}^{-1} \ln (1-T_{AX})$$

$$+ (b_{cc}-1)\, b_{cc}^{-1} \ln (1-T_{ncc}) + b_{cc}^{-1} \ln (P_{AX,f}/P_f)$$

$$+ (b_{cc}-1)\, b_{cc}^{-1} \ln (P_{ncc,f} \cdot P_f) - \phi_{NX} \ln (P_{NX,f}/P_f)$$

$$- \phi_{NM} \ln (1+T_{NM}) + \phi_{AH} (1-\phi_{NX}-\phi_{NM}) \ln P_{AH}$$

$$- \phi_{AH} (1-\phi_{NX}-\phi_{NM}) \ln P_{NH}$$

Dividing equation (25) by (12) and taking the natural logarithms of the result gives

$$(27)\quad \ln (p_{cc}/P_H) = lnR + b_{cc}^{-1} \ln (1-T_{AX})$$

$$+ b_{cc}^{-1} \ln (P_{AX,f} . P_f) - \phi_{AH} \ln P_{AH} - (1-\phi_{AH}) \ln P_{NH}$$

$$+ (1-b_{cc}^{-1}) \ln (1-T_{ncc}) + (1-b_{cc}^{-1}) \ln (P_{ncc,f} / P_f)$$

A comparison of equation (27) with (26) reveals that whereas the elasticity of P_{cc}/P_H with respect to R is equal to unity, the elasticity of P_{cc}/P_N is equal to $(1 - \phi_{NX} - \phi_{NM})$. It is evident that whereas the latter elasticity is equal to the corresponding elasticity of P_{AX}/P_H, the former is equal to the corresponding elasticity of P_{AX}/P_N.

As already derived above, P_F is given by

$$P_F = \left[R . P_{AH}^{\phi AH} . P_{NH}^{1-\phi AH} (P_{AX(F),f}/P_f) (1-T_{AX(F)})\right]^{g_{FX}} . P_{AH(F)}^{g_{FH}}$$

$$\times \left[R . P_{AH}^{\phi AH} . P_{NH}^{1-\phi AH} . (P_{AM(F),f}/P_f) (1-T_{AM(F)})\right]^{1-g_{FX}-g_{FH}}$$

Dividing P_F into equation (25) and taking the natural logarithms of the result gives (28).

The analogues of (26), (27) and (28) could be derived for coffee and sheanuts, with similar implications.

$$(28)\quad \ln (P_{cc}/P_F) = g_{FH} lnR + b_{cc}^{-1} \ln (1-T_{AX}) + b_{cc}^{-1} \ln (P_{AX,f}/P_f)$$

$$+ (1-b_{cc}^{-1}) \ln (1-T_{ncc}) - (1-b_{cc}^{-1}) \ln (P_{ncc,f}/P_f)$$

$$- g_{FX} \ln (1-T_{AX(F)}) - g_{FX} \ln (P_{AX(F),f} / P_f)$$

$$- (1-g_{FX}-g_{FH}) \ln (1-T_{AM(F)}) - (1-g_{FX}-g_{FH}) \ln (P_{AM,f} / P_f)$$

$$+ \phi_{AH} g_{FH} \ln P_{AH} + g_{FH} (1-\phi_{AH}) \ln P_{NH}$$

At the empirical level, since the focus of this study is the effect of the real exchange rate, and for reasons of data availability, the following econometric functions which are analogues of (19) to (23), (26), (27) and (28) are estimated to determine the quantitative effect of the real exchange rate on the structure of agricultural price incentives.

(29) $\ln (P_A / P_N) = f_1 (lnR, \ln (1-T_{AX}), DUM, e_1)$

(30) $\ln (P_A / P_H) = f_2 (lnR, \ln (1-T_{AX}), DUM, e_2)$

(31) $\ln (P_{AX} / P_N) = f_3 (lnR, \ln (1-T_{AX}), DUM, e_3)$

(32) $\ln (P_{AX} / P_H) = f_4 (lnR, \ln (1-T_{AX}), DUM, e_4)$

(33) $\ln (P_{AX} / P_F) = f_5 (lnR, \ln (1-T_{AX}), DUM, e_5)$

(34) $\ln (P_j / P_N) = f_{6j} (lnR, \ln (1-T_{AX}), DUM, e_{6j})$

j = cocoa (P_{cc}), coffee (P_{cf}) and sheanuts (P_{sn})

(35) $\ln (P_f / P_H) = f_{7j} (lnR, \ln (1-T_{AX}), DUM, e_{7j})$

(36) $\ln (P_j / P_F) = f_{8j} (lnR, \ln (1-T_{AX}), DUM, e_{8j})$

The variables e_i denote stochastic error terms which satisfy the classical normal regression assumptions. Using the nominal exchange rate (cedis per one US dollar), the aggregate domestic agricultural export price index, P_{AX}, and the unit value index of agricultural exports $P_{AX,f}$ obtained from various issues of F.A.O. *Production Yearbook*, $(1 - T_{AX})$ is generated via equation (9) with $i = A$. The variable DUM is a dummy defined to take on a value of zero during the structural adjustment period of 1983-7 and unity otherwise, to capture the relative effects of the structural adjustment era.

Real exchange rate and agricultural exports

It is important to note that the real exchange rate of a domestic currency does not influence the economy's agricultural exports directly; it influences agricultural exports through its effect on the incentive structure instead. Contrary to this view, Okyere (1989) and Batten and Bolongia (1986) erroneously attempted to examine the effect of the real exchange rate by including it as an explanatory variable in their output and exports equations, respectively. The Okyere (1989) model, as pointed out in Section II, is further flawed by the simultaneous occurrence of both the real exchange rate and producer price. The dependence of relative price on real exchange rate, as derived above, is plausible. To quantify the effect of the real exchange rate on agricultural exports, therefore, the present study specifies export functions which depend, *inter alia*, on relative price. These functions are combined with the relative price functions (29) to (36) to generate the effects of real exchange rate.

The following econometric export functions are employed

(37) $\ln X_{A,t} = X_A (\ln X_{A,t-1}, \ln (P_{AX}/P_F)_t, \ln (P_{AX}/P_N)_t, DUM,$

$\ln W_t, \ln T_t, \ln T, U_{1,t})$

where $X_{A,t}$, $X_{A,t-1}$ denote real aggregate agricultural exports in the current period and in the previous period, P_{AX}/P_F denotes aggregate agricultural export price relative to aggregate food price, P_{AX}/P_N denotes agricultural export price relative to non-agricultural price, W denotes national average annual rainfall, Y denotes the trade-weighted income of Ghana's trading partners, T denotes a trend term, and $U_{1,t}$ denotes a stochastic error term which obeys the classical normal regression assumptions (Fomby, Hill and Johnson (1984)).

(38) $\ln X_{cc,t} = X_{cc} (\ln X_{cc,t-1}, \ln (P_{cc}/P_F)_t, \ln Q_{cc,t}, \ln W_{c,t}, DUM,$

$\ln Y_t, \ln T, U_{2,t})$

where X_{cc} denotes the volume of cocoa exports, P_{cc}/P_F denotes cocoa producer price relative to food price, P_{cc}/P_N denotes cocoa producer price relative to non-agricultural price, Q denotes the productive capacity of the cocoa industry, W_c denotes average annual rainfall in the cocoa belt, and Y and T are as defined above. U_{2t} is a stochastic error term satisfying the classical normal regression assumptions

$$(39)\quad \ln X_{cf,t} = X_{cf}(\ln X_{cf,t}, \ln (P_{cf}/P_F)_t, \ln W_{c,t}, DUM, \ln Y_t, \ln T, U_{3,t})$$

where $X_{cf,t}$ denotes the volume of coffee exports, W_c, Y, T, P_{cf}/P_F, are as already defined, and $U_{3,t}$ is a stochastic error term satisfying the classical normal regression assumptions.

