Dynamic inter-links among the exchange rate, price level and terms of trade in a managed floating exchange rate system: The case of Ghana

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Abstract

This study examined the dynamic interrelationships among domestic price level, nominal exchange rate, terms of trade of cocoa, bank rate, domestic credit and foreign exchange reserves using the cointegration, vector error correction (VEC) and vector auto regression (VAR) approaches. The cointegration analysis confirms the presence of three economically interpretable stable long-run relationships among the relevant variables. The speeds of adjustment for the foreign exchange market, the interest market and the market for cocoa are relatively higher than the speeds of adjustment for the markets of non-tradeables and domestic credit.

The determinants of domestic inflation in the short run are bank rate, foreign exchange reserves, terms of trade of cocoa and government expenditure. For the short-run depreciation of the local currency, the determinants are the domestic price level, terms of trade of cocoa and foreign exchange reserves. For terms of trade of cocoa (which proxies collusion) in the short run, the determinants are domestic credit, foreign exchange reserves, terms of trade of gold and the price of petrol. The effects of monetary and terms of trade shocks are generally transmitted to the domestic price level, terms of trade of cocoa, and nominal exchange rate.

The determinants of bank rate in the short run are the domestic price level, domestic credit and foreign exchange reserves. For domestic credit in the short run, determinants are the domestic price level, nominal exchange rate, bank rate, foreign exchange reserves, government expenditure and terms of trade of gold. The determinants of foreign exchange reserves in the short run are the nominal exchange rate, terms of trade of cocoa and price of petrol.

From these results it is observed that the monetary authorities could control the domestic rate of inflation by reducing the relatively high bank rate. In order to arrest the continuing depreciation of the local currency, the Bank of Ghana could sell more foreign exchange in the foreign exchange market. Because the pass-through effect from the domestic price level to the nominal exchange rate is neither complete nor instantaneous, the Bank of Ghana should try to implement a consistent bank rate policy in accordance with the exchange rate intervention policy. Moreover, the Bank of Ghana should try to follow a consistent sterilization policy through domestic credit with respect to the nominal exchange rate, and, by arresting the rate of depreciation of the local currency, could solve the problem of excess liquidity. The Government of Ghana could collude with the other major producers of cocoa in order to improve its terms of trade of cocoa, and the Bank of Ghana should ensure a consistent sterilization policy through foreign exchange intervention with respect to the terms of trade of cocoa.

1. Introduction

The basic objective of various macroeconomic policies is to achieve stability of domestic price level, nominal exchange rate and terms of trade; equilibrium in the balance of payments; and in growth output. Stabilization policies are typically defined as policies aimed at reducing deviations between the short-run equilibrium (disequilibrium) and the long-run equilibrium. Such policies are generally classified into two groups, fixed rules and flexible rules. Fixed rules are rules setting policy instruments on a trajectory that will not be altered whatever happens. Perhaps the best known example is Milton Friedman's proposal that the authorities should adopt a policy of a fixed rate of growth of the nominal money stock (Friedman, 1968). Flexible rules, by contrast, are rules with "feedback". That is, they are contingent on certain outcomes in the economy. An example of a flexible rule would be one in which the money stock deviates around some target level as the short-run equilibrium level deviates from the long-run equilibrium level. Authorities are most likely to follow a flexible rule and use automatic stabilizers. The work of Poole (1970) on monetary policy in a closed economy and of Parkin (1978) on monetary and exchange rate intervention in an open economy can be regarded as dealing with automatic stabilizers. Fiscal, monetary and trade policies are generally used to achieve the stability objectives.

Policy instruments

Three instruments of monetary policy (bank rate, domestic credit and foreign exchange reserves) and one instrument of trade policy (the use of oligopoly power) can be used to target domestic price level, nominal exchange rate and terms of trade of cocoa. Ndung'u and Ngugi (1999) have shown that whenever the monetary authorities try to target a competitive exchange rate and inflation rate with interest rate as the only instrument, the result is a policy dilemma that complicates macroeconomic management. Conflicts may exist among various policy objectives. In order to minimize conflicts among policy objectives and to achieve desired policy targets, monetary authorities can manipulate variables that are under their direct control to effect changes indirectly in other policy variables to arrive at the ultimate goal (Meltzer, 1969).

The ultimate goal could be the stability of domestic price levels, nominal exchange rates and terms of trade of cocoa. Exchange rate stability is necessary for domestic price stability because Ghana's economy is heavily dependent on imports of raw materials, capital goods and consumer goods. A stable exchange rate would have positive effects on household incomes and consumption; firms' investment, import and employment

decisions; government's fiscal, debt and monetary policies; and trade balance. Moreover, exchange rate stability is likely to discourage capital flight and speculation in the foreign exchange market (Garba, 1997). Instability of terms of trade of cocoa would have repercussions in other sectors of the Ghanaian economy. The effect of these policy instruments on the targeted variables is generally achieved after some time lag. It is crucial for the policy makers to know the exact nature and timing of these lags.

In a floating exchange rate system the exchange rate adjusts to produce balance of payments equilibrium at all times (there is no change in the international reserves) and the money supply is therefore insulated from the foreign sector. In such a system, provided they can control the domestic component of money supply (through quantity targeting and price targeting), the authorities can pursue an independent monetary policy. On the other hand, in a "managed float" exchange rate system the exchange rate adjusts partially to correct imbalances on the balance of payments. The central bank intervenes in the foreign exchange market whenever need arises; reacts to any changes in the domestic price level, nominal exchange rate and terms of trade of cocoa; and uses sterilization policies to counteract the contractionary or expansionary effects. The central bank has the option of using three instruments of monetary policy—bank rate, domestic credit and foreign exchange reserves—in order to influence liquidity and ultimately stabilize the domestic price level and nominal exchange rate. The Ghanaian government, moreover, can collude with other countries in order to stabilize the terms of trade of cocoa.

In this system, agents know that the central bank always follows counter-cyclical rule in the implementation of its policies with regard to bank rate, domestic credit and foreign exchange reserves. The agents also know that the Ghanaian government would collude with other countries to offset the deteriorating effects of a fall in the terms of trade of cocoa. In a managed float exchange rate system, the money supply is therefore not insulated from the foreign sector and authorities cannot pursue independent bank rate, domestic credit, exchange rate intervention and trade policies. It is crucial for policy makers to know the extent of inter-dependence or trade-offs among the various instruments of monetary policy and trade policy.

According to the monetarists, inflation and rate of depreciation of the local currency occur when the central bank increases the money supply in excess of the demand for money. This large increase in money supply could result from the financing of fiscal deficits or extension of too much credit to the private sector and public institutions or increased exchange rate operations of central banks. The monetarists see the solution to lower inflation and depreciation rate of the local currency as the implementation of contractionary monetary policy. On the other hand, neo-classical economists divide the total change in money supply into anticipated change and unanticipated change. They argue that in a rational expectation setting only the unanticipated change in money supply can bring about short-run changes in real variables, e.g., output, employment, terms of trade, etc. Moreover, anticipated and unanticipated changes in money supply can influence the domestic price level and nominal exchange rate in the short run as well as in the long run. The monetary authorities can manipulate aggregate demand by suitable combinations of monetary, fiscal and trade policies, and thus contain inflation and reduce the depreciation of the local currency. It is therefore important to know the extent to which monetary and

trade policies can affect the domestic price level, nominal exchange rate and terms of trade of cocoa.

For the present study, we decided to ignore the economic growth aspect because no quarterly data are available for output. Moreover, the fluctuations in domestic price level, exchange rates, terms of trade and money supply are more frequent than the fluctuations in output. However, the inclusion of terms of trade in the model enables us to capture the resource allocation effects on the production of non-tradeables and tradeables. Successful liberalization of trade leads to an expansion of exports and a contraction of activity in import-competing industries, as well as an overall transfer of resources from sectors producing non-tradeables toward those producing tradeables, hence improving the balance of trade and thereby increasing foreign exchange reserves (Agenor and Montiel, 1996). Ngugi and Kabubo (1998) have used openness (exports plus imports) as a proxy for output in their model. The inclusion of terms of trade will capture the supply side that is missing because of the non-availability of quarterly data on output.

Objectives of the study

The study has three objectives: to identify the determinants of domestic price level, nominal exchange rate and terms of trade of cocoa; to identify the determinants of instruments of monetary policy; and to examine the future effects of unanticipated monetary shocks and terms of trade shocks on the domestic price level, nominal exchange rate and terms of trade of cocoa.

Justification for the study

There is a need to identify the determinants of domestic price level, nominal exchange rate and terms of trade of cocoa so that the authorities know on which variables to concentrate. The price equation provides empirical evidence on the degree of inflation inertia, the speed of adjustment of the market for non-tradeables, the exact nature and timing of the "pass-through" effect of the nominal exchange rate to the domestic price level, and the trade-off between the domestic price level and the terms of trade of cocoa. In addition, it also provides impact assessment estimates of domestic credit, foreign exchange reserves and bank rate on the domestic price level.

While there is no controversy about the impact of exchange rate depreciation on the prices of non-tradeables (Bird, 1983), the magnitude of this impact is always an empirical question (Cooper, 1971; Krugman and Taylor, 1978; Krueger, 1978; Osagie, 1985). The degree to which exchange rate depreciation causes an increase in the prices of non-tradeables in developing countries will depend on the degree to which domestic production processes depend on imported products. The nominal exchange rate equation provides empirical evidence on the exchange rate inertia, the speed of adjustment of the foreign exchange market, the exact nature and timing of the pass-through effect of the domestic price level to the nominal exchange rate, and the trade-off between the nominal exchange

rate and the real terms of trade of cocoa. In addition, it also provides impact assessment estimates of these three instruments of monetary policy on the nominal exchange rate. The real terms of trade equation provides empirical evidence on terms of trade inertia and indicates whether the instruments of monetary policy, domestic price level and nominal exchange rate lead to the increased use of oligopoly power in influencing the terms of trade of cocoa.

Identifying the determinants of bank rate, domestic credit and foreign exchange reserves also helps authorities know where to concentrate their efforts. The bank rate equation provides empirical evidence on the degree of interest rate inertia, the speed of adjustment of the interest market, and the trade-offs among the three instruments of monetary policy. In addition, it allows impact assessment estimates of domestic price level, nominal exchange rate and terms of trade of cocoa on the bank rate. From the domestic credit equation, we gain empirical evidence on the domestic credit inertia, the speed of adjustment of the domestic credit market and the extent of reserve flow sterilization, as well as impact assessment estimates of the domestic price level, nominal exchange rate and terms of trade of cocoa on the domestic credit. The foreign exchange reserves equation provides empirical evidence on foreign exchange reserves inertia, the speed of adjustment for the foreign exchange reserves and the trade-off among the three instruments of monetary policy. It also provides impact assessment estimates of domestic price level, nominal exchange rate and terms of trade of cocoa on the foreign exchange reserves.

It is important to know whether the domestic price level, nominal exchange rate, and terms of trade of cocoa can be stabilized in the future. The effect of unanticipated monetary and terms of trade shocks on the stability of domestic price level, nominal exchange rate and terms of trade of cocoa (deviation of the short-run equilibrium values from the long-run equilibrium values) can be ascertained from the impulse response functions. If the response is such that the short-run values converge to the long-run values, then it can be deduced that stability can be achieved in the future.

Organization of the report

The report contains ten sections, including this introduction. Section 2 briefly reviews Ghana's exchange rate management policy, while monetary policy is discussed in Section 3. The literature review in Section 4 provides an analytical background for the specification of our model and the theoretical framework for the use of VEC and VAR models is discussed in Section 5. The estimation procedure and data requirements are discussed in Section 6, the empirical findings in Section 7, the forecast error variance decomposition in Section 8 and the impulse response functions in Section 9. The last section presents conclusions and policy implications.

2. Ghana's exchange rate management

As shown in Table 1, Ghana's exchange rate management has undergone a number of regime changes. Initially, with the launch of the economic reform programme, a series of large devaluations of the cedi were implemented between 1983 and 1986. In April 1983, the government adopted many realistic exchange rate policy measures by devaluing the cedi in stages, from C2.75 to the US$1.00 to C90.00 per $1.00 by the third quarter of 1986. Under the new foreign exchange policy, a scheme of bonuses on exchange receipts and surcharges on exchange payments was introduced. Moreover, a multiple exchange rate system of two official rates of C23.38/$1.00 and C30.00/$1.00 were applied to specified receipts and payments. This transitory scheme continued until 10 October 1983 when exchange rates were unified at C30.00 to $1.00. After this a real exchange rate rule, in the framework of purchasing power parity (PPP), was adopted. This rule required a quarterly adjustment of the exchange rates in accordance with relative inflation rates of Ghana and its major trading partners for the period 1983–1984. The quarterly adjustment mechanism was replaced in December 1984 by more periodic exchange rate devaluation because the real exchange rate was still considered over-valued. The last discrete exchange rate adjustment before the establishment of an auction system brought the exchange rate to C90.00 per $1.00 by the end of September 1986.

In order to accelerate the adjustment of the exchange rate and attain the objective of trade liberalization the auction market was introduced on 16 September 1986. Now the forces of demand and supply were partially determining the cedi/dollar exchange rate. The new regime established a dual-window exchange rate system. Moreover, the surrender of exchange earnings to the Bank of Ghana was effected at two different rates. The window 1 exchange rate was fixed at C90.00 per $1.00, while the window 2 exchange rate was determined by demand and supply in the weekly auction system conducted by the Bank of Ghana. Transactions such as debt service payments on official debt contracted before 1 January 1986, imports of crude oil, processed petroleum products, essential inputs and drugs were conducted through window 1. Earnings from exports of cocoa and residual oil products were to be surrendered at the window 1 exchange rate. All other transactions, about 66% of external payments and receipts, were conducted through window 2. The two windows, which coexisted from September 1986, were unified on 19 February 1987. Under the dual-retail auction system, the first auction was based on the marginal pricing mechanism and all the successful bidders were supposed to pay the marginal price. But as from the second auction the Dutch auction system was resorted to and under this system the successful bidders were supposed to pay the bid price.

Table 1: Regime shifts in Ghana's foreign exchange market.

Episode	Date	Exchange rate regime
1	1983:2–1986:3	Multiple exchange rate system
2	1986:4–1987:2	Dual retail auction system
3	1987:3–1988:1	Dutch auction system
4	1988:2–1989:4	Foreign exchange bureaus
5	1990:1–1992:1	Wholesale and inter-bank auction system
6	1992:2–	Inter-bank market

Source: Dordunoo (1994).

In order to absorb the parallel market into the legal foreign exchange market, foreign exchange bureaus were allowed to operate as from 1 February 1988, with the first bureau de change becoming operative on 8 April 1988. By the end of June 1988 about 119 bureaus had come into full operation and by early 1990 over 180 were fully licensed. The foreign exchange bureaus were owned and operated by separate entities: by any individual, group of individuals, bank or institution. With the establishment of the bureaus, the foreign exchange market was characterized by the coexistence of two spot foreign exchange markets, where spot rates were quoted. The auction and the bureau markets were effectively segmented between 8 April 1988 and 29 December 1989. The bureaus were not allowed to bid for foreign exchange in the weekly retail auction.

The continued existence of the premium in the parallel market led to the introduction of the wholesale auction system, which replaced the retail system with effect from 23 March 1990 and featured the operation of a composite exchange rate system—an inter-bank system and a wholesale system. Under the wholesale auction system, the authorized dealer banks and the eligible forex bureaus were allowed to purchase foreign exchange from the Bank of Ghana for sale to their end-user customers and to meet their own foreign exchange needs. Moreover, the authorized dealers were allowed to determine freely the structure of their own bids at the wholesale auction. They could now sell the foreign exchange obtained in the auction to their customers plus a margin that is determined by each authorized dealer. The wholesale auction was based on the Dutch auction system.

Under the inter-bank market, authorized dealers were allowed to trade in foreign exchange among themselves or with their end-user customers. The main provisions of this system were: the foreign exchange traded in the inter-bank auction should not be subject to surrender requirements; the Bank of Ghana may also participate as a buyer or seller in the inter-bank market; authorized dealer banks' working balances should not exceed a given maximum and balances in excess of that after 14 days may be kept with the Bank of Ghana; banks are to provide weekly reports on their gross holding showing the bank's own balances and total balances in customers' accounts.

