DEMAND FOR MONEY IN GHANA

A COINTEGRATION AND ERROR CORRECTION APPROACH AND COMPARISON OF ALTERNATIVE MODELS

By

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DEMAND FOR MONEY IN GHANA

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SESI K. AKOENA

A Thesis/Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

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ABSTRACT

The method of cointegration and error-correction modeling has provided economists with a new approach to exploring the economic relationship between the demand for money and its determinants. The stability of this relationship is a crucial requirement in the formulation of monetary policy. Most of the initial studies, however, focused on the developed countries. This study is an attempt to apply the approach to a developing country, namely, Ghana. Employing unit root tests and Johansen maximum likelihood multivariate cointegration analysis, the study found that despite very erratic and *ad hoc* monetary policy, unstable growth and high inflation, a stable long-run money demand function could be identified with the long-run path being driven by output and inflation. The study develops a dynamic specification for money demand which quite closely tracks actual movements of money holdings around the long-run equilibrium path. Money demand functions are also estimated for Canada but in a number of aspects, the level of detail provided is on a more limited scale compared to that for Ghana.

For comparative purposes, the study estimates two other alternative forms of money demand, namely, the conventional partial adjustment model and a buffer stock model. Mixed results are obtained with regard to the performance of the models. Whereas the error-correction model performs best in terms of statistical tests, the buffer stock model yields the best results in terms of forecasting performance- especially for Canada.

A comparison of the cointegration and error-correction results for Ghana to the results obtained for Canada using similar analysis indicates that though the stability properties for the models are quite comparable for the two countries, the parameters of broad money (M2) demand for Ghana have been relatively more stable than the parameters of the broad money demand relationship for Canada.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1: PURPOSE OF STUDY

The basic purpose of the study is to estimate a money demand function for Ghana using the cointegration and error-correction approach. For comparative purposes however, two other alternative forms of money demand equations will be estimated, namely, the conventional partial adjustment model and the buffer stock model. To assess the validity of the model, various diagnostic and stability tests will be performed including tests using recursive residuals and an examination of the within-sample and post-sample properties of the models. A limited comparison will also be made with a similar analysis for the Canadian money demand function. As a background to our econometric analysis, the study will review monetary institutions and monetary policy in Ghana over the period covered by the study.

1.2: THE PROBLEM AND STUDY OBJECTIVES

The existence of a stable and predictable relationship between monetary aggregates and other economic variables such as prices, real income and interest rate is a crucial element in the formulation of monetary policy. Monetary policy of any sort or under any rule is futile if the demand for money is not relatively stable (Coats, 1980). It is therefore not surprising that "the money demand function has been one of the most extensively investigated relationships in the (economic) literature" (Leventakis & Brissimis, 1991). However, "Despite intensive analytical and empirical efforts, there is no general consensus concerning the stability (or instability) of money demand functions." (Andersen, 1985).

Up until the mid-1970s, there seemed to be the consensus that the demand for money was linked in a stable way to a small number of determinants such as output and the rate of interest. Though most of these studies were carried out in the developed countries, a substantial number of studies were also carried out in the developing countries and by and large the consensus that emerged about stable money demand functions for developed countries was carried over to developing countries. For example, Adekunle (1968) investigated the money demand function in a number of developed and developing countries and concluded that the theoretical relationships developed to explain monetary behavior and conclusions based on interpretation of monetary experience in the developed economies are applicable to other types of economic environment. Coats and Khatkhate (1980) noted that "the increasingly plentiful empirical estimates of the demand for money in less developed countries generally support the hypothesis of its stability, i.e. predictability. The functions estimated are basically the same as those in wide use in the developed countries with adjustments for special institutional factors or data limitations in the particular country being investigated." Coats (1980) further states that "Few if any economic judgments are as thoroughly documented as the stability of the demand for money. The demand for money has been found highly stable for virtually every country, developed or not, for which adequate data is available."

Statements such as the last one are obviously misplaced since by the mid-70s, doubts began to emerge on the stability of the money demand function in the developed countries. In the UK, Hache (1974) found that his estimated equations severely underestimated UK broad money aggregate, M3. Subsequent studies by Artis and Lewis (1974), Coghlan (1978) and Rowan and Miller (1979) essentially confirmed the above result even though these studies also indicated that it is possible to obtain stable demand functions for M1 by using more complex lag structures. Although there were some criticisms of some of the studies the balance of evidence was such that the question of stability in the UK money demand was, at best, less than completely resolved.

According to Thomas (1985) doubts about the stability of the UK money demand function coincided with similar doubts about the stability of the US money demand function. In contrast to the UK situation however, in the US, instability has occurred in the demand for narrow rather than for broad money. In particular existing money demand models were shown to have overpredicted money balances, a feature that has come to be known as the mystery of the missing money. The failure of money demand models to predict money balances accurately continued into the period after 1981 although this time the models were now underpredicting money balances (Leventakis and Brissimis, 1991). Even though Laidler (1980) and others succeeded in obtaining shifts that were less dramatic than those obtained by earlier workers such as Goldfeld (1976) and Enzler et al. (1976), by and large, the problem of the stability of the money demand function again remained largely unresolved and for a long time. For example, Hendry and Ericsson (1991) observe that "Despite its importance for inference, forecasting and policy, empirical parameter constancy (for the money demand function) has proved illusive."

The development of the method of cointegration and error correction modeling has presented economists with a new approach to analyzing this all important relationship. Standard econometric techniques largely estimate equilibrium relationships derived from economic theory and stationarity of variables which is required for an equilibrium relationship to exist was often taken for granted. "Cointegration has evolved from the long-recognized knowledge that with stochastic trends in economic variables, the usual techniques of regression analysis can result in misleading inferential conclusions" (Darnell and Evans, 1990). Since the advent of this approach, there has been a myriad of studies employing the approach in the study of the money demand function in the industrialized countries. Examples of such studies include those by MacDonald and Taylor (1992), Mehra (1992), McNown and Wallace (1992), Baba, Hendry and Starr (1992), Hoffman and Rasche (1992), Mehra (1991), Boughton (1991), Grivoyannis (1991), Hendry and Ericsson (1991). A predominant number of these studies seem to have adequately accounted for phenomena which previous studies could not adequately explain and the view is slowly re-emerging that stable money demand functions can indeed be identified.

1.21: THE PROBLEM

Despite the increasing application of the cointegration and error correction approach to the money demand function in the industrialized countries, there has been a dearth of such studies on developing countries. Yet the studies which originally led to the view that stable demand for money functions exist for both developed and developing economies were based on the conventional econometric techniques which we now know may result in spurious correlations and misleading inferences. It is therefore only logical that the new methods of analysis now being used should also be applied to developing countries. This study is an attempt in this direction.

1.22: OBJECTIVE OF THE STUDY

Following from the above discussion, the basic objective of the study is to apply the cointegration and error correction approach in investigating the money demand function for Ghana. The basic hypothesis to be tested is that a stable demand for money function exists. The performance of alternative forms of the money demand function will be compared and several diagnostic as well as stability tests will be performed. The results obtained for the Ghanaian money demand function will be compared with the results of a similar analysis for Canada. It should be emphasized, however, that the focus of the study is Ghana and therefore that in a number of aspects, there will be much less information and discussion on Canada as compared to Ghana.

1.3: ORGANIZATION OF THE THESIS

Following the introduction in chapter one, chapter two reviews monetary policy and monetary institutions in Ghana over the period covered by the study. This is followed in chapter three by a description of the data used in the study and an examination of their time series properties. In particular, the unit root characteristics are examined to determine the degree of integration of the various variables. This is important for the cointegration analysis that is carried out later in the study.

In chapter four, we carry out a review of the literature. The scope of this review is, needless to say, limited - in view of the large volume of studies on the demand for money. However, considerable attention is paid to the buffer stock model. The chapter ends with a review of previous studies on money demand in Ghana. Chapter five focuses on the econometric methodology, in particular the concept of cointegration. Here we review the two-stage Engle-Granger approach but, especially, the Johansen multivariate approach - the principal econometric approach used in the study. Chapter six presents the results of the cointegration and error correction analysis for both Ghana and Canada while chapter seven investigates the stability properties of the models so estimated. Implications of non weak exogeneity of the right hand side variables in the error correction equations are discussed and tested leading to an alternative estimation of the error correction equations for Ghana using instrumental variables.

Chapter eight reports the results of the partial adjustment and buffer stock models of money demand and follows this with a comparison of the three models estimated in the study, namely the cointegration and error correction model, the partial adjustment model and the buffer stock model. In chapter nine we provide a conclusion.

CHAPTER TWO

MONETARY INSTITUTIONS AND MONETARY POLICY, 1961-1990

In this chapter, we review monetary institutions and monetary policy in Ghana over the period covered by the study.

2.1: THE MONETARY SYSTEM, 1961-1983.

The first banking operation in Ghana dates back to the last decade of the nineteenth century when the Elder Dempster Shipping Company of the United Kingdom entered the banking business and established the British Bank of West Africa in March 1894, a branch of which it opened in the then Gold Coast (now Ghana) in 1897 (Howard, 1978). However, it was not until 1st March, 1957 - on the dawn of the attainment of political independence - that a central bank- the Bank of Ghana was established. Previous to that Ghana operated on the Sterling Exchange Standard (SES) in which responsibility for issuing currency for all British West African colonies was assigned to the West African Currency Board (established in 1912). An important feature of this standard was that the currency, the West African pound, was completely guaranteed a full and free convertibility into the British pound sterling. This meant that the local currency was not different from the Bank of England fiduciary issues. This fact in conjunction with the way that the banks operated had an important implication. The banks had collateral requirements similar to what existed in Britain (stock certificates, shares, insurance policies etc.) before granting loans. Since most local businesses did not have such collateral there was very little credit advanced to local businesses. The banks were therefore virtually deposit institutions and accumulated excesses. Since the system also prevented the growth of local interest bearing assets which banks could use as investment, accumulated funds were transferred overseas. This constituted resource transfer from the domestic economy to the United Kingdom.

Yet another feature of the SES was that the Currency Boards were required to maintain a 100% cover of their currency liabilities. They issued currency against sterling presented by the banks and redeemed it again when the banks wished to increase their sterling holdings. The money supply was tied to changes in the external assets in general and in particular to the balance of payments. The exercise of this jurisdiction was an extremely tight monetary control in which the money supply was allowed to expand only when there was a current account surplus. This hindered the process of monetization of the domestic economy. The monetary system proved too rigid to accommodate the rapid expansion of the economy as a whole and in particular the internal exchange sector (Killick, 1966). The colonial currency system was therefore ill-adapted to the needs of the economy it served. By creating monetary tightness the system impeded the diversification of the economy. The progress of the economy was geared to the maintenance of a healthy balance of payment.

With the attainment of political independence, a central bank- the Bank of Ghana- was established to take over the functions of the West African Currency Board. Among the functions of the central bank was the issue of currency and regulation of the financial system and most importantly, the establishment of a framework for independent monetary management. In this regard an important step was the Bank of Ghana Ordinance in 1957. The ordinance empowered the bank to create a fiduciary issue up to a maximum of 12 million Ghana pounds. Nonetheless the central bank continued to back its currency liabilities by 100% sterling until April 1961 when it created the first fiduciary issue by using Ghana government treasury bills. Two months later the second fiduciary issue was created by the use of Ghana government stocks. In September 1963, there was the redefinition of currency cover to include Ghana government treasury bills and securities, commercial bills of exchange and certain categories of securities of governments other than the government of Ghana. In October, 1963 the inland cocoa bill scheme involving the creation of a 3 month bill for cocoa financing was introduced (Ahmad, 1970). The inland cocoa bill was also to be used as a currency cover. These changes meant that the money supply could now be expanded by the acquisition of domestic assets also. As expected, the banks increased their volume of local earning assets such as Ghana government treasury bills. They also greatly expanded their activity in granting domestic credit. With these changes, it became possible to accelerate the growth in the money supply and reverse the downward trend in the ratio of money supply to national income. The adaptation of the monetary system made possible a high level of economic activity and permitted economic growth to proceed despite a rapid decline in the country's external reserves (Killick, 1966). The monetary system no longer acted as a drag on the attempt to diversify the economy since it was no longer intimately linked with the external balance.

But as was soon discovered, this freedom of action was a two-edged sword the undisciplined use of which would result in dire consequences. The leaders of the new nation embarked on an ambitious program of capital and social investment, all too eager to make up for "lost time" during the colonial administration. Foreign reserves were quickly run down and there was recourse to external borrowing. The external debt rose sharply. The government reacted by imposing price and import controls. When cocoa prices softened in 1965 necessitating a still sharper reduction in the import of consumer goods not even domestic price controls could stem the tide of rapidly rising prices. This, coupled with political discontent, led to a military coup in February 1966.

The decade and a half following 1966 was a period of considerable political instability and *ad hoc* economic policies, both monetary and otherwise, sometimes with more or less careful monetary management but other times with all caution thrown to the wind. First, the military government that followed the 1966 coup, on the advice of the International Monetary Fund, implemented an orthodox disinflationary fiscal and monetary policy. There were cuts in public sector investment and hence a reduction in the budget deficit. A 43% devaluation in conjunction with a cautious liberalization was implemented aimed at eventually abolishing import and price controls. Emphasis was placed on private enterprise and strenuous efforts were made to secure external aid.

The civilian government that followed the military regime in 1969, on the other hand, ranked economic growth above stability in its scheme of priorities. Aided by a cocoa price boom it embarked on expansionary fiscal and monetary policies coupled with an accelerated program of liberalization which however failed to substitute market rationing for administrative restrictions. There was a massive import boom especially of consumer goods and an enormous increase in commercial bank credit to the private sector to finance these imports. The central bank sought to hold down the pace of credit expansion by directives and by large mandatory liquidity ratios but this was largely ignored. The cocoa price rise did not last for long and within two years of the initial boom the country was facing the second highest balance of payments deficit in its post-independence history. The government responded with a massive devaluation in which the domestic currency was devalued from 1.02 cedis to the U.S. dollar to 1.82 cedis per U.S. dollar in December 1971. The subsequent rise in prices served as a camouflage for another military takeover in January 1972.

Despite professing loudly that mismanagement of the economy by the previous civilian administration was one of the major reasons for its overthrow of constitutional government, the period 1972-79, during which the military regime was in power, witnessed a complete breakdown of monetary discipline (within a wide spectrum of misrule). There were large budget deficits financed through borrowing from the Bank of Ghana. The growth in net credit to government accelerated and by 1978 the budget deficit rose to 127% of total revenue. Despite bottlenecks which have bedeviled almost all sectors of the economy, money supply grew sharply during the year. For example, over the twelve month period to the end of June 1978, the level of currency issued by the bank rose by 902.7 million cedis or 110% (compared to a rise of 273.9 million cedis or 50.1% in the previous year). The rise was due almost entirely to an increase in currency notes in circulation. With excess liquidity in the banking system, the main banks found it unprofitable to continue to accept deposits given that there was a limit on the amount of credit they were allowed to grant, limits on maximum bank lending rates as well as minimum bank term deposit rates. Not surprisingly the rate of inflation which was 9.7% in 1972 rose steadily to 116% by 1978.

The high inflation coupled with acute shortage of imported consumer goods led to a large demand for nominal cash balances for speculative buying and selling of goods. Price controls were in operation but were generally effective only at the official sources of supply where sales were however made only occasionally. Anyone who was lucky to be at the right place at the right time or who had the right connection and "ready money" stood the chance of obtaining substantial quantities of these commodities which could then be resold at a large profit. Thus currency notes were hoarded in anticipation of such speculative purchases and other financial contingencies. There then followed a set of drastic economic measures designed to redress the excesses of the past. In March 1979, the government decided to mop-up excess currency by changing cedi notes. This action was aimed at only those with cash outside the banking system and was ostensibly aimed at stifling smuggling activities and currency parallel markets. People with amounts not exceeding 5,000 cedis received back 70% while those with amounts above 5000 cedis got back only 50%. Although the situation slightly improved, a two-year episode of civilian administration between December 1979 and December 1981 again witnessed a complete lack of monetary control so that when the military intervened again in December1981, two additional actions again had to be taken. The first action, allegedly targeted the "dubious social elements." All individuals with amounts over 50,000 cedis in their bank accounts were vetted. Also all personal bank accounts of 50,000 cedis or more were frozen pending submission of evidence that tax obligations had been met. There is no doubt that this action violated secrecy concerning client transactions and undermined public confidence in the banking system. The second was the demonetization of 50 cedi currency notes (at that time the largest denominated note in circulation). The withdrawn monies were not paid back until 1987.

2.2: STRUCTURE OF THE FINANCIAL SECTOR

The financial system in Ghana and most other developing countries is dichotomized into two sectors usually referred to as the formal and informal sectors. The formal sector consists of the institutional banking system and other organized monetary institution. Any financial sector which does not belong to the formal sector can be considered as belonging to the informal sector.

The non-formal financial sector consists of a number of credit unions, savings and loans institutions and the "susu" system. The latter consists of groups of individuals that engage in the collection and redistribution of financial savings. In a *rotating susu* system a number of people (e.g. colleagues at a government office) place an agreed amount of savings into a pool when they receive their wages or salaries. One member of the group (determined through some agreed process, e.g. by casting lots) receives the full lump sum. The process continues until each member receives this lump sum payment. The cycle may then be repeated. In the *single collector susu* system, a collector visits shops, work places, market stalls etc. at fixed times each day or period and collects funds from individuals or groups who want to contribute towards a savings plan. The deposits are returned to the contributor after an agreed period of time (e.g., a month) less an agreed sum. In some cases, the saver, may, in terms of emergency, demand her money earlier than agreed. In the interim period the susu collector (usually) deposits any money collected with a bank but withdraws it in full for repayment at the end of each cycle.

Little information is available on the operations of the informal sector although Killick (1966), for example, provides a brief account of this sector in the 1960s. The general view is that this sector has always been very significant in Ghana's financial system. Contrary to popular believe that the informal sector declines in importance with time, Aryeettey and Gockel (1991) found that between 1976 and 1984 the informal sector grew at the expense of the formal sector as a result of general economic malaise and in particular as a consequence of repressive financial policy by successive governments. They also found that although there does exist some linkage between the formal and informal financial credit market, this linkage is largely limited to the channeling of savings mobilized by "susu" collectors to the commercial banks. The authors note that "the very limited extent of competition between formal and informal credit suppliers ..... does not help borrowers to improve their welfare by negotiating on the two markets and therefore denies them access to well-priced investable funds." In their study, Aryeetey and Gockel also investigated the relationship between banks and money lenders in a very limited way. Out of twelve money lenders they interviewed in their study, eleven had contact with the banks. Of these, eight saved with banks and had actually borrowed money from them before. "They maintained, however, that it was not easy to obtain credit from the banks. They also insisted that such credit was usually to promote their business, other than lending. Only two said credit from banks was used to promote their lending business." (Aryeettey and Gockel, 1991). As observed by the authors "this is a link between the formal and informal financial sectors that requires further investigation....." The general impression is that there is very little movement of money from banks to private money lenders mainly because private lenders are generally quite unsophisticated compared with other individuals and business firms with whom they have to compete for the limited credits that the banks are allowed to give.

The structure of the formal financial sector is well summarized by the following section in the 1992 Annual Report of the Bank of Ghana:

"The structure of the banking system remained unchanged during the period under review. It consisted of the Central Bank, deposit money banks and rural banks. The details were as follows:

1. Central Bank: Bank of Ghana

2. Deposit Money Banks

   Commercial Banks: i. Standard Chartered Bank

   ii. Barclays Bank of Ghana

   iii.Ghana Commercial Bank

   iv. Social Security Bank

v. National Savings and Credit Bank

vi. Bank of Credit and Commerce

vii. Meridien BIAO Bank

Development Banks: i. Agricultural Development Bank

ii. National Investment Bank

iii. Bank for Housing and Construction

Merchant Banks: i. Merchant Bank (Ghana) Limited

ii. Continental Acceptances Limited

iii. Ecobank Limited

Cooperative Bank: Ghana Cooperative Bank

3. Rural Banks: 123 Rural Banks

Two Discount Houses, the Consolidated Discount House Limited and the Securities Discount Company Limited and the Ghana Stock Exchange which commenced operations in November 1990 complete the formal financial sector".

The three large chartered banks, namely, the Standard Chartered Bank, the Barclays Bank of Ghana and the Ghana Commercial Bank each operate branches in several parts of the country while all the other banks engage in more limited operations being in many cases specialized institutions.

The rural banks were opened between 1977 and the early 1990s as a result of deliberate policy by the Bank of Ghana to extend banking practices and banking habits to the rural communities.

The Consolidated Discount House was set up in November 1987 in order to enhance the development of the domestic money market. It is owned by a consortium of domestic banks and insurance companies. The second discount house, the Securities Discount House was set up in June 1991 with the assistance of the International Finance Corporation. The discount houses accept money repayable at very short notice (mostly at call) from financial institutions mainly to finance government paper. In fact they are required to hold at least 70% of their assets in short-term paper. It is also required that their borrowing not exceed 25 times their capital and reserves.

The non-bank financial sector consists mostly of a number of insurance companies including the Social Security and National Insurance Trust (SSNIT), which is a state owned institution responsible for receiving social security contributions and making social security payments.

Of more immediate relevance to this study however is the operation of the financial system between the 1960s and the beginning of the 1990s. On the whole monetary management between 1960 and early 1980s was very suspect with direct intervention instruments such as direct credit control, reserve requirements and interest rates, which were fixed for long periods of time and only occasionally changed, as the only instruments of control. With respect to credit, the central bank relied on direct credit control involving the imposition of ceilings both globally and sectorally. Each year the Bank of Ghana estimated the annual credit requirements of the economy it deems consistent with its macroeconomic targets such as economic growth, inflation and the balance of payments. The programmed national credit was allocated between the government and non government sectors. Within the global ceilings, sectoral allocations were made on the basis of the specific needs of every sector as perceived by the Bank. Each bank was told at the beginning of the financial year, how much lending it could do in total as well as to each sector of the economy.

These direct credit controls were largely ineffective in checking monetary growth and inflation because bank credit to government far exceeded what was earmarked under the banks credit program, thus disrupting the whole monetary program. On the other hand the credit ceilings put restraints on the commercial banks capacity to lend thus limiting their investment avenues. Meanwhile the high reserve requirements (see below) resulted in high cost of mobilized funds to the banks with the result that it was not uncommon for banks to refuse to take deposits from the public. This was due to the credit ceiling and limits on maximum bank lending rates coupled with minimum bank term deposit rates.

Reserve requirements were also used, more or less as a quasi-direct instrument of intervention. For purposes of restraining credit expansion, in spite of credit ceilings, reserve ratios were raised beyond their justified prudent levels, with the minimum total reserve requirements reaching more than 50% by 1983 (Kwakye, 1994).

Interest rate policy consisted of administratively determined interest rates. Because the government was a major borrower from the banking system, interest rates were set low to avoid overburdening the budget. The central bank fixed the bank rate and then required the chartered banks to adjust both their deposit and lending rates. Deposit rates in particular remained substantially negative in real terms thus discouraging savings. Meanwhile the artificially low rates encouraged the inefficient use of scarce resources.

Exchange rate policy fared no better. There was a fixed exchange rate regime with occasional adjustments in the exchange rate usually through devaluation. From 1950 to early 1966, the exchange rate was fixed at 0.71 cedis to the (U.S.) dollar. After a number of occasional devaluations but also with one revaluation, the rate rose to 1.02 cedis to the dollar between 1968 and 1971, to 1.15 cedis to the dollar between 1972 and 1977, to 1.51 cedis per dollar in 1978 and finally to 2.75 cedis to the dollar between 1978 and April 1983 when the Economic Recovery Program was launched. The system as operated resulted in a grossly overvalued exchange rate that shifted relative incentives away from exports into import trade and caused a perpetual exchange rate crisis.

The above discussion clearly shows that throughout most of the period, the economy was poorly managed. The economy was pedaled into a viscious circle of large budget deficits, high inflation, an overvalued exchange rate, acute shortages and a pervasive system of controls that discouraged productive activities and led to a drop in economic activity. An erosion of the tax base due to declining exports and imports and the drop in economic activity led to a marked deterioration in the economic and social infrastructure. Things came to a head in the early 1980s with the surfacing of three other problems. First, in 1982, came the severest drought in half a century that reduced local food production to extremely low levels. Second, came a substantial fall in the price of the major imports- cocoa and gold. Thirdly, about one millions Ghanaians were repatriated from Nigeria which was itself experiencing difficulties on account of the ending of its oil boom thus increasing the population by about 8% in just a few weeks. The cumulative effect of the downward economic spiral and these "shocks" to the system can be seen in the fact that between 1970 and 1982 "per capita real income declined by 30%; import volumes fell by a third; real export earnings fell by 52% ; domestic saving and investment declined from 12% and 14% of GDP respectively in 1970 to almost insignificant levels; and inflation averaged 44% " (World Bank, 1987). Appendix 3 provides selected indicators.

2.3: THE ECONOMIC RECOVERY PROGRAM, 1983.

Faced with the eminent collapse of the economy, the socialist dogmas of the military leaders and their civilian collaborators underwent a 180 degree turn and recourse was sought from the International Monetary Fund (IMF). In August 1983, the IMF finally approved a standby and compensatory financing facility of 382 million cedis. Other donors followed and this began a process of structural adjustment - embodied in what has officially been called The Economic Recovery Program (ERP) - which has "the ultimate goal as the creation of a growth-oriented competitive, efficient and integrated economy." (Loxley, 1988) The main thrust of the ERP included restoration of fiscal and monetary discipline, a realignment of relative prices to encourage productive activities and exports, a strengthening of economic incentives, a progressive shift away from direct controls toward greater reliance on market forces and structural and institutional reforms to enhance the efficiency of the economy.

Monetary management under the ERP involved a phased introduction of liberalized monetary management culminating in institutionalization of a market-based system of monetary management in early 1992. Initially (1983-86) monetary policy was primarily directed at regaining control of credit expansion by the banking system, particularly to the Government, through restrictive monetary and credit policy. Because of the state of the financial system at the time such as the limited availability of monetary instruments, the Bank of Ghana relied on quantitative controls in the form of ceilings on the net domestic assets of the banking system and net bank credit to the government, the Cocoa Board and other statutory corporations. Strict monetary discipline helped curb growth of money supply in 1984 and 1985. Reliance on bank financing by government became insignificant at 0.9% of GDP in 1984 and 0.8% of GDP in 1985. This and lower food prices decreased inflation which fell from 123% in 1983 to 40% in 1984 and 10% in 1985 despite strong devaluations.

Subsequently, the focus of monetary policy was broadened to encompass greater emphasis on the liberalization of controls and bank credit and a gradual shift from direct to an indirect system of monetary control . To this end, the limits on the maximum bank lending rates and the minimum bank term deposit rates were liberalized in February 1988. Similarly, the controls on the sectoral allocation of bank credit were abolished in February 1988 (November,1990 for the agricultural sector). The rate of growth in net domestic credit decelerated from 61% in 1985 to 13% in 1988, reflecting largely the continued improvement in government finances and, in particular, the switch to sizable net repayments by government to the banking system from 1987 onwards. However, there were large inflows of external concessional assistance and a stronger-than-expected improvement in the balance of payments. Difficulty in sterilization as a result of the undeveloped capital market in the face of increase in net foreign assets contributed to a rapid expansion in broad money supply until 1988. Although the growth in money supply decelerated from a peak of 72% in 1984 to 43% by the end of 1988, it exceeded the targets in the Government's monetary program and the growth in nominal GDP. This led to increased liquidity in the system and an increase in reserves of the banking system which together with binding credit ceilings then still in operation led the banks to reduce deposit rates thus further widening their margins. (Kanpur, 1991 p.43).

As a result of the failure of the monetary system to respond as expected to the liberalization of deposit and lending rates as well as the removal of controls on the sectoral allocation of credit, further policy and institutional reforms were made in late 1989. These include the phasing out of controls, rationalization of minimum cash and liquidity requirements, new financial instruments, open market operations at market yields to absorb excess liquidity and conversion of Bank of Ghana revaluation losses to long-term bonds. These set of actions led to the equivalent of 12.5% of broad money, M2, being sterilized over the 10 months up to September 1990 and a slow down in credit and monetary expansion. This was followed by a broader range of measures the most drastic of which was the increase in the discount rate from 26 to 35% and opening of the purchase of Bank of Ghana instruments (such as treasury bills and bonds) to the non-bank sector at rates that were higher than previous yield rates. With these newly created opportunities of high financial investment earnings, there was increased competition for deposits by the chartered banks and deposits and lending rates finally responded.

With respect to exchange rate management, the government committed itself to a flexible and realistic exchange rate policy. We noted earlier that from the 1960s up to April 1983, Ghana generally maintained a fixed exchange rate system with occasional adjustment in the exchange rate through devaluations and provided some details of the nominal exchange rate up to that period. Kanpur (1991, p.17) provides a good account of the exchange rate policy measures adopted since the onset of the ERP.

Beginning in April 1983 a series of exchange rate reforms were undertaken. First came a *de facto* devaluation of the cedi through the imposition of a system of import surcharges and export bonuses at rates of 750% to 990% thereby establishing a complex system of multiple exchange rates. In October 1983, the import surcharges and export bonuses were replaced with a unified exchange rate at 30 cedis per dollar. This was followed by a policy of periodic adjustment with the rate rising to 90 cedis per dollar by early 1986. In September 1986, a dual exchange system was established. The first tier, with the rate fixed at 90 cedis to the dollar applied to transactions involving cocoa, petroleum and official debt. In the second window, which applied to all other transactions, the rate was determined by supply and demand through a weekly foreign exchange auction by the Bank of Ghana. In February 1987 the official and auction rates were unified at the then prevailing rate of 150 cedis per dollar. Next, the parallel market for foreign exchange was absorbed, largely through the legalization of private foreign exchange bureau - in which private individuals, meeting specified criteria, were licensed to buy and sell foreign exchange. This brought into existence an exchange rate arrangement involving the coexistence of two spot foreign exchange markets. These two markets were segmented by the regulatory framework as forex bureau were not allowed to bid for foreign exchange in the weekly retail auction. Finally, in April 1990, Bank of Ghana began a wholesale foreign exchange auction and discontinued the retail auction. The wholesale auction is used by the Bank of Ghana to price and distribute foreign exchange to authorized dealers. All authorized dealer banks were eligible to participate in the wholesale auction as were any licensed forex bureau provided it met prescribed eligibility criteria. As a result, the foreign exchange auction and the forex bureau markets were unified. The authorized dealer banks and forex bureaus may purchase foreign exchange for their end-user customers and for their own needs.

Fiscal discipline is a major component of stabilization program. In the short run this is to be achieved by curtailing government recourse to the banking system and through expenditure cuts. Over the medium term fiscal policy aims at increased domestic resource mobilization. There was also a commitment to phased reduction of external payment arrears.

By the end of 1991, the ERP had laid the foundation for the development of a market economy. Prices have been decontrolled, the banking sector has been liberalized and a conducive environment has been created for private initiative and enterprise.