The export function relating to sheanuts is given by (40).

$$(40)\quad \ln X_{sn,t} = X_{sn}(\ln X_{sn,t-1}, \ln (P_{sn}/P_F)_t, \ln T_t, \ln W_{s,t}, DUM, \ln T, U_{4,t})$$

where X_{sn} denotes the volume of the sheanut exports, W_s denotes the average annual rainfall in the area where sheanuts are grown, and $U_{4,t}$ denotes a stochastic error term fulfilling the classical normal regression assumptions.[22]

The elasticities of real aggregate agricultural exports, and exports of cocoa, coffee, and sheanuts with respect to the real exchange rate are given, respectively, by[23]

$$(41)\quad \frac{\delta \ln X_{A,t}}{\delta \ln R_t} = \frac{\delta \ln X_{A,t}}{\delta \ln (P_{AX}/P_F)_t} \cdot \frac{\delta \ln (P_{AX}/P_F)_t}{\delta \ln R_t} + \frac{\delta \ln X_{A,t}}{\delta \ln (P_{AX}/P_N)_t} \cdot \frac{\delta \ln (P_{AX}/P_N)_t}{\delta \ln R_t}$$

$$(42)\quad \frac{\delta \ln X_{cc,t}}{\delta \ln R_t} = \frac{\delta \ln X_{cc,t}}{\delta \ln (P_{cc}/P_F)_t} \cdot \frac{\delta \ln (P_{cc,t}/P_F)_t}{\delta \ln R_t}$$

$$(43)\quad \frac{\delta \ln X_{cf,t}}{\delta \ln R_t} = \frac{\delta \ln X_{cf,t}}{\delta \ln (P_{cf}/P_F)_t} \cdot \frac{\delta \ln (P_{cf}/P_F)_t}{\delta \ln R_t}$$

$$(44)\quad \frac{\delta \ln X_{sn,t}}{\delta \ln R_t} = \frac{\delta \ln X_{sn,t}}{\delta \ln (P_{sn}/P_F)_t} \cdot \frac{\delta \ln (P_{sn}/P_F)_t}{\delta \ln R_t}$$

Model estimation

Each of the following sets of equations constitutes a recursive system: equations (37), (31), (32), equations (38) and (36) for j = cocoa, equations (39) and (36) for j = coffee, and equations (40) and (36) for j = sheanuts. It is well known from econometrics literature that the ordinary least squares method is appropriate for estimating each of the equations in a recursive system (Fomby, Hill and Johnson (1984); Intriligator (1982)). This method is employed in the present study. The rest of the equations are also estimated using the ordinary least squares method. Linear logarithmic equations are estimated.

Hypothesis testing

Hypotheses concerning each of the parameters associated with the explanatory variables in the relative price and export equations are tested by conventional procedures (Fomby, Hill and Johnson (1984), for instance). Hypotheses concerning the elasticities of specific exports with respect to the real exchange rate, defined in (41) to (44), are tested via the use of the standard approximate variance formula to derive the appropriate variances and standard errors: the degrees of freedom equal sample size minus the number of parameters in the appropriate reduced form equation.

V Real exchange rate effects on agricultural price incentives

As indicated above in Sections III and IV, changes in real exchange rates could translate into changes in relative sectoral and commodity prices. However, variations in exchange rate policy or real exchange rate do not necessarily translate into relative price changes. Whether or not exchange rate policy or a change in the real exchange rate have an effect on the price incentive structure depends on the linkage.

Exchange rate transmission mechanism

The notion that changes in exchange rate policy may not be transmitted into changes in commodity prices has been studied by economists. Jabara and Schwartz (1987), for example, survey some of the relevant literature. Market imperfections, among other factors, could cause a break in the transmission mechanism between exchange rate policy and commodity prices. Under such conditions, commodity pricing by private producers may be conducted in such a way as to offset any potential negative price effects on producers of changes in exchange rate policy.

Where no opportunities for arbitrage exist because of market imperfections price revisions involve costs and therefore firms producing brand-name traded and manufactured goods tend to revise prices only when changes in demand and cost appear to be permanent (Dohner (1984), Kravis and Lipsey (1978), Richardson (1978), Isard (1977)). If changes in demand and cost are perceived by such firms to be ephemeral, then prices may not be changed in response to

exchange rate changes. This implies that the effects of exchange rate changes are not passed on. Also, exporters and importers might not pass on the effect of an exchange rate appreciation or depreciation, instead, they may absorb the change in profit margins on sales, both domestic and foreign (Feldman (1982), Dunn (1970)). Furthermore, exporters and importers could sever the linkage between exchange rate and wholesale prices where some pricing discretion operates and create opportunities for arbitrage which are less than perfect. Jabara and Schwartz (1987) indicate that

> '... exporters could increase their export prices (in dollars) in response to a dollar depreciation and thereby increase profit margins from exports,or they could lower their prices in response to a dollar appreciation in order to forestall any decline in sales or market share ... since [the importing economy's] import costs do not change. On the import side, price stabilization policies implemented by importers or wholesale marketing intermediaries could also limit the extent of the [exchange rate] pass-through.'

They argue further that any favourable exchange rate change may be absorbed in profit margins where limited domestic competition in import markets confers monopolistic or monopsonistic power on wholesaler importers. Also, given that firms do not want to lose market shares to competing local products, they would not pass on a change in exchange rate which might call for increased domestic prices. Under conditions of few competitors, few substitutes for imported commodities, and demand insensitivity to price revisions in an importing country, there is likely to be an insignificant gain in sales or market share from a reduction in price in the country, so an exporter is unlikely to pass on an exchange depreciation (Jabara and Schwartz (1987)).

The operation of exchange rate pass-through is a function of demand and supply conditions: firstly, firms' profit objectives, including their initial profit and cost positions, pricing objectives, market-share objectives, the number of foreign competitors, the speed at which importers can change suppliers, and whether they perceive the exchange rate change to be temporary or permanent; and, secondly, on government policy in terms of domestic pricing and

marketing, and the nature of its implemented price-stabilization policies. (Jabara and Schwartz (1987), Dohner (1984), Feldman (1982), Dunn (1970)).

Changes in exchange rate policy, like other forms of government intervention, may be only partially transmitted to producers if that intervention creates large parallel domestic market outlets where a significant proportion of output may be sold. In order to avoid taxation, price controls, and the effects of domestic currency overvaluation, agricultural export producers, particularly those with private licences, smuggle their output to neighbouring border countries, or under-report the volume of their exports. The effects of a change in the exchange rate are, in those circumstances, likely to be only minimal. Where no significant parallel domestic market exists because a parastatal marketing board controls all exchanges, and domestic consumption is limited (cocoa and coffee are marketed solely by the Cocoa Marketing Company, Cocobod), coupled with low incidence of under-reporting and smuggling, the policy effects will be fully transmitted to producers. In the same way, if producers sell to licensed private exporters at official prices, and there is limited smuggling and under-reporting, policy effects are also likely to be fully transmitted.

The lack of knowledge of the quantity of exports smuggled into neighbouring countries has been noted (for instance, Manu (1974) and Atsu (1965)). However, reliable estimates of the size of these operations are not available, since they take place in the underground economy. It is difficult, therefore, to argue that the incidence of smuggling and under-reporting breaks the transmission between the real exchange rate and relative agricultural price incentives, including export price incentives. Since there are no significant domestic parallel markets for cocoa and coffee which account for the largest share in agricultural exports, and smuggling and under-reporting is insignificant, then the effects of changes in the exchange rate will be substantial.

An approximate measure of the degree of government intervention in domestic agricultural export commodity markets is the proportion of the world price of the that commodity which the farmer receives. This is equal to the ratio between the domestic producer price per unit of export commodity and the algebraic product of the foreign price in foreign currency and the nominal exchange rate. Given that Ghana is a price taker on the world markets for her

agricultural export commodities, the world prices of these commodities could be considered as the relevant opportunity costs. On the average, the agricultural export farmer received 59.82 and 69.95 per cent per annum of the world prices for cocoa and coffee, respectively (Table 9). The farmers who export have tended to receive a greater proportion of world prices in the 1980s than they did during the 1960s and 1970s. For cocoa and coffee, the producer prices have been close to the world price in the 1980s. However, these proportional prices received have tended, in general, to decline (rise) for cocoa (sheanuts) during each of the decades (Table 10). It appears from Tables 9 and 10 that whereas cocoa farmers were generally taxed, the sheanut pickers were subsidized. During 1983-7, sheanut pickers received as much as 358.46 per cent of the world sheanut price per annum. This, coupled with the non-price incentives in the form of the provision of Wellington boots, gloves, bicycles with carriers which facilitate 'penetration into hinterland where motorable roads do not exist', extension services and cutlasses (Cocobod (1989)) to sheanut pickers stimulated the large export supply response observed in Section III (Figure 6).

It is important to mention that the monitoring and evaluation, as well as the marketing, personnel of Cocobod indicated to the author that, in determining the domestic producer prices of cocoa, coffee, and sheanuts, the following factors are considered: the cost of production, current rate of interest on agricultural lending, the expected nominal exchange rate, the expected world price, and the proportion of the world price to be given to the farmers. Hence, the nominal exchange rate is likely to be an important component of a model to explain public policy with respect to the setting of producer prices for cocoa, coffee and sheanuts. This assertion is borne out by the following regression equations which we have estimated by ordinary least squares (the figures in parentheses are t-ratios whereas those in square brackets are beta coefficients).

The data on the respective nominal domestic producer prices of cocoa (P_{cc}), coffee (P_{cf}) and sheanuts (P_{sn}), as well as the data on the respective nominal foreign prices of cocoa $(P_{cc,f})$ and sheanuts $(P_{sn,f})$, were obtained from the Cocobod.

Table 9 Average annual ratios of domestic prices to foreign prices of selected agricultural export commodities

Period	Cocoa	Coffee	Sheanuts
1960s	0.5491	0.4659	NA
1970s	0.3561	0.3517	0.9351a
1980s	0.9619	0.7768	5.0323b
1983-7	0.3053	0.5140	3.5846c
1960-87	0.5982	0.6995	3.5424d

Source: Computed from basic data obtained from the Ghana Cocoa Board (Cocobod), *International Financial Statistics* (IMF)(various issues), and Ghana Statistical Service.

a Figure excludes 1970-4 and 1978 due to data unavailability. NA means not available.
b Figure covers the period 1980-7 excluding 1984 for which data were not available.
c Data excludes 1984 because of unavailability.
d Figure covers 1975-87 excluding 1978 and 1984 for which data were not available.