In order to increase the supply of foreign exchange to the inter-bank market the surrender requirements remained almost the same as under the retail auction and the wholesale auction systems. However, in the new system all proceeds from exports of non-traditional products must be lodged in a commercial bank in Ghana upon receipt. Other export earnings, apart from electricity earnings, are to be surrendered to the Bank

of Ghana. On the demand side, the remaining restrictions on payment for current international transactions involving invisible payments were lifted. This was a step forward towards full liberalization of the exchange system and the cedi was made fully convertible on current account.

The wholesale auction system was abolished in April 1992 and since then, the management of the exchange rate takes place directly in the inter-bank market. Both the commercial banks and forex bureaus operate in a competitive environment. Thus, it is clear from Table 1, and the discussion above, that the Bank of Ghana has been following a managed float exchange rate policy since 1986. The Bank of Ghana's intervention in the foreign exchange market is solely at its discretion and is only to smooth wide fluctuations in the foreign exchange market. One of the objectives of this policy has been to reduce the gap between the official rate and the parallel rate. Since major foreign exchange transactions take place at the inter-bank level, the official exchange rate is first determined by the demand and supply conditions. Later on, the forex bureaus add a premium to this official exchange rate and cater for the needs of travellers and traders who trade with the neighbouring countries.

3. Monetary policy

The major instruments of monetary policy in Ghana have been open market operations, cash and liquidity ratios, credit ceilings, reserve requirements, and bank rate (re-discount rate). The open market operations include sale and purchase of treasury bills, treasury bonds, bearer bonds, development bonds, compensatory stocks, government stocks and revaluation stocks. From time to time these instruments have been used for restrictive and expansionary monetary policy. It is evident from Table 2 that the actual growth rates of M2 have exceeded the targeted growth rates of M2 in all the years, except 1998. This has led to excess liquidity in the system. Moreover, the growth rate of money supply (M3) has been erratic over the sample period of the study. The Bank of Ghana seems to have followed a restrictive monetary policy in 1984, 1987, 1988, 1992 and 1998. The growth in money supply can be traced to the rapid growth in net domestic and foreign assets. The growth rate of domestic credit has also fluctuated over the period. The highest growth rate of domestic credit was recorded in 1991, which ultimately led to the highest growth rate of money supply. The main sources for the growth of domestic credit have been credit to the government sector (which takes care of the fiscal effect), credit to the private sector and credit for cocoa financing. The growth rate of foreign exchange reserves has also been very erratic over the same period.

The bank rate rose continuously from 1983 to 1990 and stood at 33% in 1990. It seems that the Bank of Ghana used the bank rate as an active instrument of monetary policy so as to reduce the excess liquidity until 1990, but was not successful in its efforts. The bank rate was reduced to 20% in 1991, which ultimately led to the highest growth rate of money supply. From 1991 to 1997, the bank rate was again raised so as to reduce excess liquidity but this policy did not bear any fruit. The bank rate stood at 45% from 1995 to 1997, but was reduced to 37% in 1998. The Bank of Ghana's position on the relatively high re-discount rate was that it was intended to send a signal to government about the need to discourage excessive reliance on the banking system to finance the budget. The irony of the high bank rate, however, is that while the recourse to the central bank for financing the budget has come down, the policy has not deterred government from borrowing from the commercial bank and non-bank sectors, thereby raising questions about the efficacy of the policy of maintaining a high bank rate. Essentially, the credibility of the mopping up exercises in order to remove excess liquidity, using the available tools of open market operations, bank rate and reserve requirements, remains questionable in the light of a structural defect in the fiscal sector.

The domestic rate of inflation also behaved erratically over the period. The Bank of Ghana appears to have adopted a combination of both policies, setting the bank rate and

monetary growth target in line with the stability objective. It seems that the Bank of Ghana has been using these instruments ineffectively to reduce excess liquidity and control domestic inflation in the economy.

The income velocity has remained relatively very high. The lowest income velocity was recorded as 3.63 in 1987 and the highest was 7.99 in 1990. Although the income velocity has been changing as a result of the financial sector reforms over the period, one way to take this into account is to use excess domestic credit (as shown in Edwards, 1994) or excess money supply (as shown in Elbadawi, 1994) in the model formulation and estimation. However, since we do not have quarterly data on output for the sample period, we cannot use these measures. It should be kept in mind that we might get overestimates for the regression coefficients of domestic credit.

Table 2: Targeted growth rate of M2 (m_{2T}), actual growth rate of M2 (m_{2A}), inflation (D lp), Bank rate (br), income velocity (v), and growth rates of M3 (m_3), domestic credit (D lcr), and foreign exchange reserves (D lfr).

Year	μ_{2T}	μ_{2A}	Δ lp	br	v	m_3	Δ lcr	Δ lfr
1983	-	-	-	14.5	5.7	-	-	-
1984	14.6	39.6	40.16	18.0	5.5	15.74	50.24	111.43
1985	12.2	62.4	10.38	18.5	4.4	44.66	59.71	52.43
1986	18.0	53.9	24.56	20.5	4.3	41.49	53.09	11.18
1987	17.7	49.6	39.81	23.5	3.6	18.22	72.38	-64.93
1988	17.0	50.6	31.35	26.0	5.4	-42.4	9 - 4.78	23.32
1989	22.9	26.9	25.23	26.0	5.8	42.65	24.25	43.61
1990	17.5	18.0	37.24	33.0	8.0	65.52	4.60	-32.45
1991	15.1	19.9	18.06	20.0	5.6	264.65	81.08	150.79
1992	9.6	52.9	10.02	30.0	4.5	15.78	44.72	-45.76
1993	8.2	27.4	24.95	35.0	3.9	68.29	52.39	32.13
1994	5.0	46.2	24.87	35.0	4.1	45.40	19.25	43.86
1995	14.0	37.4	59.46	45.0	4.0	75.46	52.85	20.72
1996	5.0	34.2	46.56	45.0	4.9	37.48	13.82	19.76
1997	25.0	42.0	27.88	45.0	5.0	48.51	34.72	-32.01
1998	18.0	17.6	15.00	37.0	6.0	15.69	4.91	-24.92

Sources: *International Financial Statistics*, *Quarterly Economic Bulletin of Ghana*, Ghana Commercial Bank.

4. Literature review

The inter-relationships among the price level, nominal exchange rate and money supply can be explained either through the current account monetary (CAM) and the capital account monetary (KAM) models, on the one hand, or through the portfolio balance (PB) model, on the other hand. In the same vein, we can explain the inter-relationships among the price level, nominal exchange rate, money supply and output through the rational expectations augmented Mundell–Fleming model (REMF) (Mundell, 1963; Fleming, 1962). Similarly, we can explain the inter-relationship among the price level, real exchange rate, money supply and output by introducing tradeables and non-tradeables, and rational expectations into the monetary models, which we label as rational expectations cum non-tradeables augmented monetary (RECNM) models.

The CAM model, which incorporates money as the only asset in its analysis, while adopting the assumptions of PPP and the conventional demand for money, argues that in a flexible exchange rate regime domestic inflation is determined by the domestic money supply and the exchange rate by the domestic relative to the "foreign" rate of monetary expansion. The empirical studies by Fry (1976), Bilson (1978), Messe and Rogoff (1983), Sebastian (1983), Woo (1985), and Oloyede (1997), to mention a few, have shown that the CAM model can be used to explain the stylized facts of the behaviour of the inflation rate and the nominal exchange rate in many small open economies. For example, countries with relatively high rates of monetary growth are expected to have high rates of inflation and depreciating exchange rates.

The KAM model emphasizes that capital account transactions, potential and actual, are more important than current account flows in determining movements in exchange rates particularly in the short run. The KAM model assumes perfect substitutability of domestic and foreign bonds, perfect capital mobility, uncovered-interest parity condition, and rational expectations about the exchange rate. In these models, the capital account and the money market "clear" in all periods, but the goods market, where prices are sticky, does not. Dornbusch (1976) originally developed the KAM model; it was modified and empirically tested by Frankel (1979, 1984), Driskill (1981), Haache and Townsend (1981), and Demery (1984). In the Dornbusch model, the domestic price level and the nominal exchange rate are jointly determined and in the short run, the nominal exchange rate can "overshoot" its long-run equilibrium value as a result of disequilibrium in the goods or labour markets.[1] The dynamic versions of these monetary models have been empirically tested by Killick and Mwega (1989), Mwega (1990), Dornbusch et al. (1990), Cannetti and Greene (1991), Kamas (1995), and Barungi (1997).

The PB model is an inherently dynamic model of exchange rate adjustment that includes in its terms of reference asset markets, the current account, the price level and the rate of asset accumulation. The PB model gives an alternative derivation of the exchange rate overshooting that does not rely solely on price level stickiness as in the Dornbusch model. An increase in the growth rate of the money supply leads to depreciation of the local currency that overshoots its long-run value and at the same time a gradual increase in the rate of inflation and a decrease in the interest rate. The development and empirical tests of this model can be found in Artus (1976), Branson and Monoyios (1977), Branson and Buiter (1979), Dooly and Isard (1983), Backus (1984), Boughton (1984), Frankel (1984), Isard (1987), and Towe (1989).

The REMF model for a floating exchange rate system uses aggregate demand, Lucas aggregate supply (Hall and Taylor, 1991) real exchange rate function, and the definition of real exchange rate. In this model, the product, money, foreign exchange and labour markets clear in all periods. In such a model, any unanticipated increase in the money supply will not only increase the price level and output in the short run but also cause an overshooting of the nominal exchange rate. Moreover, any unanticipated increase in the nominal exchange rate will raise the domestic price level and output in the short run. The development and empirical tests for the dynamic version of REMF model can be found in Khan (1989), Montiel (1989), Ndung'u (1993), Rodriguez and Diaz (1995), Rogers and Wang (1995), Copelman and Weriner (1996), Hoffmaister and Vegh (1996), Kamin and Rogers (1997), and Akinlo and Odusola (1999).

The RECNM model uses uncovered-interest parity conditions, Fisher's real interest rate condition (Dornbush and Fischer, 1990), real exchange rate augmented Lucas aggregate supply, definition of the real exchange rate, and the product and money market equilibrium conditions. In this model, any unanticipated shock in a floating exchange rate system can cause short-run fluctuations in the real exchange rate, output and price level depending on what happens to the current account balance. For example, a fiscal shock can raise the real exchange rate and output but reduce the domestic price level whenever deficit appears on the current account; the same shock can reduce the real exchange rate and output but raise the domestic price level whenever a surplus appears on the current account. The development and empirical tests for the RECNM model can be found in Elbadawi (1992, 1994, 1997), Edwards (1994), Silumbu (1995) and Kidane (1997).

Studies for sub-Saharan Africa that examine the dynamic inter-links among the prices of non-tradeables and tradeables, exchange rate, interest rate, real output, and monetary aggregates using the VEC and/or VAR methodology are limited in number. The most recent studies that can be referred for our purpose are Killick and Mwega (1989), Mwega (1990), Cannetti and Greene (1991), Ndung'u (1993, 1994, 1997, 1998, 1999), Ryan and Milne (1994), Silumbu (1995), Adam et al. (1996), Kalulumia and Yourougou (1996), Barungi (1997), Kidane (1997), Ogun (1998), Ngugi and Kabubo (1998), Durevall and Ndung'u (1999), Atta et al. (1999), Akinlo and Odusola (1999), and Atingi-Ego et al. (2000).

Killick and Mwega (1989) and Mwega (1990) used M1, M2 and M3 as monetary aggregates and showed that inflation in Kenya is driven by money supply with no reverse

effects. They did not find any evidence of inflation inertia. Cannetti and Greene (1991) observed for Kenya that there is no long-run effect of money supply and exchange rate on the domestic price level. This was also supported by variance decomposition analysis indicating that neither monetary expansion nor the exchange rate devaluation had a dominant role in accounting for the innovations of the domestic rate of inflation. Contrary to this, Ndung'u's (1993) results for Kenya indicate that monetary base growth and the rate of inflation drive each other, the rate of inflation and exchange rate changes drive each other, and interest rate changes and the rate of inflation drive each other.[2] The exchange rate accounted for over half of the innovations in the domestic price level. Ndung'u (1994) found for Kenya that money supply affects the domestic price level only in the short run, with a degree of inflation inertia amounting to 0.30.

Also for Kenya, Ryan and Milne (1994) showed that exchange rate movements and changes in oil prices are the most important factors that determine inflation, while the contribution from monetary variables is relatively small. Adam et al. (1996) have shown for Kenya that money supply affects the domestic price level both in the short run as well as in the long run. In another paper, Ndung'u (1997) has shown for Kenya that the nominal exchange rate affects the domestic price level in a positive manner both in the short run and long run. The speed of adjustment of the foreign exchange market was shown to be 11.7% and the speed of adjustment of the product market was shown to be 9.1% in Kenya. In addition, domestic credit was found to have a positive effect on the nominal exchange rate and foreign exchange reserves were shown to have a negative effect on the nominal exchange rate in the long run.

Kalulumia and Yourougou (1996) have shown that feedback effects exist between money supply growth and real output growth for Côte d'Ivoire and Senegal; the real exchange rate does not adjust to short-run money market disequilibrium for all the countries; the rate of inflation adjusts to short-run money market disequilibrium for all the countries; and monetary aggregate M2 is more appropriate for Côte d'Ivoire and Niger and M1 is more appropriate for Senegal.

Cannetti and Greene (1991) found for Uganda that monetary growth and exchange rate depreciation are the major determinants of inflation. In another study of Uganda, Barungi (1997) used M2 as monetary aggregate and identified monetary expansion as the main source of variations in prices in the short run as well as long run, with the degree of inflation inertia at 30.8%, and a very high (1.0) speed of adjustment of the product market. Silumbu's (1995) results for Malawi were that the short-run effects of the prices of non-tradeables on the foreign exchange reserves are ambiguous. The prices of tradeables affect the foreign exchange reserves in a positive manner. Sterilization of foreign exchange reserves in Malawi was shown to lie between 30% and 35%.

Kidane (1997) showed for Ethiopia that the nominal exchange rate affects the prices of non-tradeables and tradeables in a positive manner in the long run. For Nigeria, Ogun (1998) found that the terms of trade have a negative short-run impact on the real exchange rate; i.e., an improvement in the terms of trade causes the real exchange rate to appreciate. The income effect associated with a change in terms of trade appears to dominate the substitution effect.

Back in Kenya, Ndung'u (1998) found that the domestic price level and the interest differential have negative impacts on the nominal exchange rate both in the short run and the long run. The speed of adjustment of the exchange rate market was found to be 18.4%. In a subsequent study, Ndung'u (1999) showed that Kenya's domestic price level and nominal exchange rate affect the money supply in a positive manner in the long run, while money supply and domestic price level affect the nominal exchange rate in a positive manner in the short run. The speeds of adjustment of the foreign exchange market when the money market and its own market disturb the equilibrium were found to be 30.44% and 1.5%, respectively. There exists a trade-off between the nominal exchange rate and the cyclical component of real exchange rate that also measures the international competitiveness of exports.

Ngugi and Kabubo (1998) showed for Kenya that the nominal exchange rate and domestic price level have positive effects on nominal interest rate, while income (proxied by openness) and money supply have negative effects on the nominal interest rate in the long run. The short-run effect of nominal exchange rate on the interest rate was found to be positive, while that of money supply and domestic price level was found to be negative. The speed adjustment for the interest rate (treasury bills) market was found to be 39.02% per month and the interest rate inertia was found to be 0.12.

Durevall and Ndung'u's (1999) study of Kenya indicated that the nominal exchange rate has a negative and terms of trade have positive long-run effects on inflation, while the money supply and interest rate have positive short-run effects on inflation. Inflation inertia was found to be as large as 0.42. The speed of adjustment of the product market in Kenya was found to be 6.0% per quarter.

Atta et al. (1999) have shown for Botswana that money supply and interest rate affect the domestic price level positively, while nominal exchange rate affects the domestic price level negatively in the short run. Inflation inertia was found to be 0.09 and the speed of adjustment of the product market was found to be 2.06% per month for Botswana. The pass-through effect of nominal exchange rate to the domestic price level (prices of non-tradeables) of Botswana is neither complete nor instantaneous, and there exists a trade-off between inflation and export competitiveness.