CHAPTER THREE

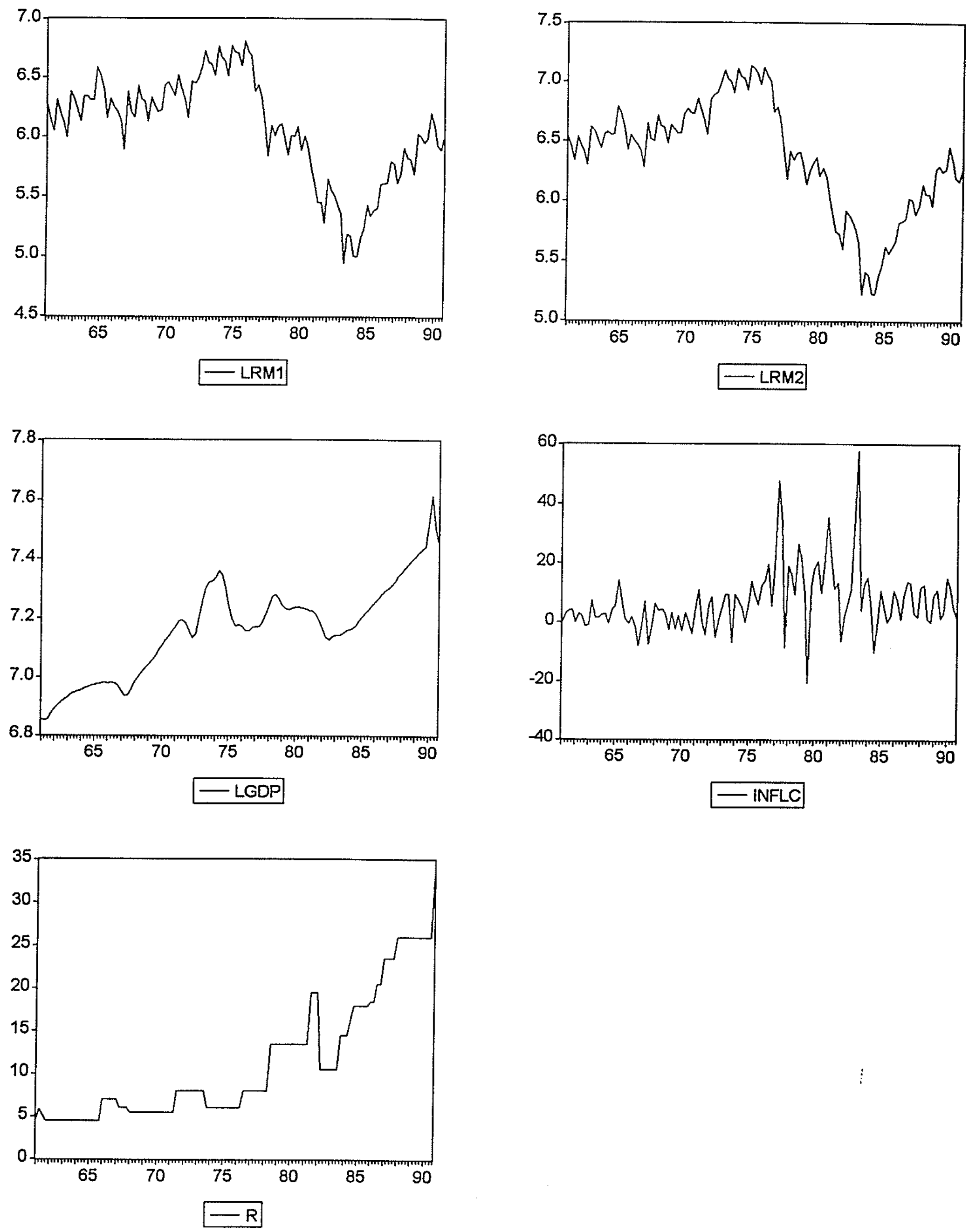
DATA USED IN THE STUDY AND THEIR TIME SERIES PROPERTIES

3.1: DATA USED IN THE STUDY

Quarterly data for the period 1961:1 to 1990:4 are used in the study. Data on narrow money - currency plus demand deposits (M1), broad money - M1 plus time and savings deposits (M2), the consumer price index and the official exchange rate as well as the discount rate are obtained from various issues of the International Financial Statistics (IFS) and the Quarterly Digest of Statistics published by the Ghana Statistical Services. The discount rate is used because it is the only interest rate available on quarterly basis over the period of the study. The consumer price index (1975=100) is used to deflate nominal money balances and to compute the rate of inflation. Data on real gross domestic product (GDP) also obtained from the IFS is available only on annual basis. Following Tegene (1992) we use the approach developed by Lisman and Sandee (1964) to derive quarterly values. Monthly data on the parallel exchange rate, obtained from Picks' Currency Yearbook, is used to compute quarterly values for the parallel exchange rate.

Figure 3.1 graphs the variables, all expressed in logs except for the interest rate and the rate of inflation. In the figure LRM1, LRM2 and LGDP represent the log of real narrow money, real broad money and real gross domestic product. INFLC and R represent the rate of inflation and the interest rate (both in percentages).

Fig. 3.1: Major Variables used in the Ghana Study



The graphs show that the money supply and inflation rate variables show no trends over time whereas the output and interest rate variables exhibit trends.

Figure 3.2: Variables for Canada

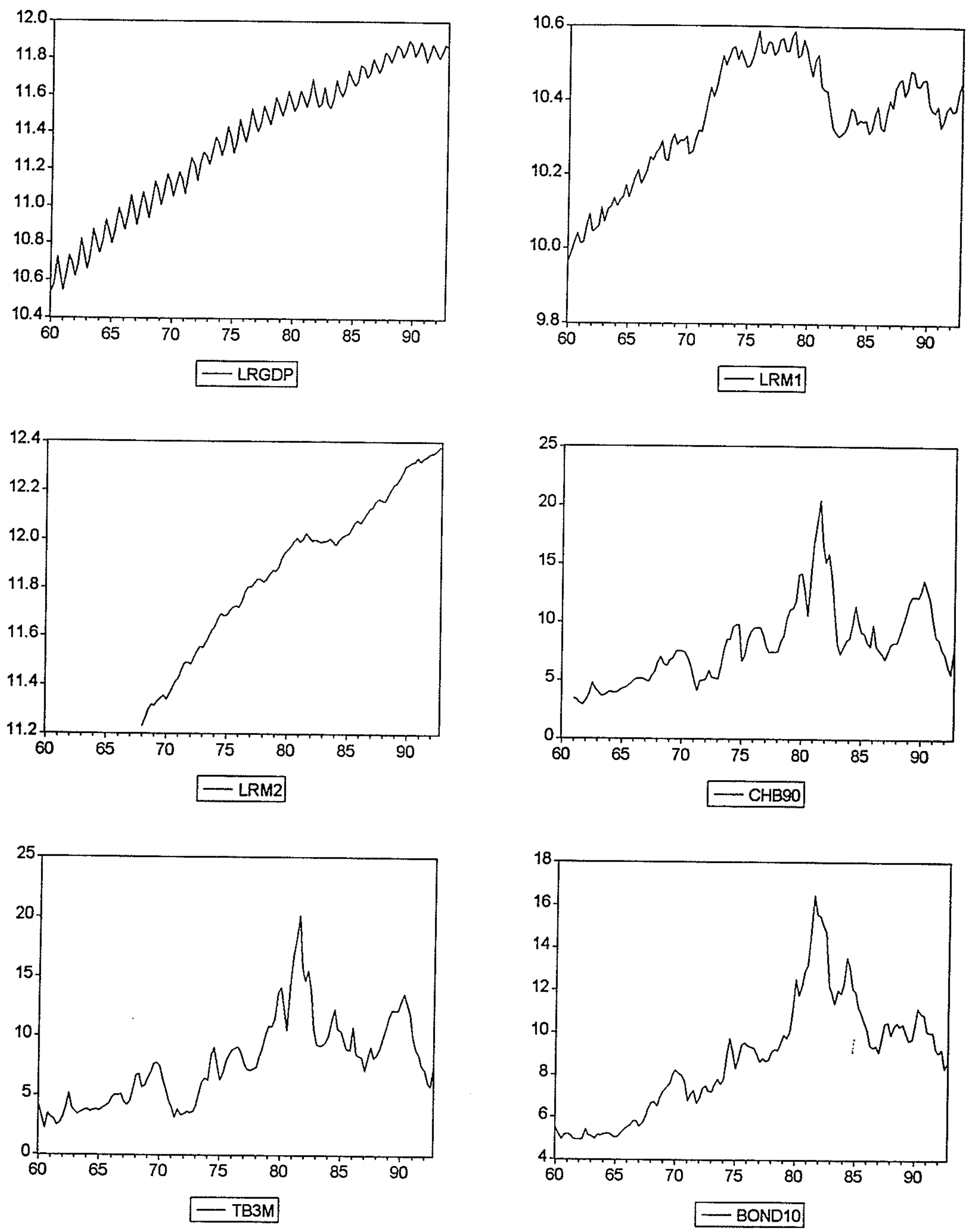


Figure 3.2 shows similar graphs for Canada for real M1, real M2 and real GDP (all expressed in logs) and three interest rate variables, CHB90 - the rate on 90-day chartered bank deposits, TB3M- the three-month treasury bill rate and BOND10- the rate on ten-year government bonds. It is clear that the log levels of the money stock and output variables exhibit clear trends over time. The Canadian data is extracted from the CANSIM data base and the base year for computing the real magnitudes is 1986.

3.2: UNIT ROOT PROPERTIES OF THE DATA

For the purpose of the cointegration analysis that will be carried out later in the study, it is important to investigate the stationarity properties of the data. Figure 3.3 shows the graphs of the first difference of the variables used in the (Ghana) study. It may be noted that the first difference of all the variables show no trend over time.

There are a number of approaches for testing for units roots but the most popular seem to be the Dickey and Fuller (DF) and the closely associated augmented Dickey-Fuller (ADF) as well as the Phillips and Perron (PP) tests.

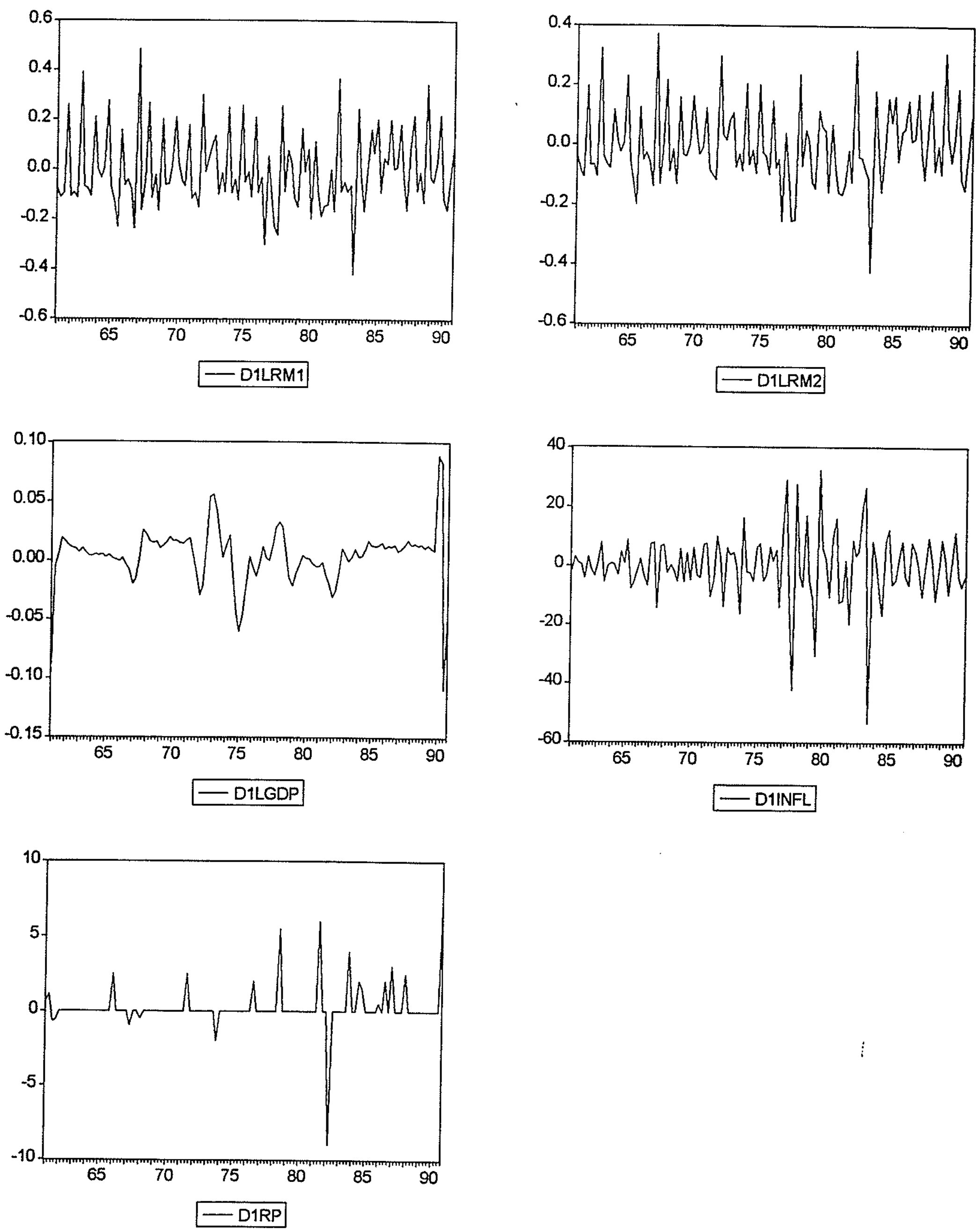
The ADF test involves running one of the following regressions:

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \Sigma\gamma_i \Delta X_{t-i} + e_t \qquad (3.1)$$

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 t + \Sigma\gamma_i \Delta X_{t-i} + e_t \qquad (3.2)$$

and testing the null hypothesis $\alpha_1 = 0$.

Figure 3.3: First Difference of Variables (Ghana Data)



The t-statistics calculated for this purpose using equations 3.1 and 3.2 above are usually designated as $Z(t\alpha^*)$ and $Z(t\tilde{\alpha})$ respectively. For the DF test no lagged dependent variables are included on the right hand side. For the ADF test the size of k, the number of lagged terms, is set so as to produce serially uncorrelated error terms. This is because the DF tests assume error homogeneity and independence. If too few lags are included, the size of the test changes in an unknown manner and if too many lags are included, the power of the test is reduced (Gordon, 1995). A number of methods are available for determining k. These include the Akaike Information Criterion, the Schwartz Criterion and the highest significance lag order from either the autocorrelation or partial autocorrelation function of the first difference of the series.

The appropriate equation for testing for units roots in a particular series depends on the series in question. Allen and Macdonald (1995) note that: (i) If the series is generated by random walk with zero drift and has zero mean then tests based on equation 3.1 but with $\alpha_0 = 0$ are appropriate. (ii) If the series is generated by random walk with zero drift and non zero mean then tests based on equation 3.1 are appropriate and (iii) If the series has non zero mean and non zero drift then estimation should include both a constant and a trend term as in equation 3.2. If equation 3.1, for example, is used to test a series with a non zero drift, then the test will be biased in favour of non rejection of the unit root null. However, if a series has a zero drift but non zero mean, then it is better to carry out the test using equation 3.1 because it has a greater power. This implies that it is not always preferable to apply equation 3.2 even though it is the more general model. Depending on the model estimated various individual statistics (t and/or z statistic) and also joint statistics (Φ) - which are F-type statistics can be calculated.

In conducting the unit root tests it is advisable to start with equation 3.2 (since this is the more general specification) especially if there is indication (for example, from a plot of the series) that the series exhibits a trend over the period. Two other test statistics (apart from the $Z(t\tilde{\alpha})$ statistic mentioned above) may be calculated from this equation. These are $Z(\Phi_3)$ and $Z(\Phi_2)$. The $Z(\Phi_3)$ statistic is used to test the null $(\alpha_0,\alpha_1,\alpha_2) = (\alpha_0,0,0)$ - a random walk unit root with drift against the alternative of trend stationarity, the assumption being that the only alternative to stochastic non stationarity in the time series is linear deterministic trend stationarity. The hypothesis of unit root with trend is rejected *a priori* since it would imply that the series (if it is in log form) would have an ever increasing (or decreasing) rate of change. If unit root null for the series is rejected then testing stops. If the null could not be rejected we then test for the significance of the drift term. This is done using the $Z(\Phi_2)$ statsistics from equation 3.2. This statistics tests the null $(\alpha_0,\alpha_1,\alpha_2) = (0,0,0)$. The interpretation is that non rejection of the null in the $Z(\Phi_3)$ test but the rejection of the null in the $Z(\Phi_2)$ test indicates non zero drift. If $Z(\Phi_2)$ is rejected then testing stops, the conclusion from $Z(\Phi_3)$ test is accepted and the series categorized as random walk with non zero drift. If the null in $Z(\Phi_2)$ could not be rejected, then tests based on model 3.1 in which $\alpha_2 = 0$ are more appropriate since it has a greater power.

Equation 3.1 yields two statistics- Z(tα*) which tests the hypothesis $\alpha_1 = 0$ in 3.1 and $Z(\Phi_1)$ which tests the hypothesis $(\alpha_0, \alpha_1) = (0, 0)$ in 3.1. An insignificant value for $Z(\Phi_2)$ means we may use Z(tα*) and $Z(\Phi_1)$ for our test. As noted by Allen and MacDonald (1995), the final hypothesis to be tested in this sequence (if all the previous less restrictive assumptions hypothesis have not been rejected) is the driftless random walk against the simple zero mean stationary AR1 process.

One limitation of the ADF test is that it assumes independently and identically distributed error process. This assumption often does not hold. In particular, the power of DF/ADF tests is likely to be low for series where moving average terms are present or where the disturbances are heterogenously distributed. One common alternative is the Phillips and Perron (PP) (1988) test. According to Serletis (1994), the PP test is "robust to a wide variety of serial correlation and time-dependent heteroscedasticity and accommodates models with a drift and a time trend so that it may be used to discriminate between unit root nonstationarity and stationarity about a deterministic trend." Thus where uncertainty exists regarding the dynamic structure of the time series in question, and where the random component may be non-white noise in quite general ways, the PP test can be superior since the non-parametric adjustments are likely to raise the power of the test in these circumstances.

In the PP test, as an alternative to the inclusion of lag terms to allow for serial correlation, a non-parametric correction for serial correlation is used. The approach first calculates the above unit root tests from regression equations with k = 0, i.e., using the DF equation. The statistics are then transformed to remove the effects of serial correlation on the asymptotic distribution of the test statistics. The critical values are the same as for the DF tests (SHAZAM, p.158). The detailed results of carrying out the ADF and PP tests are presented in tables 3.1 to 3.4 below. These results were obtained using the SHAZAM statistical program which allows both the ADF and PP unit root tests to be carried out fairly conveniently. For the ADF test the number of lags used is the default value on the SHAZAM program which "sets the order as the highest significant lag order from either the autocorrelation or partial autocorrelation function of the first differenced series." (SHAZAM, p.158). The 5% and 10% critical values are given in the tables.

3.3: RESULTS OF UNIT ROOT TESTS FOR GHANA

We first apply the ADF test to the levels (or log levels) of the data for Ghana. The null hypothesis of unit root non-stationarity is not rejected for any of the variables even at the 10% significance level except for the parallel exchange rate depreciation (PEXRDEP). The $Z(\Phi_3)$ statistic for this variable exceeds the 5% critical value of 6.25 and the $Z(t\tilde{\alpha})$ statistic is less than the 5% critical value of -3.41. This suggests stationarity around a deterministic trend.

When we apply the PP test to level variables, we find that unit root null is rejected for inflation (in addition to PEXRDEP) at the 5% level. These results imply that the parallel exchange rate depreciation is stationary around a deterministic trend, while inflation is also a candidate for stationarity around a deterministic trend (i.e. on the basis of the PP but not the ADF test).

Table 3.1: ADF Unit Root Tests, Ghana data

STATISTICS	$Z(t\alpha^*)$	$Z(\phi_1)$	$Z(t\tilde{\alpha})$	$Z(\phi_2)$	$Z(\phi_3)$
C.V.(5%)	-2.86	4.59	-3.41	4.68	6.49
C.V.(10%)	-2.57	3.78	-3.13	4.03	5.34
LRGDP	0.2132	1.3966	-1.7246	2.4427	2.2497
LRM1	-1.3343	0.9148	-1.7978	1.0948	1.6165
LRM2	-1.3956	0.9933	-1.8459	1.1496	1.7048
LCPI	0.4063	1.872	1.9058	2.8706	2.4528
LEXR	0.8058	3.2876	-1.2603	3.3759	2.0416
R	1.9394	4.6636	-0.4165	3.8512	2.9649
PEXR	3.7006	7.4144	3.575	7.354	10.425
LPEXR	0.5733	1.9683	-2.3032	3.7647	3.7081
PEXRDEP	-6.3069	19.89	-6.3606	13.492	20.236
INFL	-2.2077	2.4585	-2.3839	1.9665	2.9283
DLRGDP	-4.2189	9.0199	-4.1776	5.9599	8.8207
DLRM1	-3.1151	4.8508	-3.1002	3.205	4.8056
DLRM2	-2.8136	3.9591	-2.7999	2.6143	3.9207
DLCPI	-1.4988	1.1968	-1.3673	0.8241	1.1632
DLEXR	-3.11	4.8392	-3.3834	3.8389	5.7551
DR	-5.4457	14.922	-5.809	11.467	17.104
DPEXR	0.3899	1.1261	-1.6859	2.4096	2.511
DLPEXR	-2.8479	4.055	-3.195	3.405	5.1074
DPEXRDE	-6.4214	20.622	-6.3826	13.584	20.371
DINFL	-4.8638	11.83	-4.8778	7.9331	11.897

Applying the ADF test to first differences, we find that unit root is rejected for M1, the interest rate and the rate of inflation at the 5% level. At the 10% level, unit null is rejected for all the variables except the price level (DLCPI). On the other hand, the PP test rejects the unit root null for all the variables whether the $Z(t\alpha^*)$ or the $Z(t\tilde{\alpha})$ test statistic is used indicating integration of the first order for these variables.

Based on the two sets of test, we conclude that for the data on Ghana, the parallel exchange rate depreciation is stationary around a deterministic trend. M1, the interest rate and inflation are integrated of the first order (at the 5% level in both ADF and PP tests) though the last named may be stationary around a deterministic trend (PP test). M2 and GDP are integrated of the first order (10% level for ADF test and 5% level for PP test).

Table 3.2: Unit root (PP) tests, Ghana data

STATISTIC	Z(a*)	Z(ta*)	$Z(\Phi_1)$	$Z(\tilde{a})$	$Z(t\tilde{a})$	$Z(\Phi_2)$	$Z(\Phi 3)$
C.V(10%	-11.2	-2.57	3.78	-18.2	-3.13	4.03	5.34
C.V.(5%)	-14.1	-2.86	5.59	-21.7	-3.41	4.68	6.49
LRGDP	-2.232	-1.0247	1.9566	-9.2647	-2.1436	2.4983	2.3105
LRM2	-6.403	-1.8077	1.6248	-10.117	-2.3418	1.8229	2.7343
LRM1	-4.5073	-1.5029	1.1269	-7.0739	-1.9604	1.2921	1.9397
LCPI	1.0464	2.3752	24.831	-2.569	-1.8739	20.592	6.9383
LEXR	1.0908	0.8262	3.3614	-3.5488	-1.2535	53.3953	2.0439
R	1.9809	0.8626	1.9364	-6.8329	-1.4084	2.6849	2.4539
PEXR	4.9967	4.8268	19.361	3.177	1.8739	13.601	12.636
LPEXR	0.0714	0.0668	4.4565	-5.2357	-1.6376	4.0063	1.5463
PEXRDEP	-103.38	-11.15	62.247	-103.99	-11.097	41.294	61.863
INFL	-74.567	-1.2201	26.077	-2.043	-7.663	19.629	29.442
DLRGDP	-78.941	-7.359	27.144	-78.959	-7.3305	17.965	26.902
DLRM1	-151.38	-14.356	103.02	-151.41	-14.298	68.122	102.18
DLRM2	-138.47	-12.653	80.04	-138.52	-12.602	52.938	79.407
DLCPI	-77.002	-7.4015	27.402	-85.84	-7.8848	20.763	31.143
DLEXR	-122.51	-11.005	60.554	-125.02	-11.183	41.687	62.531
DR	-123.44	-10.047	50.535	-125.52	-10.273	35.456	53.117
DPEXR	-87.397	8.7874	38.622	-102.58	-10.441	36.347	54.507
DLPEXR	-97.696	-10.016	50.158	-98.032	-10.041	33.614	50.413
DPEXRDE	-124.91	-16.516	136.3	-124.91	-16.403	89.773	134.56
DINFL	-142.78	-13.985	97.714	-142.81	-13.929	64.602	96.902

3.4: RESULTS OF UNIT ROOT TESTS FOR CANADA.

Turning to the Canadian data, we find that for the ADF test, unit root cannot be rejected at the 5% level for the levels of any of the variables except for the rate of depreciation of the index of the exchange rate relative to the group of ten industrialized countries (G10DEP). This suggests all the other variables are candidates for first order integration. For the first differences of the variables, unit root is rejected at the 5% level for broad money M2, the group of ten exchange rate index, G10, as well as its rate of depreciation, G10DEP, the t-bill rate, TB3M, the chartered bank deposit rate, CHB90 and M3 (using the $Z(t\alpha)$ statistic in all cases since $Z(\Phi_3)$ is greater than 6.25). For M1 unit root is rejected at the 10% level (using $Z(t\alpha^*)$ statistics). It is only for the first difference of the log of the price level that unit root is not rejected at the 10% level.

Next we apply the PP test to the level of the variables for the Canadian data. At the 5% level, unit root is rejected for GDP, GNP, inflation and G10DEP but not rejected for any of the other variables even at the 10% level. When the PP test is applied to the first differences however, unit root is rejected for all variables at the 5% level.

Taking the two tests together we conclude that for the Canadian data, G10DEP is stationary around a deterministic trend. GDP and GNP are integrated of the first order but could also be stationary around a deterministic trend (PP test). M2, TB3M, CHB90, M3, inflation and the G10 exchange rate index are all integrated of the first order (both tests and at 5% level or better) whereas M1, could be considered as integrated of the first order (10% for the ADF, 5% for PP test).

Table 3:3: Unit root (ADF) tests, Canada data

STATISTIC	Z(ta*)	$Z(\Phi_1)$	Z(tâ)	$Z(\Phi_2)$	$Z(\Phi_3)$
C.V.(10%)	-2.57	3.78	-3.13	4.03	5.34
C.V.(5%)	-2.89	4.59	-3.41	4.68	6.25
LGDP	-2.283	4.7055	-0.3151	3.1111	2.5864
LGNP	-2.3019	4.5038	-0.4235	2.9751	2.6251
LRM1	-2.4445	3.5424	-2.0034	2.3399	2.9604
LRM2	-1.5218	2.0413	-1.6678	1.6999	1.6663
LRM3	-1.5016	1.642	-1.9042	1.6859	2.0109
LCP86	-1.0504	2.2652	-1.9401	2.6166	2.1775
INFL	-2.2408	2.5134	-1.8894	1.7597	2.6369
RB10	-1.5846	1.4145	-1.3651	1.0389	1.4003
RCHB90	-2.023	2.137	-2.246	1.919	2.785
RTB3M	-1.9723	2.0344	-2.2848	2.0041	2.9159
LG10	-1.3829	2.3387	-0.8537	1.5648	0.9768
G10DEP	-5.115	13.082	-5.1891	8.9779	13.467
USCLS	-1.4305	1.3898	-2.5203	2.4403	3.2836
DLGDP	-2.5602	3.3308	-3.9282	5.2414	7.8047
DGNP	-2.4377	3.0417	-3.7644	4.8301	7.1701
DLRM1	-2.7929	3.9026	-2.9589	2.9734	4.4515
DLRM2	-5.0477	12.74	-5.1208	8.7439	13.116
DLRM3	-3.7997	7.2199	-3.8522	4.9519	7.427
DLCPI	-2.1463	2.3033	-1.8335	1.6083	2.4124
DINFL	-3.4435	5.9568	-3.6395	4.4559	6.6626
DRB10	-3.1922	5.1185	-3.1922	3.7281	3.5685
DRCHB90	-4.6661	10.887	-4.6861	7.3291	11.097
DTB3M	-4.7329	11.2	-4.7714	7.5891	11.383
DLG10	-4.4423	9.8674	-4.5804	6.9969	10.495
DG10DEP	-5.2568	14.616	-5.3008	9.3662	14.049
DUSCLS	-5.3229	16.616	-5.3008	9.3662	14.049

Table 3.4: Unit root (PP) tests, Canada data

STATISTIC	Z(a*)	Z(ta*)	$Z(\Phi_1)$	$Z(\tilde{a})$	$Z(t\tilde{a})$	$Z(\Phi_2)$	$Z(\Phi_3)$
C.V.(10%)	-11.2	-2.57	3.78	-18.2	-3.13	4.03	5.34
C.V.(5%)	-14.1	-2.86	4.59	-21.7	-3.41	4.68	6.25
LRGDP	-3.3362	-1.6747	2.8741	-56.526	-5.8362	12.582	17.308
LRGNP	-3.5899	-1.7211	2.819	-56.002	-5.8088	12.375	17.146
LRM1	-5.1869	-2.3939	3.8738	-5.3195	-1.9061	2.5638	2.8462
LRM2	-2.9488	-1.5221	2.0405	-6.1187	-1.6836	1.7052	1.6899
LRM3	-3.1721	-1.4125	1.504	-8.5014	-2.0095	1.7283	2.0971
LCPI86	0.3793	1.7528	89.7	-3.5847	-2.9214	71.09	72.1219
INFL	-27.184	-3.9972	7.965	-28.546	-3.9874	5.4129	8.1172
RB10	-3.6597	-1.5093	1.2502	-4.9383	-1.2778	0.8902	1.2273
RCHB90	-8.919	-2.243	2.567	-12.305	-2.364	2.052	3.034
RTB3M	-7.261	-1.9821	1.997	-11.942	-2.2821	1.8595	2.7616
LG10	-5.2374	-1.7595	1.8211	-17.125	-2.987	3.1666	4.4812
G10DEP	-144.26	-12.582	79.155	-144.78	-12.591	52.847	79.271
USCLS	-2.2568	-1.1685	1.752	-3.8296	-1.3977	1.3809	1.0124
DLRGDP	-131.59	-11.645	67.925	-131.9	-11.645	45.183	67.771
DLRGNP	-132.19	-11.747	68.981	-132.5	-11.735	45.885	68.824
DLRM1	-128.56	-11.181	62.511	-130.44	-11.291	42.511	63.766
DLRM2	-130.37	-11.347	64.38	-130.91	-11.354	42.972	64.458
DLRM3	-160.32	-14.481	104.84	-160.46	-14.448	69.571	104.36
DLCPI	-27.603	-4.0351	8.1167	-28.78	-4.0173	5.4863	8.2273
DINFL	-166.03	-16.034	128.47	-166.27	-16.036	85.664	128.47
DRB10	-104.51	-9.2307	42.612	-105.41	-9.2649	28.62	42.927
DRCHB90	-88.95	-7.968	31.777	-89.45	-7.955	21.144	31.701
DTB3M	-100.93	-8.8412	39.119	-101.33	-8.8553	26.05	39.055
DLG10	-173.4	-16.596	137.68	-173.48	-16.552	91.283	136.92
DG10DEP	-191.85	-22.172	245.6	-191.84	-22.081	162.33	243.5
DUSCLS	-96.911	-8.4561	35.759	-96.741	-83881	23.659	35.476

CHAPTER FOUR

THEORETICAL ISSUES

4.1: MONEY DEMAND FUNCTIONS - CONVENTIONAL APPROACH

The conventional approach to money demand assumes that money stocks are demand determined such that the observed demand and supply for money were always equal to one another and that changes take place along the demand curve for money.

In this standard approach, the variables that should appear in the money demand function are largely based on Keynes theory on transactions demand and its modification by Baumol (1952) and Tobin (1956) that suggest real income, the (short-term) rate of interest and transaction costs as the important determinants of the transactions demand, the Keynesian speculative motive and its modification by Tobin (1958) that suggest non-human wealth, the long-term interest rate and risk as the important determinants of the speculative demand and Friedman's (1956) restatement of the quantity theory which suggest expected return on all assets, total wealth (proxied by permanent income) and expected inflation as important determinants of money demand.