The data on foreign prices of coffee, namely all coffee ($P_{cf,f1}$) and Brazilian coffee ($P_{cf,f2}$), were obtained from various issues of *International Financial Statistics* (IMF). Equations (45) to (48) have been estimated in the natural log-log form: these equations have been corrected for first-order autocorrelation using the first differencing method[24] (Pindyck and Rubinfeld (1981)). The equations indicate that the foreign price and the nominal exchange rate significantly determine the nominal domestic producer prices of the export commodities, cocoa, coffee and sheanuts, as demonstrated by the magnitudes of the t-ratios. The beta co-efficients demonstrate that the nominal exchange rate tends to exert a stronger effect on the domestic producer prices of cocoa, coffee and sheanuts than the foreign prices of the commodities. The foreign price and the nominal exchange rate jointly explain between 77.17 and

87.07 per cent of the variation of nominal domestic producer prices of cocoa, coffee and sheanuts. Notably, the cocoa and coffee regressions covered 1962-87 due to lack of data. The regression results suggest that there is a potential for an exchange rate pass-through. Whether this has actually materialized in real terms during the period 1960-87 is examined later on in this section, using econometric modelling procedures. It should be noted that the modelling of the relationships between the domestic relative agricultural export prices and the real exchange rate largely explains public policy with respect to the setting of agricultural export prices, since the domestic producer prices of cocoa, coffee, and sheanuts which contribute the largest share to agricultural exports are fixed by Cocobod.

Table 10 Compound percentage growth rates of ratios of domestic prices to foreign prices of selected agricultural export commodities

Period	Cocoa	Coffee	Sheanuts
1960s	-7.68	+1.62	NA
1970s	-6.78	+2.75	+30.37a
1980s	-24.07	-12.77	+29.80b
1983-87	-0.67	-26.40	+12.23c
1960-87	-1.20	+0.85	NA

Source: Computed from basic data obtained from Cocobod, Ghana Statistical Service, and *International Financial Statistics* (IMF)(various issues).

a Data cover 1975-7 due to unavailability of data.
b Data cover 1980-3 due to unavailability of data.
c The figure covers 1985-7 due to unavailability of data

$$(45)\quad \hat{P}_{cc} = \underset{(0.602)}{0.3084} + \underset{(4.902)\ [0.4774]}{0.81695\ P_{cc,f}} + \underset{(6.968)\ [0.673]}{0.78385E}$$

$$Adj.\ R^2 = 0.7717;\ F_{2,25} = 42.4595;\ D.W. = 1.433$$

$$(46)\quad \hat{P}_{cf} = \underset{(1.249)}{0.5394} + \underset{(5.251\ [0.422]}{0.7124P_{cf,f1}} + \underset{(9.953)\ [0.801]}{0.8358E}$$

$$Adj.\ R^2 = 0.8516;\ F_{2,23} = 65.9678;\ D.W. = 1.415$$

$$(47)\quad \hat{P}_{cf} = \underset{(1.553)}{0.8189} + \underset{(4.681)\ [0.354]}{0.6495P_{cf,f2}} + \underset{(10.894)\ [0.823]}{0.8706\ E}$$

$$Adj.\ R^2 = 0.8707;\ F_{2,23} = 77.4382;\ D.W. = 1.484$$

$$(48)\quad \hat{P}_{sn} = \underset{(-1.372)}{-5.9639} + \underset{(2.824)\ [0.4603]}{2.2203\ P_{sn,f}} + \underset{(3.681)\ [0.5999]}{0.6779\ E}$$

$Adj.\ R^2 = 0.8361;\ F_{2,8} = 20.4078;\ D.W. = 1.578$

A comparison of the time profile of the real exchange rate of the cedi, as seen in Figure 1, with the time profiles of P_A/P_N and P_A/P_H, shows that whereas the real exchange rate variable had a downward trend for the period 1960-87, P_A/P_N and P_A/P_H had an upward trend during the same period. The real exchange rate variable therefore seems to have been negatively related to P_A/P_N and P_A/P_H over the period 1970-87. It is significant to note, however, that for the period 1985-7, the relative price ratios P_A/P_N and P_A/P_H had an upward trend, as had the real exchange rate during the same period. This indicates that a real depreciation of the cedi is associated with improved relative agricultural price incentives over the period 1985-7 during which policy reforms under the Fund-Bank Supported Structural Adjustment Programme were in operation.

Comparing the time profile of the real exchange rate (Figure 1) with the time profiles of P_{AX}/P_N, P_{AX}/P_F and P_{AX}/P_H, P_X/P_N and P_{AX}/P_F tended to have a downward trend just as the real exchange rate did during 1960-87. During this period there was a positive relationship between the real exchange rate on the one hand, and P_{AX}/P_N and P_{AX}/P_F on the other. This implies that during this time a real appreciation of the cedi precipitated a deterioration in relative agricultural export prices. Although the real exchange rate had a downward trend over 1960-87, P_{AX}/P_H had an upward trend over the same period. The real exchange rate is, therefore, negatively related to P_{AX}/P_H. However, over the period 1985-7, the price ratio P_{AX}/P_H showed an upward trend, just as did the real exchange rate. Hence a real depreciation was associated with increased agricultural export prices relative to non-traded goods' prices during 1985-7.

Empirical econometric results

So far, the analyses have been geometrical and descriptive. To provide more concrete statistical evidence for the foregoing qualitative relationships between the relative agricultural prices and the real exchange rate, rigorous econometric modelling has been used. As discussed in Section IV, it is hypothesized that

each of the relevant relative price ratios is a function of the real exchange rate R and $(1 - T_{AX})$, where T_{AX} denotes implicit agricultural export tax. In addition, a dummy variable *(DUM)*, defined to take on a value zero during the structural adjustment period of 1983-7 and unity otherwise, is included to reveal the relative effects of the structural adjustment era. The specific mathematical equation employed is the log-log form. The natural logarithms of a given dependent variable $ln\ (P_i/P_j)$ are regressed on *DUM* and the natural logarithms of real exchange rate and $(1 - T_{AX})$. The expected signs of lnR, $ln\ (1 - T_{AX})$ and *DUM* are positive, positive, and negative, respectively. When *DUM* is equal to unity (that is, when the period under consideration is the non-structural adjustment era), we expect the intercept of any relative price ratio's curve to be lower than the corresponding curve for the structural adjustment period. The conjecture here is that the structure of price incentives has tended to favour agriculture more during the structural adjustment period than during the non-structural-adjustment period. The rationale for the expected signs of R and $(1 - T_{AX})$ has been discussed in Section IV.

The empirical effects of the real exchange rate on the structure of agricultural price incentives are reported in Table 11. From this table it is evident that the real exchange rate exerts an independent statistical influence on the relative price ratios P_A/P_H, P_{AX}/P_N and P_{AX}/P_F at the 5 per cent level, as is shown by the respective t-ratios; it does not exert a statistically significant effect on the price ratio P_{AX}/P_H, even at the 10 per cent level. Table 11 further shows that the effect of the real exchange rate on the domestic aggregate agricultural-non-agricultural price ratio is statistically significant at the 10 per cent level, showing that the real exchange rate exerts some effect on the domestic agricultural-non-agricultural price ratio. The negative sign of the effect implies that an increase (decrease) in the real exchange rate precipitates (stimulates) a decrease (increase) in the domestic agricultural-non-agricultural price ratio. A 10 per cent increase (i.e. depreciation) of the real exchange rate precipitates a 1.8 per cent fall[25] in the domestic aggregate agricultural terms of trade (see Table 11). Conversely, a 10 per cent decline (i.e. appreciation) of the real exchange rate stimulates a 1.8 per cent increase in the domestic aggregate agricultural-non-agricultural price ratio. The negative effect of the real exchange rate on domestic aggregate agricultural terms of trade P_A/P_N appears to suggest that the share of traded goods in the aggregate agricultural

price tends to be smaller than the share of traded goods in the aggregate non-agricultural price (see equation 18 in Section IV).

The positive coefficients associated with the real exchange rate variable in the P_{AX}/P_N and P_{AX}/P_F equations confirm the positive relationship observed earlier from the geometric analyses involving the time profiles of the relevant variable in Section III.

Results in Table 11 imply that a 10 per cent increase in the real exchange rate (or what amounts to the same thing, a 10 per cent depreciation of the real exchange rate) stimulates a 7.495 per cent increase in the price of agricultural exports relative to local food prices (P_{AX}/P_F). A decline in the real exchange rate, as experienced during the period under study, of say 10 per cent (that is, 10 per cent appreciation) precipitates a reduction of 7.495 per cent in the relative agricultural export price ratio P_{AX}/P_F. Also, a 100 per cent appreciation of the real exchange rate precipitates a 39.96 per cent decline in the price of agricultural exports relative to non-agricultural products.