Akinlo and Odusola (1999) have shown for Nigeria that the impact of exchange rate depreciation on output is contractionary. Official exchange rate shocks are followed by increases in prices, money supply and parallel exchange rate. The response of lending rate to official exchange rate shock is mostly positive. Prices, parallel exchange rate and real income are important sources of change in the official exchange rate. Output and money supply are major determinants of inflation dynamics. Using variance decomposition, they have identified for Nigeria the most important instrument for each of the targeted endogenous variable: for official nominal exchange rate, interest rate, domestic price level and money supply, the most appropriate instruments were found to be domestic price level, money supply, parallel exchange rate and interest rate, respectively.

Atingi-Ego et al. (2000) have shown for Uganda that the terms of trade negatively affect the equilibrium real exchange rate, in both the short and the long run. The money supply positively affects the equilibrium real exchange rate in the short run. The speed

of adjustment of the exchange rate market was found to be 43.86% per annum and the exchange rate inertia was found to be 0.36.

In most of the studies mentioned above, the role of trade policy has been completely ignored. If the country under consideration has monopoly/oligopoly power in the market for its exportables then the major producers of exportables can collude and decide to reduce the production of their exportables in order to influence the international prices. The effect of this collusive power can be captured by changes in the terms of trade.

In the case of Ghana, there seems to be no literature that uses the VEC or VAR approach to study the dynamic inter-links among the domestic price level, the nominal exchange rate, the bank rate, the terms of trade and the monetary aggregates in a managed float exchange rate system. However, there is one study by Sackey (1998) that looked at the determinants of the equilibrium real exchange rate in Ghana by using the cointegration and VEC approach. In addition, there are studies by Chhibber and Shafik (1990), Kapur et al. (1991), Younger (1992a/b), and Sowa and Kwakye (1993) that examine the inter-links among the rate of inflation, monetary aggregates, exchange rate and terms of trade by using standard regression techniques, as well as research by Dordunoo and Donkor (1998) that examines the monetary programming. Sackey (1998) showed that the terms of trade have a negative impact on the real exchange rate both in the short run as well as long run, i.e., an improvement in the terms of trade causes the real exchange rate to appreciate. This may be because the income effect associated with such improvements dominates the substitution effect. Moreover, increased trade liberalization (which permits more competition on non-tradeables relative to tradeables) has a tendency to depreciate the real exchange rate in the short and long run.

Chhibber and Shafik (1990) found that monetary growth was instrumental in determining the pace of inflation, that parallel exchange rate induced inflation was significant, and that fiscal policy had a limited role in the current inflationary spiral. Kapur et al. (1991), analysing exchange rate policy and reforms in Ghana, concluded that the pursuit of flexible exchange rate policy by the Ghanaian government has helped cushion the impact on the economy of the sharp deterioration in the terms of trade experienced since 1986. Younger (1992a) showed that devaluation in Ghana has had a small but significant impact on the domestic consumer price index. In another paper, Younger (1992b) observed that the Government of Ghana prevented the real exchange rate from appreciating by continually depreciating the nominal exchange rate in tandem with the rate of inflation.

According to Sowa and Kwakye (1993), inflation in Ghana from 1960 to 1989 was the result of both real and monetary shocks, with the supply factors being more instrumental in the post Economic Recovery Programme period, followed by the monetary factors. Dordunoo and Donkor (1998) advocated for monetary programming to be used for the management of money supply in Ghana. The present study updates the existing studies by considering recent data for Ghana and by using the VEC and VAR approaches in order to explore the dynamic inter-links among six variables: the domestic price level, the nominal exchange rate, the terms of trade of cocoa, the domestic credit, the bank rate and the foreign exchange reserves.

5. Theoretical framework

In order to study the inter-relationship among the domestic price level, nominal exchange rate, terms of trade, interest rate and monetary aggregates, three approaches are generally used: single equation regression, simultaneous equations regressions, and vector error correction (VEC) and vector auto regressions (VAR). If there exists bi-directional causality among these variables and we decide to use the single equation regression approach then we will most likely get biased estimates for the parameters. On the other hand, if we decide to use the simultaneous equation regression approach then although the estimates for the parameters will be unbiased, we cannot study the impact of unanticipated shocks (individual and system) on the endogenous variables (there are no impulse response functions). Moreover, we cannot identify the relative importance of each variable in explaining the variations of endogenous variables (there is no variance decomposition analysis). Thus if we want to know the impact of unanticipated monetary and terms of trade shocks on the domestic price level, nominal exchange rate and terms of trade, and at the same time want to identify the most effective instrument for each targeted variable, then the most appropriate option is to use the VAR approach. In addition, if the relevant variables are non-stationary and cointegrated then we must also use the VEC specification. Moreover, it has been shown in the literature that the VEC model encompasses all other models.

VEC and VAR models

Two approaches are generally used in VAR studies. The first approach, known as the structural VAR approach, allows us to specify and estimate a structural economic model. The problem of identification arises, however, and generally the system is not identified. Therefore, some identifying assumptions or restrictions must be used to get the identification. If we do not have a priori knowledge about these restrictions then it is advisable to start with a more general model that does not require a priori restrictions. That is what we do in the unrestricted reduced form VAR approach. In this approach, we represent the system by reduced form equations, estimate the parameters and draw structural inferences from the reduced form equations. The structural VAR model can be specified as:

$$B(L)X_t = U_t, \qquad t = 1, 2, ..., n \tag{1}$$

where X_t is a mx1 vector of jointly determined variables. The term L is a lag operator. The order of $B(L)$ is mxm and U's are the innovations for X, which are normally distributed with mean zero and covariance matrix $E(U_t U_t') = S$ and $E(U_t U_{t-i}') = 0$ for $i \neq 0$. After inverting the B matrix, each endogenous variable can be expressed as a linear combination of its own innovations and the lagged innovations of all the other variables:

$$X_t = [B(L)]^{-1} U_t. \tag{2}$$

In order to analyse the dynamics of the model, the contemporaneous covariance matrix, Σ needs to be decomposed into variable specific shocks, that is, it must be orthogonalized. This is achieved by expressing the contemporaneous model as:

$$\varepsilon_t = AU_t \tag{3}$$

such that $A \Sigma A' = I$, where I is an identity matrix and ε_t are the innovations of the reduced form VAR model. In such a case, the innovations U_t will be mutually orthogonal. However, there is no unique way of orthogonalizing Σ or of choosing Bernanke's structural orderings of innovations or Choleski's orderings could be used to obtain the reduced form innovations. In the present study, we will use Sim's recursive Choleski decomposition of Σ, where the matrix A is taken to be triangular with positive elements on the diagonal. Thus, we can write

$$X_t = C(L)\varepsilon_t, \tag{4}$$

where $C(L) = [\, B(L) \,]^{-1} [\, A \,]^{-1}$. The order of $C(L)$ will be 6x6. If we can write the $C(L)$ matrix as

$$C(L) = \begin{matrix} C_{11}(L) & C_{12}(L) & C_{13}(L) & C_{14}(L) & C_{15}(L) & C_{16}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) & C_{24}(L) & C_{25}(L) & C_{26}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) & C_{34}(L) & C_{35}(L) & C_{36}(L) \\ C_{41}(L) & C_{42}(L) & C_{43}(L) & C_{44}(L) & C_{45}(L) & C_{46}(L) \\ C_{51}(L) & C_{52}(L) & C_{53}(L) & C_{54}(L) & C_{55}(L) & C_{56}(L) \\ C_{61}(L) & C_{62}(L) & C_{63}(L) & C_{64}(L) & C_{65}(L) & C_{66}(L) \end{matrix}$$

then the impulse response of the endogenous variables to a unit shock in its innovations are indicated by the coefficients appearing in different columns of matrix $C(L)$. Let the X_t be represented by a vector in which variables appear in the order (*ls, lp, lcr, br, ltc, lfr*) where *ls* is the logarithm of nominal exchange rate, l*p* is the logarithm of domestic price level, *lcr* is the logarithm of domestic credit, *br* is the bank rate, *ltc* is the logarithm of real terms of trade based on the international price of cocoa, and *lfr* is the logarithm of foreign exchange reserves.[3] The changes in *ls, lp, lcr, br, ltc,* and *lfr* to a unit shock in the innovations of foreign exchange reserves are given by $C_{16}(L)$, $C_{26}(L)$, $C_{36}(L)$, $C_{46}(L)$ and

$C_{56}(L)$. Similarly, the other impulse response functions can be used to trace out the dynamic effects on endogenous variables due to the shocks in the other innovations.

In order to see the relationship between the VAR model and the VEC model we re-specify Equation 1 in its reduced form as:

$$X_t = a + \theta_1 X_{t-1} + ... + \theta_k X_{t-k} + \in_t, \quad t = 1, 2, ..., n, \tag{5}$$

where X_t contains integrated series of order one *I(1)* and *k* represents the lag length of the series. Let Δ represent the first differences. Following Johansen (1991), Equation 5 can be rewritten in error correction form as:

$$\Delta X_t = a + \Pi X_t + \Gamma_1 \Delta X_{t-1} + ... \ \Gamma_{k-1} \Delta X_{t-k+1} + \in_t \quad t = 1, 2, ..., n, \tag{6}$$

where $\Gamma_i = -(\theta_{i+1} + ... + \theta_k), \ i = 1, ..., k-1,$ and $\Pi = -(I - \theta_1 - ..... - \theta_k)$. The Γs represent the matrixes of coefficients of the first difference variables that capture the short-run dynamics. The coefficients of the lagged dependent variable indicate inertia as well as the formation of expectations. The coefficients of the other lagged endogenous variables provide estimates for pass-through effect or impact assessment. The coefficient matrix Π contains information about the long-run relationships among the variables involved in the model. Since $\in_t$ is stationary, the rank of matrix Π, denoted by *r*, determines how many linear combinations of *Xt* are stationary, i.e., the number of cointegrating vectors. The null hypothesis that there are at most r ($0 < r < m$) cointegrating vectors in the system is defined as a reduced rank condition:

$$H_0(r): \Pi = \alpha\beta' \tag{7}$$

where α and β are mxr matrixes. The r columns of β are the cointegrating vectors providing the r long-run relationships ($\beta' X_t$) among the series. These cointegrating relations are such that $\beta' X_t$ is stationary, although X_t is not. The loading matrix α contains the adjustment parameters. These adjustment parameters indicate the speeds of adjustment of various markets. The null hypothesis is tested against the alternative hypothesis H_1 (m) specifying that Π is of full rank, that is rank of $\Pi = r = m$. If the alternative hypothesis is accepted, this means that X_t is stationary and hence the VAR model in levels (Equation 5) is to be used. If, however, the rank of $\Pi = r = 0$, i.e., $\Pi = 0$, then no stationary long-run relationship exists among the variables and hence the VAR model in first differences is to be used. It is only when the null hypothesis is accepted that the error correction model is to be used, which is expressed under the null hypothesis as:

$$\Delta X_t = a + \alpha\beta' X_{t-1} + \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \in_t \ t = 1, 2, ..., n, \tag{8}$$

where ΔX_t is assumed to be I(0).

It should be noted that exogenous variables do not appear in equations (1), (5) and (8). In order to see the influence of exogenous variables on the endogenous variables, these variables must be added to these equations. The exogenous variables that seem to be relevant for the present study are: the logarithm of the real terms of trade based on the international price of gold (*ltg*), the logarithm of the index of international price of petrol (lpet), the logarithm of government expenditure (*lg*), and the logarithm of the ratio of repayment of principal and interest on the outstanding international debt to foreign exchange reserves (*li*).

In six-variable VEC and VAR models, tests for cointegration suggest that long-run equilibrium exists in five markets. In our model these markets are those for non-tradeables, cocoa, exchange rate, interest rate and money. The domestic price level, terms of trade of cocoa, nominal exchange rate, bank rate, and domestic credit and foreign exchange reserves are being determined simultaneously. The cointegrating vectors indicate the long-run relationship among these variables. A priori expectations about the past effects of independent (endogenous) variables on the dependent variables (normalized variables) can be specified only in the long run. Any idea about the past effects of lagged endogenous variables on the dependent variables cannot be ascertained a priori in the short run because the nature of these effects depends on the position of the short-run equilibrium in relation to the long-run equilibrium. In a dynamic model, the short-run equilibrium or disequilibrium is always adjusting towards the long-run equilibrium and this adjustment can be downward or upward. However, a priori expectations about the short-run effects of exogenous variables on the dependent variables can be specified.

It is generally believed that unanticipated monetary and terms of trade shocks can lead to disturbances in the prices of non-tradeables and tradeables, and the nominal exchange rate (Montiel and Ostry, 1991; Elbadawi, 1994; De Grauwe, 1994; Calvo, Reinhart and Vegh, 1995; Hausman and Gavin, 1995; Ndung'u, 1997, 1999). The effect of these unanticipated shocks on the stability of domestic price level, nominal exchange rate and terms of trade of cocoa (deviation of the short-run equilibrium values from the long-run equilibrium values) can be ascertained from the impulse response functions. If the response is such that the short-run values converge to the long-run values, then it can be deduced that stability can be achieved in the future. In such a case, the next question is, which instrument should be used to achieve stability in the future. The most effective instrument for each targeted variable can be identified through the variance decomposition.

Specification of price, exchange rate and terms of trade equations

The economy of Ghana is highly dependent on exports as well as imports. The total of exports and imports is well over 60% of GDP. The main traditional exports are cocoa, minerals (which include gold, diamond, bauxite and manganese) and timber. The main non-traditional exports are agricultural products, processed and semi-processed products, and handicrafts. The imports are mainly petroleum products, raw materials

and consumer goods. Ghana is one of the four major exporters of cocoa beans in Africa, the others being Côte d'Ivoire, Nigeria and Cameroon. The share of these four countries in the total world exports of cocoa beans is about 65%. Ghana's share in the total world exports of cocoa beans is about 19%. Thus, we can say that Ghana has some oligopoly power in the international cocoa market. Generally, policy reforms since 1983 have shifted relative prices and incentives towards the tradeable sector. Within tradeables, relative prices shifted in favour of exportables such as cocoa, timber and minerals because of the elimination of import licensing and the liberalization of export restrictions (World Bank, 1995). Lately, the prices of exportables such as cocoa and gold have been subject to a lot of fluctuation in the international market and as a result, the real terms of trade based on the prices of these two commodities have been fluctuating. In particular, a downward trend in the prices of gold and cocoa has created some problems on the trade account, which will ultimately have repercussions in the other sectors of the economy too. This has led to the diversification of its non-traditional exports. Recently Ghana joined with Côte d'Ivoire, Nigeria and Cameroon and decided to withdraw and destroy 250,000 tons of cocoa beans from the world market in order to influence the international cocoa price. This shows that oligopoly power can be used to influence the terms of trade.

Monetary issues and financial sector development continue to be problematic in economic policy development more than a decade after financial sector reforms began in Ghana. The main difficulty remains with the design and implementation of policy that will make the attainment of specific monetary targets possible. The difficulty arises out of the significant use of indirect monetary tools in an environment that is not entirely receptive to these tools without appropriate modifications. Money supply growth is usually targeted between 5 and 25% and inflation is targeted below 20%. The actual rates recorded are always well above these, however, and the reason seems to be significant instability in the system and little commitment to policy change. The relationships among money supply, general price level, terms of trade and nominal exchange rate is not easy to explain. A consequence is that the impact of monetary policy on economic outcomes is highly unpredictable, as the Bank of Ghana itself admitted when it wrote in the *Quarterly Economic Bulletin* for the second quarter of 1997 that "despite the high rates of monetary expansion and depreciation of the cedi, inflation continued on a downward trend". The impact of monetary and trade policies on the domestic price level, exchange rate and terms of trade of cocoa can be assessed from the price, exchange rate and terms of trade equations.

The VEC model is used to specify and estimate the price, exchange rate and terms of trade equations. A priori long-run relationships are used to identify the correctly specified cointegrating vectors. The following long-run relationship is expected between the domestic price level and the remaining endogenous variables:

$$\underset{\;\;+\;\;+\;\;+\;\;-\;\;+}{lp = f(ls, lcr, lfr, br, ltc)} \qquad (9)$$

We expect positive relationships between the nominal exchange rate and the domestic price level, between the domestic credit and the domestic price level, between the foreign

exchange reserves and the domestic price level, and between the terms of trade of cocoa and the domestic price level. We expect a negative relationship between the bank rate and the domestic price level.