The basic interest in the money demand function arises from whether it is a function of a small number of variables which moreover represent significant links to the real sector. As a result of this many empirical analyses often specify it as a function of real income (permanent or actual), nominal interest rates (short-run or long-run) and sometimes the rate of inflation. The problem as to the appropriate choice of a scale variable (wealth, permanent income or measured income) is treated in a similar way for both developed and developing countries. However, the nature of the problem relating to the choice of the appropriate opportunity cost variable as it relates to the two types of economies is very different. In the former, the problem revolves mainly around whether a short-term or a long-term interest rate is the more appropriate choice. In the latter, the dominant view seems to be that due to the scarcity of data, fixing of interest rates and undeveloped capital and financial markets, the rate of inflation should be the preferred opportunity cost variable. This view was argued by Adekunle (1968) who also argued that price changes are more likely to play a greater role in developing countries because of the greater proportion of real assets in total wealth and given existence near the subsistence level of the majority of the people. Similar views have been expressed by Khan (1980) and Ghatak (1981).

However, Wong (1977) argues that interest rates are still relevant in the money demand function for developing countries since there exists certain linkages between the organized and unorganized money markets and borrowing is still a means of financing economic activity. He asserts that in developing countries, economic activity is generally constrained by the unavailability of credit rather than by the cost of borrowing money and that with tight credit policy, borrowers tend to rely more on lenders in the non-organized markets and interest rates go up in those markets even though they are not recorded. Acknowledging that interest rates in the organized sector are usually fixed, he however expressed the view that the degree of credit restraint should be used as a proxy for the interest rate. He tried several alternative measures of the degree of credit restraint and found that 'the negative of domestic credit to income ratio' and 'one less the ratio of domestic credit to income' worked best in his study of money demand in five Asian developing countries.

Another variable which has been suggested is the exchange rate - as an external opportunity cost variable. As the result of the change in the international monetary system from fixed to flexible exchange rates, it has become quite common to include an exchange rate variable in money demand functions for developed countries (see, for example, Arango and Nadiri (1981) and Arize and Shwiff (1993)). A similar approach has been suggested for developing countries. For example, Blejer (1978) studied the effect of exchange rate depreciation on money demand in Brazil, Chile and Colombia and found that the money demand is significantly reduced when expectations of black-market depreciation intensify and that when this variable is omitted from money demand function, the response of money demand to changes in the expected rate of domestic inflation tends to be overestimated.

Simmons (1992) has suggested the use of both domestic and foreign interest rate variable (the latter to reflect substitution between domestic and foreign financial assets) as well as the exchange rate (to reflect currency substitution) as arguments in the money demand function for developing countries on account of the economic liberalization policies which have taken place in several developing countries over the past two decades. A similar view on the use of the exchange rate was adopted by Adam (1992).

Bahmani-Oskooee and Maxili (1991) carry the argument further by suggesting that even when the exchange rate is fixed against one currency, there are still fluctuations in the exchange rate on a multilateral basis as long as major currencies fluctuate against one another and therefore changes in the multilateral exchange rate should be used in the money demand function. In their study of thirteen developing countries, they found that in the long-run depreciation causes a decline in the demand for the domestic currency.

4.2: THE PARTIAL ADJUSTMENT MODEL.

In terms of approach, early studies on the demand for money attempted to estimate relatively simple long run relationships directly. Subsequently, attention shifted to identifying the correct short run money demand specification from which long run properties could be inferred. In this exercise, the model of choice was typically the partial adjustment model (PAM). Single equation money demand functions such as the partial adjustment model are usually derived from cost minimization problems that can be specified in quite general ways. In the context of the PAM, one specification, attributed to Huang (1985) is described in Goldfeld and Sichel (1990) on which the following description is based:

It is assumed that economic agents have a desired (long-run) level of money demand, m_t^* that is expressed by:

$$\ln m_t^* = \phi_0 + \phi_1 \ln y_t + \phi_2 \ln r_t + \phi_3 \pi_t \qquad 4.1$$

In equation 4.1 above, m_t, y_t, r_t and π_t represent in that order the real money stock, real output, the interest rate and the rate of inflation. This desired level of money demand may however not be attained in the short run because of adjustment cost of the form:

$$C = \alpha_1[\ln M^*_t - \ln M_t)^2 + \alpha_2[(\ln M_t - \ln M_{t-1}) + \delta(\ln P_t - \ln P_{t-1})]^2 \qquad 4.2$$

where M_t represent nominal balances.

Minimizing costs with respect to M_t yields:

$$\ln M_t - \ln M_{t-1} = \mu(\ln M_t^* - \ln M_{t-1}) + t(\ln P_t - \ln P_{t-1}) \qquad 4.3$$

where

$$\mu = \alpha_1/(\alpha_1+\alpha_2) \text{ and } \tau = \delta\alpha_2/(\alpha_1+\alpha_2) = \delta(1-\mu)$$

When δ =1, equation 4.3 reduces to adjustment in terms of real balances whiles when δ=0 it reduces to adjustment in terms of nominal balances. Combining 4.1 and 4.3 yields on re-arrangement:

$$\ln m_t = \mu\phi_0 + \mu\phi_1 \ln y_t + \mu\phi_2 \ln r_t + (1-\mu)\ln m_{t-1} + \beta \ln(P_t/P_{t-1})$$

with $\beta = \mu\phi_3 + (1-\mu)(\delta-1)$

When, as mentioned above, there was a breakdown in simple specifications (such as the PAM) the initial attempt to resolve the problem involved examining and improving demand functions on several fronts such as specification, functional form, dynamics and expectations (Goldfeld and Sichel, 1990). Econometrically, these empirical difficulties led to a revaluation of econometric issues in the treatment of short run dynamics. Firstly, arising from Feige's (1967) work, there was an examination of expectations in providing a dynamic structure. Adaptive expectations (in which the long-run money demand function contains expected rather than actual levels of the explanatory variables) resulted in equations in which the presence of lags on money depend on expectations rather than partial adjustment parameters. Also explored was a combination of adaptive expectations and partial adjustment. This formulation adds a second lag of money to the estimating equation obtained when only one of either partial adjustment or adaptive expectation is used. Thus it became clear that specifications other than partial adjustment also give rise to lagged money on the right hand side of the money demand function. A logical extension was then to explore the use of distributed lag models (DLM) first as an extension of PAM and the other models containing lagged variables and subsequently as models in their own right to see if they could resolve the missing money and nonhomogeneity problems of the PAM. Through the use of DLM, researchers were able to explore different adjustment patterns for each variable. DLM were found to have some advantages over PAMs and yet they also suffer from the mid-1970s breakdown (Goldfeld and Sichel, 1990).

Distributed lag models were also used as a starting point for estimating short run models in which long run relationships are imposed as illustrated in the following example by Goldfeld and Sichel (1990):

$$m_t = b_1 m_{t-1} + c_0 y_t + c_1 y_{t-1} + d_0 r_t + d_1 r_{t-1}$$

$$\Delta m_t = c_0 \Delta y_t - (1-b_1)(m_{t-1} - \theta y_{t-1})\ d_0 r_t + d_1 r_{t-1}$$

where

$$\theta = (c_0+c_1)/(1-b_1).$$

The error-correction term is $(m_{t-1} - \theta y_{t-1})$ and to estimate the error-correction model one may impose a value of $\theta = 1$. Subsequently attention shifted to approaches in which long run parameters are estimated rather than assumed and imposed on a short run specification in an error correction model. The most recent application of this, using the concept of cointegration, will be discussed in detail in chapter five.

4.3: MONEY DEMAND FUNCTIONS - THE BUFFER STOCK NOTION

Empirically, interest in alternative models for the money demand function has resulted mainly from the fact that traditional short-run money demand equations do not invariably possess sufficient predictive power outside the sample period. At the theoretical level, Laidler (1980) and Coats (1982) have argued that the manner in which short-run money demand is modeled, that is through the use of the partial adjustment mechanism is not suitable for modeling the adjustment of money demand under exogenous changes in money supply. An unpleasant implication of the conventional partial adjustment model is that in the absence of complete price flexibility, any policy-induced change in the aggregate money stock implies that some determinants of the long-run money demand must overshoot in the short-run to persuade people to change their money holdings. It is not surprising therefore that an alternative to the conventional approach- the buffer stock concept- attaches an important role to supply side developments. The buffer stock notion argues that an individual might simply want "to hold a fraction of his wealth in money as a 'temporary abode of purchasing power'" with very little thought given to a desired level of money holdings in the short-run even though people have a view as to their long-run money holdings and over time endeavor to adjust their money holdings accordingly. According to Laidler (1984), the phrase 'quantity of money demanded' should refer "to an inventory, of a buffer stock, of cash balances" but not "to an amount of money which an agent will want to hold at each and every moment." The above proposition, he argues, should be true even for an agent who is always able to fulfill his plans and for whom trading activities bring no surprises. In other words demand for money is being viewed in a context different from that of the conventional transactions, precautionary and speculative motives.

At an aggregate level the buffer stock money concept denies the view implied in traditional analysis that the economy has a well determined stock demand which is realized at every moment. It challenges the treatment of conventional analysis which suggest that the observed demand and supply for money were always equal to one another and in which the economy is treated as always being on its aggregate money demand function.

4.31: THE DISEQUILIBRIUM APPROACH

Two strands of the buffer stock money concept may be distinguished, namely, the buffer stock (or shock absorber) model and the disequilibrium adjustment (or systems) approach. Both approaches argue that observed short-run changes in money stocks are partly supply-induced and that the traditional approach, is not suitable for analyzing supply induced changes in the money stock.

The disequilibrium approach assumes that disequilibrium in the money markets will lead to changes in the financial as well as the real sectors of the economy and consequently does not attempt to estimate money demand functions directly but derives the parameters of the long-run money demand function implicitly from other macro relationships. The distinguishing features of the disequilibrium approach lie in the assumed dynamic adjustment to a situation of monetary disequilibrium and in the transmission of changes in monetary policy. The basic empirical problem is in designing an estimation procedure incorporating the channels of adjustment.

Andersen (1985) observes that, in practice, two approaches have been applied: (i) simultaneous equation models which attempt to estimate the transmission channels as well as the degree of monetary disequilibrium in a simultaneous equation system and (ii) single equation estimates, which solve the two issues sequentially: first the most likely and fastest transmission channel is used in determining the parameters of the long-run money demand function and secondly a measure of monetary disequilibrium is calculated and used as an argument in estimating other macroeconomic relationships.

4.311: THE SINGLE EQUATION DISEQUILIBRIUM APPROACH

In the single equation version of the disequilibrium approach once the money supply is assumed to be exogenous, the long-run money demand function is then inverted. By so doing different arguments in the money demand function can be made the dependent variable in an estimating equation.

Artis and Lewis (1976) used the interest rate as the dependent variable in a study of broad and narrow money in the UK and found that interest rate equations incorporating the partial adjustment mechanism yielded good results especially for the broad definitions of money and based on this they observed that "the results ...... challenge the conventional idea that the money market always clear in the short-run." Laidler (1980) on the other hand found that for the US most estimates are not significantly different from zero especially in equations using M1 as the aggregate. Andersen (1985) applied the Artis and Lewis approach to estimate money demand parameters for seven industrialized countries and concluded that in four of the seven countries (viz., US, Japan, UK, Italy) the approach yields better results than the conventional approach in estimating money demand functions but the same could not be said for Germany and especially for France and Canada.

The money demand function can also be inverted to give a price level equation. MacKinnon and Milbourne (1986) conducted a fairly extensive study of the performance of this type of equation and concluded that the equation turns out to be an abysmal equation for the price level. It is also asserted that where the restrictions implied by such an inversion are tested "they fail dramatically" (Milbourne, 1987).

The approach has problems at the theoretical level as well. Only one argument may be chosen as the dependent variable whereas on *a priori* grounds, one might expect all the arguments of the money demand function to adjust simultaneously. The use of different arguments of the money demand function as dependent variable will lead to a derivation of different sets of money demand parameters.

4.312: THE DISEQUILIBRIUM APPROACH - THE SYSTEMS VERSION

The systems version of the disequilibrium approach involves the use of simultaneous equation systems in which a monetary disequilibrium term is allowed to influence a wide range of real and nominal variables. Cuthbertson (1988) provides an outline of this approach which basically consist of the use of the following forms of equations:

$$\Delta X = f(Z) + \gamma(L)(M_s - M_d)$$

$$M_{dt} = a_0 P + a_1 R_t + a_2 Y_t$$

X may be a set of real and nominal variables such as output, prices, expenditure and the exchange rate. *Z* is a set of predetermined equilibrium variables. M_{dt} is the long-run money demand function. The first set of studies to use this type of approach was that of Jonson (1976) and Jonson et al.(1976) for the UK and Australia respectively but Laidler and others have applied the approach to the US, UK, Canada and Italy. According to Cuthbertson this type of model performs reasonably well but he observed that the approach involves a number of cross equation restrictions which are not tested or which generally fail when tested. A major disadvantage of the approach is that if one is interested in the parameters of the money demand function, the estimates of the latter are conditional on the correct specification of the whole model (if system estimation is used) and there is a reasonable chance that misspecification somewhere in the system will result in inconsistent estimates throughout the system including the money demand function.

4.32: THE SHOCK ABSORBER APPROACH

The third approach, is actually the approach that has usually enjoyed the accolade of "the buffer stock" (or "the shock absorber") approach. This approach proceeds on the view that it is of the very essence of such a stock that "the agent should expect and even perhaps plan to be away from his desired average holdings from time to time; but when he is, it might reasonably be argued that he is hardly 'out of equilibrium' in the sense of being unable to carry out his plans" (Laidler, 1984). Herein lies the conceptual difference between the shock absorber and disequilibrium versions of the buffer stock notion. Empirically, the buffer stock approach proceeds by introducing additional variables in the traditional money demand function to serve to reduce or remove discrepancies between money demand and supply. The approach is the most popular of the models based on the buffer stock notion and the one on which the claims of empirical success of the buffer stock notion have most often been based. Originated by Carr and Darby (1981), the additional explanatory variables may be a term representing either the change in the nominal money stock, the unanticipated component of the money stock or a proxy. Andersen (1985) gives the following examples of the use of buffer stock variables:

i. Unanticipated changes in money supply growth used by Carr and Darby (1981) to explain U.S. money demand.

ii. The variance of unanticipated money supply growth used by Mascaro and Meltzer (1983) to explain money demand as well as interest rates in the U.S.

iii. Changes in bank lending, used by Judd and Scadding (1981) in a money demand function for the U.S.

iv. Changes in domestic credit and in the external public debt plus the current balance of payments, used by Kanniainen and Tarkka (1986) to explain money demand in the U.S., Germany, Australia, Sweden and Finland.

A general representation of this approach uses the following forms of equations:

$$M_t = P_t + \beta \mathbf{X}_t + \alpha(M_t - \hat{M}_t) + e_t$$

In the equation above, X_t is a vector of standard money demand variables. $\hat{M}_t$ may be anticipated or the lagged money supply so that M_t - $\hat{M}_t$ represents unanticipated money or the change in the money stock. In the anticipated money version, $M_t = \gamma Z_t + u_t$ so that:

$$\hat{M}_t = \hat{\gamma} Z_t$$

where Z_t represent lagged variables.

The approach was initially considered a success because the early studies using this approach presented estimates of *a* which were both positive and significant. These include studies by Carr and Darby (1981), Judd and Scathing (1982), Kanniainen and Tarkka (1986) and Laidler (1980). The controversy that subsequently developed between Carr and Darby and others on one hand and MacKinnon and Milbourne and others on the other hand has placed this claim of success in disrepute. It is argued that OLS which most of the studies used is not valid since M_t also appears on the right hand side and that in any case a significant value for *a* would be due to the fact that a money supply shock is largely caused by a demand shock so that *a* represents the surprise in the money supply caused by a money demand shock and not the vice versa. When MacKinnon and Milbourne (1984) used a modified version of the Carr-Darby equation in which *Mt* is removed from the right hand side, results inconsistent with buffer stock model are obtained. But Carr and Darby (1985) argue that the issue really revolves around whether one assumes the money supply to be exogenous or endogenous

Milbourne (1986) also argues that the restriction of price homogeneity, implicit in the Carr-Darby equation is in most case not tested and if tested fail dramatically. Finally in the versions of the approach that use unanticipated money, X_t and Z_t generally contain common variables, so that there are a number of cross equation restrictions which must hold for the theory to be consistent. As Milbourne (1987) puts it "the restrictions are hideously rejected for all specifications of Z_t" when tested.

The original Carr-Darby formulation was basically an *ad hoc* formulation with no strong theoretical underpinnings. Kannianen and Tarkka (1986) introduced a variant in which "money balances held by the agent are actually the outcome of optimizing forward-looking behavior" in which the agent has an incentive to forecast since his money balances are subject to change outside his control. In still more recent variants of the approach it is assumed that in contrast to the Carr-Darby and Kanniainen-Tarkka models in which forward-looking behavior takes the form of expectations about the future path of the money stock, economic agents do not formulate their planned asset holdings on the basis of their expectations regarding the future path of an exogenous money supply but form a view regarding the future path of the determinants of their asset demand functions and on the basis of this plan their optimal holding of money and other assets over time. This modification of the Carr-Darby model is attributed to Cuthbertson (1984) and Cuthbertson and Taylor (1987). The approach assumes that actual money holdings consist of a planned component, M_{pt} and an unplanned component, M_{ut} which will depend on innovations in the determinants of the money demand function at a particular time. Estimated equations in these models thus incorporate both the agent's expectations with regard to the future movements of the determinants of money demand and also possible unexpected shocks in such variables to the extent that unplanned money holdings do not cause agents to revise their expectation of these variables. Buffer stock effects are thus captured by introducing unanticipated changes in the determinants of money demand.

Cuthbertson used such a forward-looking buffer stock framework incorporating a multi-period cost of adjustment scheme to estimate the demand for M1 in the UK. He compared the results of this model to an error feedback type model and concluded that the "empirical application of the model for UK M1 proved encouraging."

However Muscatelli (1988) using a similar but theoretically improved model concluded that the use of buffer stock models to infer a precise dynamic structure for the demand for money may be seriously flawed. He based this conclusion on the fact that the adoption of a different cost function led to a very different dynamic structure from that adopted in previous buffer stock models and there were problems with the estimating equations which are attributable to the dynamic specification. He counseled that given these difficulties, it may be appropriate to concentrate future research on traditional backward looking models by adopting a general to specific modeling procedure or retain forward looking models without imposing a rigid dynamic structure on the basis of theoretical considerations but instead allowing the data to play a greater part in the specification.

At the theoretical level, Milbourne (1987) has presented a strong case against the buffer stock theory. Using a simple inventory-theoretic approach, he obtained the result that most of any increase in the money stock will be transferred to other assets very quickly and the measured increase in money held over, say, a quarter would be very small. The model clearly indicates that money's role as a buffer does not yield any of the implications that have been attributed to buffer stock models. If one also takes into account the fact that the assumption of money supply exogeneity required in the buffer stock models is a dubious one in the first place, then the theoretical case against the buffer stock model seem to be even stronger.

It is clear from the above discussion that the claims of success attributed to the buffer stock model by early studies was premature. It is not surprising that Cuthbertson (1988) observed that "there is as yet no consensus on the appropriate way to model buffer stock holdings of money"

Boughton and Tavlas (1990) have shown that "the ECM in general encompasses the buffer stock approach." They suggested that "a comparison of the forecasting performances of the buffer stock model and the ECM amounts to a test of whether the addition of a money stock variable to the demand for money specification (as in the shock absorber model) sufficiently captures the short-run monetary dynamics, or whether a more complicated dynamic specification is necessary."

4.4: MONEY DEMAND STUDIES ON GHANA

There has been a number of money demand studies on Ghana. An early study was that of Blomqvist (1971) who used annual data covering the period 1955-67. Noting the lack of variability in interest rates because of interest rate regulations, he first used an estimation equation with only income and lagged money as right hand side variables and with income and money measured in real per capita terms. He obtained the following result:

$$m_t = -1.5 + 0.499y_t + 0.626m_{t-1}$$

which gives a long-run income elasticity of 1.33. Noting that there are problems of misspecification, he introduced inflation into the model but found that inflation has no significant effect on money demand.

However Abbey and Clark (1974) found a significant role for the rate of inflation when they estimate a money demand function as part of an econometric model for Ghana. The dependent variable in the model estimated is income velocity. This is regressed on either real income or real per capita income, lagged inflation and the number of bank branches per thousand of the population. Whereas the per capita income variable had a coefficient of -3.15, the (total) income variable had a coefficient of 2.3×10^{-7}. In both cases however, the coefficients were not significant causing the authors to conclude that "a strong and consistent relation does not appear to exist between income velocity and either real per capita income or real income."

Gockel (1983) estimated two alternative forms of money demand equation using annual data in his M.Sc. dissertation "Monetary Control in Ghana: Theory and Evidence." He used equations of the form:

$$m_t = a_0 + a_1 y_t + a_2 r_t$$

and

$$\Delta y_t = b_0 + b_1 \Delta m_{t-1}$$

The variables used are real money balances, m_t, the interest rate on time deposits, r_t and gross national Product, y_t and with Δ representing percentage change. The interest rate is found not to be statistically significant (in the equation in which it is used) for any of the monetary aggregates used. He attributes this to interest rate regulation and the absence of an integrated money market. The income term is generally significant and yields an income elasticity greater than one.

Amoako-Adu (1991) studied the demand for money in Ghana using a partial adjustment model. He obtained mixed results for the statistical significance of both real income and the rate of inflation in the two periods he used in his study.
Sowa (1992) estimated money supply and demand functions in his study "Monetary Control in Ghana: 1957-1988" with annual data covering the period 1960-1988. The variables used are real broad money, real GDP, interest rate, the consumer price index and the exchange rate depreciation. With all the variables expressed in logs except for the interest rate and using 2SLS he

obtained results in which only the output and price variables are significant at the 5% significance level.

Baffoe (1993) also estimated a money demand function as part of a macroeconometric model for Ghana in which he used real contemporaneous and lagged GDP, expected rate of inflation, and lagged money demand as independent variables. He obtained significant coefficients for all the variables except lagged GDP.

Adam, Ndulu and Sowa(1993) estimated an error correction model for base money in Kenya, Ghana and Tanzania as part of their study "Financial Liberalization, Exchange Rate Unification and Seiniorage Revenue in Kenya, Ghana and Tanzania." For Ghana, the authors used data for the period 1974(4) to 1989(4) and with six lags in the VAR equation, they found one significant cointegrating vector for real base money (m_t), real output (y_t), inflation (π_t), and the parallel exchange rate depreciation (b_t) which when normalized on money yields the long-run relationship:

$$m_t = 1.45y_t - 19.59\pi_t - 0.879b_t$$

From the cointegrating relationship they obtained the following error correction equation:

$$\Delta m_t = \underset{(10.6)}{0.11} - \underset{(2.46)}{0.226\Delta y_{t-3}} - \underset{(0.86)}{0.09\Sigma\Delta b_{t-i}} - \underset{(9.04)}{0.87\Delta\pi_t} - \underset{(3.57)}{0.21\Sigma\Delta m_{t-i}} - \underset{(7.60)}{0.05EC_{t-1}}$$

$R^2=0.779$; $s = 0.040$; $DW=2.009$; $LM4(6,67)=0.71$; $ARCH(6,61)=0.90$; $JB=0.97$
White $(15,57) = 1.57$

In the above error correction equation, the differenced money term on the right hand side is defined as $\Sigma\Delta m_{t-i} = \Sigma\Delta m_{t-i}/4$, $i = 0,1,2,3$ so that it consists of an average of current and lagged values. Similarly for the exchange rate, *b*.

Apart from the study by Adam, Ndulu and Sowa, none of these other studies adequately address the validity of the models used. For example, Blomqvist's study used only thirteen observations while Abbey and Scott used fifteen observations. Blomqvist, Gockel, Amoako-Adu and Sowa use their results to calculate long-run income elasticities. The implied assumption of the existence of a long-run relationship among the variables they use in their equations is very apparent. Sowa reported no stability tests of his results even though he had noted elsewhere in his work that "our previous discussions have suggested that there have been sizable shifts in the demand for money." Baffoe's money demand equation is simply the standard partial adjustment equation with the addition of lagged output as an additional explanatory variable.

As noted earlier, our study will investigate the issue of cointegration among the postulated variables of the money demand function in Ghana and therefore investigate whether a long-run relationship exists. Furthermore, our approach will involve the use of an error-correction model in investigating the short-run dynamics of the money demand function. This aspect of our study is therefore quite similar to the study by Adam, Ndulu and Sowa except that our investigation will apply to narrow money, M1 and broad money, M2 and will also cover a different time period. One of our alternative methods of study will also be a buffer stock model which no previous writer has used to examine the demand for money in Ghana.

Studies involving the application of cointegration and error correction approach to money demand functions in developing countries, especially Africa are rather scarce. Domowitz and Elbadawi estimated a structural error correction model for Sudan over the period 1956-1982 using OLS. They obtained mixed results for the significance of the parameters but reached the conclusion that the results refute the claim that income effects on cash balances should be abnormally high in developing countries. They also obtained an impact elasticity of -0.45 for inflation and a long-run elasticity of -2.5 which, in their view "does seem a little high." Similarly the error correction coefficient was highly significant and with a value of -0.18. On the other hand, the exchange rate effect was not significant and the authors attribute this to data problems.

Simmons (1992) used an error correction model to estimate money demand functions in five African countries but rightly observed that "it would be useful to apply cointegration techniques to corroborate (or amend) the results of this article." Adam (1992) explored a number of recent developments in econometric methods in which he gave a synopsis of the cointegration and error correction approach and applied it to the demand for narrow money in Kenya. Based on the results of his error correction equation as well as those of diagnostic and stability tests he conducted he concluded that his "model adequately captures the salient features of the data and is consistent with the main implications of economic theory." Adam (1992a) carried out a further study of the demand for different monetary aggregates in Kenya for the period 1973:1 to 1989:1 using the Johansen approach and states that his estimated equations "embody long-run solutions which are fully consistent with theoretical priors from the literature on the demand for money", that is "the demand for money is a positive function of income and the own rate of interest and a negative function of the rate of inflation and the expected devaluation of the parallel market exchange rate."

CHAPTER FIVE

METHOD OF STUDY

Our method of investigation will involve the use of three alternative methods of analysis similar to a study by Boughton and Tavlas (1990). We carry out a comparative estimation of the conventional partial adjustment model, the buffer stock model and the error correction model. The basic difference between the partial adjustment and buffer stock models as used by such writers as Carr and Darby (1981) and Boughton and Tavlas (1990) and followed in this study is that a monetary shock variable is added as an independent variable in the conventional partial adjustment model. Hence the approach does not require any further discussion than that in chapter three. However, unlike Boughton and Tavlas who derive an error correction model by starting from a general distributed lag (current and four lagged values) of the variables appearing in their study, this study directly incorporates an error correction term consisting of the residual from a cointegrating equation obtained through the Johansen cointegration approach.

The cointegration and error-correction technique has become a very popular econometric approach and is described in works by several writers. Muscatelli and Hurn (1992), Perman (1991) and Dolado et al. (1990) are among writers who provide good summaries at easily accessible levels.

5.1: COINTEGRATION AND ERROR CORRECTION MODELING

Cointegration is a technique for establishing the long-run equilibrium relationship between variables. A variable (non-stationary time series) y_t is said to be integrated of order *d* if it achieves stationarity after being differenced *d* times. This is denoted by $yt \sim I(d)$. Thus a time series integrated of order zero is stationary in levels while for a time series integrated of order 1, the first difference is stationary. If we consider two time series y_t and x_t that are both integrated of the same order *d*, which imply they have comparable long-run properties, then according to Granger (1986) and Engle and Granger (1987), it will generally be true that a linear combination $z_t = y_t - gx_t$ will also be $I(d)$. However if there exists a vector $(1,-a_1)'$ such that the combination

$$z_t = y_t - a_0 - a_1 x_t$$

is such that $z_t \sim I(d-b)$ where $b>0$ then y_t and x_t are said to be cointegrated of order (d,b) [or $y_t, x_t \sim CI(d,b)$], with $(1,-a_1)'$ called the cointegration vector.

The concept of cointegration tries to mimic the existence of a long-run equilibrium to which an economic system converges over time. If, for example, economic theory suggests the long-run relationship between y_t and x_t such that $y_t = a_o + a_1 x_t$, then z_t can be interpreted as the distance the system is from equilibrium at any time (i.e. the equilibrium error).

5.21: THE 2-STAGE ENGLE-GRANGER APPROACH TO COINTEGRATION

There are now two common approaches for testing for cointegration. The two-stage approach developed by Engle and Granger (1987) and the Johansen approach. In the Engle-Granger approach for testing for cointegration, we first test to see that both series are integrated of the same order. Then we test to see if the two series are cointegrated by running the cointegration regressions:

$$x_t = b_1 + b_2 y_t + e_{1t} \tag{5.1}$$

$$y_t = c_1 + c_2 x_t + e_{2t} \tag{5.2}$$

using OLS or other estimation methods. The null hypothesis that the residuals from the above equations are $I(d\text{-}b)$ where $b>0$ is tested against the alternative that they are not $I(d\text{-}b)$. For example if $x_t \sim I(1)$ and $y_t \sim I(1)$, in order for x_t and y_t to be cointegrated, e_{1t} or e_{2t} should be $I(0)$. The rejection of the null hypothesis implies absence of any long-run relation between x and y.

Engle and Granger also showed that if y_t and x_t are $CI(1,1)$, then there exists an EC model of the following form:

$$\Delta y_t = b_0 + b_1 z_{t-1} + \Sigma b_{2i} \Delta x_{t-i} + \Sigma b_{3i} \Delta y_{t-i} + e_t \tag{5.3}$$

where Δ denotes the first-order time difference, i.e., $\Delta y_t = y_t - y_{t-1}$. The term z_{t-1} represents the extent of the disequilibrium between levels of y and x in the previous period. The ECM states that changes in y_t depend not only on changes in x_t but also on the extent of the disequilibrium between the levels of y_t and x_t. The appeal of the ECM formulation is that it combines flexibility in dynamic specification with desirable long-run properties and captures the dynamics of the system whilst incorporating the equilibrium suggested by economic theory.

5.22: THE JOHANSEN APPROACH

The Engle-Granger approach is being largely superseded by an approach developed by Johansen (1988, 1989) and Johansen and Juselius (1990). As noted by Moosa (1994), the Engle-Granger approach makes the implicit assumption that the cointegrating vector is unique. However, there is no guarantee that any single cointegrating vector is the true long-run relationship. In fact it is more likely to be a linear combination of independent cointegrating vectors. Secondly the approach yields results that depend on the direction of normalization. Even though we can treat all the variables in the Engle-Granger framework also as endogenous variables by running regressions with each variable in turn on the left hand side, the result obtained depend on the direction of normalization, i.e. depends on which variable is treated as the left hand side variable. Thirdly, in the E-G approach, the distribution of the test statistics will, in general, be slightly different in any particular application since they are not invariant with respect to the nuisance parameters which characterize any particular application. Additionally, the presence or absence of drift terms in the non-stationary variables can crucially affect the form of the distribution. Thus the critical values given by Engle and Granger can be taken only as a rough guide. The Johansen approach, on the other hand, yields results that are invariant with respect to the direction of normalization because it makes all the variables endogenous. Furthermore, it provides estimates of all the cointegrating vectors that exist within a system of variables and provides test statistics for determining their number. Another advantage of the method is that the likelihood ratio test statistic has an exact known distribution. Given these distributional properties of the ML estimator, specification tests can be carried out on the cointegrating vectors. However, the cointegrating vector from the Johansen approach may also face problems of interpretation as discussed below.