The implicit agricultural export tax variables are statistically significant in the P_{AX}/P_N, P_{AX}/P_F and P_{AX}/P_H regression equations and also exhibit the expected positive signs. The implicit agricultural export tax variables show unexpected negative signs in the P_A/P_N and P_A/P_H equations. However, the relevant estimated coefficients are neither significant at the 5 per cent nor the 10 per cent level. The implications of the expected results are as follows. An increase (decrease) in the magnitude of the implicit tax on agricultural exports which results in a 10 per cent reduction (rise) in $1 - T_{AX}$ induces a 6.5 per cent decline (rise) in the price ratio between agricultural exports and non-agricultural goods. Similarly, if the change in the implicit agricultural export tax generates a 10 per cent fall (rise) in $1 - T_{AX}$, then the relative price of agricultural exports-to-food price will fall (rise) by 8.65 per cent, while the agricultural export price-to-non-tradable goods price decreases (increases) by 5.0 7 per cent. Table 11 shows that, of the three relative price ratios P_{AX}/P_N, P_{AX}/P_F and P_{AX}/P_H, it is the agricultural export to food-price ratio that responds most to a change in the implicit agricultural export tax, *and* P_{AX}/P_H responds least.

The coefficient of *DUM* in equation (3) is neither statistically significant at the 5 per cent level nor at the 10 percent level (Table 11).

Table 11 Regression showing the effect of real exchange rate on agricultural price incentives

Equation number	Dependent variable	Constant	ln R	ln $(1-T_{AX})$	DUM	Adjusted R-squared	$F(V_1,V_2)$	DW	LM
12	ln (P_A/P_N)	0.1170	-0.1800[b]	-0.0544	-0.0119	0.4864	6.9183	1.5511	8.0764
		(0.5805)	(-1.768)	(-0.561)	(-0.0750)		(4,21)		
2	ln (P_A/P_H)	5.0887[a]	-0.5263[a]	-0.2094	-0.3829[a]	0.4909	33.7785[a]	1.3098	2.6369
		(26.4474)	(-5.5757)	(-1.5285)	(-3.0667)		(3,23)		
3	ln (P_{AX}/P_N)	4.1486[a]	0.3996[a]	0.6504[a]	0.0383	0.7618	28.7149[a]	1.4299	1.9226
		(42.0686)	(8.2609)	(9.2633)	(0.5980)		(3,23)		
4	ln (P_{AX}/P_F)	3.7301[a]	0.7495[a]	0.8651[a]	0.2648[a]	0.8734	60.8065[a]	1.4261	1.6163
		(30.4558)	(12.4742)	(9.9218)	(3.3316)		(3,23)		
5	ln (P_{AX}/P_H)	4.7930[a]	0.0192	0.5072	-0.6159[a]	0.7188	23.1525[a]	1.7615	0.1276
		(21.145)	(0.1731)	(3.1425)	(-4.1870)		(3,23)		

LM denotes Chi-squared value of Lagrange multiplier test for serial correlation.
Figures in parentheses are computed t-ratios.
Equation 12 is a Cochrane-Orcutt regression correcting for autocorrelation in the corresponding OLS regression.

a Significant at the 5 per cent level
b Significant at the 10 per cent level

Estimated equations (2) and (5) indicate that the price ratios P_A/P_H and P_{AX}/P_H tend to begreater during the structural adjustment era than during the non-structural-adjustment period. Conversely, it appears that the price ratio P_{AX}/P_F has tended to be smaller during structural adjustment than during the other periods. Although this result is unexpected because Ghana has promoted exports under the structural adjustment programme, similar results are obtained in the case of the relative price ratios between cocoa and food, as well as between coffee and food (Table 12). As expected, the statistically significant negative coefficient of *DUM* in estimated equation (3) implies that the relative price ratio between sheanuts and food favoured sheanuts during the structural adjustment period.

As noted above, sheanut production, unlike cocoa and coffee, has enjoyed more than 300 per cent implicit subsidy from the government of Ghana. The favourable price incentive, plus the package of non-price incentives, has induced large increases in sheanut exports, particularly during the period 1983-7.

The implicit agricultural export tax and the real exchange rate coefficients in Table 12 exhibit the expected signs. A 10 per cent rise (fall) in $1 - T_{AX}$ as a result of a fall (rise) in the implicit agricultural tax stimulates increases (declines) in the cocoa to food price ratio, coffee to food price ratio and sheanut to food price ratio of 8.7 per cent, 1.10 per cent, and 8.3 per cent, respectively. Hence a reduction in implicit tax on agricultural exports turns the terms of trade in favour of agricultural-export producers and against food farmers.

Table 12 shows further that the real exchange rate exerts independent statistically significant effects on the domestic prices of the individual traditional export commodities at the 5 and 10 per cent levels. A 10 per cent real appreciation of the cedi (that is, a fall in R) generates declines of 7.5 per cent, 4.19 per cent and 3.95 per cent, respectively, in the cocoa to food, coffee to food, and sheanut to food price ratios.

Our analysis in this section has proceeded on the implicit assumption that the response of the price relative to a real depreciation is equal in magnitude to the corresponding response to a real appreciation. However, the magnitude of the two types of responses may not be equal, giving rise to an asymmetric response, a 'ratchet effect'.

Table 12 Regression results showing the effect of real exchange rate on domestic prices of cocoa, coffee, and sheanuts relative to food.

Equation number	Dependent variable	Constant	ln R	ln $(1-T_{AX})$	DUM	Adjusted R-squared	F(3,23)	DW	LM
1	ln (P_{cc}/P_F)	7.4151[a]	0.7516[a]	0.8700[a]	0.2634[a]	0.8710	59.5377[a]	1.4230	1.6477
		(59.5417)	(12.3624)	(9.8615)	(3.2756)				
2	ln (P_{cf}/P_F)	8.0015[a]	0.4198[a]	0.1098	0.2517[a]	0.7529	27.4084[a]	1.9807	0.0001
		(44.5273)	(4.7616)	(0.8582)	(2.1586)				
3	ln (P_{sn}/P_F)	7.0431[a]	0.3954[b]	0.8286[a]	-0.0557	0.2005	3.1740a	1.4323	2.3154
		(17.3117)	(1.9811)	(2.8606)	(-0.2112)				

LM denotes Chi-squared value of Lagrange multiplier test for serial correlation.
Figures in parentheses are computed t-ratios.

a Significant at the 5 per cent level
b Significant at the 10 per cent level

To gauge the operation (or otherwise) of asymmetric relationships between the relative prices considered in the present study and the real exchange rate, various regressions were run with the relevant relative prices as dependent variables and the real exchange rate *R*, unity minus the implicit import tariff rate *(1 - T_{AX})*, and a variable *ASYMM* as explanatory variables. ASYMM captures the effects of an asymmetric response. *ASYMM* is defined as the algebraic product of the natural logarithm of the real exchange rate and a dummy variable defined to take on a value of unity when the real exchange rate *R* rises (i.e. depreciates) and zero when *R* does not change, or falls (i.e. appreciates). The regression results are presented in Tables 13 and 14. The variable employed to capture the operation of asymmetric relationships *(ASYMM)* turns out to be statistically insignificant at the 5 per cent level in all the equations in Table 13. This implies that the relative price ratios P_A/P_N, P_A/P_H, P_{AX}/P_F, and P_{AX}/P_H respond to changes in real exchange rate in a symmetric rather than an asymmetric manner. Hence, real exchange depreciations tend to exert the same effect (in terms of magnitude) on the price ratios discussed above as real exchange appreciations. Similarly, Table 14 shows that *ASYMM* exerts insignificant independent effects on the cocoa to food, coffee to food, and sheanut to food price ratios at the 5 per cent level. Hence, the various commodity export-to-food price ratios do not respond to changes in the real exchange rate in an asymmetric, but in a symmetric manner. Depreciation of real exchange rate tends to exert the same effect on the various commodity export to food price ratios as real exchange appreciation.

It is important to note that although the real exchange rate is held to be exogenous in the present study, it may indeed be related to the overall trade deficit, external terms of trade, the implicit export and import tax, and monetary and fiscal policies. Hence, there is a need to endogenize the real exchange rate. This endogenization exercise will be undertaken in the next phase of this study.

Table 13 Real exchange rate effects on agricultural prices: testing asymmetric response

Equation number	Dependent variable	Constant	ln R	ln $(1-T_{AX})$	ASSYM	Adjusted R-squared	$F(V_1,V_2)$	DW
1a	ln (P_A/P_N)	0.1157	-0.1742	-0.0487	-0.0003	0.4685	5.6270	1.5483
		(0.4779)	(-1.3452)	(-0.3637)	(-0.1461)		[4,17]	
2a	ln (P_A/PH_H)	4.7425	-0.3679	-0.2444	0.0023	0.7999	21.9895	1.9435
		(7.8013)*	(-2.0781)*	(-1.4111)	(0.9207)		[4,17]	
3	ln (P_{AX}/P_N)	4.2183	0.3783	0.6105	-0.0013	0.6435	14.2371	1.6653
		(33.1655)*	(4.6055)*	(5.9439)*	(-0.6623)		[3,19]	
4a	ln (P_{AX}/P_I)	3.9453	0.7378	0.8125	-0.0008	0.7436	16.2235	1.9466
		(17.4119)*	(5.8050)*	(5.8050)*	(-0.3597)		[4,17]	
5	ln (P_{AX}/P_H)	4.3634	-0.0470	0.5641	0.0087	0.5671	10.6061	1.1017
		(11.7334)*	(-0.1958)	(1.8784)	(1.5334)		[3,19]	

The equations differentiated with 'a' are Cochrane-Orcutt regressions which correct for autocorrelation i th corresponding ordinary least squares regression.