Whenever the nominal exchange rate increases, it causes the imported inputs to be more expensive and as a result, the volume of imported inputs is reduced. This leads to a reduction in the output of non-tradeables, which causes the domestic price level to increase. An increase in the domestic credit causes the domestic component of money supply to increase, which increases the aggregate demand for non-tradeables, thereby increasing the domestic price level. An increase in the foreign exchange reserves causes the foreign component of money supply to increase, which again causes the aggregate demand for non-tradeables to increase and thereby increases the domestic price level. An increase in the bank rate discourages government's borrowing and as a result, the domestic credit is reduced, which in turn will reduce the domestic price level. An improvement in the terms of trade increases the production of tradeables and reduces the production of non-tradeables, thereby causing an increase in the domestic price level.

The following long-run relationship is expected a priori between the nominal exchange rate and the remaining endogenous variables:

$$\underset{+}{ls} = f(\underset{+}{lp}, \underset{+}{lcr}, \underset{+}{lfr}, \underset{-}{br}, \underset{-}{ltc}) \qquad (10)$$

We expect a positive relationship between the domestic price level and the nominal exchange rate. Whenever the prices of non-tradeables increase, there will be reallocation of resources in favour of non-tradeables and as a result the output of tradeables will decline, thereby generating an unfavourable current account position. This will cause the reserve inflow to reduce and thus put up an upward pressure on the nominal exchange rate, which will ultimately depreciate the local currency.

We also expect a positive relationship between the domestic credit and the nominal exchange and between the foreign exchange reserves and the nominal exchange rate. An increase in the domestic credit could be due to the financing of fiscal deficit of the government and whenever the government is likely to spend this amount on the tradeables, the demand for foreign exchange will increase, thereby causing a depreciation of the local currency. The foreign exchange reserves of the central bank can increase whenever the central bank buys foreign exchange from the foreign exchange market. This act will reduce the supply of foreign currencies, thereby causing the depreciation of the local currency.

The relationship between the bank rate and the nominal exchange rate is expected to be negative. An increase in the bank rate will increase the domestic interest rates. If the increase in domestic rates is more than the foreign interest rates then capital inflow will increase, which will increase the availability of foreign exchange, and thus ultimately leading to an appreciation of the local currency. We expect the terms of trade of cocoa and the nominal exchange rate to be inversely related to each other. Deterioration in the terms of trade is likely to lead to collusion among the major producers of tradeables, so that the production of tradeables is reduced, which will ultimately cause the local currency to depreciate.

According to Kidane (1997), the effects of terms of trade on the exchange rate are ambiguous. The following long-run relationship is expected between the terms of trade of cocoa and the remaining endogenous variables:

$$\underset{+}{ltc} = f(\underset{+}{lp}, \underset{-}{ls}, \underset{+}{lcr}, \underset{-}{lfr}, \underset{+}{br}) \qquad (11)$$

We expect that an increase in the domestic price level will increase the production of non-tradeables and reduce the production of cocoa, which may cause the price of cocoa to increase if the production of cocoa is also reduced in the colluding partner countries. We expect the nominal exchange rate and the terms of trade of cocoa to be negatively related to each other. A depreciation of the local currency will make the exportables more competitive on the international market, which can lead to an increase in the production of cocoa and this may reduce the price of cocoa if the country has some oligopoly power.

Whenever the monetary authorities decide to increase credit allocation for the government and private sectors, it may reduce the production of cocoa (less credit is allocated for cocoa), which may put an upward pressure on the prices of cocoa. Therefore, we anticipate a positive relationship between the domestic credit and the terms of trade of cocoa. However, we expect a negative relationship between the foreign exchange reserves and the terms of trade of cocoa. An increase in the foreign exchange reserves can be due to the purchase of foreign currencies by the central bank from the foreign exchange market. This intervention will cause the local currency to depreciate, which in turn can lead to a reduction in the terms of trade of cocoa. But the bank rate is expected to be positively related to the terms of trade of cocoa. A reduction in the bank rate may lead to an increase in credit allocation for cocoa financing, which is most likely to increase the production of cocoa and thus may put up a downward pressure on the price of cocoa.

In the short run, the domestic price level may depend on its lagged values, lagged values of nominal exchange rate, domestic credit, foreign exchange reserves, bank rate, real terms of trade of cocoa, and current values of the price of petrol, government expenditure and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta lp = f(\underset{\pm}{\Delta lp_{t-i}}, \underset{\pm}{\Delta ls_{t-i}}, \underset{\pm}{\Delta lcr_{t-i}}, \underset{\pm}{\Delta lfr_{t-i}}, \underset{\pm}{\Delta br_{t-i}}, \underset{\pm}{\Delta ltc_{t-i}}, \underset{+}{\Delta lpet}, \underset{+}{\Delta lg}, \underset{+}{\Delta ltg}) \qquad (12)$$

We expect a positive relationship between the price of petrol and the domestic price level. An increase in the price of petrol increases the cost of production of non-tradeables, which reduces the production of non-tradeables, thus causing an increase in the domestic price level. We expect government expenditure to be positively related to the domestic price level because an increase in government expenditure increases the demand for non-tradeables, which causes the domestic price level to increase. We expect the terms of trade of gold and the domestic price level to be positively related to each other. An improvement in the terms of trade of gold will increase the production of gold and

reduce the production of non-tradeables, which will cause the domestic price level to increase.

In the short run, the nominal exchange rate may depend on its lagged values and the lagged values of the domestic price level, domestic credit, foreign exchange reserves, bank rate, real terms of trade of cocoa, and current values of the ratio of repayment of principal and interest on the outstanding international debt to reserves, government expenditure and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta ls = f\ (\Delta lp_{t-i}^{\pm}, \Delta ls_{t-i}^{\pm}, \Delta lcr_{t-i}^{\pm}, \Delta lfr_{t-i}^{\pm}, \Delta br_{t-i}^{\pm}, \Delta ltc_{t-i}^{\pm}, \Delta lid^{+}, \Delta lg^{+}, \Delta ltg^{-}) \quad (13)$$

We expect the debt-service burden and the nominal exchange rate to be positively related to each other and that government expenditure will be positively related to the nominal exchange rate. As the amount of debt servicing increases, this reduces the availability of foreign exchange, which will cause the local currency to depreciate. An increase in government expenditure increases the demand for tradeables, which causes the demand for foreign exchange to increase and ultimately lead to a depreciation of the local currency. Terms of trade of gold and the nominal exchange rate are expected to be negatively related to each other. An improvement in the terms of trade of gold will increase the production of gold and the availability of foreign exchange, which will cause the local currency to appreciate.

In the short run, the terms of trade of cocoa may depend on its lagged values and lagged values of the domestic price level, nominal exchange rate, domestic credit, foreign exchange reserves, bank rate, and current values of the price of petrol, and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta ltc = f\ (\Delta lp_{t-i}^{\pm}, \Delta ls_{t-i}^{\pm}, \Delta lcr_{t-i}^{\pm}, \Delta lfr_{t-i}^{\pm}, \Delta br_{t-i}^{\pm}, \Delta ltc_{t-i}^{\pm}, \Delta lpet^{+}, \Delta ltg^{+}) \quad (14)$$

The price of petrol is expected to be positively related to the domestic price level, while the terms of trade of gold and the terms of trade of cocoa may be positively related to each other. An increase in the price of petrol will increase the domestic price level, which will cause the production of non-tradeables to increase and the production of cocoa to reduce, which may lead to an increase in the price of cocoa. An improvement in the terms of trade of gold will lead to increased production of gold and reduce the production of cocoa, which may put an upward pressure on the price of cocoa.

Specification of bank rate, domestic credit and foreign exchange reserves equations

Empirical studies show that central banks tend to have some advantage, though imperfect, in controlling money supply in the short run (Herring and Marson, 1977; Hausman, 1978; Obstfeld, 1980, 1982, 1983; Silumbu, 1995). Some economists have cast doubt on the plausibility and feasibility of sterilization in LDCs: implausible because the rate of domestic credit expansion in these countries is presumed to be largely determined by the fiscal deficit financing requirements (Cooper, 1971; Caves et al., 1990), and unfeasible because of scarcity of reserves (Magee, 1976). Furthermore, the "no-sterilization" assumption has been theoretically rationalized on the basis that small, dependent economies lack appropriate monetary instruments because their financial sectors are not sufficiently deepened (Caves et al., 1990).

In a managed float system, the central bank has the option to follow a sterilization cum intervention policy or an unsterilized-intervention policy (no sterilization). In the former case, the sterilization can be complete or partial. Whenever the central bank sells foreign exchange in the foreign exchange market to smoothen fluctuations in the market, the foreign exchange reserves decrease and as a result, the external component of money supply decreases. In addition, whenever the central bank raises the bank rate, the domestic component of money supply is also reduced. These two together are likely to generate contractionary effects in the economy. In order to offset such effects, the central bank (if the central bank follows counter-cyclical rule and behaves consistently) is most likely to react by increasing the domestic component of money supply by allocating more domestic credit. In such a case, the causality is from foreign exchange reserves and bank rate to domestic credit, and the central bank has used the sterilization policy through domestic credit (Raghavan and Saggar, 1989; Silumbu, 1995).

On the other hand, the causality can also be from domestic credit and bank rate to foreign exchange reserves (Kannan, 1989; Ndung'u,(1997). For example, if the central bank decides to increase domestic credit by financing the fiscal deficit of the government and at the same time reduces the bank rate, then the domestic component of money supply will increase, which is likely to generate expansionary effects in the economy. In order to offset these expansionary effects, the central bank is again most likely to react and can decrease the foreign component of money supply by selling foreign exchange in the foreign exchange market (foreign exchange reserves decrease). Here the causality is from domestic credit and bank rate to foreign exchange reserves and the central bank has used the sterilization policy through exchange rate intervention.

Moreover, whenever the central bank decides to increase credit for cocoa financing and at the same time intervenes in the exchange rate market by buying foreign exchange, this will cause both the domestic and foreign components of money supply to increase, which is likely to have expansionary effects on the economy. In order to offset these expansionary effects, the central bank is again most likely to increase the bank rate, so that the causality is from domestic credit and foreign exchange reserves to bank rate and the central bank has used the sterilization policy through the bank rate.

It is important to know from the policy perspective whether the Bank of Ghana has been following sterilized cum intervention policy or unsterilized intervention policy over the sample period of the study. Moreover, the exact nature and timing of the linkages among the instruments of monetary policy, domestic price level, nominal exchange rate and terms of trade of cocoa can only be ascertained from the bank rate, domestic credit and foreign exchange reserves equations.

The VEC model is used to specify and estimate the equations for instruments of monetary policy. A priori, long-run relationships are used to identify the correctly specified cointegrating vectors. The following long-run relationship is expected between the bank rate and the remaining endogenous variables:

$$\underset{\text{lbr}}{} = f(\underset{+}{\text{lp}}, \underset{+}{\text{ls}}, \underset{\pm}{\text{lcr}}, \underset{\pm}{\text{lfr}}, \underset{-}{\text{ltc}}) \qquad (15)$$

We expect a positive relationship between the domestic price level and the interest rate because of the Fisher's effect, (Dornbusch and Fischer, 1990). An increase in the domestic price level results in an increase in nominal value of these goods and services and a rise in demand for money, leading to an increase in the level of interest rate. Empirical studies testing the Fisher effect found its magnitude less than one, suggesting that nominal interest rates are extremely slow to adjustment to inflation, so that there is a tendency for the inflation rate to expand the gap between nominal and real interest rates. We also expect a positive relationship between the nominal exchange rate and the interest rate because an expected depreciation of the local currency leads to an increase in demand for money resulting in an increase in inflation and nominal interest rates. The domestic credit and the foreign exchange reserves can be positively or negatively related to the nominal interest rate. From the Keynesian framework, changes in monetary expansion (either through the domestic component or the foreign component of money) induce changes in the nominal rate of interest through the portfolio allocation behaviour of asset holders. The analysis concludes an inverse relationship between money and nominal interest rates. For monetarists, the impact of a change in monetary policy on nominal rates of interest is influenced by the rate at which expectations adjust to new economic policy. With expansionary monetary policy, the public expects a higher rate of inflation and the nominal rate of interest rises as lenders anticipate that demand will raise interest rates and borrowers will be willing to pay a higher rate. Angeloni and Prati (1993) have shown that interest rates are driven almost entirely by exchange factors either directly or through the liquidity effects of central bank intervention. Edwards and Khan (1985) have advocated that the terms of trade shocks can produce changes in real income and prices that will affect domestic demand for credit and thus the equilibrium rate of interest.

An inverse relationship is expected between the terms of trade of cocoa and the interest rate. Deterioration in the terms of trade is likely to lead to collusion among the major producers of tradeables, so that the production of tradeables is reduced, which will ultimately cause the local currency to depreciate. An expected depreciation of the local currency leads to an increase in demand for money resulting in an increase in inflation and nominal interest rates.

The following long-run relationship is expected a priori between the domestic credit and the remaining endogenous variables:

$$\underset{\text{lcr}}{} = \underset{+}{\text{lp}}, \underset{+}{\text{lsr}}, \underset{+}{\text{lfr}}, \underset{-}{\text{br}}, \underset{+}{\text{ltc}}) \quad (16)$$

We expect positive relationships between the domestic price level and the domestic credit, between the nominal exchange rate and domestic credit, and between the foreign exchange reserves and domestic credit. An increase in the domestic price level will increase the government expenditure on non-tradeables, which is most likely to be financed through the increase in domestic credit. A depreciation of the local currency will increase the government expenditure on tradeables, which is again most likely to be financed through the increase in domestic credit. An increase in the foreign exchange reserves may be due to the purchase of foreign currencies by the central bank from the foreign exchange market, which will cause the local currency to depreciate. This may increase the private sectors' expenditure on tradeables, which is most likely to be met by an expansion in the domestic credit for the private sector.

We expect the bank rate and the domestic credit to be inversely related to each other and the terms of trade of cocoa and the domestic credit to be positively related to each other. An increase in bank rate is likely to reduce borrowing by the government and private sector because of higher costs of borrowing. An improvement in the terms of trade of cocoa is likely to increase the production of cocoa, which may require increased allocation of credit for cocoa.

The following long-run relationship is expected between the foreign exchange reserves and the remaining endogenous variables:

$$\underset{\text{lfr}}{} = \underset{-}{\text{lp}}, \underset{+}{\text{ls}}, \underset{+}{\text{lcr}}, \underset{+}{\text{br}}, \underset{+}{\text{ltc}}) \quad (17)$$

The domestic price level is expected to be inversely related to the foreign exchange reserves. An increase in the domestic price level will reduce the production of tradeables, which will have unfavourable effects on the trade balance and thus lead to a reduction in the foreign exchange reserves.

Positive relationships are expected between the nominal exchange rate and the foreign exchange reserves, between domestic credit and the foreign exchange reserves, between the bank rate and the foreign exchange reserves, and between the terms of trade of cocoa and the foreign exchange reserves. A depreciation of the local currency will make the exportables more competitive and this may lead to a greater inflow of foreign exchange, which will increase the foreign exchange reserves. An increase in the allocation of credit for the export sector will certainly increase the production of exportables and this may lead to a greater inflow of foreign currencies, which will increase the foreign exchange reserves. An increase in the bank rate is likely to increase the domestic interest rates. This may lead to higher capital inflows if the domestic interest rate exceeds the foreign interest rates. A favourable capital account will increase the foreign exchange reserves' holdings. An improvement in the terms of trade of cocoa will have a favourable impact

on the trade balance and thus can increase the foreign exchange reserves. A rise in the relative price of tradeables means that at constant domestic expenditures, more tradeables are produced and fewer consumed, while more of the relatively cheaper non-tradeables is consumed, thereby generating a favourable current account position. Given the assumption of a relatively small open economy, with inelastic external capital account, reserve inflow will be directly associated with current account improvement (Caves et al, 1990).