The Johansen approach begins by setting up vector autoregressive (VAR) system of the variables of interest. The basis of the system of equations used is summarized by Lilien et al. (1994, p.193) as follows. Consider a system consisting of p variables. If the variables are integrated of order zero, that is the levels of the variables are stationary, then a VAR can be formulated in terms of levels of the variables. In effect we have p cointegrating equations. If the variables are integrated, say of order 1 and there is no cointegration between them, then again standard time series analysis, (such as a VAR) can be applied to the first differences of the data. The system, so to speak, is being driven by p separate integrated elements. Levels of the series do not appear in the VAR. If the variables are integrated of the first order and there happens to be one cointegrating relationship among them, then one error correction term is added involving the levels of all variables on the right hand side of the VAR. If there are r cointegrating relationships, then r error correction terms involving levels of all the variables are added to the right hand side. There is thus a sequence of nested models in this framework. The most restricted model is that with no cointegrating equation and it is a VAR strictly in first differences. Each cointegrating equation adds the parameters associated with the term involving levels of the series which needs to be added to each equation. The Johansen method computes the likelihood ratio statistics for each added cointegrating equation

In implementing the Johansen procedure, we begin by expressing the data generation process of a vector of variables X, as an unrestricted vector autoregression in the levels of the variables:

$$X_t = \Pi_1 X_{t-1} + \Pi_{12} X_{t-2} \dots + \Pi_{1k} X_{t-k} + e_t \qquad t = 1,\dots, T \qquad (5.4)$$

In the above X is a vector of p variables all of which are I(1) and $\Pi_1, \Pi_2, \dots \Pi_k$ are $p \times p$ matrices of unknown parameters. The minimum lag of the system is chosen at which the residuals are white noise.

The above VAR system may be reparameterised in error correction form as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + e_t \qquad (t = 1,\dots,T) \qquad (5.5)$$

where

$$\Gamma_i = -I + \Pi_1 + \Pi_2 + \dots + \Pi_i \qquad i = 1, \dots, k \qquad (5.6)$$

$$\Pi = -(I - \Pi_1 - \dots - \Pi_k), \qquad i = 1,\dots, k-1. \qquad (5.7)$$

To obtain equation 5.5 from equation 5.4, we proceed as follows:

$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \Pi_3 X_{t-3} + \ldots\ldots\ldots\ldots \qquad (5.4)$$

Adding $(-X_{t-1})$ to both sides and collecting terms gives:

$$X_t - X_{t-1} = \Delta X_t = (\Pi_1 -1)X_{t-1} + \Pi_2 X_{t-2} + \Pi X_{t-3} + \ldots\ldots \qquad (5.8)$$

Next we add $-(\Pi_1 -1)X_{t-2}$ to both sides of equation 5.8 to obtain:

$$\Delta X_t - (\Pi_1 - 1)X_{t-2} = -(\Pi_1 - 1)X_{t-2} + (\Pi_1 -1)X_{t-1} + \Pi_2 X_{t-2} + \Pi_3 X_{t-3} + \ldots\ldots$$
$$= (\Pi_1 -1)\Delta X_{t-1} + \Pi_2 X_{t-2} + \Pi_3 X_{t-3} + \ldots\ldots$$

Collecting terms gives:

$$\Delta X_t = (\Pi_1 -1)\Delta X_{t-1} + (\Pi_1 + \Pi_2 -1)X_{t-2} + \Pi_3 X_{t-3} + (\Pi_1 - 1)X_{t-2} + \ldots \qquad (5.9)$$

We then add $-(\Pi_1 + \Pi_2 - 1)X_{t-3}$ to both sides of equation 5.9 and collect terms. Proceeding in this fashion and collecting terms leads to equation 5.5

Since the first differenced variables are I(0), the final term on the right hand side must also be I(0). This will occur only if $\Pi = 0$ (which also means rank(Π) = 0) or if the parameters of Π, the long-run impact matrix, are such that ΠX_{t-k} is also I(0). This latter occurs if the level variables are cointegrated, i.e., some linear combination of X_t are stationary. But if this is the case, then the matrix Π must not be full rank, that is the rank, r is less than p, the number of variables. If Π is of rank r where $r < p$, then there exist r cointegrating vectors or stationary long-run relationships among the p variables in X_t and $p-r$ common stochastic trends. Thus cointegrating is equivalent to a reduced rank of Π and the rank of r determines the number of cointegrating vectors. If rank(Π) = p (i.e., $r = 0$), then all of the variables in X_t are stationary in levels - which contradicts the assumption that all variables are I(1).

In the case where Π is of rank r where $r < p$ (i.e., there is cointegration), then there exist matrices α and β of dimension $p \times r$ such that $\Pi = \alpha\beta'$ with α and β being of full rank. The columns of matrix β are the r distinct cointegrating vectors, and α is called the adjustment matrix (also referred to as factor loadings or error correction parameters). It represents the matrix of weights with which each cointegrating vector enters each equation of the VAR system. Johansen has developed a maximum likelihood procedure for estimating α and β as well as the likelihood ratio test for determining the value of r (the number of significant cointegrating vectors). If the X_t vector does in fact cointegrate, then by the Granger representation theorem, we know that α must contain at least one non-zero element.

The actual mechanics of the Johansen (1988) procedure is as follows. We first regress first difference of X_t on its lagged values and a column of ones and save the residuals as R_{0t} .Then we regress X_{t-k} also on the lagged values and a column of ones and save the residuals as R_{kt}. The determination of k is discussed later on in the study. The fitted residuals are used to construct the following product moment matrices:

$$S_{ij} = (1/T)\Sigma\hat{R}_{it}\hat{R}'_{jt} \qquad (i, j = 0, k)$$

These product moment matrices are then used in order to find the maximum likelihood estimate (MLE) of β the cointegrating vectors. This is done by solving the determinant:

$$|\lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k}| = 0$$

This yields the *p* estimated eigenvalues $(\hat{\lambda}_1,\ldots, \hat{\lambda}p)$ and the *p* estimated eigenvectors $(\hat{v}_1,\ldots,\hat{v}p)$, which are normalized such that $\hat{V}'S_{kk}\hat{V} = I$ where V is the matrix of estimated eigenvectors. The *r* cointegrating vectors are given by the *r* 'most significant' eigenvectors, that is:

$$\hat{\beta} = (\hat{v}_1,\ldots, \hat{v}_r)$$

and

$$\hat{\alpha} = S_{0k}\hat{\beta}.$$

The problem is that of determining which (and how many) of the eigenvectors in fact represent significant cointegrating relationships. In effect what we are looking for are those b vectors which have the largest partial correlation with the (first differenced) stationary variables conditional on their lags (and any dummy variables which may be used). Johansen uses canonical correlation methods to estimate all the distinct combinations of the levels of X which produce high correlations with the I(0) elements in equation 5.5. We choose the eigenvectors which correspond to the r largest eigenvalues and these constitute the cointegration vectors.

In order to find the value of r we employ test statistics suggested by Johansen (1988,1989). Johansen suggests two likelihood ratio tests for the number of cointegrating vectors. The first is the trace test, λ_{trace}. The likelihood ratio test statistics (λ_{trace}) for the null hypothesis of at most r cointegrating vectors against a general alternative of more than r vectors is given by $-T\Sigma^{p}_{r+1} ln(1-\hat{\lambda}_i)$ (Johansen and Juselius, 1990, p.177) where T is the number of observations. The second is the maximal eigenvalue test, whose test statistic is denoted by λ_{max} and which gives the likelihood ratio test statistics for the null hypothesis of r cointegrating vectors against the alternative of $r+1$ cointegrating vectors and is given by $-Tln(1-\hat{\lambda}_{r+1})$ (Johansen and Juselius, 1990, p.178). Assume, for example, that we have a sample of size 120 and that with three variables the cointegration analysis yields the eigenvalues 0.38499, 0.18021 and 0.083106. Then if our null hypothesis is zero cointegrating vector, the value of the maximal eigenvalue statistic is given by -120ln(1-0.18021) and if the null hypothesis is one cointegrating vector, the value of the statistic is given by -120ln(1-0.083106)

Thus the Johansen procedure enables us to test for the order of integration and to find the values of the r significant cointegrating vectors. Muscatelli and Hurn

(1992) note that in general the Johansen procedure may yield quite different estimates for the long-run elasticities of a model compared to the static regression suggested in the E-G procedure since, among other things, the estimates obtained using the E-G method are based on an arbitrary normalisation of the variables wheareas the Johansen method uses information from the equation from each of the variables in order to obtain the ML estimates of β, which are not dependent upon any normalisation. Muscatelli and Hurn write: "As Johansen (1989) demonstrates, the ML method and the static regression method will only yield identical results in the special case where *r=1* and where the error correction term only enters the equation for the variables of interest."

Having found the significant cointegrating vectors, we may also test restrictions on these vectors by employing the following likelihood ratio test in order to test the null hypothesis that the restriction is valid:

$$T \Sigma^{r}_{i=1} [(1-\tilde{\lambda}_i)/(1-\hat{\lambda}_i)]$$

where r is the order of cointegration, and $\tilde{\lambda}_i$ and $\hat{\lambda}_i$ represent the estimated characteristic roots from the restricted and unrestricted model respectively. Under the null this test statistic asymptotically follows a $\chi^2(r \times s)$ distribution where *s* is the number of restrictions imposed on the cointegrating vector(s).

While finding more than one cointegrating vector indicates a more stable system and hence is desirable, it also has some problems (Moosa,1994). First it leads to the problem of identifying the single long-run relation that may be the relationship of interest since multiple cointegrating vectors span a space in which any linear combination may also be a cointegrating vector (Johansen, 1990; Muscatelli and Hurn, 1992). A course of action often suggested is that one should pick the vector that makes economic sense, that is, one in which the estimated coefficients are close to and have the same signs as those predicted by economic theory (Muscatelli and Hurn, 1992; Moosa, 1994). However as exemplified in his study of the monetary theory of exchange rates (Moosa, 1994), there may not be any single vector that is consistent with theory with respect to the signs and magnitude of all the coefficients.

If more than one cointegrating vector is obtained, an arbitrary selection of one statistically significant cointegrating vector, in order to move from the Johansen framework to the estimation of a single structural equation, involves making the implicit assumption that the conditional model which is isolated is valid. This problem is faced in the Johansen approach because although the approach explicitly recognizes the multivariate nature of the estimation problem by relying on the ML principle, it does not partition the variables into endogenous and (weakly) exogenous variables - which is central to estimating a single behavioral equation (Muscatelli and Hurn, 1992).

It is with this in mind that Johansen (1992, P.216) expressed the view that the real importance of the approach is that it allows the precise formulation of a number of testable hypothesis including tests for linear structural hypothesis on the cointegrating vectors which are structural in the sense that they do not depend on any normalization of the parameter β (Johansen, 1992 p.225). He suggests that testing should be used as a device to find out whether any specified structural relation can be contained in the space spanned by β. However, Muscatelli and Hurn (1992) point out that the Johansen procedure "only permits one to impose and test the same restrictions across all cointegrating vectors simultaneously" and therefore the fundamental difficulty regarding the identification of separate long-run structural equations still remains.

The basic model represented by equation 5.4 may be augmented with constant and trend terms in order to take into account deterministic terms which may enter the model as well as with seasonal dummies. The issue of whether or not there is a deterministic term (a constant or no constant, linear trend, quadratic trend etc.) in the overall VAR model and whether or not such a term belongs to the stationary component, the nonstationary component or to both has received a lot of attention. In short, any deterministic term in such a model is, in general, made up of a complex combination of terms that belong to the stationary and the nonstationary parts of the model. One must therefore identify the appropriate components of the constant and trend coefficients of the overall model with the corresponding stationary or nonstationary components of the model. This process, which is a rather thorny one, has been discussed by Johansen and others in a number of articles, for example, Johasen and Juselius (1990), Johansen (1991, 1994) and Osterwald-Lenum (1992).

Assume we specify the vector autoregressive model in the reduced form error correction model as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots\dots + \Gamma_{k-1}\Delta X_{t-k+1} + \Pi X_{t-k} + \mu_0 + \mu_1 t + e_t \quad (t = 1,\dots\dots,T)$$

and that the system is cointegrated. Then the presence or absence of a deterministic term is impinged upon by the cointegration relationship. The exact way that the deterministic term behaves depends critically on the relationship between the deterministic component, $\mu_t = \mu_0 + \mu_1 t$ and the adjustment coefficient, α, of the cointegration vector. We decompose the parameters, μ_0 and μ_1 in the direction of α and $\alpha_\perp$ as follows (Johansen, 1994, p.208)

$$\mu_i = \alpha \beta_i + \alpha_\perp \gamma_i$$

that is $\mu_0 = \alpha \beta_0 + \alpha_\perp \gamma_0$ and $\mu_1 = \alpha \beta_1 + \alpha_\perp \gamma_1$ where $\alpha_\perp$ is a vector orthogonal to α.

To analyze the model, it is useful to define a number of nested models based on the possible combination of relationships between μ_t and α as follows (Johansen, 1994, p. 208)

Model 1: H(r): $\mu_t = \alpha \beta_0 + \alpha_\perp \gamma_0 + (\alpha \beta_1 + \alpha_\perp \gamma_1)t$

Model 2: H*(r): $\mu_t = \alpha \beta_0 + \alpha_\perp \gamma_0 + (\alpha \beta_1)t$

Model 3: H1(r): $\mu_t = \alpha \beta_0 + \alpha_\perp \gamma_0$

Model 4: H1*(r): $\mu_t = \alpha \beta_0$

Model 5: H2(r): $\mu_t = 0$

Now Johansen (1994) points out that in general, the constant term in an autoregressive model of non-stationary variables gives rise to a trend. A linear trend in such a model gives rise to a polynomial trend of degree determined by the coefficients of the autoregressive model. In the VAR model above, if the coefficients are chosen such that it defines I(1) variables, then the linear term implies a quadratic term in the variables and the constant term implies a linear trend in the variables. If the model allows for I(2) variables, then the constant term will imply a quadratic term in the variables. In the following, we assume we are dealing with I(1) variables.

The model can be interpreted in different ways depending on the different restrictions placed on the constant and linear terms. For example, since in submodel 1 above the linear term, $(\alpha\beta_1 + \alpha_\perp\gamma_1)t$ is unrestricted, a quadratic trend in the Xt process is possible. The coefficient of this quadratic trend arises from the slope coefficient μ_1 in $\mu_1 t$ and is given by $\tau_2 = \beta_\perp(\alpha_\perp\Gamma\beta_\perp)^{-1}\alpha_\perp'\alpha_\perp\gamma_1$. However, when there is cointegration, a linear combination of the variables generate β and since $\beta'\tau_2 = 0$, this linear combination, which is stationary, eliminates the quadratic term.

As a second example, consider the submodel 3, H1(r). There is no trend component in the VAR in this submodel and hence there could be no quadratic trend in the model. The submodel however has a constant term. Thus a linear trend is possible- the coefficient of which is given by $\tau_1 = \beta_\perp(\alpha_\perp\Gamma\beta_\perp)^{-1}\alpha_\perp'\alpha_\perp\gamma_0$. Analogous to the situation in model 1, this trend is eliminated by the cointegrating relations and hence the process contains no trend stationary component.

If we consider the submodel 2, H*(r), on the other hand, we find that it allows for the possibility of a linear trend in all components of the X_t process. The linear trend coefficient in this model is given by:

$$\tau_1=\{\beta(\beta'\beta)^{-1}\}_\perp\Gamma^{-1}\alpha_\perp\beta_\perp\gamma_0+\{\beta(\beta'\beta)^{-1}\}_\perp\Gamma^{-1}\alpha_\perp\beta_\perp\Gamma\alpha_\perp\beta\beta_1-\beta(\beta'\beta)^{-1}\beta_1.$$

Therefore a trend can exist in the cointegrating relationship - since $\beta'\tau_1= -\beta_1$ (all terms except the last one drop out). This trend will not be eliminated by the cointegration vector, β, and as such the cointegrating relations have a trend given by $-\beta_1 t$.

The above discussion shows that though there may be a constant or a trend etc. in a nonstationary combination of the variables, this constant or trend may be eliminated when the system is cointegrated. Johansen and Juselius (1990, p.181) and Johansen (1994, p.213) provide tests for determining whether the absence of a constant or trend from the cointegration vector is data consistent. For example, testing whether the constant is eliminated from the cointegration relationship involves comparing models 4 and 5, that is H_1*(r) and H_2(r). The test statistics is given by $-T\Sigma^p{}_{r+1}ln\{(1-\lambda_i^*)/(1-\lambda_i)\}$ where λ_i^* and λ_i are the largest eigenvalues from models 5 and 4 respectively and is asymptotically distributed as χ^2 with *p-r* degrees of freedom. Thus while estimates are chosen that accord with theoretical priors, the choice of statistical model is, at least to some extent, empirical.

CHAPTER SIX

RESULTS OF COINTEGRATION ANALYSIS

In this chapter, we carry out cointegration tests for money demand functions for Ghana and Canada using the Johansen multivariate procedure. This is a maximum likelihood approach for estimating all the distinct cointegrating vectors which might exist between a set of variables and for testing their statistical significance. We also estimate dynamic error correction models based on the cointegration relationships obtained.

6.1: MODEL SPECIFICATION FOR GHANA

Based on the review in chapter three, we initially specify the money demand function for Ghana as:

$$m_t = f\,(y_t,\, r_t,\, \pi_t, \varphi_t) \tag{6.1}$$

where m_t is the demand for real money balances, y_t is real gross domestic product, r_t is the rate of interest (proxied by the discount rate), π_t is the rate of inflation and φ_t is the rate of depreciation of the parallel market exchange rate.

However, both r_t and φ_t are omitted from the variables that we eventually use. This is because preliminary tests, in which we include φ_t (which, as would be recalled from the unit root tests in chapter 3, is stationary around a deterministic trend) with the other variables, did not yield a plausible cointegrating relationship. This is not particularly surprising since all the other variables are integrated of the first order. The interest rate, on the other hand, is omitted because it entered insignificantly into the equation that we finally estimate. This again is in consonance with all other money demand studies in Ghana which have found the interest rate not to be significant (mainly on account of the fact that interest rates were kept fixed for long periods of time.)

6.2: THE COINTEGRATION ANALYSIS

We apply the Johansen approach to the above model using the EVIEWS econometric program. This program allows tests to be conducted under three basic conditions:

(i) the VAR assumes no deterministic trend in the data

(ii) the VAR assumes a linear deterministic trend in the data

(ii) the VAR assumes a quadratic deterministic trend in the data

Since real GDP has a trend, we first carry out the analysis on equation 6.1 under the basic assumption that there is a linear trend in the data and under two sub-assumptions: (i) there is an intercept but no trend in the cointegrating equation and VAR and (ii) there is an intercept and trend in the cointegrating equation, but no trend in the VAR.

6.21: RESULTS OF COINTEGRATION ANALYSIS FOR GHANA.

The results of the analysis for narrow money under the two sub-assumptions above are presented in tables 6.1a and 6.1b. The equations are estimated over the period 1961:1 to 1990:4. The results generally indicate 0 or 1 significant cointegrating vector which however does not represent a plausible money demand function. A typical cointegrating relationship for *m1, y,* π, *r* and a constant normalized on *m* is (1, -4.30, 0.1754, 0.0508, 22.916). Similar results are obtained when *m2* is used.

Due to the results obtained above, we also carry out the analysis under the assumption of "no deterministic trend" in the VAR since real GDP is the only variable which shows a trend and this trend is not very pronounced. When an intercept term is included in this analysis, we obtain results (table 6.1c) similar to that obtained under the assumption of linear deterministic trend in the VAR. However, when the intercept term is omitted from this analysis, more plausible results are obtained. Because of this the model we finally use assumes the absence of both a deterministic trend in the data and of an intercept in the cointegrating equation.

The absence of a deterministic term from the VAR and cointegration equation was discussed in chapter 5. Here we carry out the test specified in that chapter to determine whether the varnishing of the constant term from our cointegration equation is data consistent. For the model without a constant term in the cointegration vector, the eigenvalues are 0.132459, 0.062032 and 0.020958 while for the model with a constant term, the corresponding eigenvalues are 0.157690, 0.062059 and 0.044494. For one cointegration vector, the test statistics for the absence of a constant term is given by the expression $-T \Sigma^3_2 \ln\{(1-\lambda_i^*)/(1-\hat{\lambda}_i)\}$ where λ_i^* and $\hat{\lambda}_i$ repesent, respectively, the eigenvalues for the model with and without a constant term.

Table 6.1a: Cointegration Result Assuming Linear deterministic Trend in the Data and Intercept (but no trend) in the Cointegration Equation and VAR: M1 Equation

No. of Lags	No. of C. Vs.	Trace statistic 1st	Trace statistic 2nd	Cointegrating Vector (normalized on *m*) m	y	π	r	c
1	1	77.74	17.21	1	-3.788	0.1391	0.0660	19.269
2	1	53.86	11.78	1	-3.763	0.1364	0.0635	19.204
3	1	68.01	12.05	1	-4.301	0.1754	0.0508	22.916
4	0	46.20	12.79	1	-4.513	0.1547	0.0607	24.469
5	0	42.66	14.69	1	-4.204	0.1457	0.0612	22.325
6	0	28.63	11.07	1	-4.696	0.2031	0.0427	25.644
7	0	38.11	15.29	1	-4.800	0.2506	0.0383	26.101
8	0	35.53	17.36	1	-2.766	0.1453	0.0433	12.216

Critical Values: 47.21 (5%), 54.46 (1%); H_0: r=0 H_1: r≥1) $LR_{trace} = -T\ S\ P_{r+1}\ln(1-\lambda_i)$

Table 6.1b: Cointegration Result Assuming Linear deterministic Trend in the Data and Intercept and trend in the Cointegration Equation but no Trend in VAR: M1 Equation

No. of Lags	No. of C Vs.	Trace statistic 1st	Trace statistic 2nd	Cointegrating Vector (normalized on *m*) m	y	π	r	t	c
1	2	114.37	43.64	1	-5.834	-0.1454	-0.1035	0.0604	34.022
2	1	74.83	29.37	1	12.312	-1.0730	-0.7132	0.2726	80.203
3	1	90.54	34.56	1	-4.179	0.2135	0.0656	-0.0065	22.024
4	1	64.20	30.77	1	-4.486	0.1701	0.0677	-0.0029	24.277
5	1	69.31	32.60	1	-4.832	0.0322	0.0034	0.0235	26.766
6	0	49.59	26.05	1	-4.834	0.0163	-0.0073	0.0274	26.754
7	0	58.61	30.55	1	-4.822	0.0411	-0.0014	0.0237	26.667
8	0	56.18	34.63	1	-4.954	0.0183	-0.0169	0.0294	27.574

Critical Values: 47.21 (5%), 54.46 (1%); H_0: r=0 H_1: r≥1) $LR_{trace} = -T\ S\ P_{r+1}\ln(1-\lambda_i)$

Table 6.1c: Cointegration Result Assuming no Deterministic Trend in the Data but Intercept in the Cointegration Equation and VAR: M1 Equation

No. of Lags	No. of C. Vs.	Trace statistic 1st	Trace statistic 2nd	Cointegrating Vector (normalized on *m*) m	y	π	r	c
1	1	83.04	60.48	1	-3.784	0.1398	0.0661	19.351
2	1	60.48	17.89	1	-3.801	0.1361	0.0648	19.562
3	1	75.52	19.98	1	-4.316	0.1752	0.0514	23.108
4	1	58.63	24.89	1	-4.552	0.1520	0.0640	24.841
5	1	49.33	21.26	1	-4.223	0.1426	0.0618	22.516
6	1	37.32	19.62	1	-4.601	0.2056	0.0462	25.153
7	1	46.70	23.08	1	-4.673	0.2447	0.0393	25.478
8	0	44.26	24.33	1	-2.514	0.1467	0.0401	10.715

Critical Values: 47.21 (5%), 54.46 (1%); H_0: r=0 H_1: r≥1) $LR_{trace} = -T\ S\ P_{r+1}\ln(1-\lambda_i)$

Using the above eigenvectors, yields a test statistic of 115(0.02951+0.00331) = 3.77 which is less than the $\chi^2(2)$ value of 5.99 at the 5% level. We conclude therefore that the constant term does indeed varnish from the cointegration equation and the model as specified is data consistent.

Table 6.2 shows the trace test for our final model. The interest rate is omitted from the analysis because it did not enter significantly into the cointegration relationship. As noted above, the insignificance of the interest rate is in line with the results of other studies on the demand for money in Ghana. Selected cointegration results over different time periods, with the interest rate as an included explanatory variable, are presented in appendices 1 and 2. These illustrate the non-significance of the interest rate as an explanatory variable.

The results show that the value of the test statistics varies with the lag length. This issue was first explored by Hall (1991) who suggests that the test statistics should be reported for a range of lag lengths or the lag length should be chosen based on the VAR with the minimum test statistic. We follow Hall's suggestion of reporting results for a range of lags. It can be observed that in general the lag length has very little effect on the number of cointegrating vectors. Except for lag order 6 for which there is no significant vector and lag orders 9 and 12 where there are 2 significant cointegrating vectors, all the other lag orders gave one significant cointegrating vector. Again, our results are in consonance with Hall's (1991) observation that the likelihood ratio test statistic for a first order lag system is very high. The value of the test statistics then falls as the lag order increases until a minimum is reached. It then begins to rise again as small sample effects gain in importance. Hall's second criterion of using the minimum test statistics occurs at lag 6 with a test statistics of 20.97 which misses being significant (at the 5% level).

Table 6.2: Trace test for M1 (Ghana); $LR_{trace} = -T\,\Sigma^{p}_{r+1} ln(1-\lambda_i)$

lag (k)	H_0: r=0 H_1: r≥1	H_0: r≤1 H_1: r≥2	Significant vectors
1	58.01	3.59	1
2	43.70	6.54	1
3	51.40	5.25	1
4	32.85	8.02	1
5	25.75	5.02	1
6	20.97	8.00	0
7	26.14	9.80	1
8	24.55	10.46	1
9	29.45	13.42	2
10	29.96	10.79	1
11	36.40	12.47	1
12	31.84	12.90	2
Critical values:	5% = 24.31	5% = 12.53	
	1% = 29.68	1% = 16.31	

We also tested the specification lag length of the VAR using likelihood ratio tests reported in table 6.3. LR(1/2) tests whether the restriction imposed in moving from a VAR of lag length 2 to a VAR of lag length 1 is valid. For this test, we used the log likelihood values reported for a specified number of cointegrating equations. For example, for one cointegrating vector the log likelihood value is -399 when k=3 and the value when k=4 is -361. The LR test statistic for the restriction imposed in moving from k=4 to k=3 is given by: -2(-399 - (-361)) = 76 and has a $\chi^2(9)$ distribution since one lagged term for each of the three variables is deleted from each of the (three) VAR equations.

The likelihood ratio statistic shows that among the range of lags explored, the restriction from 8 to 7 lags with a test statistic of 10.5 is not rejected when compared with a $\chi^2(9)$ value of 16.9 (5%). All other restrictions from a higher to a lower number of lags are rejected. Finally, we note that there is very little difference in the values of the cointegrating vector for most of the lag orders as shown in table 6.4. Taking into account the various factors we have discussed, we choose a VAR of lag length 7.

Table 6.3: LR Test Statistics for specification length of M1 VAR

LR (1/2)	33
2/3	37
3/4	30
4/5	32
5/6	32
6/7	28
7/8	11
8/9	37
9/10	22

Table 6.4: Cointegrating Vectors for Different lag Lengths (normalized on "m")

Lag	m	y	π
1	1	1.0335	-0.1891
2	1	1.0141	-0.1777
3	1	1.0213	-0.1768
4	1	1.0199	-0.1754
5	1	1.0090	-0.1590
6	1	0.9960	-0.1695
7	1	1.0164	-0.1616
8	1	0.9763	-0.1490

The choice of a lag order of seven gives a cointegrating vector normalized on *M1* of (1, -1.0164, 0.1616), the other variables being the real GDP, y_t and the rate of inflation, π_t respectively. The cointegrating equation is therefore given by $m_t = 1.0164y_t - 0.1616\pi_t$ with t-statistic of 20.41 and 3.62 for output and inflation respectively. The long-run income elasticity is unity and the inflation elasticity is 0.1616(7.08) = -1.14, the mean value of quarterly inflation being 7.08%.

6.3: ERROR-CORRECTION MODEL FOR GHANA M1

Based on the above cointegrating relationship, we construct an error correction model by regressing the first difference of real money balances, Δm_t, on seven lags each (lags 1 to 7) of the first difference of *m, y* and π and on one period lag of the residual from the above cointegrating relationship as well as on seasonal dummies. We then reduce the system to a "parsimonious" relationship by elimination of the terms which were insignificant at the 10% level by successive elimination of the most insignificant term. The process yields the error correction equation presented below. For the estimated equation, the figures in parenthesis are t-values while for the accompanying test/diagnostic statistics the values in parenthesis represent the prob-value of the relevant statistic.

The EC variable is correctly signed and highly significant. This suggests the validity of the equilibrium relationship, indicating the existence of market forces that operate to restore long-run equilibrium after a short-run shock. It implies that there is causality from the independent variables in levels to real balances. The size of the EC coefficient indicates the speed of adjustment of monetary disequilibrium to long-run equilibrium and has a rather low value of about 4% per quarter. Though the evidence is rather weak, the results also suggests that current period changes in real M1 is affected by lags of up to 7 quarters.

The residual autocorrelation is quite flat and the Jarque-Bera statistics for residual normality is low signifying that the assumption of normal distribution of the residual cannot be rejected. However, the ARCH LM test indicates the presence of auto-regressive conditional heteroscedasticity and the White's heteroscedasticity test (without cross terms) has a prob-value of 0.26. The adjusted R^2 is quite low with a value of 0.42 but this is not unacceptably low in view of the fact that the dependent variable is in first difference form. We note that differenced income does not appear in the above EC equation thus suggesting the absence of any short run income effect on real narrow money holdings other than through deviations from long-run equilibrium as expressed in the error correction term.

Table 6.5: Error Correction Equation for M1 (Ghana)

$$\Delta m_t = -0.3773\Delta m_{t-1} - 0.1870\Delta m_{t-3} - 0.1510\Delta m_{t-7} - 0.0030\Delta\pi_{t-2} + 0.0035\Delta\pi_{t-5}$$

(-4.46) (-2.24) (-1.94) (2.67) (3.14)

(0.000) (0.027) (0.054) (0.009) (0.002)

$$- 0.0395EC_{t-1} - 0.0960QD2 + 0.09350QD4$$

(-4.58) (-4.01 (3.52)

(0.000) (0.000) (0.001)

Adj R^2=0.416; S.E=0.1201; AIC=-4.17; SIC=-3.98; F=12.70; D-W=2.04

LM(2): F = 0.8020(0.4511); ARCH(4): F = 3.12(0.018); WHITE: F = 1.23(0.267)

JB=3.02(0.221); CHOW(1989:1-1990:4) F=0.54(0.82)

Correlogram of Residuals:

Autocorrelation -0.053 -0.099 0.069 0.056 -0.026 -0.040 0.030 0.001 -0.017

Partial Correlation -0.053 -0.102 0.059 0.054 -0.007 -0.036 0.015 -0.004 -0.007

6.4: COINTEGRATION RESULTS FOR GHANA M2

The results of the analysis using broad money, M2 are presented in tables 6.6a and 6.6b Proceeding as under the discussion for M1, the lag length of the VAR was again set at 7. This yields the cointegration relationship normalized on money (with t-values in brackets) as:

$$m_t = 1.070y_t - 0.183\pi_t$$

(28.80) (3.91)

with long-run income and inflation elasticities of 1.1 and -1.30 respectively.