All other equations are ordinary least squares regressions.

* Statistically significant at the 5 per cent leve. Figures in parentheses are t-ratios, and those in square brackets are degrees of freedom.

Table 14 Real exchange rate effects on the relative prices of cocoa, coffee and sheanuts: testing asymmetric response

Equation number	Dependent variable	Constant	ln R	ln $(1-T_{AX})$	ASSYM	Adjusted R-squared	$F(V_1,V_2)$	DW
1a	ln (P_{cc}/P_F)	7.6312*	0.7386*	0.8147*	-0.0008	0.7379	15.9048	1.9508
		(33.5404)	(5.7679)	(5.7636)	(-0.3436)		[4,17]	
2	ln (P_{cf}/P_F)	8.0975*	0.4942*	0.1537	-0.0023	0.6674	15.7179	1.6042
		(31.1783)	(2.9465)	(0.7327)	(-0.5895)		[3,19]	
3	ln (P_{sn}/P_F)	6.9586*	0.4461	0.8670*	-0.0053	0.1413	2.2064	1.4988
		(12.7887)	(1.2693)	(1.9731)	(-0.6385)		[3,19]	

Equation 1a is a Cochrane-Orcutt regression which corrects for autocorrelation in the corresponding ordinary least squares regression. Equations 2 and 3 are ordinary least squares regressions.

* Statistically significant at the 5 per cent level. Figures in parentheses are t-ratios, and those in square brackets are degrees of freedom.

VI Effects of the real exchange rate on agricultural exports

In Section V, it was observed that the real exchange rate influences the agricultural price incentive structure, particularly in relation to agricultural export prices. Since price incentive structure is an important determinant of intersectoral (and inter-commodity) resource flows, which in turn determine the levels of sectoral and commodity output, it could be argued that the real exchange rate is likely to be a major determinant of the volumes of agricultural exports.

Comparing the time profile of the real exchange rate of the cedi R (Figure 1) with the time profile of total real agricultural exports X_A (Figures 5a and 5b) and the time profiles of cocoa (X_{cc}), coffee (X_{cf}), and sheanut (X_{sn}) exports (Figure 6), as well as with the time profile of the share of agricultural exports in agricultural GDP, it is seen that during 1960-87, the real exchange rate decline was associated with simultaneous declines in real total agricultural exports (X_A), volumes of cocoa (X_{cc}) and coffee (X_{cf}) exports, and in the share of exports in agricultural GDP. Sheanut exports (X_{sn}), conversely, had an upward trend during the same period. Cocoa, coffee and sheanut exports, real total agricultural exports and the share of agricultural exports in agricultural GDP showed a positive trend during the period 1983-7, as did the real exchange rate following the implementation of World Bank and IMF structural reforms.

It appears from the above geometric and descriptive analyses that the real appreciation of the cedi (that is, a decline in the real exchange rate) has been associated with declines in X_A, X_{cc}, X_{cf} and the share of exports in GDP, as the time profiles depict. To examine the issue in greater detail, econometric modelling is employed. In Section IV the real exchange rate was modelled to

influence exports indirectly through its effect on prices, which in turn influence volumes of exports. Annual data covering 1960-87 are used.

Four agricultural export functions are estimated using the ordinary least squares method. First, is an aggregate real agricultural exports function with natural logarithm of X_A (lnX_A) as the dependent variable and the following agricultural exports $(lnX_{A,t-1})$, price ratios $ln\ (P_{AX}/P_N)$, $ln\ (P_{AX}/P_F)$, trade-weighted foreign real income of the country's trading partners (lnW), a trend term (lnT), and a dummy variable (DUM) equal to zero for the structural adjustment period, and equal to unity otherwise. Second, a cocoa exports function which includes, *inter alia*, Ghana's cocoa base production capacity $(ln \leq Q_{cc})$ was estimated. The data on Q_{cc} were obtained from Frimpong-Ansah (1989). For the cocoa exports equation, weather is proxied by the average annual rainfall in the cocoa-growing areas. The same rainfall variable is included in a third export function which relates to coffee, since cocoa and coffee are grown in the same ecological zone. The fourth export function relates to sheanuts. The weather variable here is proxied by average annual rainfall in the sheanut-producing areas. All rainfall data were obtained from the Ghana Meteorological Services Department. The OLS regression results are presented in Table 15.

With reference to aggregate agricultural exports, the lagged exports variable turns out to be the only significant variable at the 5 per cent level. The cocoa exports function shows the following variables as statistically significant at the 5 per cent level: cocoa base capacity Q_{cc}, cocoa to food price ratio P_{cc}/P_F, and the trend term. The statistically significant negative elasticity of cocoa export volume with respect to cocoa base capacity seems to suggest the need to diversify exports away from on cocoa. Table 15 further shows that a 10 per cent increase in the price of cocoa relative to food price stimulates a 2.42 per cent increase in the volume of cocoa exports.

Although the response of cocoa exports to the cocoa to food price ratio is inelastic, the response of coffee exports to the coffee to food price ratio is not (Table 15). A 10 per cent increase in the domestic producer price of coffee relative to food price stimulates a 10.52 per cent increase in the volume of exports. Similarly, the response of coffee exports to foreign income tends to be elastic, whereas the corresponding response for cocoa is inelastic; the response relating to cocoa is, however, not statistically significant at the 5 per

cent level. The negative signs of the responses imply that, contrary to expectation, an increase in foreign income tends to precipitate falls in the volume of coffee and cocoa exports, although the potential fall in the latter is not statistically significant at the 5 per cent level. A 10 per cent increase in foreign income tends to generate a 13.73 per cent fall in the volume of coffee exports. It does appear, therefore, that the volume of coffee exports may not increase when her trading partners move out of recession and their incomes increase.

With reference to the sheanut exports equation, only the dummy variable capturing the relative effect of the structural adjustment period is statistically significant at the 5 per cent level (Table 15). Sheanut export volume tended to be relatively higher during the structural adjustment era.

The elasticities of agricultural exports with respect to the real exchange rate of the cedi, computed from equations (40) to (43), are presented[26] in Table 16. All the computed elasticities are less than unity, implying that the response of agricultural exports to a change in the real exchange rate is inelastic. For example, a 10 per cent depreciation (appreciation) of the real exchange rate stimulates a 1.82 per cent and 4.42 per cent increase (decrease) in cocoa and coffee export volumes, respectively. It is important to note that the short-run elasticities of sheanut exports and aggregate real agricultural exports are unexpectedly not significantly different from zero at the 5 per cent level and even at the 10 per cent level. This implies that a 10 per cent change in the real exchange rate exerts zero per cent effect on real aggregate agricultural exports and sheanut export volume. This is because the responses of aggregate agricultural exports and sheanut export volume to the relative price ratios P_{AX}/P_F, P_{AX}/P_N, and P_{SH}/P_F are statistically insignificant, although these relative price ratios respond significantly to changes in the real exchange rate. The magnitudes of the elasticities of individual commodities are greater than the corresponding elasticity of aggregate real agricultural exports. This could be due to the greater substitution possibilities in the production of the individual agricultural export commodities than for aggregate agricultural exports. It should be noted that the modelling of agricultural commodity exports is a complex exercise; it involves both the behaviour of farmers and the behaviour of the public marketing board.

Table 15 Results of agricultural exports regressions

Explanatory variables	Dependent variables ln Xa	ln Xcc	ln Xcf	ln Xsn
ln XA, t-1	0.6661*			
	(2.8375)			
ln Xcc t-1		0.0590		
		(0.2720)		
ln Xcf t-1			-0.1240	
			(0.5659)	
ln Xsn t-1				-0.0469
				(-0.2171)
ln Qcc		-2.7969*		
		(2.5433)		
ln PAX/PN	-0.0263			
	(-0.0785)			
ln PAX/PF	0.0337			
	(0.1465)			
ln Pcc/PF		0.2423*		
		(2.4019)		
ln Pcf/PF			1.0521*	
			(3.0955)	
ln Psn/PF				0.3466
				(0.8143)
ln Y	-0.1643	-0.0755	-1.3730*	1.6761
	(-0.6596)	(0.4641)	(-2.5867)	(1.4314)
ln W	0.2194	-0.2748	-0.6069	0.9122
	(0.6268)	(-1.2989)	(-1.0902)	(0.5798)
ln T	0.0960	0.5687*	1.0274*	-1.2840
	(0.4605)	(2.2322)	(2.5417)	(-1.3220)
DUM	0.0599	0.1122	1.2902*	-1.9517*
	(0.2944)	(0.9231)	(3.0517)	(-2.4000)
Constant	1.9574	27.9801*	17.2824*	-17.6505
	(0.5240)	(3.2130)	(2.0136)	(-0.9910)
ADJ. R2	0.5379	0.8213	0.7308	0.1972
F	5.3237*	18.0935	12.7632*	2.0641
	[7,19]	[7,19]	[6,20]	[6,20]
LM	0.2821	1.1985	4.0474	0.0535

Figures in parentheses are t-ratios. LM denotes Lagrange multiplier test for serial correlation (Chi-squared statistic).