In the short run, the bank rate may depend on its lagged values and lagged values of the domestic price level, exchange rate, domestic credit, foreign exchange reserves, real terms of trade of cocoa, and current values of the government expenditure and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta br = f\ (\Delta lp_{t-i}^{\pm}, \Delta ls_{t-i}^{\pm}, \Delta lcr_{t-i}^{\pm}, \Delta lfr_{t-i}^{\pm}, \Delta br_{t-i}^{\pm}, \Delta ltc_{t-i}^{-}, \Delta\ lg^{-}, \Delta\ ltg) \qquad (18)$$

We expect negative relationships between the government expenditure and the bank rate, as well as between the bank rate and the terms of trade of gold. An increase in government expenditure can be financed through the increase in domestic credit, which can be obtained if the central bank lowers the bank rate. An improvement in the terms of trade of gold will increase the production of gold and this may require expansion in the domestic credit, which can be obtained if the central bank lowers the bank rate. Whenever the central bank follows a counter-cyclical policy, we expect the bank rate to be positively related to the remaining five endogenous variables. If the signs of the coefficients turn out to be contrary to the a priori expectations then this implies that the central bank has not used consistent sterilization policy through the bank rate with respect to that particular variable.

In the short run, the domestic credit may depend on its lagged values and lagged values of the domestic price level, exchange rate, foreign exchange reserves, bank rate, real terms of trade of cocoa, and current values of the government expenditure and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta lcr = f\ (\Delta lp_{t-i}^{\pm}, \Delta ls_{t-i}^{\pm}, \Delta lcr_{t-i}^{\pm}, \Delta lfr_{t-i}^{\pm}, \Delta br_{t-i}^{\pm}, \Delta ltc_{t-i}^{+}, \Delta\ lg^{+}, \Delta\ ltg) \qquad (19)$$

Government expenditure is expected to be positively related to domestic credit, and domestic credit to the terms of trade of gold. An increase in government expenditure can be financed through the increase in domestic credit. An improvement in the terms of trade of gold is likely to increase the production of gold and this may require higher allocation of credit for the private sector. Whenever the central bank follows a counter-cyclical policy, we expect the domestic credit to be inversely related to the remaining endogenous variables, except the bank rate. If the signs of the coefficients turn out to be contrary to expectations, then this implies that the central bank has not used consistent sterilization policy through domestic credit with respect to that particular variable.

In the short run, the foreign exchange reserves may depend on its lagged values,

lagged values of the domestic price level, nominal exchange rate, domestic credit, bank rate, real terms of trade of cocoa, and current values of the price of petrol, debt-service burden and real terms of trade of gold. The expected relationship among these variables is indicated by the following equation:

$$\Delta lfr = f\ (\overset{\pm}{\Delta lp_{t-i}}, \overset{\pm}{\Delta ls_{t-i}}, \overset{\pm}{\Delta lcr_{t-i}}, \overset{\pm}{\Delta lfr_{t-i}}, \overset{\pm}{\Delta br_{t-i}}, \overset{\pm}{\Delta ltc_{t-i}}, \overset{-}{\Delta lpet}, \overset{-}{\Delta lid}, \overset{+}{\Delta ltg}) \qquad (20)$$

As the price of petrol increases, more amount of foreign exchange will be spent on the import of petrol and the foreign exchange reserves will be reduced. Therefore, we anticipate that the price of petrol will be inversely related to the foreign exchange reserves. We also expect the debt-service burden and the foreign exchange reserves to be inversely related to each other. As the amount of debt servicing increases, the foreign exchange reserves are likely to deplete at a faster rate. We expect the terms of trade of gold and the foreign exchange reserves to be positively related to each other. An improvement in the terms of trade of gold may increase the production and exports of gold, which will increase the availability of foreign exchange reserves. Whenever the central bank follows a counter-cyclical policy, we expect the foreign exchange reserves to be negatively related with the remaining endogenous variables, except the bank rate. If the signs of the coefficients turn out to be contrary to the expectations, the implication is that the central bank has not used a consistent sterilization policy through the exchange rate intervention with respect to that particular variable.

6. Estimation procedure and data requirements

To eliminate the possibility of spurious regressions and erroneous inferences, the first stage of the testing procedure involves determining the order of integration through unit root tests. Several tests are used to test for unit root, but the most widely acceptable and reliable ones are the augmented Dickey–Fuller (ADF) and the Phillips–Perron (PP) tests.[4] Both of these tests are used to determine the order of integration. To determine the number of significant cointegrating relationships, we use Johansen's cointegration test (Johansen, 1988), which yields maximum likelihood estimates for the unconstrained cointegrating vectors.

In case some of the variables turn out to be non-stationary but cointegrated, their dynamic relationship must be specified correctly by an error correction representation in order to capture both the short-run and long-run relationships. The general reduced form VEC model is estimated by using the full information maximum likelihood (FIML) procedure and then the VEC model is reduced until we arrive at the preferred parsimonious reduced form VEC model. In order to test the validity of the VEC model, we re-estimate this model by using a recursive full information maximum likelihood (RFIML) procedure. This enables us to point out whether the estimated parameters of the model are relatively stable or not. We use recursive graphs of one-step residuals to check for structural breaks and the Chow's test to test for structural breaks in the trend of the series.

Since in the long run we expect all the markets to be in equilibrium, the VAR model is also estimated by using the ordinary least squares (OLS) method.[5] The forecast error variance decomposition, which is obtained from the VAR model, is used to identify the most important variable for each of the endogenous variables. The impulse response functions of the VAR model are used to trace the effect of unanticipated monetary and terms of trade shocks on the prices of non-tradeables and tradeables, and nominal exchange rate. The empirical evidence on impulse response functions will enable the policy makers to predict the consequences of these unanticipated shocks in advance so that they will be well prepared to react to these changes in future.

The study uses quarterly series from 1983:1 to 1998:4. The prices of non-tradeables are proxied by the domestic price level (*p*) that is represented by the quarterly consumer price index of Ghana (*CPI*). For the nominal exchange rate (s), we use the end of quarter inter-bank exchange rates between the cedi and the US dollar. The bank rate (*br*) is the end of quarter rate that is used for lending to the commercial banks. The weighted price index for importables is calculated by using the unit price indexes of exportables of Ghana's major trading partners (Germany, Japan, Netherlands, UK and USA) and the share of these partners in Ghana's total imports (which are used as weights). The domestic credit (*cr*) proxies the open market operations and is calculated by adding the central

bank credit and commercial bank credit. The foreign exchange reserves (*fr*) or "official" reserves proxy the extent of exchange intervention; these are calculated from the net foreign assets and revaluation account. For cocoa price, average quarterly cocoa price expressed in UK pounds per metric ton is used and this is expressed in index form. The real terms of trade based on the international price of cocoa (*tc*) proxy the extent of collusion in tradeables and are calculated by taking the ratio of the cocoa price index to the weighted price index of importables. For gold price, average quarterly gold price in US dollars per ounce is used, expressed in index form. The real terms of trade based on the international price of gold (*tg*) are calculated by taking the ratio of the gold price index to the weighted price index of importables. For the price of petrol (*pet*), the average quarterly petrol price in US dollars per barrel is used and this is expressed in index form. Government expenditure (*g*) is represented by the average quarterly total expenditure. The debt-service burden (*id*) is calculated by taking the ratio of repayment of principal and interest on the outstanding international debt to reserves. These data are collected from *International Financial Statistics, Quarterly Economic Bulletin* of the Bank of Ghana and other relevant publications.

7. Empirical results

This section covers two types of results. The first subsection gives the findings on non-stationarity and cointegration. The second subsection presents the estimated VEC model, including evidence on the variables to be stabilized, evidence on instruments of monetary policy, and evidence on stability and structural change.

Non-stationary and cointegration

To determine the order of integration for the relevant variables, the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests are used. The results of these tests are presented in Table 3.

Table 3: Results of unit root tests

Variable	Levels		First difference	
name	ADF	PP	ADF	PP
lp	-2.1462	-3.6668	-5.3106*	-10.3422*
	(IT,2)	(IT,3)	(IT,2)	(IT,3)
ls	-2.1785	-4.0635	-5.3110*	-6.2294*
	(IT,4)	(IT,1)	(IT,4)	(IT,1)
lcr	-1.9341	-2.6106	-3.5452**	-8.8865*
	(IT,3)	(IT,3)	(IT,3)	(IT,3)
lf	-3.4143	-3.2042	-3.7424**	-8.1447*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)
lc	-1.2520	-3.1639	-5.5292*	-11.9113*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)
lg	-3.1579	-5.3490*	-4.5337*	-
	(IT,4)	(IT,3)	(IT,4)	
dg	-3.6759	-4.0778	-3.9457**	-15.6103*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)
ld	-2.1296	-3.2869	-3.6719**	-15.8837*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)
lpet	-2.7437	-2.6178	-3.3419***	-8.5359*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)
lw	-2.0416	-3.0429	-4.2995*	-5.5298*
	(IT,4)	(IT,3)	(IT,4)	(IT,3)

Notes: 1. * indicates that the statistic is significant at 1% level of significance.
2. ** indicates that the statistic is significant at 5% level of significance.
3. The numerical figures in parentheses indicate the lag length for the augmented Dickey–Fuller test and the lag truncation for Bartlett kernel for Phillips–Perron test.
4. IT indicates that both the intercept and trend are included.
5. l stands for the logarithmic value.

Both the ADF and PP tests indicate that all the relevant variables are integrated of order one (non-stationary) in levels but integrated of order zero (stationary) in first differences, except the terms of trade of gold. However, according to ADF, the terms of trade of gold is also integrated of order one in levels but integrated of order zero in first differences. This suggests that in order to eliminate the possibility of spurious regression results and erroneous inferences, we should use the first differences of the relevant variables in the estimation process.

The long-run relationship for domestic credit is expressed as:

$$lcr = 0.562292*lp + 0.889343*ls - 0.027588*br + 0.584429*ltc + 0.312979*lfr$$

The first error correction term is:

$$Ec1 = lcr - 0.562292*lp - 0.889343*ls + 0.027588*br - 0.584429*ltc - 0.312979*lfr$$

This long-run relationship indicates that a 100% increase in the domestic price level, nominal exchange rate, terms of trade of cocoa, and foreign exchange reserves increases the domestic credit by 56.23%, 88.93%, 58.44%, and 31.3% respectively. The highest increase comes from the nominal exchange rate. On the other hand, a 100% increase in the bank rate reduces the domestic credit by about 2.76%. This shows that the bank rate is least effective in influencing the volume of domestic credit.

The long-run relationship for the terms of trade for cocoa is expressed as:

$$ltc = 0.157204*lp - 1.279304*ls + 0.010306*br + 0.968613*lcr - 0.141686*lfr$$

The second error correction term is generated as:

$$Ec2 = ltc - 0.157204*lp + 1.279304*ls - 0.010306*br - 0.968613*lcr + 0.141686*lfr$$

This long-run relationship indicates that a 100% increase in the domestic price level, bank rate and domestic credit increases the terms of trade of cocoa by 15.72%, 1.03%, 96.86%, respectively. On the other hand, a 100% increase in the nominal exchange rate and foreign exchange reserves deteriorates the terms of trade of cocoa by about 128.0% and 14.17%, respectively. The nominal exchange rate influences the terms of trade of cocoa to the largest extent, whereas the bank rate has the least effect on the terms of trade of cocoa.

Cointegration can be used to establish whether there exists a linear long-term economic relationship among the variables (Johansen, 1991). Cointegration also helps us in pointing out whether there exists disequilibrium in various markets (Pesaran and Shin, 1996). Furthermore, cointegration allows us to specify a process of dynamic adjustment among the cointegrated variables (Johansen, 1991). The results of the Johansen cointegration tests are presented in Table 4.

Table 4: Johansen's cointegration test results

Test assumption: No deterministic trend in the data
Series: lp, ls, br, ltc, lcr, lfr
Lags interval: 1 to 4

Eigenvalue	likelihood ratio	5% Critical value	hypothesized No. of CE(s)
0.574875	126.7934	82.49	None**
0.406876	76.32643	59.46	At most 1**
0.353863	45.50772	39.89	At most 2**
0.197717	19.73987	24.31	At most 3
0.092081	6.742539	12.53	At most 4
0.017525	1.043157	3.84	At most 5

Un-normalized cointegrating coefficients

lp	ls	br	ltc	lcr	lfr
1.561962	2.470462	-0.076635	1.623456	-2.777849	0.869408
0.161887	-1.317417	0.010613	-1.029792	0.997470	-0.145907
-1.203355	2.755229	-0.011403	0.770056	-0.631615	-0.567050
-0.763036	1.607758	0.020078	0.446604	-0.301897	-0.455928
0.809012	0.902152	0.006279	1.289024	-1.103670	-0.237225
2.715909	-0.181469	-0.068985	0.641609	0.224653	-1.159507

Notes: 1.**denotes the rejection of the hypothesis at 5% significance level.
2. LR test indicates 3 cointegrating equations at 5% significance level.

The long-run relationship for the nominal exchange rate is expressed as:

$$ls = 0.474596*lp - 0.012488*br - 0.277781*ltc + 0.187775*lcr + 0.283580*lfr$$

The third error correction term is indicated by the following equation:

$$Ec3 = ls - 0.474596*lp + 0.012488*br + 0.277781*ltc - 0.187775*lcr - 0.283580*lfr$$

It is clear from the fourth column of Table 4 that the null hypothesis of at most three cointegrating vectors is accepted at 5% level of significance. This confirms the presence of stable long-run relationships among the domestic price level, nominal exchange rate, bank rate, terms of trade of cocoa, domestic credit and foreign exchange reserves. The first vector appears to be the one on which we can normalize the domestic credit. The second vector appears to be the one on which we can normalize the terms of trade of cocoa. The fourth vector appears to be the one on which we can normalize the nominal exchange rate. The choice of these vectors is based on expectations about the long- run relationships as indicated in equations (16), (11) and (10), respectively.

This long-run relationship indicates that a 100% increase in the domestic price level, domestic credit and foreign exchange reserves increases the nominal exchange rate by about 47.46%, 18.78% and 28.36%, respectively. On the other hand, a 100% increase in

the bank rate and terms of trade of cocoa reduces the nominal exchange rate by 1.25% and 27.78%, respectively. The domestic price level seems to exert the maximum impact on the nominal exchange rate in the long-run, whereas the bank rate seems to exert the least impact on the nominal exchange rate.

The unit root tests have indicated that the simultaneous equation models must be specified in first differences of the relevant variables. The cointegration test has provided some evidence on the existence of long-run relationships among the endogenous variables and the possibility of disequilibrium in the various markets, which could arise due to the disequilibrium in the markets for domestic credit, nominal exchange rate and tradeables. After conducting these tests, we now have enough evidence to allow us to proceed to estimate the VEC model.

The VEC model

Since the endogenous variables are non-stationary in levels but cointegrated, their dynamic relationship must be specified by an error correction representation in order to capture both the short-run and long-run relationships. First of all, we have used the FIML method to estimate the general VEC model that include four lags of the endogenous variables and current values of the exogenous variables.[6] The general VEC model is re-estimated by deleting the insignificant variables until we arrive at the parsimonious reduced form VEC model. The FIML estimates of the parsimonious reduced form VEC model are presented in Appendix A.

Evidence on variables to be stabilized

The estimated VEC specification for the domestic inflation rate (prices of non-tradeables) suggests that the speed of adjustment of the market for non-tradeables towards its long-run equilibrium when disturbed by disequilibrium in the domestic credit market is 1.48 % per quarter or 5.78 % per year. The market for non-tradeables in Ghana, therefore, remains in disequilibrium for a number of years. The speed of adjustment of the market for non-tradeables in Ghana is relatively lower than what has been observed for Kenya (9.1%; Ndung'u, 1997), Uganda (100.0%; Barungi, 1997), and Botswana (2.06% per month; Atta et al., 1999). In the short run, the degree of inflation inertia is observed as 0.18, which is relatively lower than what has been observed by Ndung'u (1994) (0.30), Isaksson (1997) (0.30), and Durevall and Ndung'u (1999) (0.42) for Kenya, and Barungi (1997) (0.31) for Uganda, but more than what has been observed for Botswana by Atta et al., (1999) (0.09). The model suggests a positive relationship between domestic inflation rate and bank rate. Such a relationship has been observed by Atta et al., 1999) for Botswana and by Durevall and Ndung'u (1999) for Kenya.