Table 6.6a: Trace test for M2 (Ghana); $LR_{trace} = -T\,\Sigma^{p}{}_{r+1}\ln(1-\lambda_i)$

lag (k)	H_0: r=0 H_1: r≥1	H_0: r≤1 H_1: r≥2
2	48.59	6.29
3	50.74	5.15
4	29.23	7.87
5	24.67	5.82
6	22.74	7.53
7	27.26	10.16
8	25.06	10.05
Critical values:	5% = 24.31	5% = 12.53
	1% = 29.68	1% = 16.31

Table 6.6b: Test statistics for the specification of lag length of M2 VAR

LR(1/2)	32
2/3	30
3/4	35
4/5	31
5/6	32
6/7	27
7/8	11
8/9	43
9/10	21

6.5: ERROR-CORRECTION MODEL FOR GHANA M2

The error correction equation resulting from the above cointegrating relationship is given in table 6.7

Table 6.7: Vector Error Correction Equation for M2, Ghana,

$$\Delta m_t = -0.2928\Delta m_{t-1} - 0.2994\Delta m_{t-3} + 0.0034\Delta\pi_{t-1} + 0.0044\Delta\pi_{t-2} + 0.0029\Delta\pi_{t-5}$$

(-3.044) (-3.060) (2.16) (3.23) (3.10)

(0.003) (0.003) (0.03) (0.001) (0.002)

$$-.0478EC_{t-1} - 0.0913QD2 + 0.1000QD4$$

(-5.10) (-4.11) (4.26)

(0.000) (0.0001) (0.000)

R^2 adj.= 0.401; S.E.= 0.1043; AIC=-4.55; SIC=-4.27; F=12.07; D-W=2.04

LM(4):F=1.86(0.1609); ARCH(4): F= 4.754(0.010); WHITE: F= 4.796 (0.00022)

JB = 0.461(0.794); CHOW(1989:1-1990:4) F= 0.3466 (0.94);

Correlogram of Residuals

Autocorrelation: -0.023 -0.093 0.036 -0.027 -0.014 -0.080 0.011 0.044 0.032

Partial Correlation -0.023 -0.093 0.032 -0.034 -0.009 -0.029 -0.082 0.002 0.030

The results for M2 are quite similar to those for M1 with respect to most of the test statistics. The residuals tests accept normality and absence of significant serial correlation while failing the test for homoscedasticity. As with M1, the error correction term is correctly signed and highly significant and no differenced income term appears in the error correction equation again signifying the fact that income affects changes in real broad money only through deviations of the money stock from the long-run equilibrium value.

6.6: COINTEGRATION AND ERROR-CORRECTION EQUATIONS FOR GHANA

Within-sample stability tests, using recursive residuals, of the model and its coefficients presented later on in the next chapter confirm the relative stability of the parameters with the error-correction parameters well defined and relatively stable over the period. Similarly, direct tests of forecast stability of the model show that forecast stability cannot be rejected for the 8 quarter forecast although there is a systematic forecast error during the period of 1978-83. On account of the acceptable long-run relationship, the in-sample forecast stability, the evidence from the recursive analysis of the model coefficients and the standard goodness of fit tests, we conclude the models for M1 and M2 represent adequate characterization of the data.

6.7: COINTEGRATION RELATIONSHIPS FOR CANADA M2

For the two monetary aggregates investigated, M1 and M2 we obtained meaningful cointegrating relationships only for the latter. Since broad money supply, M2 and the interest rate measures, CHB90 and TB3M are clearly integrated of the first order, we first investigate the cointegrating status of M2 and GDP first separately with each of these interest rate variables and then with both interest rates. Plausible cointegrating relationships were obtained for M2, GDP and TB3M and also for M2, GDP, TB3M and CHB90 but not for M2, GDP and CHB90. Tables 6.8 and 6.9 give the trace statistics and LM test for lag length specification for the cointegrating test for M2, GDP and TB3M.

Table 6.8: Trace test for M2, GDP and TB3M (Canada); $LR_{trace} = -T\Sigma^{p}_{r+1} ln(1-\lambda_i)$

lag (k)	H_0: r=0 H_1: r≥1	H_0: r≤1 H_1: r≥2	Significant vectors
1	65.85	10.81	1
2	30.94	11.90	1
3	75.17	4.60	1
4	30.01	5.54	1
5	24.07	7.53	0
6	38.10	11.20	1
7	44.99	10.91	1
8	40.06	9.97	1
9	36.39	11.20	1
10	42.72	13.39	1
Critical values:	5% = 24.31	5% = 12.53	
	1% = 29.68	1% = 16.3	

The trace statistics indicates one cointegrating vector for lags 1 to 10 except for lag 5 where there is a very marginal failure (trace statistics of 24.07 compared to a 5% critical value of 24.31). We therefore accept one cointegrating vector.

Table 6.9 presents the LM test for the specification of the lag length. Using a $\chi^2(9)$ value of 16.9 (5% level), we find that restriction from 4 to 3 lags is rejected but that from 5 to 4 is not. We therefore choose the lag length to be 4 yielding the cointegrating equation:

$$m_t = -1.567 + 1.182y_t - 0.0199r_t$$
$$(23.43) \quad (-2.33)$$

With a mean interest rate of 8.98%, the above gives an interest elasticity at the mean of -0.0199(8.98) = -0.18. As is noted by Laidler (1985), "a single interest rate is best interpreted as standing as a representative measure of the rates of interest to be earned on holding the many assets that agents could substitute for money in their portfolios" Thus the above elasticity compares favorably with the value of -0.16 that Caramazza (1989, p.9) obtained for his "net interest rate effect" over a similar period (1970:1 to 1987:4). As an example for an earlier period (1954:1 to 1975:3), Cameron (1979) obtained elasticities that range between -0.115 and -0.266 for six interest rate differentials (using the differentials between 90-day financial paper or 90-day treasury bill rate and the weighted average rates paid on chequable saving deposit and a number of savings deposits). Similar elasticities have been found in other studies, for example Laidler (1985) notes that "the interest elasticity for M2 with respect to the short term rate appears to have varied roughly between -0.12 and -0.15 and with respect to the long run between -0.2 and -0.6" for studies for the US covering the period 1892 to 1960. Of course, much different elasticities have been found in some other studies.

Table 6.9: LR Test Statistics for specification length for M2 ,GDP and TB3M

LR(1/2)	140.2
2/3	121.4
3/4	33.4
4/5	11.5
5/6	21.0
6/7	-19.0
7/8	35.4
8/9	23.4

6.7: ERROR-CORRECTION EQUATIONS FOR CANADA M2.

From the above cointegrating equation, we derive the error correction equation presented in table 6.10 below.

Table 6.10: Error Correction Equation 1, M2 (Canada; Sample: 1969:1 1992:4)

$$\Delta m_t = 0.013 + 0.189\Delta m_{t-1} + 0.261\Delta m_{t-2} - 0.254\Delta m_{t-3} - 0.161\Delta y_{t-1} - 0.214\Delta y_{t-2}$$

(7.87) (2.09) (2.87) (-2.80) (-4.31) (-10.68)

$$-0.121\Delta y_{t-3} + 0.00157\Delta rtb_{t-2} + 0.00380\Delta rtb_{t-3} - 0.0586EC_{t-1}$$

(-3.58) (1.94) (4.74) (-6.19)

R^2=0.64 Adj R^2= 0.604 S.E= 0.00834 AIC=-9.48 SIC=-9.21 F=17.07 D-W 1.96

Correlogram of Residuals

Autocorrelation 0.018 0.013 -0.042 -0.133 -0.053 -0.008 -0.233 -0.035 -0.092

Partial Correlation 0.018 -0.013 -0.041 -0.132 -0.051-0.013 -0.251 -0.061 -.130

ARCH(4): F=0.436 (0.782);WHITE: F=1.174 (0.304); CHOW: (1990:1 to 1992:4) F=0.775 (0.673)

For the analysis involving M2, GDP, the t-bill rate (rtb) and the ninety day chartered bank deposit rate, (rch), the trace test statistics and LM test for lag length specification of VAR are given in tables 6.11 and 6.12 respectively.

Table 6.11: Trace test for M2, GDP, CHB90 and TB3M ; $LR_{trace} = -T\Sigma^{p}{}_{r+1} ln(1-\lambda_i)$

lag (k)	H_0: r=0 H_1: r≥1	H_0: r≤1 H_1: r≥2	Significant vectors
1	93.12	22.36	1
2	45.91	19.46	0
3	100.00	19.63	1
4	43 .39	20.17	0
5	49.69	25.99	1
6	63.72	35.61	2
7	78.15	37.93	2
8	81.26	35.02	2
9	74.92	34.81	2
10	90.22	44.14	2
Critical values:	5% = 24.31	5% = 12.53	
	1% = 29.68	1% = 16.3	

Based on these results and using a $\chi^2(16)$ value of 26.30 (5%).we chose a lag length of 5 for the VAR and this gives a cointegrating relationship:

$$m_t = -3.126 + 1.285y_t + 0.0958rch_t - 0.0780rtb_t$$

(24.54) (3.62) (-3.51)

For M2, the chartered bank deposit rate can be considered as an "own" rate hence the positive sign on "rch". The treasury bill rate, on the other hand represents an opportunity cost variable, hence the negative sign. The larger (unexpected) absolute value for the coefficient for the chartered bank rate could be explained by the fact that chartered bank deposit rate, "rch", has experienced a smaller percentage change (216.7%) over the period of the study compared to a change of 224.2% for the treasury bill rate, "rtb".

Table 6.12: LR Test Statistics for specification length of M2 VAR

LR(1/2)	154.0
2/3	120.0
3/4	35.0
4/5	29.8
5/6	30.2
6/7	39.8
7/8	31.2
8/9	36.0

The "parsimonious" error correction equation resulting from the above cointegrating relationship is presented in table 6.12. A comparison of tables 6.9 and 6.12 shows that although there is close similarity between the two equations the result using only the 3-month treasury bill rate shows an improvement over the one in which both the treasury bill rate and the chartered bank deposit rate are used. This is true for the goodness of fit statistics. It is also observed that the EC term coefficient is not significant in the equation using both interest rates.

Table 6.13: Error correction equation 2 for M2 (Canada;Sample: 1969:1 1992:4)

Δm_t= 0.0037+0.251Δm_{t-1}+0.311Δm_{t-2} -0.214Δm_{t-3}+0.109Δy_{t-3} +0.208Δy_{t-4}

(2.15) (2.51) (3.36) (-2.22) (3.01) (9.62)

+0.091Δy_{t-5}+0.0071Δrch_{t-2} -0.0020Δrtb_{t-1} - 0.0074Δrtb_{t-2} - 0.0024Δrtb_{t-4}

(2.64) (3.02) (-2.31) (-3.19) (-2.50)

-0.0261EC_{t-1}

(-1.60)

R-sq = 0.617 Adj R-sq= 0.566 S.E.= 0.0087 AIC=-9.36 SIC=-9.04 F =12.28 DW = 1.92

Correlogram of Residuals

Autocorrelation 0.033 0.007 0.029 -0.074 -0.074 -0.025 -0.102 0.018 -0.046 -0.011

Partial Correlation 0.033 0.006 0.028 -0.076 -0.070 -0.020 -0.096 0.023 -0.057 -0.011

CHOW: (1991:1 to 1992:4) F=0.551 (0.814); ARCH Test: F= 3.20(0.017)

CHAPTER SEVEN

STABILITY OF PARAMETERS OF ERROR CORRECTION EQUATIONS AND TESTS OF EXOGENEITY

7.1: INTRODUCTION

For the vector error correction equations, which are estimated by OLS, we are able to carry out additional tests of stability of the parameters using recursive residuals. A basic issue of interest is whether the money demand function suffers from structural instability. The standard goodness of fit and diagnostic statistics tests deal with the characteristics of the model and its parameters over the entire sample period. Inferences based on the estimated full-sample parameters will be invalid if these coefficients have not remained stable. Unstable parameters could also indicate that money demand does not maintain consistent dynamic relationships with its determinants or that the implicit weak exogeneity conditions of the model are not valid. We therefore carry out further tests using recursive residuals as well as several other tests derived from recursive residuals to assess the stability of the parameters.

We also carry out exogeneity tests to determine the exogeneity or endogeneity of the variables used in the cointegrating equations. Although the Johansen approach used in this study considers all the variables as endogenous and applies the MLE approach in estimating the cointegrating vectors, nothing precludes any of the variables from being exogenous and indeed (weak) exogeneity of the independent variables is required for the consistent estimation of the parameters of the dynamic EC model.

7.2: RECURSIVE RESIDUALS

As mentioned above, the stability tests carried out are based on recursive residuals and we therefore first provide a brief description of the method. We use the testing procedure in EVIEWS and the succeeding discussion relies on the description in the EVIEWS manual.

In recursive least squares, the equation is estimated repeatedly, starting with the minimum possible set of observations that can be used to obtain an estimate of the coefficient vector, β. The next observation is then added to the data set which is then used to compute a second estimate of β. The process is repeated until the full set of observations are used. At each step, the last estimate of β is used to predict the next value of the dependent variable. The standardized value, w_t, of the one-step forecast error is called the recursive residual. If the maintained model is valid, the recursive residual will be independently and normally distributed with zero mean and constant variance. This facilitates tests of serial correlation and heteroscedasticity, but one of the most important applications of recursive residuals is testing for structural change in the model. The tests we use in this study are plots of (i) the recursive residuals, (ii) the cumulative sum (CUSUM) of recursive residuals, (iii) the cumulative sum of squares (CUSUM of squares) and (iv) the recursive coefficients.

The recursive residual diagram gives a plot of w_t about the zero mean line as well as bands with plus and minus two standard errors. Residuals outside the bands suggest instability in the parameters of the equation.

The CUSUM test is based on the statistic

$$W_t = 1/s\, \Sigma w_t \qquad t = k+1, \ldots., T$$

In the above, s is the standard error of the regression fitted to all T sample points. W_t is plotted against time. If the coefficient vector, β, remains constant from period to period, then $E(W_t) = 0$, but if β changes, W_t diverges from the zero mean value line. The CUSUM test produces a plot of W_t against t and also shows 5% critical lines. Movement of W_t outside this band indicates parameter instability.

The CUSUM of squares test is based on the test statistic

$$s_t = \Sigma^t{}_{k+1}\, w_t^2 \,/\, \Sigma^T{}_{k+1}\, w_t^2 \qquad t = k+1, \ldots\ldots, T$$

and

$$E(s_t) = t\text{-}k/T\text{-}k$$

Under parameter constancy, this gives the mean value line which goes from zero at $t = k$ to unity at $t = T$. The CUSUM of squares plots s_t against t and shows the mean value line as well as a pair of 5% critical lines with movement of s_t outside the critical lines indicating parameter instability

The recursive coefficient test plots the recursive coefficients for all feasible recursive estimation with the two standard error bands around the estimated coefficients. If the coefficients display significant variation as more data is added to the estimating equation, then the parameters are unstable.

7.3: RECURSIVE RESIDUALS TESTS FOR GHANA

Fig. 7.1 and 7.2 present graphs for various stability tests for the error correction equation for narrow money for Ghana. The recursive residuals graph in fig. 7.1 generally indicates stability with the width of the two standard error band remaining fairly constant over the period. There is however a consistent set of large forecast errors over the period 1978:2 to 1983:2 this being the result of the excessively large increases in money supply over that period.

The plots of cumulative sum of residuals (CUSUM) also indicates parameter stability since the actual cumulative sum remains well inside the 5% critical lines. Similarly the CUSUM of squares also lies within the 5% critical lines showing that the ratio of the sum of the squared residual up to a particular data point to that of the sum of the squared residuals for all the data points does not deviate significantly from the expected value thus indicating homoscedasticity in the data. However, a clear change in direction can be detected in the plots around the second half of 1983. This coincides with the introduction of the Economic Recovery Program.

Fig. 7.1: Graphs for Stability Tests, VEC Equation, M1 (Ghana)

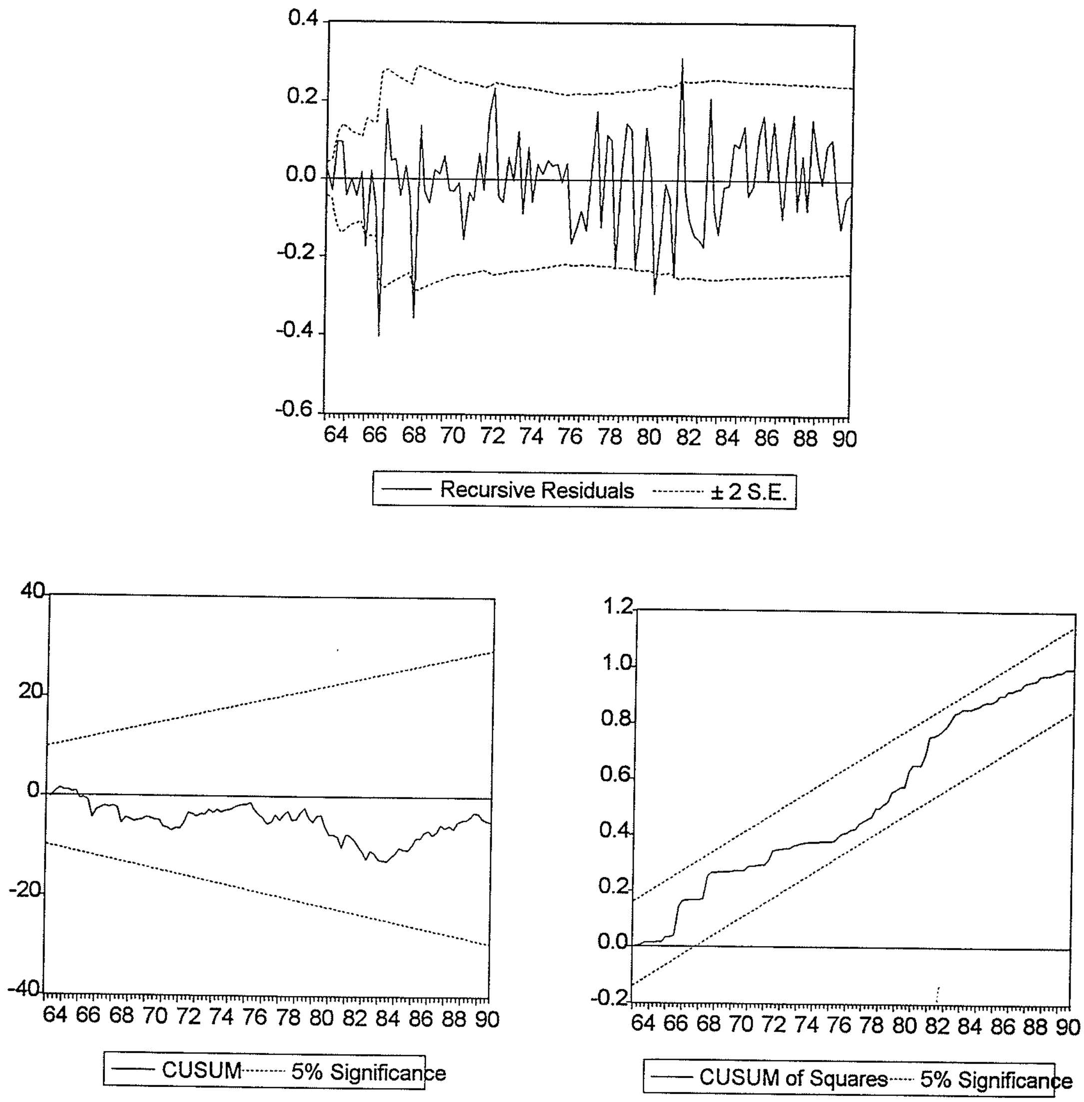
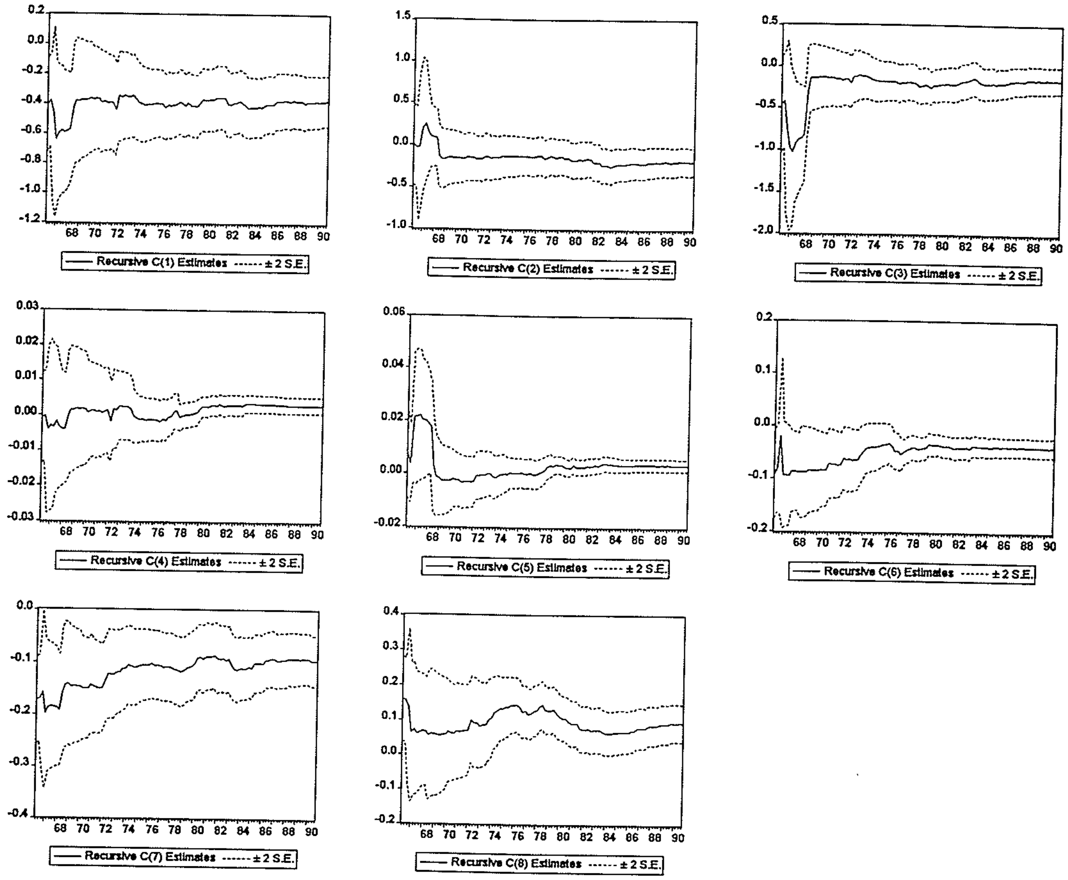


Figure 7.2: Recursive Coefficient Estimates (M1, Ghana)

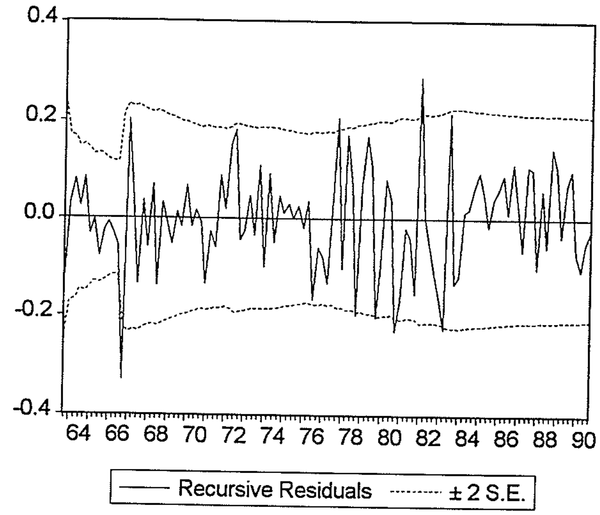


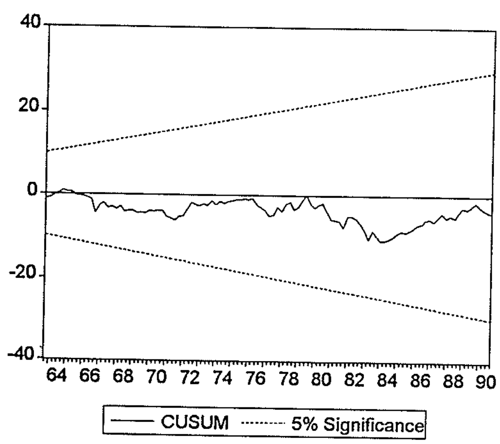
$$\Delta m_t = \underset{(C1)}{-0.3773\Delta m_{t-1}} \underset{(C2)}{-0.1870\Delta m_{t-3}} \underset{(C3)}{-0.1510\Delta m_{t-7}} \underset{(C4)}{-0.0030\Delta \pi_{t-2}} \underset{(C5)}{+0.0035\Delta \pi_{t-5}}$$

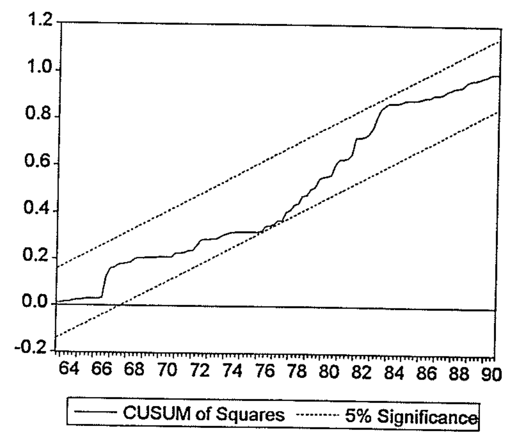
$$\underset{(C6)}{-0.0395EC_{t-1}} \underset{(C7)}{-0.0960QD2} \underset{(C8)}{+0.09350QD4}$$

The recursive coefficients together with bands of plus-or-minus two standard errors are presented in figure 7.2 above. They show substantial stability in all the parameters (including the error correction coefficient) and in fact the bands become narrower as more information becomes available as one would expect if the regime does not change. The largest fluctuation occurs in the seasonal parameters.

Fig. 7.3: Graphs for Stability Tests, VEC Equation, M2 (Ghana)

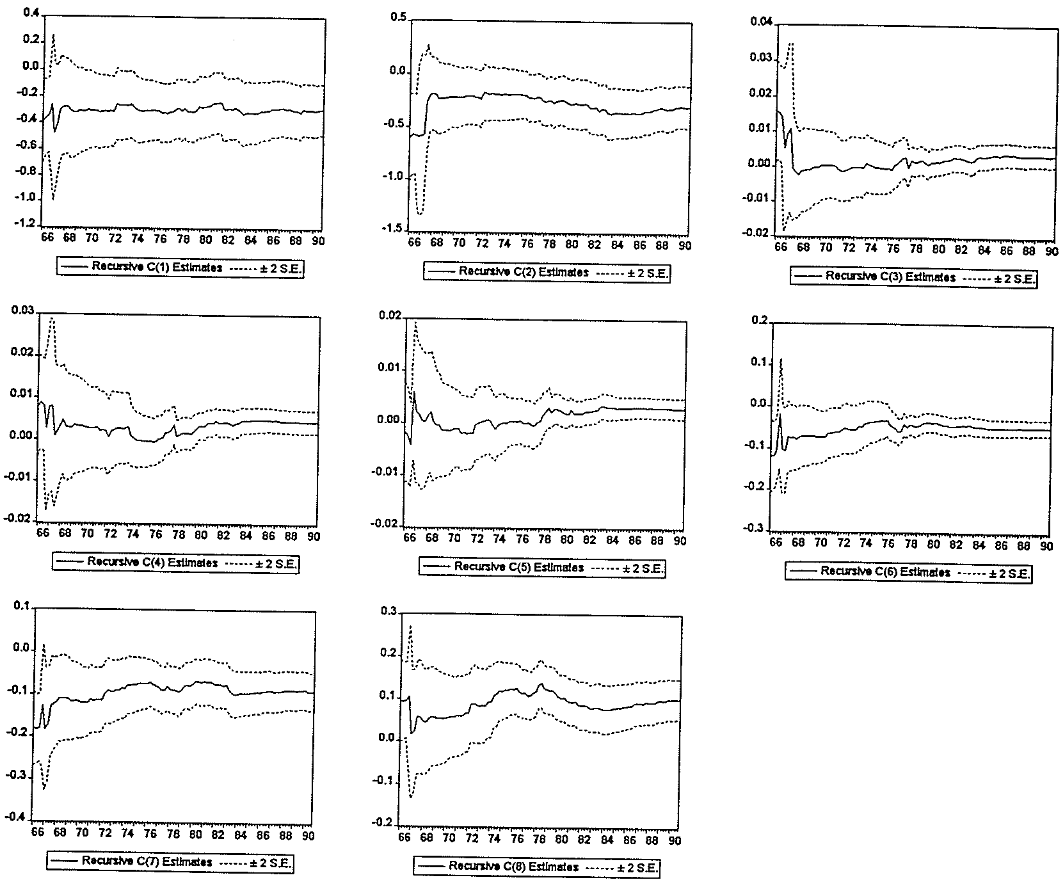






The stability tests for broad money, M2, are presented in figures 7.3 and 7.4. The results closely mirror those for M1 and do not require much discussion. It may however be noted that there is enough variation in the variance to push the cusum of squares plots to the lower limit of the 5% error band in 1976-77.