* Significant at the 5 per cent level.

Table 16 Elasticities of agricultural exports with respect to the real exchange rate

	Export short-run elasticities
Aggregate real exports	0.0147
Cocoa exports	0.1821*
Coffee exports	0.4417*
Sheanut exports	0.1370

Source: Computed from the regression results in Tables 11, 12 and 15.

* Significant at the 5 per cent level.

The inelasticity of agricultural export response to changes in the real exchange rate implies that large changes may be needed to stimulate increases in agricultural exports. This, coupled with the smaller elasticity of aggregate agricultural exports, implies that relying only on changes in the real exchange rate changes to stimulate increased agricultural exports is not feasible. There is a need to complement real exchange rate policy with implementing non-price policies for improving the infrastructure at farm level, for efficient handling of agricultural export commodities, and for enhancing export procedures.

As discussed above, the incidence of smuggling (particularly cocoa) to neighbouring countries has been reported by Manu (1974) and Atsu (1965). To understand the effects of smuggling on agricultural exports, it must be recognized that when the cedi value of the producer price of a given agricultural export commodity in a neighbouring country is higher than the producer price of the same commodity in Ghana, an incentive is created for smuggling. An increase in the producer price of a commodity in a neighbouring country decreases Ghana's export potential of that product. This suggests that the effects of smuggling could be gauged by including the relative cedi value of the producer prices of cocoa in neighbouring Côte

d'Ivoire and Togo in agricultural exports equations. The data on the cedi value of cocoa producer prices in Côte d'Ivoire and Togo were obtained from Younger (1989). These data and information on the black market exchange rates between the cedi and CFA Franc cover the period 1965-82. Data covering 1960-4 and 1983-7 were not available. Data on coffee were not available, they were not, therefore, included in the present study.

The econometric results showing the effects of smuggling are presented in Tables 17 and 18. The two variables proxying smuggling, namely *SMUG1* and *SMUG2,* turn out to be insignificant at the 5 per cent level for the aggregate agricultural export function (Table 17). Note that *SMUG1* is the ratio of cocoa producer price in cedis in Côte d'Ivoire to the cedi cocoa producer price in Ghana. Similarly *SMUG2* is the ratio of cedi cocoa producer price in Togo to the cedi cocoa producer price in Ghana. Comparing the results in Table 17 with the aggregate agricultural exports regression *XA* in Table 15, it shows that the inclusion of either the smuggling variable *SMUG1* or *SMUG2*, or both, tends to reduce explanatory power from 0.5379 to between 0.4188 and 0.4991; the F-value also falls. Hence, the effect of smuggling on aggregate agricultural exports tends to be minimal. On the other hand, cocoa smuggling to Côte d'Ivoire tends to exert a negative effect on the volume of Ghana's cocoa exports (Table 18).

A 10 per cent increase in the cedi value of the Côte d'Ivoire cocoa producer price relative to the corresponding price in Ghana precipitates a 1.7 per cent decline[27] in the volume of Ghana's cocoa exports (note that equation 2 in Table 18 is preferred).

Table 17 Aggregate agricultural export regressions including effects of smuggling

Explanatory variables	Equations 1 (OLS)	Equation 2 (OLS)	Equation 3 (OLS)
lnXA,t-1	0.3328	0.5248	0.4379
	(0.9697)	(1.6664)	(1.3108)
lnY	-1.1257a	-0.9905a	-1.0329a
	(-3.111)	(-2.7940)	(-2.9045)
lnW	-0.6312	-0.5812	-0.5386
	(-1.4635)	(-1.3176)	(-1.2570)
lnT	1.1154a	0.9137a	0.9781a
	(2.5386)	(2.1779)	(2.2904)
lnPAX/PF	-0.3700	-0.1241	-0.2307
	(-1.1927)	(-0.5049)	(-0.8023)
lnPAX/PN	-0.0366	-0.0722	-0.0119
	(-0.0825)	(-0.1586)	(-0.0264)
ln SMUG1	-0.2464		-0.0522
	(-1.2453)		(-0.5453)
ln SMUG2	0.2357	0.0049	
	(-1.1172)	(0.0472)	
Constant	21.8935a	18.0481a	19.0546a
	(3.3242)	(3.0204)	(3.0977)
Adjusted R2	0.4491	0.4188	0.4354
F	2.7324	2.7498	2.8731
[V1, V2]	[8,9]	[7,10]	[7,10]
LM	0.0436	0.5126	0.0677

SMUG1 denotes cocoa producer price in Côte D'Ivoire converted to cedis using parallel market exchange rate, whereas SMUG2 denotes the corresponding price in Togo.

a Significant at the 5 per cent level.

Table 18 Regression capturing the effects of smuggling on cocoa exports

Explanatory variables	Equation 1	Equation 2
lnXcc t-1	-0.2299	-0.1966
	(-0.9931)	(-0.8655)
ln Y	-0.3465	-0.3173
	(-1.4594)	(-1.3571)
lnWc	-0.2511	-0.1894
	(-1.1097)	(-0.8818)
ln T	-0.0247	-0.0549
	(-0.0902)	(-0.2034)
lnPcc/Pf	0.0784	0.1353
	(0.6162)	(1.2222)
ln SMUG1	-0.2743a	-0.1715*
	(-2.1806)	(-2.9191)
ln SMUG2	0.1341	
	(0.9258)	
Constant	21.4370a	19.7840a
Adjusted R2	0.7554	0.7585
F	8.4986a	9.9009a
[V1,V2]	[7,10]	[6,11]
L	0.000052	0.2169

T-ratios are in parentheses, and degrees of freedom are in square brackets. *SMUG1* denotes the cocoa producer price in Côte d'Ivoire converted to cedis using the parallel market exchange rate, whereas *SMUG2* denotes the corresponding price in Togo.

a Significant at the 5 per cent level.

VII Conclusions

The study shows that the cedi appreciated in real terms by 7.81 per cent during the period 1960-87. This is due to the fact that the real appreciation of the currency during the 1960s and 1970s was greater than the real depreciation observed for the 1980s, particularly during 1983-7. The real depreciation of the cedi during 1983-7 was as high as 123.18 per cent per annum. Real appreciation of the cedi was faster in the 1970s than during the 1960s. During 1960-87, the real exchange rate appreciation was largely due to a 32.85 per cent per annum increase in the domestic price level, and a 16.24 per cent per annum nominal depreciation of the cedi. The major source of the real depreciation of the cedi in the 1980s, particularly over the structural adjustment period of 1983-7, is a nominal exchange rate depreciation. During periods when the real exchange rate of the cedi appreciated, this was largely due to increases in the domestic price level. In contrast, during periods when the real exchange rate depreciated, this was largely due to depreciation of the nominal exchange rate, with the foreign price playing an insignificant role.

The domestic aggregate agricultural export price relative to the domestic aggregate non-agricultural price (P_{AX}/P_N) declined by a compound rate of 0.83 per cent per annum during 1960-87. The ratio of cocoa domestic producer price to domestic aggregate non-agricultural price (P_{cc}/P_N) declined by a compound rate of 0.82 per cent per annum, whereas the ratio of domestic coffee producer price to domestic aggregate non-agricultural (P_{cf}/P_N) declined by 1.46 per cent per annum. The ratio of aggregate agricultural export price to food price (P_{AX}/P_F), domestic cocoa to food price (P_{cc}/P_F), domestic coffee to food price (P_{cf}/P_F), and domestic sheanut to food price (P_{sh}/P_F) declined by 3.81 per cent, 3.79 per cent, 4.46 per cent, and 0.01 per cent per annum, respectively, during 1960-87. However, during the structural adjustment period

1983-7, the price ratios P_{AX}/P_F, P_{cc}/P_F, and P_{cf}/P_F increased by 11.43 per cent, 11.38 per cent, and 22.38 per cent per annum, respectively. During the structural adjustment period, the price ratios P_{AX}/P_N, P_{cc}/P_N and P_{cf}/P_N increased by 5.81 percent, 5.75 per cent, and 16.20 per cent per annum, respectively. Hence, during the structural adjustment period, price incentives favoured of agricultural exports in the aggregate, and cocoa and coffee relative to food production and non-agricultural commodity production. In contrast, over the whole period 1960-87, price incentives appear to have favoured food and non-agricultural commodity production over agricultural exports in the aggregate, and cocoa and coffee.

On average, cocoa, coffee, and sheanut producers received a greater proportion of the world price in the 1980s than they did in the two previous decades. However, sheanut producers were subsidized, and cocoa and coffee farmers were taxed. Information supplied by Cocobod indicates that the producer price of traditional agricultural export commodities producer price takes into consideration not only the relevant production costs but also the expected nominal exchange rate of the cedi. Under a flexible nominal exchange rate regime, production costs, particularly in the case of imported inputs, tend to rise (fall) as the domestic currency depreciates (appreciates). Policy makers expect the effects of nominal exchange rate changes to be passed on when they set those export prices. The results of this study confirm this expectation.