An increase in the bank rate is most likely to cause a reduction in domestic credit, which will reduce the aggregate demand for non-tradeables. At the same time, a reduction in domestic credit could reduce the investment in the production of non-tradeables, which will then reduce the production of non-tradeables. If the supply side effect offsets the

demand side effect then the prices of non-tradeables may increase. The model suggests a negative relationship between the growth rate of foreign exchange reserves and the domestic rate of inflation. This result conforms with the findings of Adam et al. (1996). A decrease in the foreign exchange reserves signifies a reduction in the total money supply, which will reduce the aggregate demand for non-tradeables. At the same time, a reduction in money supply could reduce the investment in the production of non-tradeables, which will then reduce the production of non-tradeables. If the supply side effect offsets the demand side effect, then the prices of non-tradeables may increase. The model suggests a negative relationship between the prices of tradeables and non-tradeables, which shows that there exists trade-off between them. An increase in the terms of trade of cocoa could be due to the fall in the prices of importables. If because of this, imports increase and they are utilized in the production of non-tradeables then the production of non-tradeables will increase, thus causing a downward pressure on the prices of non-tradeables. A 100% increase in the growth rate of government expenditure seems to have a contractionary effect of about 6.14% on the domestic rate of inflation. This may be because the government spends more on the tradeables rather than the non-tradeables. The price equation shows the presence of serial correlation but the error terms are normally distributed.

The estimated VEC specification for the growth rate of nominal exchange rate suggests that the speed of adjustment of the foreign exchange market towards its long-run equilibrium when disturbed by the domestic credit market is 3.71% per quarter and its own market is 4.84 % per quarter. Thus the total speed of adjustment of the foreign exchange market is 8.55 % per quarter or 30.06% per year. The foreign exchange market in Ghana, therefore, remains in disequilibriums for a number of years. The speed of adjustment of the foreign exchange market seems to be more than the speed of adjustment of the market for non-tradeables. Moreover, the differentials in adjustment speeds suggest that the foreign exchange market disequilibriums adjust quickly to one market rather than the other market. The speed of adjustment of the foreign exchange market in Ghana is relatively higher than what has been observed for Kenya (11.7% in 1997, 18.4% in 1998; Ndung'u, 1997, 1998), but lower than what has been observed for Uganda (43.86%; Atingi-Ego, 2000). In the short run, the model suggests a negative relationship between the domestic inflation rate and the growth rate of nominal exchange rate, which shows that there exists a trade-off between the domestic price level and nominal exchange rate.

An increase in the domestic price level could increase the production of non-tradeables and reduce the production of tradeables, which could increase the prices of tradeables. If because of these changes the availability of foreign exchange reserves increases, then there could be a downward pressure on the nominal exchange rate. Moreover, we have observed that the pass-through effect of the domestic price level to nominal exchange rate is neither complete nor instantaneous as hypothesized in PPP theory. The exchange rate inertia in Ghana seems to be 0.05, which is lower than what has been observed for Uganda (0.36; Atingi-Ego, 2000). The model suggests a positive relationship between the foreign exchange reserves and the rate of growth of nominal exchange rate. Moreover, the model suggests a positive relationship between the growth rate of terms of trade of cocoa and the rate of depreciation of the local currency. An increase in the terms of trade

of cocoa could be due to the fall in the prices of importables. If because of this, imports increase and the availability of foreign exchange reserves is reduced, then this would cause an upward pressure on the nominal exchange rate. This finding is contrary to the findings of Sackey (1998). The exchange rate equation shows the presence of serial correlation and at the same time the error terms are not normally distributed.

The estimated VEC specification for the growth rate of terms of trade of cocoa suggests that the speed of adjustment of the market for tradeables towards its long-run equilibrium when disturbed by a disequilibrium in its own market is 18.76 % per quarter or 56.44 % per year. The market for tradeables in Ghana, therefore, remains in disequilibrium for a few years. The speed of adjustment of the market for tradeables seems to be more than the speeds of adjustments of the markets for non-tradeables, foreign exchange, interest rate and domestic credit. In the short run, the model suggests a negative relationship between the growth rate of domestic credit and the growth rate of terms of trade of cocoa. An increase in domestic credit could result in higher investment in the production of cocoa, which would increase the production of cocoa and thus put a downward pressure on the prices of cocoa. Moreover, the model suggests a positive relationship between the growth of foreign exchange reserves and the growth rate of terms of trade of cocoa. An increase in the foreign exchange reserves implies increase in money supply, which could increase the investment in the production of cocoa. Thus, the total production of cocoa would increase. If the government of Ghana could collude with the other major producers of cocoa and destroy part of the produce, then this action could lead to an improvement in the prices of cocoa. The terms of trade of gold seem to cast a positive impact on the terms of trade of cocoa. The price of petrol seems to be negatively related to the terms of trade of cocoa. An increase in the price of petrol signifies an increase in the prices of importables and thus directly deteriorates the terms of trade of cocoa. The terms of trade equation shows the absence of serial correlation and the error terms are normally distributed.

Evidence on instruments of monetary policy

Since the dependent variable in the VEC specification for the bank rate is not expressed in logarithmic form, the estimated coefficients must be divided by the average bank rate so that we can interpret the results correctly. The average bank rate for the whole period works out to be 29.5%. We have divided the estimated coefficients for bank rate equation as shown in Appendix A by the average bank rate. The estimated VEC specification for the bank rate suggests that the speed of adjustment of the interest rate market towards its long-run equilibrium when disturbed by disequilibrium in the foreign exchange market is 13.37% per quarter or 43.67% per year.

The speed of adjustment of the interest market seems to be more than the speeds of adjustment for the markets for non-tradeables and exchange rate. The speed of adjustment of the interest market in Ghana is less than what has been observed for Kenya (39.02% per month). In the short run, the model suggests a positive relationship between the domestic rate of inflation and the growth rate of bank rate. Since the price equation suggests a positive relationship between the domestic rate of inflation and interest rate,

we can say that there exists an inflation–interest rate spiral in Ghana. The interest rate inertia works out to be about 0.02 in Ghana. which is lower than that observed for Kenya (0.12). In addition, the model suggests a positive relationship between the growth rate of domestic credit and the growth rate of bank rate.

Moreover, the model suggests a negative relationship between the growth of foreign exchange reserves and the growth of bank rate. Since the sign of the coefficient of the foreign exchange reserves is contrary to expectations, we can say that the central bank takes decisions about its sterilization policy through a bank rate that is not consistent with the exchange rate intervention policy. The bank rate equation shows the presence of serial correlation and at the same time the error terms are not normally distributed.

The estimated VEC specification for the growth rate of domestic credit suggests that the speed of adjustment of the domestic credit market towards its long-run equilibrium when disturbed by disequilibrium in its own market is 9.61% per quarter and when disturbed by disequilibrium in the foreign exchange market is 7.55% per quarter. The differential in adjustment speeds reflects the fact that the domestic credit movements respond quickly to one type of disequilibrium and slowly to the other. Thus the total adjustment speed of the domestic credit market works out to be 2.06% per quarter or 8.0% per year. The speed of adjustment of the domestic credit market seems to be more than the speed of adjustment of the market for non-tradeables but less than the speeds of adjustment for interest and foreign exchange markets.

In the short run, the model suggests a negative relationship between the domestic inflation rate and the rate of growth of domestic credit. On the other hand, the model suggests a positive relationship between the growth rate of nominal exchange rate and the growth rate of domestic credit. Since the sign of this coefficient is contrary to the counter-cyclical policy rule, we can say that the central bank does not adjust its sterilization policy through domestic credit, which is consistent with the changes in nominal exchange rate. A 100% increase in the growth rate of foreign exchange reserves in the second quarter reduces the rate of growth of domestic credit by about 12.2%, thus indicating that about 12.2% of reserve flows could be sterilized through domestic credit. Reserve flow sterilization in Ghana (12.2%) seems to proceed at a slower pace than what has been observed by Silumbu (1995) for Malawi (35%). Moreover, the model suggests a positive relationship between the growth of bank rate and the growth rate of domestic credit. However, the bank rate seems to cast a very low impact on the domestic credit. The central bank seems to adjust its domestic credit in response to any changes in the terms of trade of gold. The growth rate of government expenditure seems to have a positive and significant effect on the growth rate of domestic credit. The domestic credit equation shows the presence of serial correlation but the error terms are normally distributed.

The estimated VEC specification for the growth rate of foreign exchange reserves suggests a positive relationship between the growth rate of nominal exchange rate and the rate of growth of foreign exchange reserves. Since the sign of the coefficient of the exchange rate is contrary to the counter-cyclical rule of the central bank, we can say that the central bank does not adjust its sterilization through exchange rate intervention policy consistently with respect to changes in the nominal exchange rate. The foreign exchange

reserves inertia in Ghana seems to be 0.21. Moreover, the model suggests a negative relationship between the growth rate of terms of trade of cocoa and the growth rate of foreign exchange reserves. This finding goes against the finding of Silumbu (1995) for Malawi. The growth rate of the price of petrol seems to have a negative impact on the foreign exchange reserves. The foreign exchange reserves equation shows the presence of serial correlation and the error terms are not normally distributed.

Evidence on stability and structural change

To test the validity of the VEC models, we have re-estimated the models by using the recursive full information maximum likelihood (RFIML) method. The estimated results that emerged from the VEC model show that the parameters of the model are relatively stable. To check for any structural breaks in the trend of the series, we have used the one-step residuals of the recursive graphics. These graphs, which are found in Appendix B, show no evidence of structural break in the trend of the relevant series. We have also tested for any structural breaks by using the Chow's test. These graphs are shown in Appendix C, and again show no evidence of any structural break.

8. Variance decomposition

In the long run, it is expected that equilibrium will prevail in all the concerned markets. Thus we can move from the VEC model to the VAR model. After the estimation of the VAR model, we decomposed the forecast error variance by using Sim's recursive Choleski method in order to identify the most effective instrument for each targeted variable. We used the VAR model (with four lags) to decompose the innovations of the endogenous variables into portions that can be attributable to its own innovations and to innovations in the other variables. The results of the forecast error variance decomposition of the endogenous variables, at various quarters, generated by the six-variable, reduced form VAR model are shown in Appendix D.

The predominant source of variations in the domestic price level's forecast errors is "own shocks". The innovations of bank rate and domestic credit are other important sources of the forecast error variance of the domestic price level. The source of least forecast error variance of the domestic price level is innovations of terms of trade of cocoa. The most effective instrument for the domestic price level seems to be the bank rate. This finding stands in contrast with the findings of Ndung'u (1993) and Akinlo and Odusola (1999).

In explaining the forecast error variance of nominal exchange rates, we have observed that the innovations of foreign exchange reserves are next to its "own shocks". The other important variable for the forecast error variance of nominal exchange rate seems to be the terms of trade of cocoa. The source of least forecast error variance of nominal exchange rate is the innovations of the domestic price level throughout the medium-term and long-term horizons. The most effective instrument for the nominal exchange rate seems to be the foreign exchange reserves. This finding also contrasts with the finding of Akinlo and Odusola (1999). The predominant source of variations in the terms of trade of cocoa's forecast errors is "own shocks". The innovations of the domestic price level and foreign exchange reserves are other important sources of the forecast error variance of the terms of trade of cocoa. The source of least forecast error variance of the terms of trade of cocoa is the innovations of bank rate. The most effective instrument for the terms of trade of cocoa seems to be the domestic price level.

While looking at the decomposition of the forecast error variance of bank rate, we have observed that the innovations of foreign exchange reserves and the terms of trade of cocoa are its two most important sources of variations, besides its "own shocks". The source of least forecast error variance of the bank rate seems to be the innovations of the domestic price level. The most effective instrument for the bank rate seems to be the foreign exchange reserves. This finding is in conformity with the finding of Akinlo and

Odusola (1999). In explaining the forecast error variance of domestic credit, we have observed that the innovations of nominal exchange rate are next to its "own shocks". The other important variable for the forecast error variance of domestic credit seems to be the domestic price level. The source of least forecast error variance of domestic credit is the innovations of foreign exchange reserves throughout the short-term, medium-term and long-term horizons. The most effective instrument for the domestic credit seems to be the nominal exchange rate. This finding stands in contrast with the finding of Akinlo and Odusola (1999).

While looking at the decomposition of the forecast error variance of foreign exchange reserves, we have observed that the innovations of the terms of trade of cocoa and the domestic price level are its two most important sources of variations, besides its "own shocks". The source of least forecast error variance of the foreign exchange reserves seems to be the innovations of the domestic credit. The most effective instrument for the foreign exchange reserves seems to be the terms of trade of cocoa. This finding also contrasts with the finding of Akinlo and Odusola (1999).

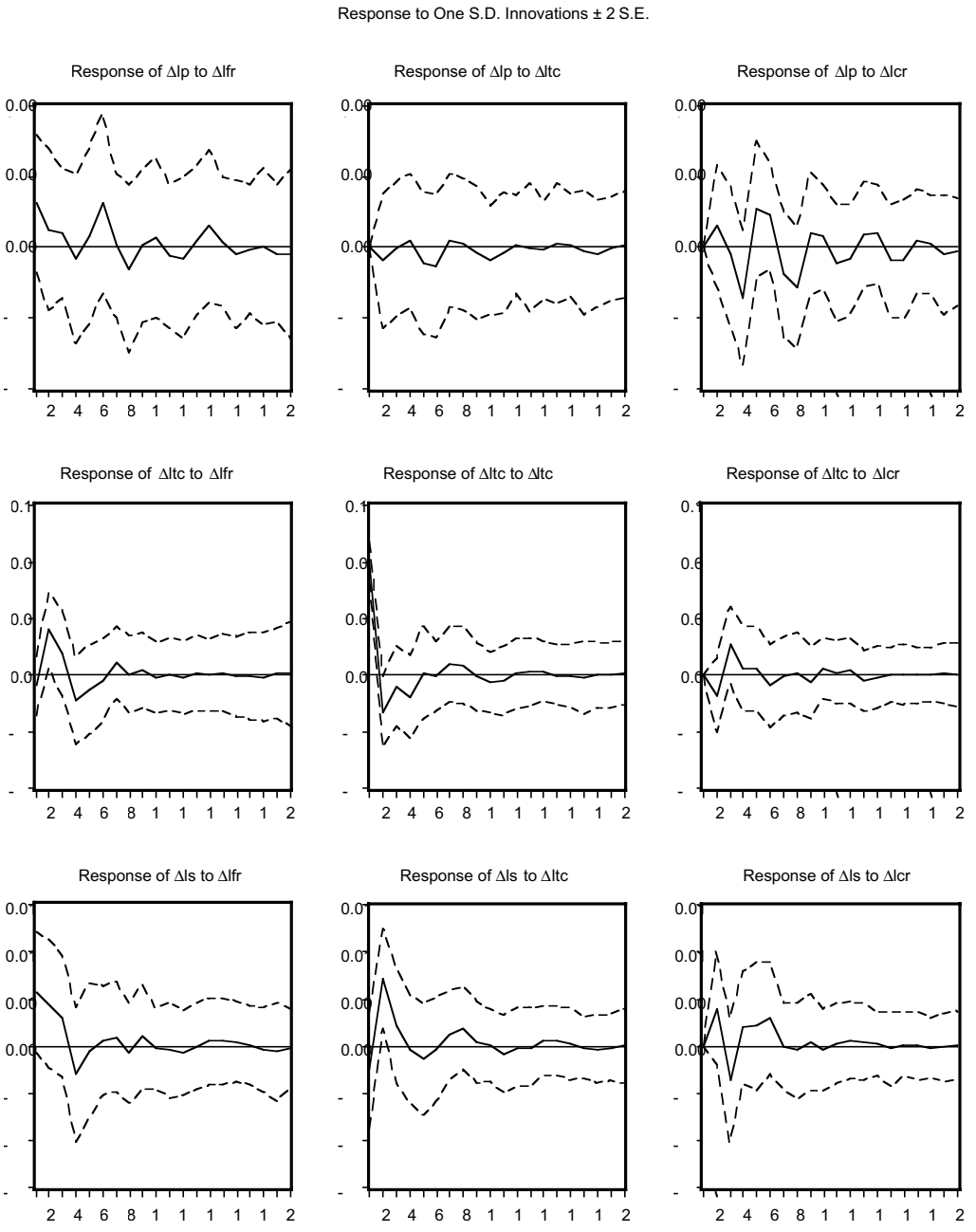
9. Impulse response functions

It is generally believed that unanticipated monetary shocks that arise from either the domestic component of money supply (domestic credit) or the foreign component of money supply (foreign exchange reserves) or unanticipated terms of trade shocks can lead to disturbances in the prices of non-tradeables and tradeables and nominal exchange rate. The effect of these unanticipated shocks on the stability of prices of non-tradeables and tradeables and nominal exchange rate (deviation of the short-run equilibrium values from the long-run equilibrium values) can be ascertained from the impulse response functions of a reduced form VAR model. If the response is such that the short-run values converge to the long-run values then it can be deduced that stability can be achieved in the future. We are interested in knowing the impact of these shocks on the domestic price level, terms of trade of cocoa and nominal exchange rate. This information enables the policy makers to predict the consequences of unanticipated shocks so that they are well prepared to react to these changes in future. The impulse responses of different variables to one standard deviation shock in one of the innovations of all the endogenous variables are presented in Appendix E. However, the impulse responses of the domestic price level, terms of trade of cocoa, and the nominal exchange rate owing to the one standard deviation shock in the innovations of foreign exchange reserves, domestic credit and terms of trade of cocoa are presented in Figure 1.