Figure 7.4: Recursive coefficient estimates, M2 (Ghana)



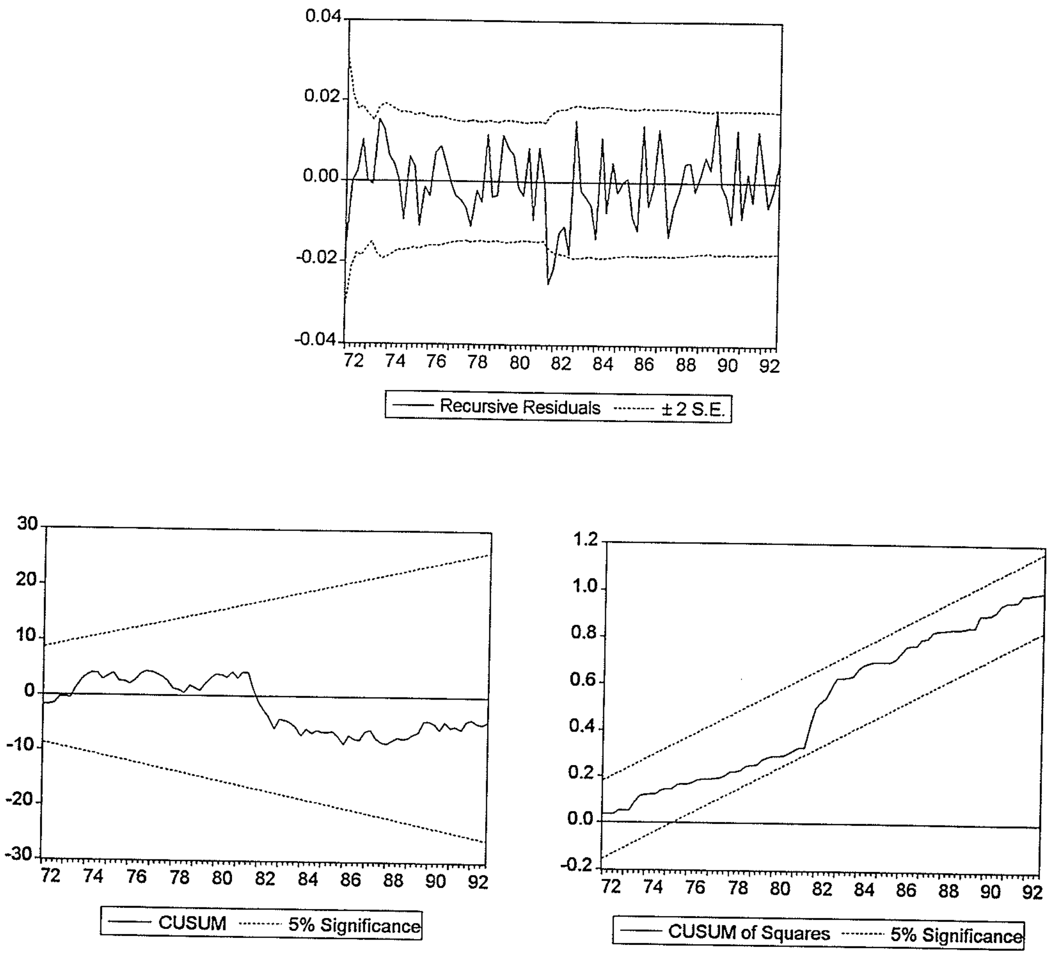
$$\underset{}{\Delta m_t} = \underset{(C1)}{-0.2928\Delta m_{t-1}}\underset{(C2)}{-0.2994\Delta m_{t-3}}\underset{(C3)}{+0.0034\Delta\pi_{t-1}}\underset{(C4)}{+0.0044\Delta\pi_{t-2}}\underset{(C5)}{+0.0029\Delta\pi_{t-5}}$$

$$\underset{(C6)}{-.0478EC_{t-1}}\underset{(C7)}{-0.0913QD2}\underset{(C8)}{+0.1000QD4}$$

7.4: RECURSIVE RESIDUAL TESTS FOR CANADA M2

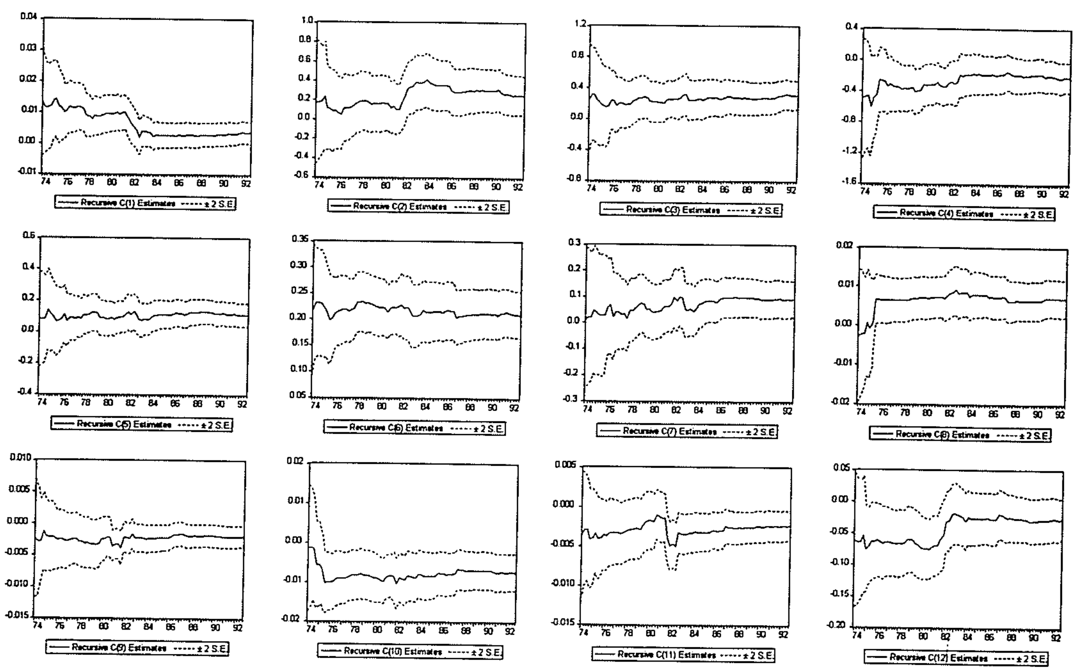
Figures 7.5 to 7.8 present the corresponding graphs for broad money, M2, for Canada and for the two sets of equations estimated. There is a substantial similarity in the results. The CUSUM and CUSUM of squares plots both remain between the critical lines indicating that any departures from their respective expected values are not significant, i.e., the residuals are sufficiently stationary and homoscedastic. However, all the plots indicate a clear shift in the second half of 1981. This is quite evident in both recursive residual graphs which show clear widening of the critical bands and in the CUSUM and CUSUM of squares graphs for the equation having output and the two interest rates as explanatory variables but less clear with the CUSUM and CUSUM of squares plots for the equation in which only the t-bill rate is used. There are also some differences in the shapes of the two graphs. In the equation with both interest rates, the cusum plot lies above the mean line up to the time of the regime shift in 1981 and then below it thereafter indicating under-prediction real balances in the earlier periods but over-prediction in later periods. However, that for the equation with only the t-bill rate drifts above and away from the mean line over the period up to the second half of 1981 and then starts to fall (though still lying above the zero mean line). Similarly, whereas the cusum of squares plots for the two equations lie above the mean after 1981 that using both interest rates rises sharply from near the lower 5% critical line in 1981 while that using only the t-bill rate rises by about only half as much (from around the mean value line). Thus while the plots for both equations remain acceptably stable, there is a difference in the pattern of stationarity and homoscedasticity of the forecast residuals .

Fig 7.5: Stability graphs for VEC equation for M2 (Canada, CHB90, TB3M)



The recursive coefficients show reasonable stability (after expected variations in the early stages due to small sample size). A number of the parameters register clear shifts in the second half of 1981 but more or less revert to their previous levels fairly rapidly. A noticeable exception is the error correction coefficient (the last coefficient) in the equation using both interest rates. This coefficient remains at a higher level of about -0.025 following an upward shift in 1981. Prior to 1981, the value of this coefficient lies closer to -0.05 indicating a faster rate of adjustment to equilibrium in the pre-1981 period. This faster rate of adjustment is closer to the error correction coefficient obtained for the equation that uses only the t-bill rate. It is worth recalling that the coefficient of the error correction term in the equation using both interest rate variables is not significant.

Fig. 7.6: Recursive Coefficient Estimates, M2 (Canada)



$$\Delta m_t = \underset{C1}{0.0037} + \underset{C2}{0.251}\Delta m_{t-1} + \underset{C3}{0.311}\Delta m_{t-2} \underset{C4}{-0.214}\Delta m_{t-3} + \underset{C5}{0.109}\Delta y_{t-3}$$

$$+\underset{C6}{0.208}\Delta y_{t-4} + \underset{C7}{0.091}\Delta y_{t-5} + \underset{C8}{0.0071}\Delta rch_{t-2} \underset{C9}{-0.0020}\Delta rtb_{t-1} \underset{C10}{-0.0074}\Delta rtb_{t-2}$$

$$\underset{C11}{-0.0024}\Delta rtb_{t-4} \underset{C12}{-0.0261}EC\text{-}1$$

We note that the parameters of the equation using only the t-bill rate show greater stability compared to that of the equation using both interest rates. We also note that the parameters of the money demand relationships for Ghana exhibit relatively more stable characteristics compared to the money demand relationships obtained for Canada.

Fig.7.7: Stability Graphs for M2 Equation using M2, GDP and TB3M variables.

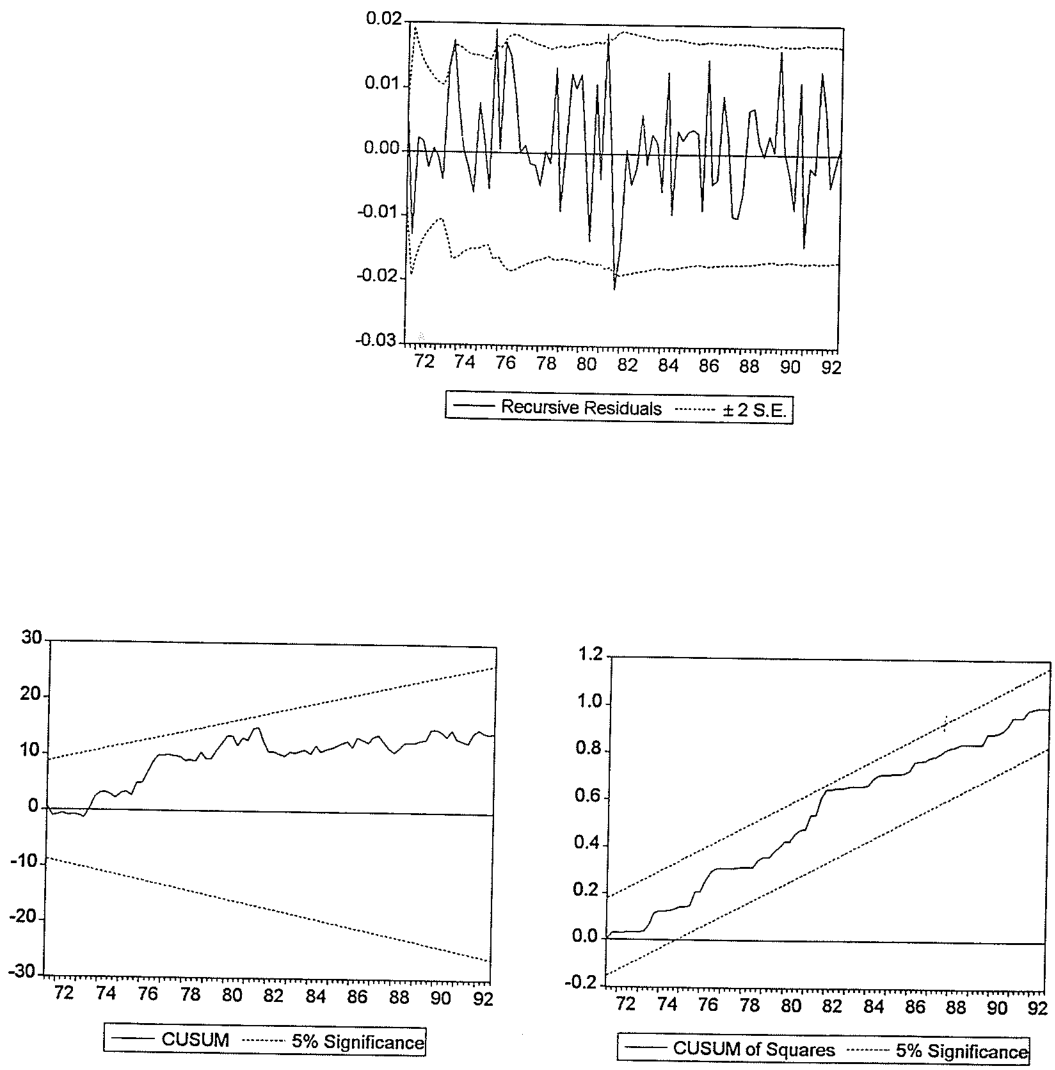
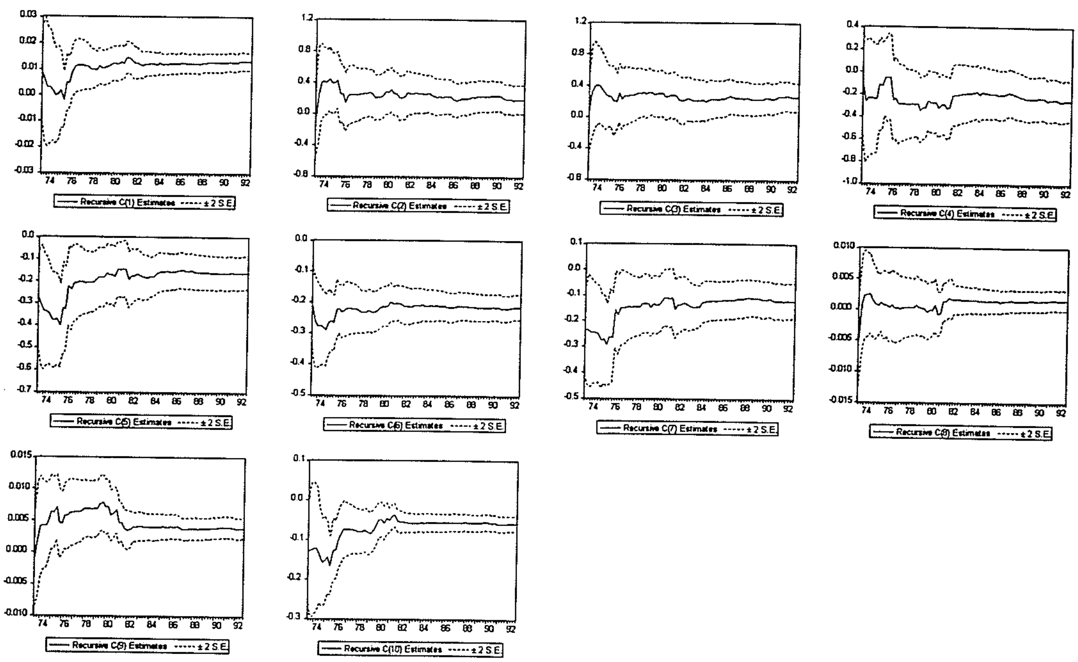


Fig. 7.8: Recursive Coefficients (M2, GDP, TB3M)



$$\Delta m_t = \underset{C1}{0.013} + \underset{C2}{0.189} Dm_{t-1} + \underset{C3}{0.261} \Delta m_{t-2} - \underset{C4}{0.254} \Delta m_{t-3} - \underset{C5}{0.161} \Delta y_{t-1} - \underset{C6}{0.214} \Delta y_{t-2}$$

$$- \underset{C7}{0.121} \Delta y_{t-3} + \underset{C8}{0.00157} \Delta rtb_{t-2} + \underset{C9}{0.00380} \Delta rtb_{t-3} - \underset{C10}{0.0586} EC_{t-1}$$

7.5: TESTS OF EXOGENEITY

So far the error correction equations have been interpreted as valid dynamic money demand equations. For this to be true, the explanatory variables must be (weakly) exogenous. This is because if these variables are not weakly exogenous with respect to the coefficients of the money demand function, then parameters of the error correction model cannot be consistently estimated by imposing the estimated cointegrating vector in this (EC) model and we cannot use t-statistic for inference about the significance of the parameters. It is therefore necessary to investigate the exogeneity properties of these variables.

7.51: WEAK EXOGENEITY

Before proceeding to test for (weak) exogeneity of the independent variables we first provide a brief description of the concept of weak exogeneity and its relevance in the estimation of our models.

Let x_t be a vector of observations on all variables in period t which can partition as (w_t, y_t, x_t) and let $X_{t-1} = (x_{t-1}, \ldots x_1)'$. The joint probability density of the sample x_t, the data generation process (DGP), may be specified as:

$$D(x_1, \ldots, x_t, X_0, \Theta) = \Pi\, D(x_t/X_{t-1}; \Theta)$$

where Θ is a vector of unknown parameters.

This joint density of the complete sample can always be sequentially factorized according to the partitioning of x_t as:

$$D(x_1, \ldots, x_t, X_0, \Theta)=D(x_t/X_{t-1};\Theta)=A(W_t/Xt;\alpha)\ B(Y_t/Y_{t-1},Z_t;\ \beta)\ C(Z_t/Y_{t-1}, Z_{t-1}; \gamma)$$

Thus given the above general DGP, we may specify the model to be estimated by factorizing the DGP into conditional and marginal processes as above (Cuthbertson, Hall and Taylor, 1992, p.99)

In the above, Θ is partitioned as (α, β, γ). The first component, A, specifies the determination of W_t, the variables of no interest (or the nuisance variables), as a function of all the variables, X_t. We can, in fact, ignore the nuisance variables in further discussion of the issue. The second term, B, gives the endogenous variables of interest, Y_t, as a function of lagged Y and the exogenous variables Z_t. The final term C, gives the determination of the exogenous variables, Z_t, as a function of the lagged endogenous and exogenous variables.

The above decomposition implies that there is a submodel, C, that contains DGPs for the explanatory variables, Z_t only and a conditional submodel, B that contains DGPs for the endogenous variables, Y_t, conditional on the explanatory variables, Z_t. The full model consists of all joint DGPs (μ^x,μ^y) where μ^x and μ^y are arbitrary elements in C and B respectively (Davidson and MacKinnon, 1993).

For the conditioning assumptions of the model to be valid, it is required that the Z_t variables be at least weakly exogenous for the parameters, $\psi \in \beta$, of the model of interest. This means that Z_t is independent of Y_t as is assumed in 'C'. It also requires that the parameters of interest of the model to be finally estimated, ψ, are a function of β only, that is, the model parameters depend only on the conditional DGP which generates the Y_t's conditional on the X_t's. β and γ must also be variation free, that is, the marginal distribution of Z_t does not depend on β and the conditional distribution of Y_t/Z_t depends on β only. In other words, the parameters associated with the DGP (μ^y,μ^x) depend only on μ^y. If μ^x is replaced by another DGP for the explanatory variable, say ν^x, the parameters do not change (Davidson and MacKinnon, 1993). As such weak exogeneity implies the absence of cross-restrictions between β and γ and the joint density of the entire sample can factorize as above. Thus when weak exogeneity holds, the precise specification of the marginal distribution of $C(Z_t/Y_{t-1}, Z_{t-1}; \gamma)$ is irrelevant for the estimation of the parameters of the conditional model and we therefore do not need to model the process generating Z explicitly and jointly with Y. Urbain (1992) notes that "weak exogeneity of the right hand side variables means that no useful information is lost when we condition on the variables without specifying their generating process."

This requirement for weak exogeneity may be violated in a cointegrated system. This can be illustrated with a simple example. Assume Y_t and X_t are cointegrated such that

$$Y_t = \alpha X_t + e_t \qquad 8.1$$

and we write error-correction representations as:

$$\Delta Y_t = Y_t - Y_{t-1} = c_i \Sigma \Delta X_{t-i} + d_i \Sigma \Delta Y_{t-i} + b(Y_{t-1} - \alpha X_{t-1}) + u_{yt} \qquad 8.2$$

$$\Delta X_t = X_t - X_{t-1} = \gamma_i \Sigma \Delta X_{t-i} + \delta_i \Sigma \Delta Y_{t-i} + \beta(Y_{t-1} - \alpha X_{t-1}) + u_{xt} \qquad 8.3$$

with the usual assumptions of normally distributed error terms with zero mean and variance-covariance matrix given by $\Sigma = E(u_t, u_t')$ where $u_t = (u_{yt}', u_{xt}')$. In the model above, we cannot write a submodel that contains DGPs for the explanatory variable ΔX_t only - because of the presence of α, the adjustment coefficient in both equations. Hence one of the necessary conditions for weak exogeneity of ΔX_t with respect to the parameters of the ΔY_t equation is violated. In the model above, u_{yt} and u_{xt} both depend on α. Hence $\Sigma = E(u_t, u_t')$ is not diagonal and the error terms are correlated with the result that σ_{xy} is not equal to zero. Thus ΔX_{t-i} is correlated with u_{yt} and estimation by OLS will not be consistent. As noted above, the problem arises because of the presence of the parameter α - the adjustment parameter of the cointegrating relationship, in both equations. Under this condition, the specification of the marginal distribution of X is not irrelevant for the specification of the parameters of the ΔY_t equation.

In their multivariate maximum likelihood approach to cointegration, Johansen and Juselius (1990) have shown that "ΔX_{it} is weakly exogenous for the parameters, α and β (of the cointegration vector) in the sense that the conditional distribution of ΔX_t given ΔX_{it} as well as the lagged values of X_t contains the parameters α and β whereas the distribution of ΔX_{it} given the lagged X_t does not contain the parameters α and β" if for some variable X_i, $\alpha_i = 0$ (Johansen and Juselius (1992). α, represents the matrix of weights with which each cointegrating vector enters each of the ΔXt equations. Thus in general the cointegrating vectors will determine the current value of the conditioning variables in the model (through the adjustment vector, α,) thereby violating weak exogeneity. "Intuitively then, this violation will not occur if there is no feedback from the cointegrating vector to the marginal processes for the (conditioning variables), ... which will be the case if and only if the relevant adjustment coefficients in the α vector are zero." (Adam et al., 1993).

Similarly to designing tests for restrictions on the cointegrating vectors, Johansen and Juselius (1990, 1992) also formulated tests for testing restrictions on the α matrix as a test of exogeneity of any of the variables with respect to the long-run parameters of the cointegrating vector.[1] An alternative testing procedure, which we apply below, is due to Engle and Granger (1987) and has been used by a number of writers. Within the context of an ECM model, exogeneity is tested by inverting the equations and testing the significance of the ECM term in the inverted equation normalized on the variable of interest. If $\alpha_i = 0$ then the cointegrating vector will not appear in the marginal equation for the variable in question. Thus an insignificant EC term means that the chosen normalization does not respond to the past disequilibrium in the error-correcting system, and is thus weakly exogenous in the system. This approach has been used, for example, by Choudhry (1995) for Argentina, Hansen and Kim (1995) for Germany, Huang (1994) for China and Masih and Masih (1995) for Singapore and South Korea and Barnhart and Wallace (1994) for the UK.

7.6: EXOGENEITY TESTS FOR GHANA

Tables 7.1 to 7.3 present the inverted equations normalized on the relevant variables for Ghana and Canada. Since the variables used in the equations for Ghana are money, output and inflation inverted equations are presented for output and inflation for each of the two monetary aggregates, M1 and M2. For Canada, the inverted equations (for M2) are presented for output, the treasury bill rate and the chartered bank deposit rate.

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[1] Econometric programs such as Microfit have procedures for readily carrying out tests along the lines suggested by Johansen. Such programs are however not available to us.

Table 7.1: Inverted Equations (Ghana)

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a) Narrow Money, M1

(i) $\Delta y_t = -0.0080 + 1.255\Delta y_{t-1} - 1.895\Delta y_{t-2} + 2.395\Delta y_{t-3} - 2.002\Delta y_{t-4} + 1.165\Delta y_{t-5}$

(-3.188) (12.03) (-9.15) (8.08) (-6.22) (4.64)

$-0.607\Delta y_{t-6} + 0.216\Delta y_{t-7} - 0.00133EC_{t-1} + 0.0200QD2 + 0.0222QD4$

(-4.23) (-2.35) (-1.38) (4.86) (5.04)

Adj R-sq= 0.552 S.E.= 0.0154 AIC =-8.251 SIC = -7.990 F=15.187 D-W=1.82

(ii) $\Delta\pi_t = -0.210\Delta\pi_{t-2} - 0.160\Delta\pi_{t-5} + 5.058QD2 - 3.120QD4 - 3.525EC_{t-1}$

(-2.661) (-1.931) (2.851) (-1.650) (-6.090)

Adj R-sq=0.376; S.E= 9.212; AIC= 4.483; SIC=4.601; F=18.46; D-W=1.97

(b) Broad Money

(i) $\Delta y_t = -0.0078 + 1.255\Delta y_{t-1} - 1.895\Delta y_{t-2} + 2.395\Delta y_{t-3} - 2.002\Delta y_{t-4} + 1.165\Delta y_{t-5}$

(-3.143) (12.03) (-9.15) (8.08) (-6.22) (4.64)

$-0.607\Delta y_{t-6} + 0.216\Delta y_{t-7} - 0.00119EC_{t-1} + 0.0200QD2 + 0.0222QD4$

(-4.23) (-2.35) (-1.41) (4.86) (5.04)

Adj R-sq= 0.553; S.E.= 0.0154; AIC = -8.25 SIC= -7.99; F=15.206; D-W= 1.82

(ii) $\Delta\pi_t = 4.644 - 0.1495\Delta\pi_{t-5} - 10.37QD2 - 7.848QD4 - 2.934EC_{t-1}$

(3.919) (-1.892) (-5.017) (3.592) (-6.189)

AdjR-sq=0.423; S.E= 8.859; AIC= 4.404; SIC= 4.522; F= 22.25; D-W= 2.0

It is observed that for both M1 and M2, the coefficients of the error correction term in the inverted equations normalized on the inflation rate, are negative, large in magnitude and significant. This indicates that inflation is very responsive to monetary disequilibrium. With the equations normalized on output however, the coefficients have negative signs which are small in magnitude and are not significant. Furthermore, only lagged changes in income are significant (and therefore appear) in the marginal equation for output. Thus while inflation is endogenous in the model, output is (weakly) exogenous. Such output exogeneity has also been found by Hansen and Kim (1995) for M1 and M3 for German quarterly data, by Masih and Masih (1995) for quarterly M1 and M2 data in Singapore and South Korea and by Barnhart and Wallace (1994) for quarterly UK M3 (though not for M0 and M1) and by Choudry (1995) for annual M1 and M2 data for Argentina. Such a result could be expected for small (open) economies such as Ghana where a large part of the output is agricultural and largely depend on factors other than domestic monetary policy and where industrial production depends heavily on foreign exchange availability which again depends heavily on the export of agricultural (cocoa) and mineral exports. Masih and Masih point out that in Singapore the growth strategy and therefore real output has depended heavily on the inflow of capital whereas in South Korea export sales has been a dominant factor in the growth of output. These are the factors that account for the exogeneity of output in these countries. As will be seen later, such output exogeneity does not hold for Canada.

INSTRUMENTAL VARIABLE ESTIMATION OF THE ECM FOR GHANA

In our model of money demand for Ghana, since the adjustment coefficient for inflation is not zero, inflation is not weakly exogenous for the parameters of interest in the error correction equation for real balances. We therefore need to apply a simultaneous equation procedure in estimating our error-correction equation.

The cointegration literature has been largely silent on the approach to be adopted in estimating the ECM if some of the variables in the cointegration relationship are not (weakly) exogenous. For one thing, several writers in the area, including Soren Johansen (arguably the most prolific writer in the cointegration literature) seem to be primarily interested in long-run relationships, their reliance on cointegration arising from the fact that even though one may primarily be interested in the long-run relationship, using a model specification that classifies the variables into nonstationary and stationary components and which also allows for short-run and long-run effects permits a more accurate estimation of the long-run relationship.

The common approach to dealing with the problem of the non weak exogeneity of some of the right hand side variables is to omit the contemporaneous values of the independent variables from the right hand side. However, this does not completely resolve the issue since lagged value of the variables also depend on the adjustment parameter and are therefore not weakly exogenous. It is this same fact which makes the choice of appropriate instruments rather difficult compared to situations where cointegration is not the source of the non exogeneity since lagged values cannot be used as instruments. It is apparently because of this difficulty that the very few studies which attempt to use instrumental variables in estimating error correction models within the framework of cointegration have had to include instruments which are unorthodox to some extent. For example, Adam, in a money demand study for Kenya includes current and four lagged values of the US long-run domestic interest rate among his list of instruments (the particular interest rate is not stated). We do not consider such variables as appropriate instruments for Ghana. Instead, we use the following variables as instruments to carry out an estimation of the error correction model by 2SLS: a constant, time, current and four lagged values of the first difference of real GDP, the discount rate, real domestic credit, parallel exchange rate depreciation, and three quarterly seasonal dummies. We also include contemporaneous inflation in the equation since we are using IV approach. The estimated equations for the two monetary aggregates are presented table 7.2 below.

Table 7.2: IV Estimation of ECMs for Ghana

(i) M1 Equation

$$\Delta m_t = \underset{(-2.055)}{-0.3994\Delta m_{t-1}} \underset{(-1.941)}{- 0.377\Delta m_{t-7}} \underset{(-3.238)}{- 0.0059\Delta\pi_t} \underset{(1.983)}{+ 0.00359\Delta\pi_{t-1}} \underset{(-3.577)}{- 0.0521ec_{t-1}}$$

R-sq= 0.415; Adj R-sq= 0.388; S.E.= 0.1246; AIC=-4.11; SIC = -3.986;
F = 10.314; D-W= 2.249.

(ii) M2 Equation:

$$\Delta m_t = \underset{(-2.155)}{-0.544\Delta m_{t-3}} \underset{(-4.846)}{- 0.00688\Delta\pi_t} \underset{(1.857)}{+ 0.0053\Delta\pi_{t-1}} \underset{(1.719)}{+ 0.0045\Delta\pi_{t-2}} \underset{(-1.615)}{- 0.0476QD2}$$

$$\underset{(2.976)}{+0.1347QD4} \underset{(-4.130)}{- 0.0638ec_{t-1}}$$

R-sq= 0.448; Adj R-sq = 0.4094; S.E.= 0.1052; AIC=-4.4312; SC=-4.239;
F = 9.45; D-W = 2.60

If we compare the IV and OLS estimates, we find that despite some differences, there is substantial agreement between the two results. The major difference is that the inclusion of contemporaneous inflation eliminates the quarterly dummies, QD2 and QD4 from the M1 equation. The OLS error correction coefficients of -0.04 and -0.05 for M1 and M2 respectively compare favorably with the values of -0.05 and -0.06 for M1 and M2 respectively obtained from the IV estimation. There is also surprising similarity in the goodness of fit measures. For M1, values of 0.416, 0.120, -4.17 and -3.98 for adjusted R^2, standard error of regression, the Akaike Information Criterion and the Schwartz criterion, in that order, from the OLS regression closely mirror the corresponding values of 0.414, 0.124, -4.11 and -3.98 from the IV regression. Similar results are obtained for M2. We can therefore conclude that the OLS estimates are in reasonably close agreement with the IV estimates. Because of this substantial similarity in results and cognizant of the fact that the choice of instruments is not without problem, we let stand the results of our OLS estimation.

7.7: EXOGENEITY TESTS FOR CANADA

The inverted equations for the M2 VEC models for Canada are presented in tables 7.3 and 7.4. For the equation using both interest rates, the error correction coefficient is positive and significant when the equation is normalized on output and the chartered bank deposit rate and is positive but insignificant when normalized on the treasury bill rate. This implies that both output and the chartered bank deposit rate are not weakly exogenous. These results indicate that when the money stock rises above its equilibrium value, output and the chartered bank deposit rate both rise. Rather unexpectedly, in the equation using only the treasury bill rate the error correction coefficients are negative and significant. This would imply that positive deviation of the money stock from the equilibrium value lead to a fall in both output and the treasury bill rate. While these results are not what one would expect, we note that Barnhart and Wallace (1994) obtained a similar result for the treasury bill rate for the UK Such result could be due to the fact that, in general, the full impact of changes in any of the variables must take into account the changes in the other variables and their feedback to the variable of interest. Furthermore, a more thorough understanding of the long-run error-correction mechanism and the resulting causal implications between the variables could only be gained by analysis of impulse response functions (which we do not carry out in this study).