The study's econometric results indicate that the real exchange rate exerts independent, statistically significant effects on P_A/P_H, P_{AX}/P_N, and P_{AX}/P_F. A 10 per cent increase (decrease) in the real exchange rate stimulates a 7.5 per cent increase (decrease) in P_{AX}/P_F; it causes increases (decreases) of 7.5 per cent, 4.2 per cent, and 3.95 per cent in the respective price ratios P_{cc}/P_F, P_{cf}/P_F, and P_{sh}/P_F. Similarly, a 10 per cent appreciation (depreciation) in the real exchange rate causes a 4.0 per cent decline (increase) in P_{AX}/P_N. The effect of the real exchange rate on the domestic aggregate agricultural to non-agricultural price ratio is statistically significant at the 10 per cent level. A 10 per cent increase (that is, depreciation) of the real exchange rate precipitates a 1.8 per cent fall in the domestic aggregate agricultural terms of trade, whereas a 10 per cent decline (that is, appreciation) of the real exchange rate causes a 1.8 per cent increase in the domestic aggregate agricultural terms of trade. The study

further shows that nominal exchange rate changes influence public policy regarding the pricing of cocoa, coffee and sheanuts. A 10 per cent nominal devaluation of the cedi results in a 7.8 per cent, 8.3 per cent and 6.8 per cent increase, respectively, in the domestic producer prices of cocoa, coffee and sheanuts administered by the parastatal marketing board (Cocobod). No evidence of an asymmetric response of the agricultural price incentive structure to changes in the real exchange rate was recorded in the present study.

Implicit tax on agricultural exports is also observed to influence the price incentive structure. An implicit tax on agricultural exports which results in a 10 per cent reduction (increase) in $(1\text{-}T_{AX})$ induces a 6.5 per cent, 8.65 per cent, 8.7 per cent, and 8.3 per cent decline (increases) in P_{AX}/P_N, P_{AX}/P_F, Pcc/PF, and Psn/PF, respectively. Hence, a reduction in implicit tax on agricultural exports turns the terms of trade in favour of agricultural export producers, but against food producers. This could have an adverse effect on the achievement of food security.

The study notes that the structural adjustment period showed relatively higher levels of P_{AX}/P_N and P_A/P_H than other periods, whereas P_{AX}/P_F, P_{cc}/P_F, P_{cf}/P_F tended to be smaller. Structural adjustment tended to exert a positive effect on P_{sn}/P_F. This, coupled with the vigorous support sheanut producers received from the government, stimulated an increase in sheanut export volume. The current attempt by government to organize the sheanut pickers into co-operatives to enable efficient delivery of inputs and extension services is a step in the right direction.

Coffee exports tended to be relatively smaller during the structural adjustment era. Information supplied to the author by Cocobod indicates that during the earlier part of structural adjustment Ghana promoted cocoa and sheanut exports at the expense of coffee. It was argued, at the time that, the infrastructure for exporting agricultural commodities was inadequate and that its use had to be rationed. Cocoa and sheanuts were given preference over coffee in this rationing.

This study indicates that real aggregate agricultural exports declined by 4.59 per cent per annum during 1960-87, whereas they increased by 2.59 per cent per annum during the 1960s, fell by 4.92 per cent per annum in the 1970s, and rose by as much as 20.42 per cent per annum during the 1980s. The share of exports in real aggregate agricultural output declined over the

period 1960-87, while it rose during the 1980s, particularly 1983-7. The volumes of cocoa and coffee exports declined respectively by 3.28 per cent per annum and 7.34 per cent per annum during 1960-87, whereas both export volumes increased by 2.82 per cent per annum and 1.32 per cent per annum respectively, during the structural adjustment era of 1983-7. In contrast, the volume of sheanut exports generally increased by 5.24 per cent per annum during 1960-87 but increased sharply by as much as 111.03 per cent per annum. The volumes of cocoa, coffee and sheanuts declined during the 1970s but all volumes rose during 1983-7. The study demonstrates that real exchange appreciation during 1960-87 has been associated with declines in real aggregate agricultural exports, volumes of exports of cocoa and coffee, and with the share of exports in real aggregate agricultural output.

The study shows that the response of agricultural exports to a change in the real exchange rate is inelastic. For example, a 10 per cent depreciation (appreciation) of the real exchange rate stimulates a 1.82 per cent increase (decrease) in cocoa exports and a 4.42 per cent increase (decrease) in coffee exports. An increase in the production of particular individual traditional agricultural exports confers larger elasticities on individual products than aggregate agricultural exports, the elasticity of which is equal to zero. Although the smuggling of cocoa to Côte d'Ivoire tended to exert a negative effect on the volume of cocoa exports, it tended to exert no significant effect on aggregate agricultural exports.

The weak response of aggregate agricultural, and sheanut, exports to changes in the real exchange rate has been due to a lack of response to the relative prices. The inelastic response to changes in real exchange rate suggests that larger changes may be required to stimulate the desired increases in agricultural exports. This, coupled with the extremely low corresponding elasticity for aggregate agricultural exports, suggests that reliance on changes in the real exchange rate to stimulate increased agricultural exports is not a fruitful policy. There is a need to complement real exchange rate policy with effective measures to provide improved infrastructure at farm level, for the handling of agricultural exports for transport from production areas and at the ports, and for facilitating and advising exporters.

Finally, the study demonstrates that a 10 per cent increase in the price of cocoa relative to food price stimulates a 2.42 per cent increase in the volume

of cocoa exports. However, volume of cocoa exports tended to respond negatively its base capacity. This suggests the need to diversify exports away from over-dependence on cocoa. It is suggested that the promotion of non-traditional exports needs to be vigorously pursued.

Appendix I

Frimpong-Ansah (1989) indicates that he obtained the time series data on domestic non-agricultural price index from Stryker *et al.* (1988). This set of time series data had a base year of 1963. For the purpose of the present study, the conventional method of splicing time series data was employed to transform the data set to a price series with 1980 as the base year.

The details of the computation of the cocoa base capacity variable, Q_{cc}, can be obtained from Frimpong-Ansah. In brief, he computes Ghana's cocoa base capacity as the algebraic difference between the sum of the normal traditional productive capacity, the insecticide yield factor and the hybrid yield factor on the one hand, and the swollen shoot cutout factor on the other. The normal traditional capacity is in turn measured as the algebraic produce of cocoa farmers' long run planting response and the Bateman coefficient estimated from a Bateman-type cocoa capacity equation. The farmers' long run response factors for each year enter the relevant vintage Matrix as vintage planting factors for each year.

> "Each vintage factor is multiplied by the respective coefficients of the cocoa yield profile spread over the 55 year life of the cocoa trees to form the columns in the vintage matrix. Estimated normal capacity is tonnes in each year is obtained by summing the factors across all vintages in that year, and multiplying by the appropriate Bateman derived coefficient." (Frimpong-Ansah (1989)).

The yield profile was based on actual experimental results obtained from the Cocoa Research Institute at Tafo in Ghana (formerly called the West African Cocoa Research Institute).

Appendix II

Table A1 Absolute annual percentage share of nominal exchange rate, foreign price and domestic price level in real exchange rate changes.

Period	Share of nominal exchange rate	Share of foreign price	Share of domestic price level
1960s	23.99	5.47	70.54
1970s	11.19	16.36	72.44
1980s	71.52	0.56	27.92
1983-7	88.05	4.51	7.44
1960-87	29.83	9.84	60.33

Source: Basic data are from the IMF *International Financial Statistics*, various issues, and the Ghana Statistical Service.

Notes

1. The cedi is the official currency of Ghana.

2. In this study, the word 'exports' refers to official exports only, since information on non-official (illegal) exports is not available.

3. Okyere appears to underestimate the seriousness of the multi-collinearity problem by arguing that it is 'a common phenomenon in time series regressions' (Okyere (1989), p. 14).

4. It should be pointed out that Batten and Bolongia (1986), another empirical study, also encountered a similar problem. In their study, the US real agricultural price variable was not statistically significant, whereas the real trade-weighted exchange rate variable was statistically significant in the US agricultural export equation estimated by the authors. This result seems to be paradoxical since if agricultural export producers do not respond to the structure of price incentives then they will not respond to the real exchange rate (RER) even in the situation where the structure of incentives responds to RER changes.

5. The thesis of the present study, and this is one of the important contributions of the study, is that changes in the RER exert profound effects on the structure of price incentives which, in turn, influence the volume of agricultural exports. Hence, agricultural export producers respond indirectly to RER changes.