It is evident from Appendix E and Figure 1 that any unanticipated increase in the foreign exchange reserves will reduce the deviation between the short-run equilibrium values of the domestic price level and its long-run equilibrium values in the short-term horizon. However, the domestic price level when disturbed by a shock in foreign exchange reserves could be stabilized only after four years. Any unanticipated increase in the terms of trade of cocoa will reduce the deviation between the short-run equilibrium value of the domestic price level and its long-run equilibrium value in the second quarter. In the third quarter, the domestic price level when disturbed by a shock in the terms of trade of cocoa could be stabilized.

On the other hand, any unanticipated increase in the domestic credit will increase the deviation between the short-run equilibrium value of the domestic price level and its long-run equilibrium value into the second quarter. However, the domestic price level when disturbed by a shock in the domestic credit shock could not be stabilized within a period of five years. According to the variance decomposition, foreign exchange reserves and the terms of trade of cocoa are not the most important variables in accounting for the innovations of the domestic price level. Therefore, we may have to look at the effect of an unanticipated shock in the bank rate on the deviation between the short-run equilibrium

Figure 1: Selected impulse response functions from the reduced form VAR model



values of the domestic price level and its long-run equilibrium values. The domestic price level when disturbed by a shock in the bank rate could be stabilized after one year. Thus, we have observed that the effects of monetary and terms of trade shocks are transmitted to the domestic price level and what Ghana needs is a bank rate shock to stabilize its domestic price level. The first part of this finding is in conformity with the finding of Montiel and Ostry (1991).

Regarding the impulse response functions for the terms of trade of cocoa, we have noticed that any unanticipated increase in the foreign exchange reserves will increase the deviation between the short-run equilibrium value of the terms of trade of cocoa and its long-run equilibrium value to the second quarter. However, the terms of trade of cocoa when disturbed by a shock in foreign exchange reserves could be stabilized in the eighth quarter. Any unanticipated increase in the terms of trade of cocoa will reduce the deviation between its short-run and long-run equilibrium values until the second quarter, but the terms of trade of cocoa when disturbed by its own shock could be stabilized only after a period of four years. On the other hand, any unanticipated increase in the domestic credit will reduce the deviation between the short-run equilibrium value of the terms of trade of cocoa and its long-run equilibrium value unto the second quarter. The terms of trade of cocoa when disturbed by a shock in the domestic credit could not be stabilized within a period of five years, although the deviations between the short-run and long-run equilibrium values are gradually minimized. Thus we have observed that the effects of monetary and terms of trade shocks are again transmitted to the terms of trade of cocoa and what Ghana needs is a foreign exchange reserves shock to stabilize its terms of trade of cocoa.

As for the impulse response functions for the nominal exchange rate, we have noticed that any unanticipated increase in the foreign exchange reserves reduces the deviation between the short-run equilibrium value of the nominal exchange rate and its long-run equilibrium value unto the fourth quarter. The nominal exchange rate when disturbed by a shock in foreign exchange reserves could be stabilized only after a period of three years, so that any unanticipated increase in the terms of trade of cocoa will increase the deviation between the short-run equilibrium value of the nominal exchange rate and its long-run equilibrium value into the second quarter. The nominal exchange rate when disturbed by a terms of trade shock could be stabilized only after a period of two years, but any unanticipated increase in the domestic credit will increase the deviation between the short-run equilibrium value of the nominal exchange rate and its long-run equilibrium value into the second quarter. And the nominal exchange rate when disturbed by a shock in the domestic credit could be stabilized after a period of one year. Thus, we have observed that the effects of monetary and terms of trade shocks are again transmitted to the nominal exchange rate. This finding is in line with the findings of Ndung'u (1997, 1999). In view of the empirical evidence of the cointegrating relationship, VEC model and variance decomposition, Ghana needs a foreign exchange reserves shock to stabilize its nominal exchange rate.

10. Conclusions and policy implications

The cointegration analysis confirmed the existence of three stable long-run relationships among the domestic price level, nominal exchange rate, bank rate, terms of trade of cocoa, domestic credit and foreign exchange reserves. The empirical evidence from the parsimonious reduced form VEC model shows that agents form expectations about the domestic price level, nominal exchange rate, bank rate and foreign exchange reserves. Inflation inertia, measured by the size of the estimated coefficient on lagged inflation, is 0.18. Exchange rate inertia, measured by the sum of the estimated coefficients on lagged growth rate of nominal exchange rate, is 0.05. Interest rate inertia, measured by the size of the modified coefficient on lagged bank rate growth, is 0.02. Foreign exchange reserves inertia, measured by the size of the estimated coefficient on lagged growth rate of foreign exchange reserves, is 0.21.

The speeds of adjustment of the foreign exchange market, interest market and the market for tradeables are 30.06%, 43.67% and 56.44% per year, respecively, which are relatively higher than the speeds of adjustment for the non-tradeables (5.78%) and domestic credit markets (8.0%). The determinants of inflation in the short run are bank rate, foreign exchange reserves, terms of trade of cocoa and government expenditure. The determinants of the rate of depreciation of the local currency in the short run are the domestic price level, terms of trade of cocoa and foreign exchange reserves. The pass-through effect from the domestic price level to the nominal exchange rate is neither complete nor instantaneous. The determinants of terms of trade of cocoa in the short run are domestic credit, foreign exchange reserves, terms of trade of gold and the price of petrol. The determinants of bank rate in the short run are the domestic price level, domestic credit and foreign exchange reserves. The determinants of domestic credit in the short run are the domestic price level, nominal exchange rate, bank rate, foreign exchange reserves, government expenditure and terms of trade of gold. Lastly, the determinants of foreign exchange reserves in the short run are the nominal exchange rate, terms of trade of cocoa and price of petrol.

The empirical evidence on the forecast error variance decomposition suggests that the most effective instrument for the domestic price level is the bank rate and therefore, in order to control the domestic rate of inflation, the monetary authorities could reduce the relatively high bank rate. The most effective instrument for the nominal exchange rate seems to be the foreign exchange reserves, and in order to arrest the continuous depreciation of the local currency, the Bank of Ghana could sell more foreign exchange in the foreign exchange market. The most effective instrument for the terms of trade of cocoa seems to be the domestic price level and the most relevant variable for the bank

rate seems to be the foreign exchange reserves, implying that the Bank of Ghana should implement a consistent bank rate policy in accordance with the exchange rate intervention policy.

For the domestic credit, the most relevant variable seems to be the nominal exchange rate, suggesting that the Bank of Ghana should follow a consistent sterilization policy through domestic credit with respect to nominal exchange rate. By arresting the rate of depreciation of the local currency, the Bank of Ghana could solve the problem of excess liquidity. Regarding foreign exchange reserves, the most relevant variable seems to be the terms of trade of cocoa. The Government of Ghana could collude with the other major producers of cocoa in order to improve its terms of trade of cocoa and the Bank of Ghana should continue to follow consistent sterilization policy through foreign exchange intervention with respect to the terms of trade of cocoa.

Empirical evidence from the impulse response functions indicates that the effects of monetary and terms of trade shocks are transmitted to the domestic price level, terms of trade of cocoa and nominal exchange rate. Any unanticipated shock in the bank rate would stabilize the domestic price level. In addition, any unanticipated shock in the foreign exchange reserves would stabilize both the terms of trade of cocoa and the nominal exchange rate. The results suggest that policy makers may wish to devote their attention to the markets for domestic credit, tradeables and foreign exchange in the long run. Policies should be designed in such a way that agents are encouraged to form expectations about the domestic credit and the terms of trade of cocoa. This can be achieved by providing information about the allocation of domestic credit by the central bank, commercial banks and other financial institutions and the prices of tradeables in the broadcast and print media. Too much intervention in the markets for domestic credit and non-tradeables should be avoided so that the speeds of adjustment of these markets could be raised. Any unanticipated shock in the bank rate could be used to stabilize the domestic price level and any unanticipated shock (this shock is a random shock and it works through the impulse response functions) in the foreign exchange reserves could be used to stabilize the nominal exchange rate and the terms of trade of cocoa.

Notes

1. It should be kept in mind that the exchange rate overshooting can indeed, and generally will, occur in equilibrium open economy models also.

2. There have been some studies establishing that the direction of causality is from exchange rate to inflation (Montiel, 1989; Dornbusch et al., 1990).

3. The variance decomposition analysis is very sensitive to the order of appearance of the endogenous variables.

4. If there has been a structural change over the sample period, Perron (1990) has pointed out that the occurrence of a structural break in the mean of a time series biases the ADF test toward non-rejection of the unit root hypothesis. Under these conditions, the ADF test may indicate the presence of a unit root, but in actuality the series may be a stationary series. A traditional approach to examining stationarity when a structural change is suspected involves conducting unit root tests on a split sample. But split sample unit root tests may suffer from low power. Perron (1990) and Perron and Vogelsang (1992) have developed unit root tests that allow for a one-time structural shift in the mean of a time series. In particular, their innovational outlier (IO) model is a Dickey–Fuller type test for stationarity that allows a one-time gradual shift in the mean of a time-series. The IO model must be used to test for stationarity of a series if it is found that a one-time structural change has appeared in the sample period.

5. One major problem in the estimation of VAR and VEC models is the selection of an appropriate lag length. Most researchers have selected lag lengths in an arbitrary way. The lag length plays a crucial role in diagnostic tests (whether pre-estimation or post-estimation) as well as in the estimation of VEC and VAR models. We estimate VAR models with increasing lag lengths, save the estimated residuals, and then perform both normality and serial correlation tests on these estimated residuals. The final model is selected among alternative lag length specification on the basis of both normality and serial correlation tests on estimated residuals. The criterion for selection is that the estimated residuals are normally distributed white noise processes with no serial correlation. If the two lag lengths yield the same results, then the Schwartz and Akaike information criterion is used to select the appropriate lag length.

6. The lag length of four was selected initially on the basis that the estimated residuals of VAR models pass both the normality and the serial correlation tests.

7. Since the variance decomposition analysis is very sensitive to the order of appearance of the endogenous variables, we have looked at the results obtained from other orderings and presented the results that are consistent with the cointegration analysis and the estimated results of VEC model.

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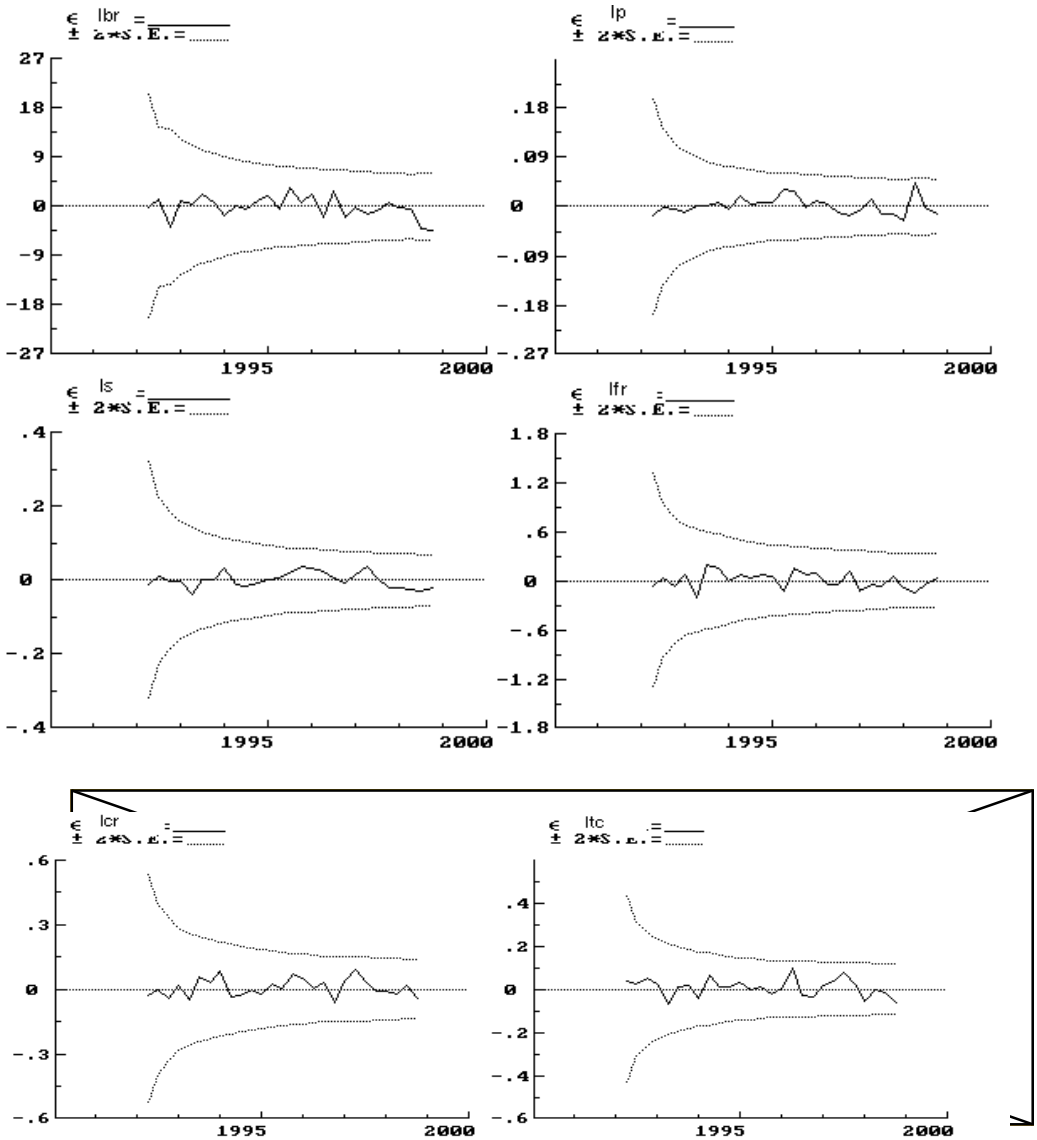
Appendix A: FIML estimates of parsimonious reduced form VEC model