Table 7.3: Inverted VEC equations for Canada broad money, M2 Sample: 1969:1 1992:4

(a) Equation with both interest rates

(i) $\Delta y_t = 0.00016 + 0.904\Delta y_{t-4} - 0.0037\Delta rtb_{t-4} + 0.0701EC_{t-1}$

(0.102) (33.23) (-2.64) (3.72)

Adj R^2= 0.940; S.E.= 0.015; AIC=-8.34; SIC=-8.23; F= 498.4; D-W= 2.24

(ii) $\Delta rch_t = -0.162 - 20.2\Delta m_{t-2} + 26.1\Delta m_{t-3} + 4.96\Delta y_{t-1} + 5.46\Delta y_{t-2} + 0.473\Delta rtb_{t-1}$

(-0.85) (-1.69) (2.44) (2.081) (1.97) (4.75)

$+0.196\Delta rtb_{t-5} + 4.65EC_{t-1}$

(1.84) (3.03)

Adj R^2= 0.215; S.E=1.071; AIC= 0.218; SIC= 0.431; F= 4.708; D-W=1.98

(iii) $\Delta rtb_t = -0.410 + 11.3\Delta y_{t-1} + 13.77\Delta y_{t-2} + 8.91\Delta yt\text{-}3 + 9.61\Delta y_{t-4} - 21.80\Delta m_{t-2}$

(-1.80) (2.11) (2.45) (1.66) (1.86) (-1.74)

$+ 25.2\Delta m_{t-3} + 0\ .283\Delta rtb_{t-1} - 0.223\Delta rtb_{t-2} + 0.145\Delta rtb_{t-5} + 1.7188EC_{t-1}$

(2.19) (2.58) (-1.85) 1.28 (0.962)

Adj R^2=0.127; S.E=1.101; AIC= 0.299; SIC=0.593; F=2.39 (0.015); D-W=1.93

Table 7.4: Inverted VEC equations for Canada M2 with only t-bill rate (Sample: 1969:1 1992:4)

(i) $\Delta yt = 0.0122 - 0.348\Delta y_{t-1} - 0.395\Delta y_{t-2} - 0.306\Delta y_{t-3} + 0.595\Delta y_{t-4} + 0.0033\Delta rtb_{t-1}$

(4.03) (-3.85) (4.64) (-3.72) (7.39) (2.18)

$-0.0036\Delta rtb_{t-4} - 0.0625EC_{t-1}$

(-2.64) (-3.25)

Adj R^2=0.943; S.E.=0.0149; AIC=-8.33; SIC=-8.12; F=232.1; D-W=2.002

(ii) $\Delta rtb_t = -16.43\Delta m_{t-2} + 20.40\Delta m_{t-3} - 0.335\Delta rtb_{t-1} - 0.172\Delta rtb_{t-2} - 2.16EC_{t-1}$

(-2.09) (2.7) (3.4) (-1.74) (-2.13)

Adj R^2=0.152; S.E.=1.085; AIC=0.215; SIC=0.348; F=5.25 (0.00075); D-W=1.93

CHAPTER EIGHT

PARTIAL ADJUSTMENT AND BUFFER STOCK EQUATIONS AND COMPARISON OF ALTERNATIVE MODELS

8.1: PARTIAL ADJUSTMENT AND BUFFER STOCK EQUATIONS

In this chapter we present the results of the partial adjustment model (PAM) and the buffer stock model (BSM) regressions and also carry out a comparison of these models with the error correction models. Two-stage least squares regression is used in the estimation of the PAM and BSM regressions with correction for first order serial correlation if this improves the results. The instruments used consist of a constant, time trend, and two or three lagged values each of the relevant explanatory variables and a one period lag of the relevant money supply variable. We also investigate equations incorporating dummy variables for various shocks in the late 1970s and early 1980s as discussed in chapter two, for example the withdrawal of currency notes from circulation and the freezing and/or vetting of the accounts of certain categories of deposit holders. Though we used a number of dummies to try to capture the effects of these changes, they turn out not to be significant and are therefore omitted though we present examples of such equations below. In the regression results presented, m_t, y_t, π_t, um_t and AR1 represent, in that order, the log of real money balances, log of real GDP, the rate of inflation (in percentage terms), unanticipated money (or monetary shock) and first order serial correlation term. The monetary shock term is obtained as the residual of a twelve period distributed lag equation containing a term for first order serial correlation. SIC and AIC represent the Schwartz and Akaike Information criteria, F is the F-statistics and S.E. is the standard error of regression. LM represents the Breusch-Godfrey Lagrange multiplier test for serial correlation, ARCH is the test for Auto-Regressive Conditional Heteroscedasticity and WHITE is White's heteroscedasticity test (without cross terms).

Before presenting the regression results, it may be helpful to give a preview. There is a strong evidence of serial correlation in all the estimated equations- both the PAM and the BSM- for both Canada and Ghana. As noted in chapter 4, the most popular approach to buffer stock modeling simply introduces an additional explanatory variable into the traditional money demand function to serve to reduce or remove discrepancies between money demand and money supply. This additional term is obtained as the difference between the money stock and its anticipated component. Commonly, this anticipated component is proxied by the one period lag or by estimates obtained using distributed lag regression or ARIMA modeling. Thus Carr and Darby (C-D) (1981), in their pioneering work, obtained the anticipated component through an ARIMA (1,2,2) model but MacKinnon and Milbourne (1984) in their critique of the C-D study chose a three period distributed lag model after exploring a number of models including the ARIMA (1,2,2) model used by C-D as well as other ARIMA models. Boughton and Tavlas (1990) used a twelve period distributed lag model and it is the approach we follow in this study. It gives results very similar but marginally better than other lag lengths we experimented with.

All the above approaches for obtaining the unanticipated component of money, whether of the distributed lag or ARIMA variety, imply that the buffer stock term involves terms containing current and lagged values of the money stock. For example, if the one-period lag money is used as a proxy, then the buffer stock term, um_t is given by: $um_t = m_t - m_{t-1}$, while if a distributed lag model is used then $um_t = m_t - \Sigma b_i m_{t-i}$. This implies that in the full buffer stock regression, in which the um_t is added to the right hand side of the partial adjustment model, m_t is on both the left and right hand sides of the estimated equations and, m_{t-1} appears twice on the right hand side in addition to other lagged values of money. One would therefore expect problems of serial correlation, which is likely to occur in time series data of this kind, to worsen in the buffer stock model compared to the partial adjustment model (in addition to problems of multicollinearity that would arise from the introduction of successive lagged money terms on the right hand side of the buffer stock model). What we found rather surprising was the *extent* of serial correlation in the (traditional) PAM. Even for Ghana narrow money where the evidence of serial correlation is least among the models estimated for both Ghana and Canada, the autocorrelation and partial autocorrelation functions show clear evidence of serial correlation and the Ljung-Box Q-statistics rejects the hypothesis of uncorrelated residuals at all lags at any standard significance level. Similarly the LM test for no serial correlation is decisively rejected as can be seen in table 8.1. This calls into some doubt the extensive use (at least until recently) of the partial adjustment mechanism in modeling the money demand function. This also implies that the use of derivatives of the PAM, such as the buffer stock model used in this study, is also subject to serious question.

8.2: PAM AND BSM EQUATIONS FOR GHANA.

Tables 8.1 and 8.2 report the results of the partial adjustment and buffer stock regressions for Ghana for narrow and broad money respectively. For broad (but not for narrow) money the estimation is carried out with correction for first order serial correlation since this yields improved results.

Table 8.1: Partial Adjustment and Buffer Stock Equations, M1, Ghana.

(i) PAM equation (Sample:1961:1 to 1990:4)

$$m_t = -0.4371 + 0.9153m_{t-1} + 0.1448y_t - 0.0125\pi_t$$

(-0.6275) (30.25) (1.577) (-4.556)

Adj R^2=0.900; S.E= 0.1416; AIC = -3.876; SC=-3.876; F =343.19; D-W =2.50

LM2 = 10.15(0.000); LM4 = 10.10 (0.000); ARCH2 = 3.16(0.046); ARCH4 = 2.211(0.072); WHITE = 5.466(0.000)

Autocorrelation: -0.256 0.084 -0.169 0.355 -0.111 -0.043 -0.033 0.234 -0.062

Partial Correlation -0.256 0.019 -0.153 0.300 0.051 -0.108 0.017 0.154 0.021

(ii) BS Equation (Sample: 1963:4 1990:4)

$$m_t = -0.2273 + 0.9249m_{t-1} + 0.1055y_t - 0.0104\pi_t + 0.1511um_t$$

(-0.289) (31.20) (0.884) (-1.119) (0.221)

Adj R-sq= 0.933; S.E.=0.1205; AIC=-4.187; SIC=-4.064; F= 354.42; D-W= 2.54

LM2; F= 34.80 (0.000); LM4; F=19.75(0.000); ARCH2; F=3.63 (0.030) WHITE; F= 7.38(0.000)

Correlogram of Residuals

Autocorrelation: -0.275 0.115 -0.135 0.299 -0.115 -0.021 0.013 0.178 -0.064

Partial Correlation: -0.275 0.043 -0.101 0.257 0.036 -0.092 0.038 0.140 0.019

Table 8.2: Partial Adjustment and Buffer Stock Equations, M2, Ghana.

(i) PAM Equation (Sample: 1961:1 1990:4)

$$m_t = -0.5127 + 0.9598m_{t-1} + 0.1159y_t - 0.00898\pi_t - 0.3361AR1$$

(-1.44) (63.54) (2.48) (-7.44) (-3.83)

Adj R^2= 0.96; S.E.= 0.0998; AIC=-4.569; SIC=-4.452; F= 625.97; D-W=2.10

ARCH Test: F=1.685 (0.158); WHITE; F=3.15 (0.0068); JB=0.3725 (0.8301)

Correlogram of Residuals

Autocorrelation-0.050 -0.204 -0.078 0.330 -0.094 -0.209 -0.028 0.262 -0.019

Partial Correlation -0.050 -0.207 -0.106 0.291 -0.105 -0.132 -0.021 0.121 0.018

(ii) BS Equation (Sample: 1963:4 1990:4)

$$m_t = -0.260 + 0.964m_{t-1} + 0.0741y_{t-1} - 0.00595\pi_t + 0.302um_t - 0.388AR1$$

(-0.831) (87.68) (1.58) (-1.54) (0.816) (-1.83)

Adj R^2= 0.981; S.E.= 0.0687; AIC=-5.30; SIC=-5.15; F=1053.9; D-W= 2.062

ARCH(4); F=2.032(0.096); WHITE; F=6.964(0.000)

Correlogram of Residuals

Autocorrelation -0.033 -0.207 -0.057 0.275 -0.080 -0.166 -0.016 0.184 -0.0325

Partial Correlation -0.033 -0.208 -0.076 0.238 -0.094 -0.090 -0.021 0.077 -0.010

The results indicate that the coefficient of the monetary shock term has the expected positive sign in the equations for both M1 and M2. The introduction of this term resulted in an improvement of several of the measures of goodness of fit and diagnostic statistic such as R^2, the Akaike and Schwartz information criteria and the D-W statistic. (Durbin's h statistic computed using the expression $h = (1-DW/2)\{(T/(1-T\sigma^2)\}^{1/2}$ where T is the number of observations and σ^2 is the variance of the coefficient of m_{t-1} in the estimated equation show similar improvement). However for both monetary aggregates the coefficient is not significant. We conclude therefore that our results do not lend support to the buffer stock model. One should however take into account the problem of residual serial correlation that occurred in the estimated equations.

Using the regression results, the PAM equation for M1 gives an income elasticity of 0.1148/(1-0.9153)=1.71. The mean value of inflation is 7.08 giving an inflation elasticity (at the mean) of 7.08(0.0125)/(1-0.9153)=1.05. The BS equation yields income and inflation elasticity of 1.41 and 1.05 respectively. The corresponding elasticities for M2 are 2.88 and 1.58 for PAM and 2.06 and 1.25 for BS. The income elasticities, especially those for the PAM, are rather high. In particular, they are much higher than the value of about unity obtained in the cointegration equations. The high income elasticities for the PAM could be due to the fact that the assumption of a demand determined money stock, which the PAM model entails, is quite unrealistic for Ghana in view of the high degree of credit control.

Due to various shocks in the late 1970s and early 1980s as discussed in chapter 2, for example, the withdrawal of currency notes from circulation and the introduction of the ERP in April 1983, we used dummy variables to see if shifts could be detected in the PAM and BS equations for Ghana. Though we used several dummies to try to capture the effects of these changes, they turned out not to be significant. As examples, we present in table 8.3 below the PAM equations for M1 and M2 incorporating dummies. "D791" represents a dummy that takes a zero value up to 1978:4 and a value of one thereafter.

Table 8.3a: PAM Equations Incorporating Dummy Variables

Narrow money, M1

(i) $m_t = -0.830 + 0.272yt - 0.012\pi_t + 0.836mt\text{-}1 - 0.101D791$

(-1.01) (1.55) (-4.38) (8.49) (-0.842)

Adj. R^2 =0.902 SE=0.137 AIC = -3.93 SIC = -3.82 F=274.57 DW=2.52

(ii) $m_t = -1.057 + 0.299y - 0.012\pi_t + 0.840mt\text{-}1 - 0.130D831$

(-1.27) (2.03) (-4.40) (13.22) (-1.33)

Adj. R^2 =0.898 SE=0.140 AIC = -3.88 SIC = -3.77 F=262.12 DW=2.44

(iii) $m_t = -1.147 + 0.284y - 0.013\pi_t + 0.872mt\text{-}1 - 0.100D841$

(-1.57) (2.07) (-7.37) (27.51) (-0.647)

Adj. R^2 =0.899 SE=0.140 AIC = -3.88 SIC = -3.77 F=263.19 DW=2.52

Table 8.3b: PAM Equations Incorporating Dummy Variables

Broad money, M2

(i) $m_t = -0.726 + 0.181y_t - 0.009\pi_t + 0.923m_{t-1} - 0.049D791 - 0.335ar1$

(-1.56) (1.76) (-7.41) (17.16) (-0.721) (-3.77)

Adj. R^2 =0.956 SE=0.099 AIC = -4.58 SIC = -4.44 F=510.2 DW=2.10

(ii) $m_t = -0.673 + 0.152y_t - 0.009\pi_t + 0.940m_{t-1} - 0.030D821 - 0.331ar1$

(-1.57) (2.07) (-7.37) (27.51) (-0.647) (-3.72)

Adj. R^2 =0.955 SE=0.100 AIC = -4.56 SIC = -4.42 F=501.6 DW=2.11

(iii) $m_t = -0.573 + 0.137y_t - 0.009\pi_t + 0.946m_{t-1} - 0.024D831 - 0.329ar1$

(-1.24) (1.60) (-7.27) (26.63) (-0.427) (-3.72)

Adj. R^2 =0.955 SE=0.100 AIC = -4.56 SIC = -4.42 F=500.0 DW=2.10

(iv) $m_t = -0.697 + 0.153y_t - 0.009\pi_t + 0.948m_{t-1} - 0.027D841 - 0.326ar1$

(-1.42) (1.86) (-6.92 (36.82 (-0.584) (-3.67)

Adj. R^2 =0.955 SE=0.100 AIC = -4.56 SIC = -4.42 F=500.1 DW=2.11

Furthermore, taking a cue from the stability tests for the error correction models, we also carry out break point Chow tests over the period during which the recursive residual plots showed the greatest volatility, namely over the period 1978-1983. The results are reported in table 8.4 where the quarters shown represent the breakpoints.

Table: 8.4: Breakpoint Chow Tests (Ghana)

	1978:2	1979:1	1979:3	1983:2
M1 PAM	2.28(0.065)	2.16(0.078)	2.79(0.034)	4.16(0.004)
BS	10.45(0.000)	4.25(0.0015)	3.24(0.009)	3.06(0.013)
M2 PAM	2.83(0.019)	0.898(0.485)	1.03)(0.405)	4.54(0.0008)
BS	1.60(0.156)	1.45(0.203)	1.02(0.415)	5.63(0.00005)

If, temporarily, we abstract from the limitations of these models, then these results indicate two things. First, that M1 equation has been more unstable than the M2 equation. All the M1 BS statistics are significant at the 1% level as is the M1 PAM for 1983:2, while the other two M1 PAM statistics are significant at the 10% level. A possible explanation is the monetary changes which occurred over the period. As noted in chapter 2, over the twelve month period to the end of June 1978, the level of currency issued by the bank rose sharply by 110%, with the rise almost entirely due to currency notes in circulation. The currency was also devalued from 1.51 to 2.75 cedis per dollar in August 1978. This was followed by the currency reform in March 1979 in which currency notes were withdrawn from circulation. These changes are more likely to affect the demand for M1 than for M2.

Secondly, the results suggest a shift in the parameters of the money demand function in the second half of 1983 since all the test statistics are significant for that breakpoint. This coincides with the commencement of the Economic Recovery Program. We note that similar changes were observed with the recursive residual tests of the VEC equations where the plots show directional changes in 1983 which however did not push them beyond their 5% significance bands. This indicates the VEC does a better job in dealing with the short-run dynamics.

8.3: PARTIAL ADJUSTMENT AND BUFFER STOCK EQUATIONS FOR CANADA

The regression results for M1 are presented in table 8.5: (i) for PAM without any AR correction and (ii) for BSM with AR1 correction. As could be seen from the table, the autocorrelation and partial autocorrelations are high and the LM tests reject the hypothesis of no serial correlation. The buffer stock equation also shows strong evidence of serial correlation. Although this coefficient is positive as expected, it has a magnitude greater than unity and a rather high t-statistic of 45.67. The inclusion of the buffer shock term caused substantial reduction in the coefficients of several of the other variables as well as in their significance. For example the coefficient of the output variable fell from 0.053 to 0.0004 and the t-statistics fell from 3.88 to 0.074. The equation also yields an extremely large F-value. It is clear that serial correlation exhibited by the PAM equation is further exacerbated by the introduction of the buffer stock term in addition to likely problems of multicollinearity.

Table 8.5: PAM and BSM Equations for Canada M1 .

(i) PAM Equation, Canada (sample 1961:3 to 1992:4)

m_t= 0.212 + 0.0533y_t + 0.0086rch_t - 0.0136rtb_t + 0.925m_{t-1}

(0.915) (3.88) (1.56) (-2.52) (30.66)

R^2-adj =0.964; SE=0.0268; F=839.4; AIC=-7.198; SC=-7.085; DW=2.16

JB=3.9808(0.1366); LM2, F=15.281(0.000); LM4 F=19.08 (0.000)

ARCH2 F=0.8489(0.4304); WHITE F=2.388 (0.020).

Correlogram of Residuals:

Autocorrelation -0.083 -0.342 -0.012 0.551 -0.080 -0.266 -0.080 0.597 -0.026

Partial Correlation -0.083 -0.351 -0.091 0.485 0.008 -0.007 -0.157 0.402 0.082

(ii) M1 BS Equation (Sample: 1963:4 1992:4)

m_t=0.5504+0.946m_{t-1}+0.00041y_t+0.0024rch_t-0.00177rtb_t+1.052um_t+ 0.601AR1

(6.97) (98.37) (0.074) (1.26) (-0.891) (45.67) (7.14)

Adj R^2=0.9991; S.E=0.00368; AIC=-11.15; SC=-10.99; F=20291.67; D-W=1.42

ARCH2: F=0.524(0.718); WHITE: F=1.2567(0.2644)

Correlogram of Residuals:

Autocorrelation 0.284-0.374 -0.114 0.143 -0.133 -0.400 0.010 0.482 0.135

Partial Correlation 0.284 -0.495 0.267 -0.151 -0.196 -0.276 0.235 0.194 -0.142

Table 8.6 show the results for broad money. The buffer stock equations with and without AR1 correction are very similar and we therefore present the result only for the latter. As for M1, the coefficient of the monetary shock term is positive. Again this coefficient is highly significant (t-value = 8.1). The inclusion of the buffer shock term improves most of the measures of fit such as the standard error, AIC and SIC. Although the buffer stock equation for M2 seems more plausible to us than that for M1, it is to be noted that there is a strong evidence of serial correlation in this equation also.

Table 8.6: PAM and BSM Equations for Canada M2.

(i) PAM Equation, Canada

$m_t = -0.169 + 0.937m_{t-1} + 0.081y_{t-1} + 0.0047rch_t - 0.0054rtb_t$

(-1.73) (36.46) (2.47) (2.36) (-2.73)

Adj R^2= 0.9987; S.E.= 0.0111; AIC=-8.95; SC=-8.82; F=19358.9; D-W=1.73

JB=5.28 (0.071) LM4=15.84(0.000) LM2 = 8.53 (0.000); ARCH2 = 0.0624(0.939)

ARCH4 = 1.188(0.322) JB = 5.28(0.071); WHITE = 1.595(0.137)

Correlogram of Residuals:

Autocorrelation 0.122 -0.157 -0.074 0.207 -0.127 -0.245 -0.186 0.200 -0.089

Partial Correlation 0.122 -0.174 -0.032 0.204 -0.220 -0.153 -0.161 0.149 -0.178

(ii) BS Equation (Sample: 1971:4 1992:4)

$m_t = -0.0044 + 0.981m_t + 0.0209y_t + 0.00258rch_t - 0.00271rtb_t + 0.822um_t$

(-0.111) (133.4) (2.039) (3.981) (-3.981) (8.183)

Adj R^2 = 0.99988; S.E. = 0.00267; AIC = -11.781; SIC = -11.610; F=146858.0; D-W= 1.48; LM2 = 2206; LM4 = 1043; ARCH2 =3.788(0.027); ARCH4 = 4.307(0.066); WHITE = 3.342(0.00012) JB = 2.553(0.957)

Correlogram of Residuals:

Autocorrelation 0.444 -0.063 0.013 -0.066 -0.248 -0.411 -0.347 -0.175 -0.094

Partial Correlation 0.444 -0.166 0.069 -0.117 -0.217 -0.277 -0.111 -0.040 -0.071

8.4: COMPARISON OF FORECASTING PERFORMANCE OF MODELS

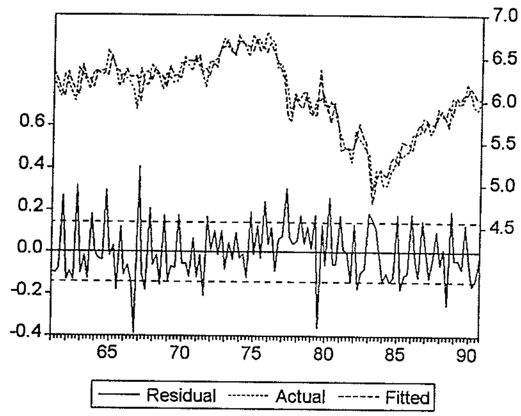
In this section we compare actual and fitted values of the estimated equations, their historical forecasting performance and to gauge their post-sample forecasting performance we calculate Chow forecast tests in which a number of observations are held back for forecasting purposes. Over both the historical and post-sample forecast zone, we provide several statistics for the evaluation of the forecasts, namely, the root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), Theil's inequality coefficient (TIE) and the breakdown into its various components - bias proportion (BP), variance proportion (VP) and covariance proportion (CP). With respect to these statistics, the first line in the relevant table represents historical while the second line represents the post-sample forecast evaluation statistics.

8.41: ACTUAL AND FITTED VALUES FOR GHANA.

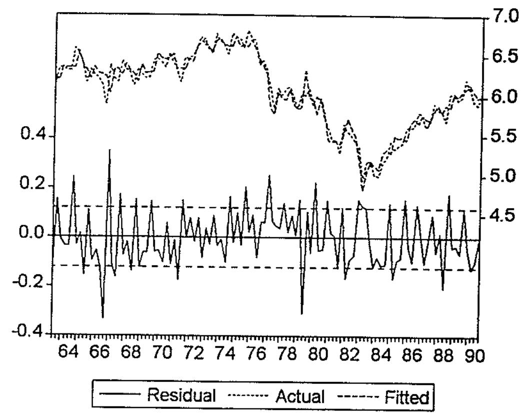
Fig 8.1 and 8.2 present graphs for in-sample actual and fitted values for the two monetary aggregates for Ghana. The graphs seem to suggest reasonable track between actual and fitted values but also reveal that particularly large deviations occur in 1966/67 for both M1 and M2 and in 1979 for M1. These reflect changes that occurred at the time of the first military coup in April 1966 and the effect of the demonetization exercise in 1979. The standard error of regression which is a measure of in-sample forecasting performance, is better for the BS compared to the PAM models. This is true for both M1 and M2.

Fig 8.1: Actual and fitted values for Ghana M1

(i) PAM Model (1961:1-1990:4)



(ii) BS Model (1963:3-1990:4)



((iii) VEC Model (1962:1-1990:4)

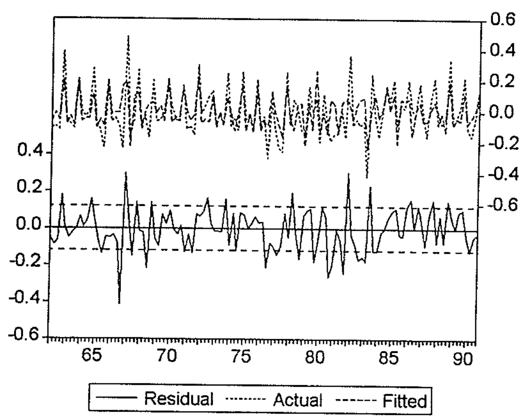
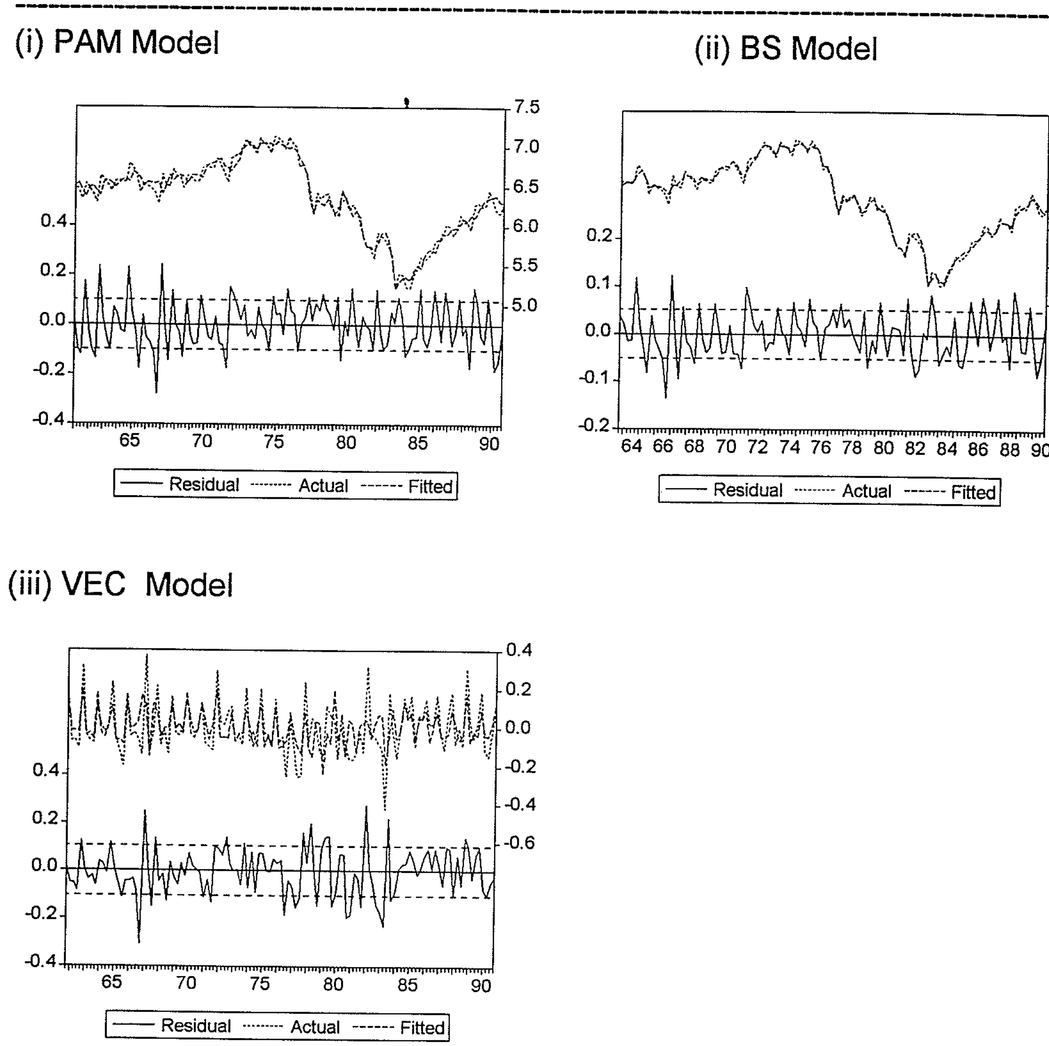


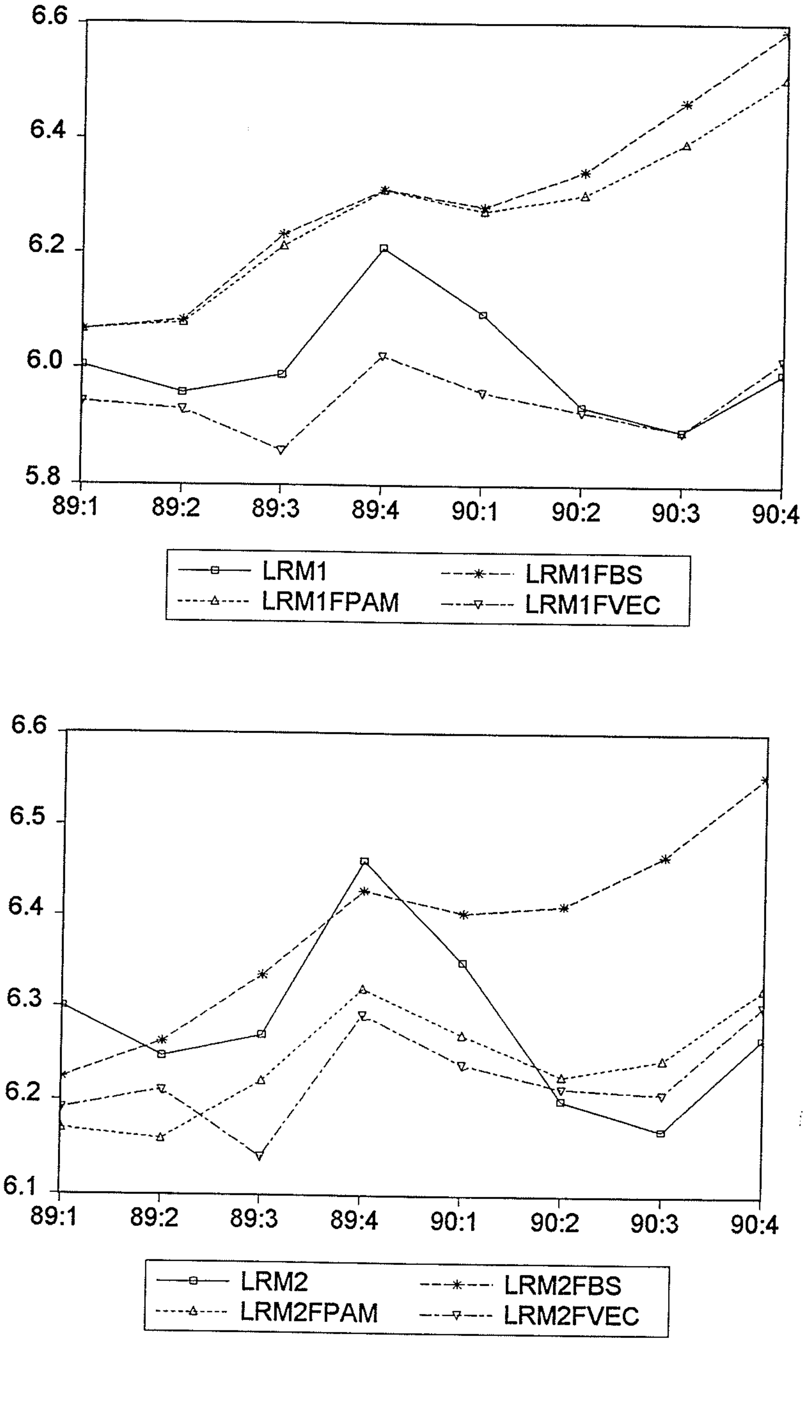
Fig. 8:2: Actual and fitted values for Ghana M2



8.42: POST-SAMPLE FORECAST GRAPHS FOR GHANA

Figure 8.3 gives the plot of post-sample dynamic simulation comparing actual and forecast values for Ghana. The graphs show that for M1, the VEC provides the best track between actual and forecast values. A similar conclusion is reached for M2 though the tracking is not as close as for M1. The graphs show that in general, the VEC equations tend to underpredict, while PAM and BS tend to overpredict. Section 8.5 further discusses these and other results.

Fig. 8.3 : Out-of-sample dynamic simulations for M1 and M2



8.43: FORECAST EVALUATION STATISTICS FOR GHANA

We now turn to the forecast evaluation statistics for Ghana. For each statistic, the first line pertains to in-sample valuation and the second to post-sample forecasts. The model is estimated using data up to 1988:4 - and the historical forecasts are therefore made over this period. Forecasts are made over the period 1989:1 to 1990:4. The post-sample statistics therefore pertain to this latter period.

The statistics are provided in tables 8.7 for M1 and 8.8 for M2. The RMSEs for the buffer stock models are smaller than those for the partial adjustment models for both the within-sample and the post-sample forecasts. For the within-sample RMSEs, both the partial adjustment and buffer stock models have lower values than the corresponding error correction model. Similar results are obtained for the MAE and MAPE and TIE. Post-sample however, the error correction equations yield results that are far superior to those of the other two models.

The Theil inequality coefficients have values far below unity (all the values are below 0.03) suggesting that the forecasting performance of the models are good. But the within-sample bias proportion (BP) for the error correction model as well as the out-of-sample BP for all the models are still quite high indicating relatively large systematic errors in these particular aspects suggesting that there is still room for improvement.