6. This foreign price index implicitly allocates equal weights to Ghana's trading partners. Indeed, the existing relevant literature suggests that where each trading partner's share in the *sum* of imports and exports (a_j) is available, it could be used in the weighting exercise as follows:

$$(i) \quad P_f^* = a_{us,t} \cdot WP_{us,t} + \sum_{j=1}^{n} a_{jt} \cdot e_{us,jt} \cdot WP_{jt}$$

the symbols being similar to those in Equation (2). P_f^* is very useful in that it incorporates the relative importance of each trading partner in the *aggregate* trade picture of a given domestic economy. However, its operationalization sometimes encounters a number of difficulties. For example, the destinations of exports and the sources of imports of a given economy as well as the share of each trading partner could change substantially over time implying that the set of trading partners incorporated could change over time. Hence, there is the need to vary the countries included in the basket to reflect such changes. However, some researchers suggest that the set of trading partners and the weights used should be kept constant over the period under study to ensure that foreign price index changes truly reflect changes in prices rather than changes in the composition of the basket. It is intuitively plausible that the cost (in terms of measurement error) of using this approach is likely to be huge if changes in import sources and export destinations are substantial and the actual shares differ significantly from the relevant mean share for the period under study. In addition the measurement of P_f^* is highly information-intensive, requiring data on total imports as well as data on the sources and magnitudes of imports and the destinations and magnitudes of exports. Unfortunately, the full relevant dataset may not always be available, hence the equal waiting approach rather than that of (i) is preferred in situations of inadequate information. In the present study, all the information required for computing P_f^* as in (i) was not readily available, so the foreign price index in the main text (Equation (2)) was employed.

7. Getting a perfect home goods price index is not an easy exercise. This is because the traditional domestic price indices available do not cover non-traded goods as a whole. Aggregate domestic price indices, or their components, usually cover a combination of non-traded goods, import-competing and export goods. It should be pointed out that although some researchers recommend the use of the housing component of the consumer price index as the proxy for home goods price, the present study does not follow this suggestion as the corresponding index for Ghana is a combination of housing, fuel and electricity prices, and that fuel has a very large traded component. Fosu (1989a, 1991) put forward the idea of the use of the sand, stone and unskilled labour components of the prime building cost index as a proxy for the home goods price. Unfortunately, the series were not readily available for the whole of the 1960s. Following this idea, therefore, would have resulted in a heavy loss of statistical degrees of freedom in this case, the period under study being 1960-87, and so it was not used. This component comprises mostly non-traded commodities and was available for the entire period under study. Local food prices in Ghana have been observed to be a major component of (and therefore strongly influences) the national domestic consumer price index and national inflation (see, for example, Fosu (1989b)).

8. The linear trend regression results were better than the double corresponding logarithmic regression results, and were therefore used in the present study.

9. See Appendix 1.

10. If data on agricultural gross domestic product measured in both current (G_1) and constant (G_2) prices were readily available, the domestic aggregate agricultural price could simply be computed as the ratio G_2/G_1. However, since G_2 was not readily available, the approach employed was that summarized in Equation 8.

11. The use of the wage rate as a proxy for home goods price has been suggested by harberger (1986) and Snape (1988, 1990) who provide a

rationale for this. In this study, the minimum wage proxies non-agricultural home goods price because data on market-determined wage rate were not readily available, complete time series data on aggregate non-agricultural non-traded goods, moreover, were not readily available. Neither could Fosu's (1989a, 1991) theory be used, as the relevant data for the period under study were unavailable.

12. The world 'profitable' is not used in its absolute but in its relative sense. For example, the growth in the relative price P_{AX}/P_N of 1.34 per cent per annum in the 1980s (Table 4) implies that the terms of trade turned in favour of the production of agricultural export commodities during the 1980s.

13. It is worth noting that the observed negative compound growth rate of -8.4 per cent per annum in P_{AX}/P_F during the 1960s when the price of agricultural export commodities in the rest of the world increased relative to the corresponding prices of manufactures, illustrating the distortion story.

14. See footnote 12.

15. See footnote 12.

16. During the pre-1983 period, whereas dollar prices of exports remained within a factor of about 2, the share of agricultural exports in agricultural value-added declined from about 25 per cent to about 1 per cent with the volume of major exports falling by about 50-60 per cent. This observation seems to suggest that the real exchange rate tended to be increasingly misaligned during the period.

17. The observation that real dollar values of exports declined by only 50 per cent while real cedi valued declined by a factor of 20 generally suggests that the real exchange rate tended to be increasingly misaligned.

18. Sheanuts comprise the fruits (specifically, the nuts) of the Shea Butter Tree. Belonging to the botanical family Sapotaceae, the Shea Butter Tree (*Butyrospermum parkii*) has a rough, square-fissured bark with a corky layer, giving the appearance of crocodile skin. The tree is common on fry laterite slopes in the northern savannah zone of Ghana, where it grows naturally. Sheanut 'producers' penetrate the savannah to pick the fallen nuts. These nuts are either processed into shea butter for local consumption, or sold in their raw state to the Cocobod for later export. During 1983-7 the Government of Ghana became interested in promoting increased export of sheanuts, perhaps because of its relatively more favourable world price (Cocobod (1989), and personal communication with Cocobod personnel). Hence, the Government subsidized the domestic sheanut industry by providing sheanut producers with extension service, cutlasses, bicycles with carriers to facilitate 'penetration into hinterland where motorable road to not exist', hand gloves, and wellington boots (see Cocobod (1989)), and also by increasing the domestic producer price of sheanuts to an annual average of about 3.58 the world price. It is intuitively plausible, therefore, that the picking of sheanuts increased tremendously, and that a substantial amount of the sheanuts that would formerly have gone into local processing for domestic consumption, were now being sold to Cocobod for export during 1983-7, hence the steep increase in sheanut exports during that time.

19. The increase in sheanut export during 1960-87 was not able to offset the declines in cocoa and coffee exports (see Table 7); consequently, real aggregate agricultural exports declines during the period (see Table 6).

20. The responses of cocoa and coffee exports to the post-1983 reforms were a smaller than the corresponding response of sheanuts (see Table 7); it could be inferred that the increase in real aggregate agricultural exports during 1983-7 largely originated in the steep increase in sheanut exports during the period.

21. Complete and reliable datasets on transportation, handling and other transactions costs for Ghana covering the period under study were not

readily available, hence this assumption. The use of this assumption, however, does not imply that the aforementioned costs are irrelevant, indeed when relevant costs data become available, it would be useful to examine the sensitivity of the results to a relaxation of the assumption. Transaction costs are important in RER discussions as they determine to a large extent, what is tradable and non-tradable. High transaction or transfer costs tend to create a large gap between import and export parity prices.

22. Lack of data limits the use of the productive capacity variable to cocoa alone. The cocoa productive capacity data were obtained from Frimpong-Ansah (1989). The Appendix presents a brief outline of the measurements of the cocoa base capacity variable. The rainfall data were obtained from the Ghana Meteorological Services Department. Basic data for generating Y were obtained from the *International Financial Statistics* (IMF)(various issues). All the data used cover the period 1960-87.

23. These are short run elasticities. The corresponding long run elasticities are given by

$$(ii) \quad (\delta \ln X_{it} / \delta \ln R_t)(1 - \delta \ln X_{it} / \delta \ln X_{i,t-1})^{-1}$$

where $i = A, cc, df, sn.$

24. The first differencing method for rectifying autocorrelation entails running a regression of the form:

$$Y_t^* = Y(X_{1t}^*, X_{2t}^*, ..., X_{kt}, e_t),$$

where

$$Y_t^* = Y_t - \rho \cdot Y_{t-1}$$

and

$$X_t^* = X_t - \rho \cdot T_{t-1}.$$

The variables Y and X_i constitute the original data, and ρ denotes the autocorrelation coefficient.

25. This is an average figure for the period under study. The magnitude of the response may vary over time, in which case the more appropriate approach would be time varying parameter econometric modelling.The response to change of each relative price could also be endogenized.

26. The corresponding approximate long run elasticities for real aggregate agricultural exports, cocoa, coffee, and sheanuts, are higher, 0.3779, 1.1345, 0.3930 and 0.1309 respective (see footnote 23). However, these

$$Y_t^* = Y_t - \rho \cdot Y_{t-1}$$

long run elasticities are not statistically significant at the 5 per cent level. It is important to note that better long run elasticities could be obtained by employing a general equilibrium model which incorporates the actual dynamics of intersectoral resource flows and endogenous technology (see Mundlak (1985, 1988) for a critique of the Nerlovian-type model from which these elasticities were computed). An important issue is the time it takes for short run fixed factors to become mobile between sectors. Such resource flows are likely to respond not only to real exchange rate changes, but also to public investment in the mobilization of private investment by farmers, through research, extension, feeder and trunk roads, storage facilities, etc.

27. This result suggests that Côte d'Ivoire sold a significant proportion of Ghana's cocoa output (the proportion smuggled from of Ghana) on the world market during the pre-1987 period. This phenomenon was particularly intense during the second half of the 1970s. It is worth noting that the cocoa producer price rationalization policy of the post-1983 (structural adjustment) era has tended to turn the cocoa domestic producer differential between Ghana and Côte d'Ivoire in favour of Ghana. Consequently, during the post-1983 period, Ghanaian cocoa is again being sold by Ghana.

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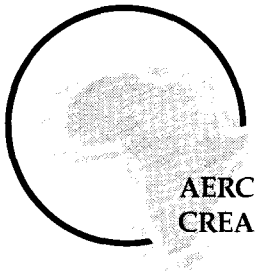

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