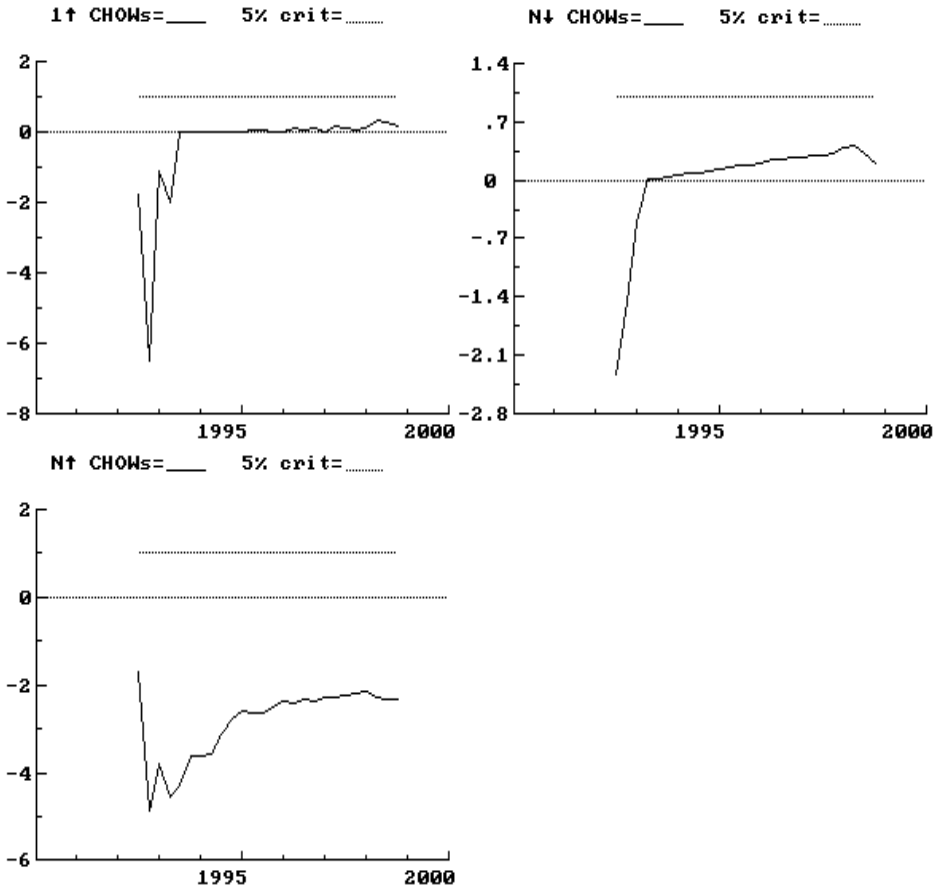
Exogenous variables, and diagnostic statistics	Endogenous variables					
	Δlp	Δls	Δbr	Δltc	Δlcr	Δlfr
Δlp(-1)	-	-	24.428**	-	-1.3131*	-
	(11.710)	(0.2488)				
Δlp(-3)	-	-	27.496***	-	-	-
	(14.151)					
Δlp(-4)	0.1796**	-0.3002*	-	-	-	-
	(0.0826)	(0.1025)				
Δls(-2)	-	-	-	-	-	0.4032*
	(0.1371)					
Δls(-3)	-	-	0.1184*	-	-	- -
	(0.0278)					
Δls(-4)	-	0.0727**	-	-	0.1137***	-
	(0.0335)	(0.0632)				
Δbr(-1)	0.0035*	-	-	-	-	-
	(0.0009)					
Δbr(-2)	-	-	-	-	0.0048**	-
	(0.0020)					
Δbr(-3)	-	-	-	-	0.0080*	-
	(0.0019)					
Δbr(-4)	-	-	-0.5453*	-	-	-
	(0.1149)					
Δltc(-1)	-0.0485**	0.1296*	-	-	-	-
	(0.0196)	(0.0243)				
Δltc(-2)	-	0.1247*	-	-	-	-
	(0.0237)					
Δltc(-3)	-	0.0819*	-	-	-	-
	(0.0223)					
Δtc(-4)	-	0.0538*	-	-	-	-0.2874**
	(0.0191)	(0.1109)				
Δlcr(-1)	-	-	-	-0.3231*	-	-
	(0.0920)					
Δlcr(-4)	-	-	8.4737***	-	-	-
	(4.7753)					
Δlfr(-1)	-	0.0358***	-3.5798***	0.1270*	-	-
	(0.0186)	(1.8637)	(0.0349)			
Δlfr(-2)	-	-	-	0.1064*	-0.1220*	-
	(0.0346)	(0.0323)				
Δlfr(-3)	-	-	-	-	-	0.2151**
	(0.0862)					
Δlfr(-4)	-0.0263***	-	-	-	-	-
	(0.0139)					
EC1(-1)	0.0148**	-0.0371*	-	-	0.0961*	-
	(0.0073)	(0.0096)	(0.0181)			
EC2(-1)	-	-	-	0.1876*	-	-
	(0.0398)					
EC3(-1)	-	-0.0483*	-3.9440**	-	-0.0755**	-
	(0.0166)	(1.6574)	(0.0341)			
Constant	0.0241*	0.0521*	-	0.0580*	0.0726*	-
	(0.0037)	(0.0058)	(0.0146)	(0.0120)		
Δltg	-	-	-	0.8337*	0.1052**	-
	(0.0535)	(0.0455)				
Δlpet	-	-	-	-0.2557*	-	-0.5268**
	(0.0865)	(0.2306)				
Δlg	-0.0614***	-	-	-	0.2212*	-
	(0.0329)	(0.0684)				
Serial Correlation F(4,28)	9.2793*	5.0775*	6.3446*	4.1079	5.7425*	4.5208*
normality $\chi^2(2)$	6.4742	12.157*	17.274*	0.3342	1.7022	11.157*

Notes: 1. The figures in parentheses indicate the standard errors.
2. * indicates that the statistic is significant at 1% level of significance.
3. ** indicates that the statistic is significant at 5% level of significance.

Appendix B: One-step residuals of the recursive graphics



Appendix C: Chow's test results



Appendix D: **Variance decomposition from the reduced form VAR model**[7]

Variables	Horizons/ Quarters	ε_p	ε_s	ε_{br}	ε_{tc}	ε_{cr}	ε_{fr}
Δlp	2	85.99	0.02	9.71	0.26	0.65	3.18
	4	77.33	3.34	11.94	0.29	3.88	3.23
	8	74.28	4.25	9.21	0.80	6.94	4.52
	12	73.30	4.17	10.20	0.95	6.96	4.42
	16	72.79	4.27	10.18	0.93	7.18	4.66
	20	72.48	4.25	10.44	0.98	7.18	4.67
Δls	2	2.70	74.94	1.79	9.45	2.62	8.51
	4	2.78	70.52	1.80	9.39	4.96	10.55
	8	3.03	67.61	3.81	9.41	6.35	9.78
	12	3.42	66.60	4.38	9.38	6.35	9.86
	16	3.55	66.14	4.70	9.40	6.34	9.88
	20	3.62	65.92	4.83	9.39	6.33	9.92
Δbr	2	10.52	0.02	83.91	0.93	1.58	3.06
	4	12.87	1.62	79.59	1.06	1.77	3.09
	8	11.35	3.15	70.35	2.40	4.77	7.97
	12	11.32	3.07	69.49	2.59	4.75	8.78
	16	11.24	3.05	69.09	2.63	4.66	9.33
	20	11.15	2.99	69.13	2.64	4.55	9.54
Δltc	2	11.39	7.12	1.26	68.05	1.99	10.19
	4	11.79	8.86	3.12	58.17	5.39	12.67
	8	12.66	11.62	3.11	54.10	5.52	12.99
	12	12.85	11.70	3.23	53.44	5.87	12.91
	16	12.94	11.69	3.37	53.15	5.98	12.87
	20	12.97	11.68	3.42	53.08	5.97	12.88
Δlcr	2	4.09	19.69	9.58	2.89	61.62	2.12
	4	10.94	19.04	9.34	2.94	55.03	2.71
	8	14.23	18.36	9.44	3.09	52.09	2.79
	12	15.50	18.03	9.77	3.06	50.87	2.77
	16	16.22	17.85	9.74	3.02	50.27	2.90
	20	16.41	17.78	9.82	3.01	50.05	2.93
Δlfr	2	5.09	0.58	0.03	1.13	0.70	92.46
	4	7.17	0.81	0.37	4.95	1.31	85.39
	8	7.20	2.58	1.88	8.66	1.46	78.23
	12	7.38	2.66	2.08	8.69	1.59	77.60
	16	7.41	2.67	2.19	8.72	1.62	77.38
	20	7.43	2.67	2.30	8.71	1.64	77.24

Notes: 1. Ordering of the variables is Dlfr, Dlp, Dbr, Dltc, Dls, and D lcr.
2. Entry (i,j) is the percentage of forecast error variance of variable i at different quarters attributable to innovations in variable j.

Appendix E: Impulse responses from the reduced form VAR model

Type of lfr inno-vation	horizons/ Quarters	Dlp	Dls	Dbr	Dltc	Dlcr	D
L_p	2	0.0045	0.0006	0.6030	0.0218	-0.0078	-0.0228
		(0.0020)	(0.0035)	(0.2270)	(0.0133)	(0.0074)	(0.0138)
	4	0.0000	-0.0002	0.3243	0.0137	0.0109	-0.0019
		(0.0025)	(0.0036)	(0.2841)	(0.0166)	(0.0079)	(0.0143)
	8	-0.0009	-0.0007	-0.1243	0.0029	0.0079	-0.0016
		(0.0029)	(0.0033)	(0.2830)	(0.0138)	(0.0080)	(0.0123)
	12	0.0003	0.0009	0.1526	0.0003	0.0046	-0.0002
		(0.0031)	(0.0031)	(0.2777)	(0.0124)	(0.0065)	(0.0099)
	16	-0.0005	-0.0001	-0.0782	0.0000	0.0038	0.0019
		(0.0040)	(0.0033)	(0.2869)	(0.0108)	(0.0070)	(0.0099)
	20	0.0002	0.0005	0.1026	-0.0010	0.0017	0.0000
		(0.0046)	(0.0038)	(0.3347)	(0.0118)	(0.0064)	(0.0109)
L_p	2	-0.0007	0.0044	0.0260	-0.0274	-0.0002	-0.0077
		(0.0019)	(0.0031)	(0.2241)	(0.0114)	(0.0056)	(0.0120)
	4	-0.0021	-0.0014	-0.1558	-0.0070	0.0034	0.0048
		(0.0015)	(0.0023)	(0.1997)	(0.0121)	(0.0045)	(0.0111)
	8	-0.0019	-0.0014	-0.0226	-0.0084	0.0027	-0.0012
		(0.0018)	(0.0022)	(0.2006)	(0.0105)	(0.0042)	(0.0085)
	12	-0.0006	0.0007	0.0243	0.0004	0.0008	0.0031
		(0.0016)	(0.0023)	(0.1628)	(0.0089)	(0.0040)	(0.0068)
	16	-0.0007	0.0000	-0.0299	-0.0003	0.0011	0.0010
		(0.0019)	(0.0024)	(0.1781)	(0.0090)	(0.0037)	(0.0010)
	20	-0.0002	0.0003	0.0225	-0.0002	0.0006	0.0000
		(0.0024)	(0.0030)	(0.1982)	(0.0106)	(0.0033)	(0.0058)
L_{br}	2	0.0047	0.0030	0.2028	-0.0106	-0.0109	-0.0018
		(0.0018)	(0.0033)	(0.2424)	(0.0131)	(0.0071)	(0.0106)
	4	-0.0019	0.0004	-0.4043	-0.0066	0.0026	0.0041
		(0.0017)	(0.0033)	(0.2450)	(0.0137)	(0.0073)	(0.0134)
	8	-0.0010	-0.0021	0.3198	0.0045	0.0023	-0.0022
		(0.0016)	(0.0025)	(0.2684)	(0.0109)	(0.0050)	(0.0107)
	12	-0.0002	0.0011	-0.1706	-0.0046	-0.0015	0.0024
		(0.0017)	(0.0020)	(0.2835)	(0.0097)	(0.0053)	(0.0085)
	16	-0.0008	-0.0008	0.0573	0.0027	0.0015	-0.0004
		(0.0014)	(0.0019)	(0.3056)	(0.0092)	(0.0058)	(0.0069)
	20	0.0001	0.0006	-0.0047	-0.0016	-0.0007	0.0005
		(0.0017)	(0.0020)	(0.3411)	(0.0087)	(0.0067)	(0.0066)
L_{tc}	2	-0.0008	0.0072	-0.1828	-0.0263	0.0084	0.0107
		(0.0020)	(0.0028)	(0.2591)	(0.0136)	(0.0070)	(0.0151)
	4	0.0004	-0.0003	-0.0782	-0.0156	-0.0033	-0.0127
		(0.0019)	(0.0035)	(0.2514)	(0.0160)	(0.0061)	(0.0133)
	8	0.0002	0.0019	-0.0439	0.0070	-0.0002	0.0030
		(0.0019)	(0.0027)	(0.2327)	(0.0121)	(0.0046)	(0.0109)
	12	0.0002	-0.0001	0.0544	0.0011	-0.0004	-0.0008
		(0.0017)	(0.0019)	(0.2124)	(0.0107)	(0.0043)	(0.0082)
	16	0.0000	0.0002	-0.0546	-0.0008	0.0001	-0.0008

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		(0.0014)	(0.0014)	(0.1961)	(0.0086)	(0.0045)	(0.0080)
	20	0.0001	0.0000	0.0378	0.0013	-0.0001	0.0002
		(0.0012)	(0.0016)	(0.2237)	(0.0091)	(0.0061)	(0.0066)
L_{cr}	2	0.0012	0.0040	0.2386	-0.0145	-0.0081	-0.0085
		(0.0016)	(0.0027)	(0.2304)	(0.0108)	(0.0059)	(0.0119)
	4	-0.0029	0.0020	-0.0628	0.0046	0.0070	-0.0012
		(0.0018)	(0.0031)	(0.2459)	(0.0142)	(0.0069)	(0.0128)
	8	-0.0023	-0.0005	-0.0677	0.0018	0.0047	-0.0008
		(0.0020)	(0.0025)	(0.2395)	(0.0126)	(0.0056)	(0.0098)
	12	-0.0007	0.0006	0.0932	0.0032	0.0022	0.0002
		(0.0016)	(0.0018)	(0.2003)	(0.0103)	(0.0055)	(0.0073)
	16	-0.0007	0.0002	-0.0776	0.0005	0.0014	0.0015
		(0.0018)	(0.0019)	(0.1822)	(0.0076)	(0.0057)	(0.0060)
	20	-0.0003	0.0000	0.0489	0.0001	0.0011	-0.0004
		(0.0020)	(0.0016)	(0.1980)	(0.0066)	(0.0057)	(0.0066)
L_{fr}	2	0.0010	0.0045	-0.2504	0.0319	0.0012	-0.0155
		(0.0020)	(0.0035)	(0.2888)	(0.0150)	(0.0076)	(0.0135)
	4	-0.0007	-0.0030	0.0557	-0.0183	0.0047	-0.0052
		(0.0020)	(0.0038)	(0.2676)	(0.0157)	(0.0085)	(0.0154)
	8	-0.0012	-0.0007	-0.1058	0.0004	0.0004	0.0078
		(0.0022)	(0.0026)	(0.2758)	(0.0139)	(0.0066)	(0.0117)
	12	-0.0007	-0.0008	0.1241	-0.0022	0.0006	-0.0015
		(0.0020)	(0.0018)	(0.2129)	(0.0100)	(0.0046)	(0.0089)
	16	-0.0004	0.0005	-0.0952	-0.0012	0.0000	0.0018
		(0.0021)	(0.0015)	(0.2303)	(0.0086)	(0.0042)	(0.0073)
	20	-0.0004	-0.0003	0.0557	0.0013	0.0006	-0.0001
		(0.0023)	(0.0015)	(0.2218)	(0.0074)	(0.0051)	(0.0066)

Notes: 1. Ordering of the variables is Dlfr, Dlp, Dbr, Dltc, Dls, and D lcr.
2. Entry (i,j) is the dynamic response of variable j to a one standard deviation shock in variable i.
3. The figures in parentheses are the standard errors.

Appendix F: List of variables

D = Change in a variable
l = Logarithmic value
s = Nominal exchange rate
fr = Foreign exchange reserves
cr = Domestic credit
br = Bank rate
p = Domestic price level
tc = Terms of trade of cocoa
tg = Terms of trade of gold
v = Income velocity
m_{2T} = Targeted growth rate of M2
m_{2A} = Actual growth rate of M2
m_3 = Growth rate of M3
g = Government expenditure
pet = Price of petrol
id = Ratio of repayment of principal and interest on outstanding international debt to reserves
Ec = Error correction term
e = Unanticipated shock

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