Table 8.7: Forecast Evaluation Statistics, M1 (Ghana data)

	CHOW	RMSE	MAE	MAPE	THEIL'S
M1 PAM(61:1-90:4)	---	0.325	0.255	4.86	0.0267
	0.54(0.82)	0.307	0.258	4.32	0.0251
					BP=0.011
					=0.703
					VP=0.178
					=0.023
					CP=0.811
					=0.274
M1 BS(63:4-90:4)	----	0.294	0.237	3.96	0.0242
	0.39(0.93)	0.348	0.286	4.79	0.0282
					BP=0.012
					=0.677
					VP=0.204
					=0.043
					CP=0.785
					=0.280
M1 VEC(62:1-90:4)	-----	0.361	0.283	4.96	0.0291
	0.35(0.94)	0.097	0.072	1.18	0.0081
					BP=0.545
					=0.462
					VP =0.283
					=0.174
					CP =0.171
					=0.362

Table 8.8: Forecast Evaluation Statistics, M2 (Ghana data)

	CHOW	RMSE	MAE	MAPE	THEIL'S
M2 PAM (61:1-90:4)	---	0.203	0.166	2.64	0.016
	1.23(0.27)	0.205	0.155	2.49	0.016
					BP=0.024
					=0.402
					VP=0.327
					=0.034
					CP=0.647
					=0.564
M2 BS (1963:4-90:4)	---	0.124	0.103	1.63	0.00973
	0.35(0.94)	0.169	0.130	2.08	0.01330
					BP=0.014
					=0.366
					VP=0.199
					=0.0092
					CP=0.787
					=0.624
M2 VEC(1961:4-90:4)	---	0.354	0.305	4.97	0.0271
	0.52(0.84)	0.097	0.080	1.26	0.0076
					BP= 0.732
					=0.368
					VP= 0.073
					=0.136
					CV=0.195
					=0.492

8.44: ACTUAL AND FITTED VALUES FOR CANADA

The in-sample actual and fitted values for the equations estimated for Canada are shown in fig. 8.4 and 8.5. Good fits are obtained between actual and fitted values. A surprising result, in view of the serial correlation problems discussed previously, is the very good fit for the BS model for M2 which gives results that are better than even the VEC model.

Fig. 8:4: Actual and fitted values for Canada M1 PAM (top) and BSM (below)

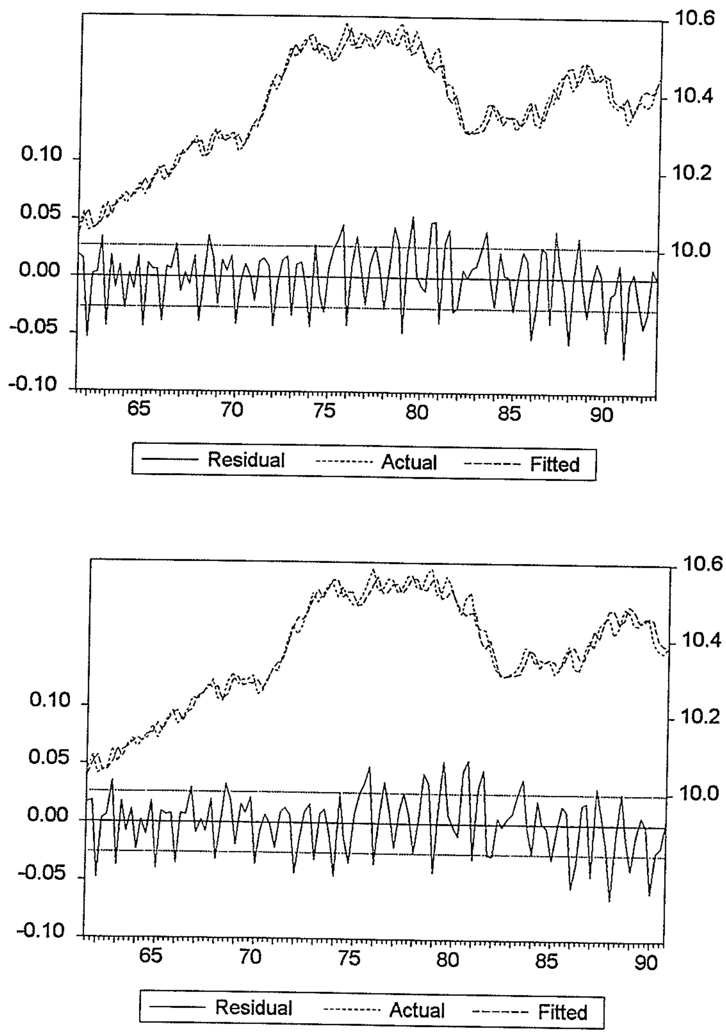
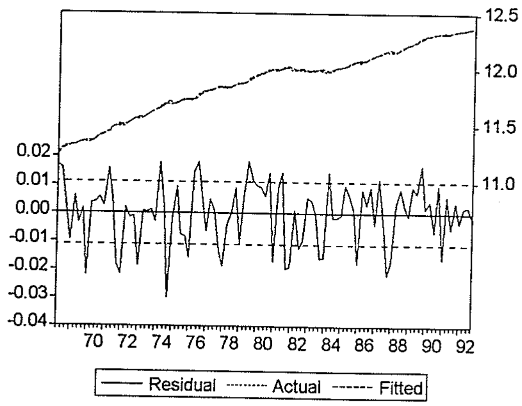
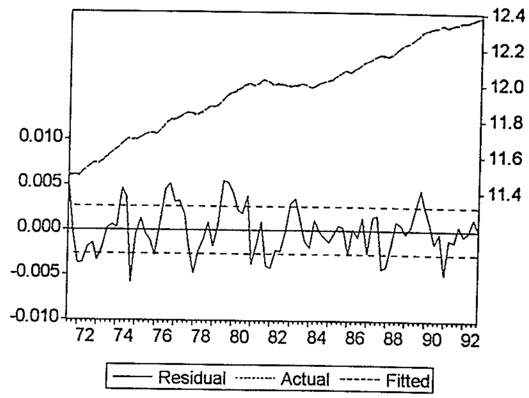


Fig. 8.5: Actual and fitted values for Canada M2

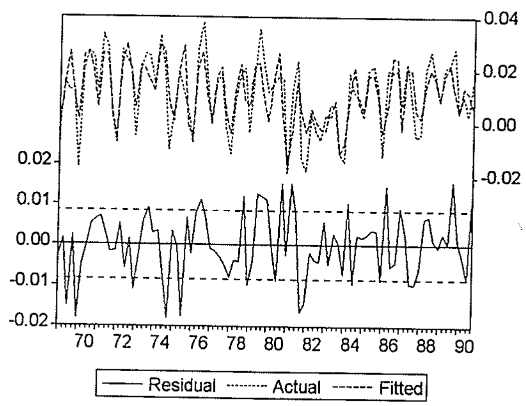
PAM Model



BS Model



VEC



8.45 : POST-SAMPLE FORECAST GRAPHS FOR CANADA.

For Canada all the models surprisingly show underprediction. However the BS model performs best. This is surprising on account of the high degree of serial correlation in that equation. When we compare the two VEC equations for M2, that using only the treasury bill rate gives a closer track between forecast and actual values.

Fig. 8.6: Out-of-sample dynamic simulations, M2 (Canada)

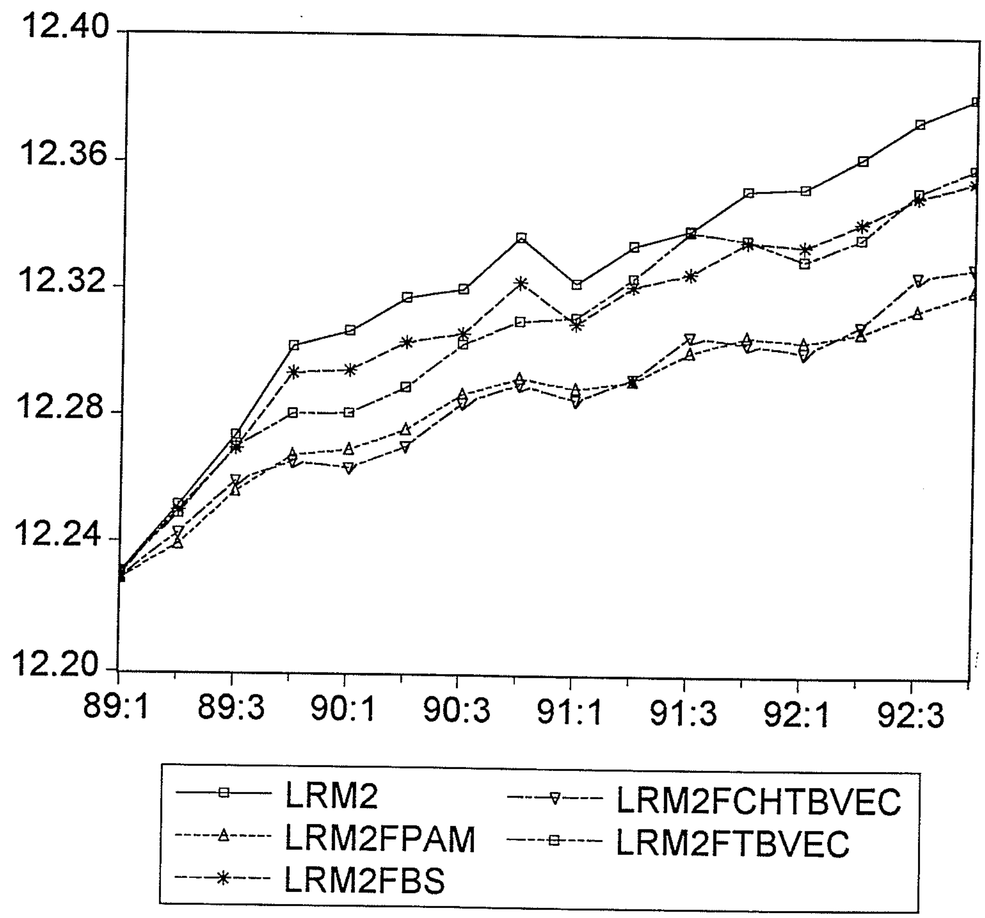
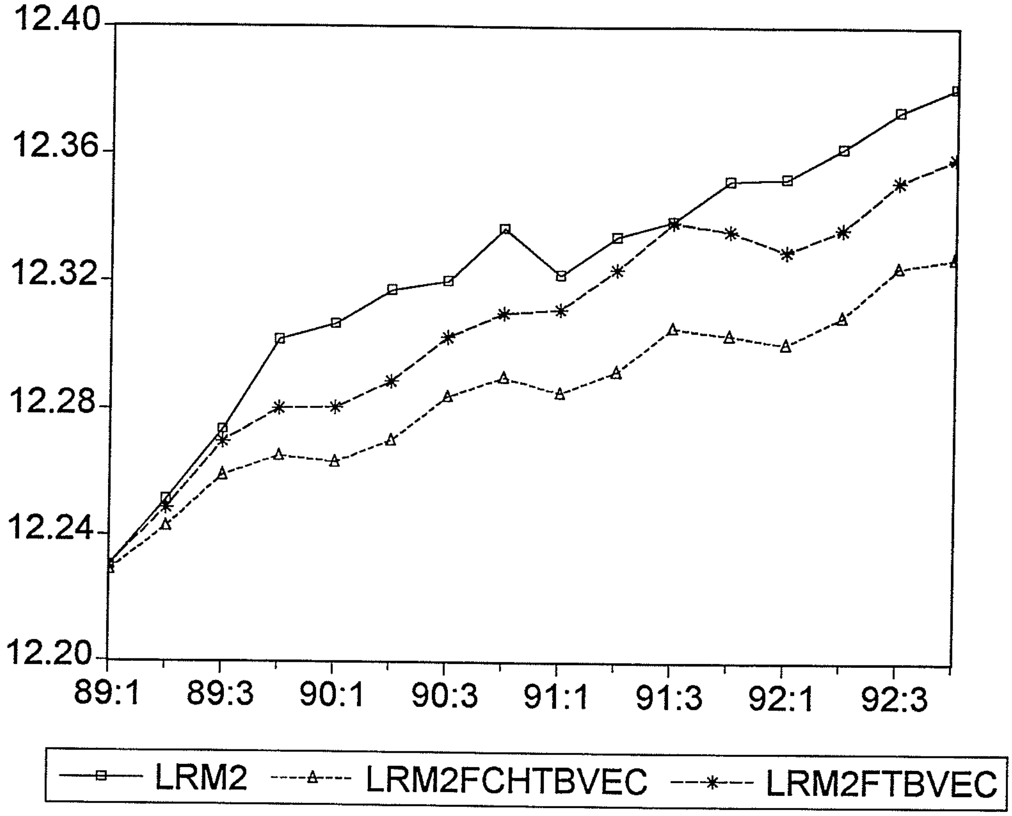


Fig. 8.7: Out-of-sample dynamic simulations, M2 VEC Equations (Canada)



8.46: FORECAST EVALUATION STATISTICS FOR CANADA

Tables 8.9 and 8.10 show the evaluation statistics for the Canadian data, the model is estimated up to 1988:4 and forecasted over the period 1989:1 to 1992:4. The BS model yields smaller RMSE, MAE and TIE values than the PAM. The VEC regressions estimated for M2 generally yield poorer statistic than the PAM and BSM and even for the post-sample results the VEC do not show any clear improvement over the other models.

Table 8.9: Forecast Evaluation Statistics for Canada M1

	CHOW	RMSE	MAE	MAPE	THEIL'S
M1 PAM(1961:1-92:4)	-----	0.066	0.052	0.503	0.0031
	1.91	0.130	0.124	1.199	0.0062
					BP=0.013
					=0.914
					VP=0.020
					=0.058
					CV=0.967
					=0.028
M1 BS(1963:4-92:4)	-----	0.016	0.013	0.125	0.0078
	46.30	0.043	0.034	0.325	0.0021
					BP=0.0334
					=0.625
					VP=0.029
					=0.194
					CP=0.937
					=0.181

Table 8.10: Forecast Evaluation Statistics for Canada M2

	CHOW	RMSE	MAE	MAPE	THEIL'S
M2 PAM(1968:2-92:4)	---	0.020	0.017	0.142	0.00085
	1.75	0.012	0.010	0.082	0.00050
					BP=0.0045
					=0.302
					VP=0.0002
					=0.646
					CP=0.99
					=0.052
M2 BS(1971:3-92:4)	---	0.0069	0.0055	0.046	0.0003
	36.68	0.0029	0.0026	0.021	0.00012
					BP=0.024
					=0.658
					VP=0.037
					=0.228
					CP=0.938
					=0.114
M2TBVEC(1969:1-92:4)	---	0.029	0.024	0.207	0.0012
	0.775	0.015	0.013	0.107	0.0006
					BP=0.621
					=0.747
					VP=0.079
					=0.060
					CP=0.300
					=0.193
M2VECTBCH(1969:1-92:4)	---	0.036	0.027	0.227	0.0015
	0.664	0.0083	0.0061	0.049	0.00034
					BP=0.059
					=0.518
					VP=0.053
					=0.178
					CP=0.888
					=0.303

8.5: COMPARISON OF THE PERFORMANCE OF THE THREE MODELS

The results do not give us a definite conclusion as to which is the best model. In terms of statistical criteria, the error correction models are superior with residuals that passed stationary, normality and other statistical tests much better than the partial adjustment and buffer stock models. The latter two models suffer from serious problems of serially correlated residuals and the buffer stock model has additional problems of multicollinearity. In terms of forecasting performance, on the other hand, if we consider the results for both Ghana and Canada and the in-sample as well as out-of-sample forecasting performance, it seems fair to say that the buffer stock model performs rather very well compared to the PAM and ECM. For Canada M2, whether we use the RMSE or the Theil inequality coefficient (TIE), the BSM comes up tops. For Canada M1, for which we do not estimate any ECM, the BSM performs better than the PAM for all measures except for the within sample TIE. For Ghana, the BSM gives the best in-sample forecasting performance, though out-of-sample, the ECM does the best job.

Bought and Tavlas (1990) reached a similar inconclusive decision in their study of the US, UK, Germany, France and Japan. They found, in their study, that within sample, the ECM has lower RMSE than either the PAM or the BSM. Post-sample however, the BSM performs best - with lower RMSE in four out of the five cases investigated. They observed that "these findings are preliminary and it is certainly possible that further work on specifying the ECM equations, or even changes in the arbitrary choice of forecast period, would reverse them." Such an observation is also certainly true for our study.

The mixed results could partly be attributed to the fact that autocorrelation correction for the PAM and BSM augments the structural components of these models with time series (autoregressive) procedures. This could explain the fact that even though the BSM, for example, nests the PAM structurally and though they are both estimated by similar methods, the BSM does not yield better forecasting results than the PAM in all cases. If one were therefore to be solely interested in forecasting performance, it may be preferable to apply a purely time series forecasting model. In this study, however, we are also interested in the estimates of the structural parameters.

CHAPTER NINE

COMPARISON OF RESULTS WITH OTHER STUDIES AND CONCLUSION

Most of the previous studies on the demand for money in Ghana (which we reviewed in chapter 4) were conducted over short time periods using annual data. For example, Blomqvist's (1970) study used annual data covering the period 1955-67, i.e., only 13 observations. Gockel and Sowa also used annual data consisting of 20 and 29 observations respectively. Furthermore, in most of these studies, statistical tests are limited to the standard goodness of fit tests such as R^2 and t-statistic. For example, none of the studies carry out tests for serial correlation which is a common problem in models of this type. The PAM and BSM equations we have estimated in this study clearly illustrate the serious problems of serial correlation that can occur with these approaches.

In addition to the above limitations, we also note that the stationarity and cointegration tests reported in this study as well as by Adam et al. (1993) clearly suggest that the variables used in the above mentioned studies, namely, money and income only (Blomqvist, 1971 and Gockel, 1983), income velocity, number of banks per thousand of population, real income or real per capita income and lagged inflation (Abbey and Clark, 1974), money, income and the rate of interest (Gockel, 1983), money, income, interest rate, (consumer) price index, exchange rate and lagged money (Sowa, 1992), all involve non-stationary variables and therefore the classical econometric techniques (OLS and 2SLS) which these studies applied are invalid. Baffoe's (1993) money demand function, as mentioned previously, is just a conventional partial adjustment equation which incorporates lagged output as an additional explanatory variable. No attempt is made to investigate the stationarity properties of the variables used.

In contrast to the studies mentioned above, Adam et al. (1993) use the cointegration approach to estimate the demand for base money. Since the central focus of their study was not the estimation of the money demand function per se, full details of tests are not available. The limited information reported suggest that they obtain results that are better than our own. The following statistics are reported for their error correction equation: R^2 = 0.779; DW = 2.009; LM6 =0.71; ARCH6 = 0.90; JB=0.97. Typical values from our study for Ghana would be 0.44 for R^2, 2.04 for DW, 1.86 for LM4, 4.75 for ARCH4. A number of factors could account for this difference. First, the two studies cover different time periods; 1961:1 to 1990:4 in our study compared to 1974:4 to 1989:4 in the study by Adam and others. Secondly, the two studies used different approaches to derive quarterly output values from annual data. Thirdly Adam and others use a different monetary aggregate in their study, namely, base money as compared to narrow and broad money in our study. We also note that, the parallel exchange depreciation entered into their cointegration and error correction equations (in addition to money, output and inflation variables). We noted in chapter 4 that the differenced exchange rate term, $\Sigma\Delta b_{t-i}$, on the right hand side of their EC equation, is defined as $\Sigma\Delta b_{t-i}=\Sigma\Delta b_{t-i}/4$, i = 0,1,2,3 so that it consists of an average of current and lagged values. This term has a t-value of only -0.87 and it is not clear to us why it is retained in the equation. As reported in chapter 6, we omitted this variable from our vector of variables because, over the period covered by our study, it was stationary around a deterministic trend and furthermore, trial tests carried out including this variable in the vector of variables investigated did not yield any plausible cointegration relationship. It is also interesting to note that whereas our study found inflation to be endogenous, Adam and others found that variable to be marginally weakly exogenous and thus include contemporaneous inflation in their error correction equation.

The long-run income elasticity from our cointegration model has a value of 1.01 which would provide a vindication of the use of real balances in our model. This compares with income elasticites of 1.71 and 1.41 for our PAM and BS models. Thus the income elasticity from the cointegrating relationship is substantially lower than those from the PAM and BS models as well as from those of previous studies reported in chapter 4- which are of course based on models similar to the PAM. But it is also substantially lower than the value of 1.45 that Adam and others obtained for base money.

In conclusion we note that the main purpose of this study is to estimate a money demand function for Ghana using cointegration and error-correction approach The methodology employed uses unit root tests and Johansen's cointegration test to estimate the long-run money demand relationship followed by a vector error-correction model in order to capture the dynamic properties of the model. This process is supplemented with forecast and stability tests aimed at assessing the stability of the parameters of the estimated model.

The results of our cointegration analysis suggest that despite the use of quarterly values for output which were derived from annual values, a plausible long-run money demand function has been identified. The study reveals that there is no significant long-run interest rate effect. This finding is in consonance with other money demand studies on Ghana and is explained by government control that kept interest rates fixed for long periods of time. The long-run path of money demand is driven by income and inflation. We have also developed a dynamic specification for money demand which quite closely tracks actual movements of holdings of real money balances around the long-run equilibrium path. Despite very erratic monetary policy, unstable growth and high inflation, the money demand function has remained relatively stable.

We have also estimated two other alternative forms of the money demand function, namely, the PAM and BSM models. The long-run solutions for the three models are surprisingly similar with respect to inflation but are quite different for income. For narrow money, the PAM, BSM and cointegration analysis yield long-run income elaticities of 1.71, 1.41 and 1.01 in that order and a surprisingly close inflation elasticities of -1.05, -1.05 and -1.14. The disparities in the M2 elasticities are greater with income elasticity of 2.88, 2.06 and 1.1 and long-run inflation elasticity of -1.58, -1.25 and -1.3

The results of the dynamic (out-of-sample) simulation show the PAM and BS overpredict money demand balances significantly. The VEC thus gives us better forecast results. However, the rather low speed of adjustment of about 4%

per quarter suggests that a monetary policy based on the assumption of fairly fast-adjusting money balances can cause problems for the economy.

Though our results are inconclusive as to which model is the best one, if we consider the results for both Ghana and Canada, then in terms of forecasting performance, the buffer stock model seems to perform better than the error correction and partial adjustment models. We note, however, that the coefficients of the monetary shock terms were not significant in the buffer stock equations for Ghana and that all partial adjustment and buffer stock equations suffer from fairly severe problems of serially correlated residuals and that the buffer stock models have additional problems of multicollinearity.

A limited comparison of our cointegration and error-correction results for Ghana to the results obtained for Canada using similar analysis indicates that though the stability properties for the model are quite comparable, the parameters of the Ghanaian money demand function have remained more stable than the parameters of the long-run money demand relationship for Canada. Evidence indicates that in the sea of ad hoc economic policies in general and very erratic monetary policy in particular, the monetary system and indeed the overall economy has remained rather static in Ghana. Apparently, such erratic policies have not resulted in significant shifts in the long-run money demand relationship for Ghana as, for example, innovations in the banking system have had on the long-run money demand relationship in Canada.

Appendix 1

*Selected Cointegration Results for M1 with the Interest Rate as an Included Independent Variable (standard errors in parentheses)**

Lags in VAR	Cointegrating Vector (normalized on M1)			
	Period: 1961: 1- 1990:4			
	LRM1	LGDP	INFLC	R
1-2	1.0000	-1.0247	0.1991	9.49E-05
		(0.0718)	(0.1152)	(0.0411)
1-4	1.0000	-1.0441	0.2630	-0.0392
		(0.0934)	(0.1838)	(0.0753)
1-7	1.0000	-1.0896	0.4561	-0.0813
		(0.2022)	(0.5569)	(0.1841)
	Period: 1971: 1- 1990:4			
1-2	1.0000	-1.2066	0.2665	0.0367
		(0.2071)	(0.1794)	(0.0396)
1-4	1.0000	-1.3571	0.4361	-0.0186
		(0.4015)	(0.3974)	(0.0862)
1-7	1.0000	4.6989	-8.5222	1.8775
		(95.703)	(144.64)	(30.85)
	Period: 1981: 1- 1990:4			
1-2	1.0000	-0.4198	-0.0883	-0.1006
		(0.1322)	(0.0388)	(0.0371)
1-4	1.0000	-0.0216	-0.3144	-0.1127
		(0.4045)	(0.1894)	(0.0565)
	Period: 1983: 2- 1990:4			
1-2	1.0000	-0.6804	0.0240	-0.1059
		(0.1129)	(0.0425)	(0.0627)
1-4	1.0000	-0.5721	-0.0451	-0.0445
		(0.0126)	(0.0083)	(0.0043)

* LRM1, LGDP, INFLC and R represent, in that order, the log of real M1, log of real GDP, rate of inflation and the discount rate, with the last two expressed in percentages. The coefficient of R has the wrong sign or is insignificant or both. Similar results are obtained even if the inflation rate is excluded.

Appendix 2

*Selected Cointegration Results for M2 with the Interest Rate as an Included Independent Variable (standard errors in parentheses)**

Lags in VAR	Cointegrating Vector (normalized on M2)			
		Period: 1961: 1- 1990:4		
	LRM2	LGDP	INFLC	R
1-2	1.0000	-1.1076	0.3001	-0.0336
		(0.1091)	(0.2123)	(0.0736)
1-4	1.0000	-1.1146	0.3384	-0.0464
		(0.1254)	(0.2751)	(0.0972)
1-7	1.0000	-1.2326	0.7524	-0.1756
		(0.3743)	(1.1058)	(0.3642)
		Period: 1971: 1- 1990:4		
1-2	1.0000	-1.3063	0.3365	0.0237
		(0.2381)	(0.2288)	(0.0481)
1-4	1.0000	-1.3821	0.4327	-0.0029
		(0.3275)	(0.3455)	(0.0734)
1-7	1.0000	-1.6928	1.2632	-0.2352
		(1.3226)	(2.3691)	(0.5816)
		Period: 1980: 1- 1990:4		
1-2	1.0000	-0.4147	-0.1271	-0.0959
		(0.1636)	(0.0603)	(0.0400)
1-4	1.0000	0.1145	-0.4415	-0.1056
		(0.5927)	(0.3135)	(0.0627)
		Period: 1983:2- 1990:4		
1-2	1.0000	-0.6172	-0.0188	-0.0608
		(0.0115)	(0.0029)	(0.0034)
1-4	1.0000	-0.5975	-0.0469	-0.0480
		(0.0117)	(0.0076)	(0.0038)

* LRM2, LGDP, INFLC and R represent, in that order, the log of real M2, log of real GDP, rate of inflation and the discount rate, with the last two expressed in percentages. The coefficient of R has the wrong sign or is insignificant or both. Similar results are obtained even if the inflation rate is excluded.

APPENDIX 3: SELECTED ECONOMIC INDICATORS

Table A: Output, Prices, Discount Rate and Exchange Rate.

OBS	CURRENT GDP	REAL GDP 1985 PRICES (million cedis)	REAL GDP GROWTH (%)	CPI (1985=100)	DISCOUNT RATE (%)	EX. RATE CEDIS/US$
1961	1022.00	238484.00	NA	0.20	4.50	0.71
1962	1094.00	250003.00	4.83	0.20	4.50	0.71
1963	1208.00	258674.00	3.47	0.20	4.50	0.71
1964	1237.00	264243.00	2.15	0.20	4.50	0.71
1965	1466.00	267851.00	1.37	0.30	4.50	0.71
1966	1518.00	268104.00	0.09	0.30	7.00	0.71
1967	1504.00	260066.00	-3.00	0.30	6.00	1.02
1968	1700.00	276775.00	6.42	0.30	5.50	1.02
1969	1999.00	293041.00	5.88	0.40	5.50	1.02
1970	2259.00	312851.00	6.76	0.40	5.50	1.02
1971	2501.00	330257.00	5.56	0.40	8.00	1.82
1972	2815.00	322029.00	-2.49	0.40	8.00	1.28
1973	3502.00	371143.00	15.25	0.50	6.00	1.15
1974	4660.00	383738.00	3.39	0.60	6.00	1.15
1975	5283.00	334371.00	-12.86	0.80	8.00	1.15
1976	6526.00	322598.00	-3.52	1.30	8.00	1.15
1977	11163.00	329877.00	2.26	2.70	8.00	1.15
1978	20986.00	357852.00	8.48	4.70	13.50	2.75
1979	28222.00	346523.00	-3.17	7.30	13.50	2.75
1980	42853.00	346523.00	0.00	11.00	13.50	2.75
1981	72526.00	340320.00	-1.79	23.80	19.50	2.75
1982	86451.00	315826.00	-7.20	29.10	10.50	2.75
1983	184048.00	318041.00	0.70	64.90	14.50	30.00
1984	270561.00	326428.00	2.64	90.70	18.00	50.00
1985	343048.00	343048.00	5.09	100.00	18.50	59.99
1986	511400.00	360884.00	5.20	124.60	20.50	90.01
1987	746000.00	378169.00	4.79	174.20	23.50	176.06
1988	1051200.00	401713.00	6.23	228.80	26.00	229.88
1989	1417200.00	419800.00	4.50	286.50	26.00	303.03
1990	2031700.00	433700.00	3.31	393.20	33.00	344.83

Source: International Financial Statistics Yearbook. Real GDP growth rate is computed from the real GDP values.

Table B: Nominal Monetary Aggregates and their Growth Rates.

OBS	CURRENCY	M1	M2	GROWTH RATE OF AGGREGATES currency	M1	M2
1961	87.00	147.00	174.00	NA	NA	NA
1962	96.00	165.00	200.00	10.34	12.24	14.94
1963	98.00	173.00	215.00	2.08	4.85	7.50
1964	133.00	240.00	294.00	35.71	38.73	36.74
1965	116.00	238.00	298.00	-12.78	-0.83	1.36
1966	116.00	247.00	314.00	0.00	3.78	5.37
1967	119.00	240.00	318.00	2.59	-2.83	1.27
1968	125.00	258.00	351.00	5.04	7.50	10.38
1969	151.00	289.00	388.00	20.80	12.02	10.54
1970	151.00	302.00	423.00	0.00	4.50	9.02
1971	159.00	318.00	472.00	5.30	5.30	11.58
1972	239.00	459.00	664.00	50.31	44.34	40.68
1973	245.00	536.00	766.00	2.51	16.78	15.36
1974	336.00	656.00	964.00	37.14	22.39	25.85
1975	486.00	981.00	1358.00	44.64	49.54	40.87
1976	707.00	1386.00	1860.00	45.47	41.28	36.97
1977	1157.00	2276.00	2927.00	63.65	64.21	57.37
1978	2122.00	3909.00	4914.00	83.41	71.75	67.89
1979	2459.00	4332.00	5594.00	15.88	10.82	13.84
1980	3521.00	5611.00	7475.00	43.19	29.52	33.63
1981	6049.00	9359.00	11975.00	71.80	66.80	60.20
1982	6957.00	11005.00	14639.00	15.01	17.59	22.25
1983	10389.00	15866.00	19952.00	49.33	44.17	36.29
1984	17631.00	26409.00	31522.00	69.71	66.45	57.99
1985	22557.00	35797.00	44207.00	27.94	35.55	40.24
1986	32000.00	50000.00	64000.00	41.86	39.68	44.77
1987	49000.00	74000.00	96000.00	53.12	48.00	50.00
1988	68000.00	100000.00	133000.00	38.78	35.14	38.54
1989	83000.00	176000.00	229000.00	22.06	76.00	72.18
1990	80000.00	191000.00	256000.00	-3.61	8.52	11.79

Source:International Financial Statistics Yearbook

Note: Aggregates are in millions of cedis. Growth rates are computed from the aggregates and are annual percentage changes.

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