EXCHANGE RATE OVERSHOOTING AND ITS TRANSMISSION THROUGH THE MONETARY POLICY IN KENYA

By

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DECLARATION

I, Oduor Obuong Jacob, do hereby declare that this research paper is my original work.

A similar work has not been presented or is due for presentation for any award at any university.

Signature____________________ Date 25th August 2003

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DEDICATION

To my parents Francis and Domtila.

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For those whose efforts made this paper and my studies generally successful and their names are not here, their efforts and help are not forgotten. Space does not allow me the opportunity to express my appreciation to them individually

Otherwise I take responsibility for errors and imperfections that are to be found in this research paper.

ABSTRACT

With the floating exchange rate regime that Kenya is currently under, it was suspected at the beginning of this study, that the exchange rate channel of monetary policy transmission mechanism is effective in Kenya and that exchange rates overshoot in Kenya. If exchange rates overshoot and this channel is effective in Kenya, then both would impact negatively on aggregate incomes. This paper therefore set out to establish how the effects of exchange rate overshooting are transmitted into the macroeconomic variables in Kenya. Empirical evidence to prove that exchange rates overshoot in Kenya was sort before its effects in the economy can be traced.

Two models were estimated in the paper. The first one aims at establishing for the evidence of exchange rate overshooting in Kenya under the floating exchange rate regime using quarterly data from 1993:1 to 2001:4. The second model traces the transmission of exchange rate overshooting to the other macroeconomic variables in the economy using monthly data from January 1993 to December 2001. To establish for the evidence of exchange rate overshooting, due to the non-existence of cointegration in the overshooting variables therefore making the estimation of an error correction model impractical, a short-run equation was estimated with the result that exchange rates overshoot in the short-run. The results of the short run overshooting equation show evidence for exchange rate overshooting in Kenya in the short run. The lags of money supply in the preferred model are positive up to the second quarter. This means that exchange rates overshoot on impact and reaches the overshooting peak at the end of the second quarter then starts to trace back its long run path. The short run path and the long run path converge after eight months.

To trace the transmission of exchange rate overshooting in the economy, vector autoregression (VAR) analysis was used. A VAR (5) model was estimated and the results analyzed using impulse response analysis and variance decomposition analysis. The results from impulse response analysis show that exchange rate channel of monetary policy transmission mechanism is effective in Kenya and the tightening of monetary policy though this channel reduces aggregate output. It is found that prices are sticky in the short run and flexible in the long run while exchange rates and money supply adjustments from a monetary policy change are instantaneous. This leads to exchange rate overshooting its long run path in the short run. Therefore from the results of this study, it can be concluded that, sticky prices and money supply are the major causes of exchange rate overshooting in Kenya. From the impulse response analysis, a monetary policy change is neutralized after eight months. This gives evidence to the fact that exchange rates do not overshoot in the long run. Variance decomposition analysis further provides support for the effectiveness of the exchange rate channel of the monetary policy transmission mechanism.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Problem

Exchange rate as a component of monetary policy is one of the key tools in economic management and in the stabilization and adjustment policies in developing countries where low inflation and international competitiveness have become major policy targets. With the adoption of a floating exchange regime in Kenya in the 1990's, it was expected that Kenya would benefit from several advantages from such a regime including first, a more continuous adjustment of the exchange rate to shifts in demand for and supply of foreign exchange. Secondly, it was expected that the demand and supply of foreign exchange would equilibrate by changing the nominal exchange rate rather than the level of reserves. Thirdly, it was hoped that the regime would allow Kenya the freedom to pursue its own monetary policy without being concerned about balance of payments effects (Ndung'u 1999). The exchange rate is therefore a very important policy variable for economic stability and management since it is a relative price hence important in making spending and investment decisions (Marrinan 1989).

The Central Bank of Kenya (CBK) currently runs a restrictive stance of the monetary policy management through tight policies to contract money supply and domestic credit. The contractionary monetary policy though good in keeping inflation rates to the desired one-digit target limits of below five per cent, did not help in improving output levels. For instance, the gross domestic product (GDP) was negative two per cent in 2001. This may be due to the overshooting behavior of the foreign exchange in response to monetary shocks that works through the monetary policy transmission mechanism to impact negatively on investments and aggregate output.

A prediction of the Dornbusch overshooting model (Dornbusch 1980), is that countries which quickly tighten monetary policy, should experience exchange rate overshooting (over-appreciation of the domestic currency). The basis of the Dornbusch overshooting model is that sticky output prices is the main cause of exchange rate overshooting.

1.1.1 Currency Overshooting

Exchange rate overshooting refers to a temporary overreaction of the nominal exchange rate due to a monetary shock, before returning to its equilibrium value in the long run. The major fundamental economic reason for currency overshooting is the sticky goods prices combined with instantaneous adjustment in the asset market. The overall price level increases less than the money supply, leaving the demand for money lower than the supply. Sticky prices implies that the domestic price levels does not move instantaneously in response to unanticipated monetary policy shocks in the short run and adjusts only slowly over time. This is the price puzzle of the monetary policy.

Assuming that money is neutral in the long run, a permanent rise in the money supply leads to a proportionate rise in both the price level p, and the exchange rate e, in the long run. Unanticipated rise for instance in the money supply m with the price levels temporarily fixed in the short run therefore, will lead to a rise in the supply of real balances m-p. To equilibrate the money market, the demand for real balances must also rise. For the demand for real balances to go up, the domestic rates of interest r, will fall. The domestic rates of interest will only fall if and only if over the future life of the bond contract, the home currency is expected to depreciate. The initial depreciation of the currency will, on impact, be larger than the long run depreciation. This means that it overshoots its long run value. This initial excess depreciation of the currency leaves room for the ensuing appreciation needed to clear the bond and the money markets in the long run.

1.1.2 Monetary Policy Transmission Mechanisms

Kamin et al (1998) identifies four channels through which the workings of monetary policy are transmitted to the other economic activities including through its impacts via the interest rates channel, credit allocation channel, asset price channel, and the exchange rate channel. This study would however only limit its analysis on how monetary policy is transmitted through the exchange rate channel. However a highlight of the other channels is necessary.

(a) The Interest Rate Channel

The interest rate channel is the textbook channel, that is, it operates within the IS-LM framework (Nikolov et al. 2002). A change in the interest rates affects new marginal spending by modifying the user-cost of capital and borrowing conditions (neoclassical view of investments). This direct effect works on consumption and investment. It is believed to act most strongly on the consumer durables and investments via the user cost. With a contractionary monetary policy for instance, real interest rates increase, the returns to savings increase and raises the required return from investment projects, thus depressing consumption and reducing business investments (Keynesian view of investments).

(b) The Credit Channel

According to Bernanke and Gertler (1995), the credit channel works when loans and bonds are imperfect substitutes in the balance sheet of banks and firms. Following a contractionary monetary policy, banks reduce the amount of loans they supply; firms could turn to the bond market, but if bonds and loans are imperfect substitutes, the external finance premium will go up, amplifying the effects of the monetary tightening. A broad credit channel associated with the credit constraints, which may arise when firms' ability to borrow depends on the collateral, instead works independently of the imperfect substitutability between loans and bonds. An increase in interest rates reduces the value of collateral (real estate values, for instance.) thus affecting a firm's access to bank lending (Kiyotaki and Moore, 1997).

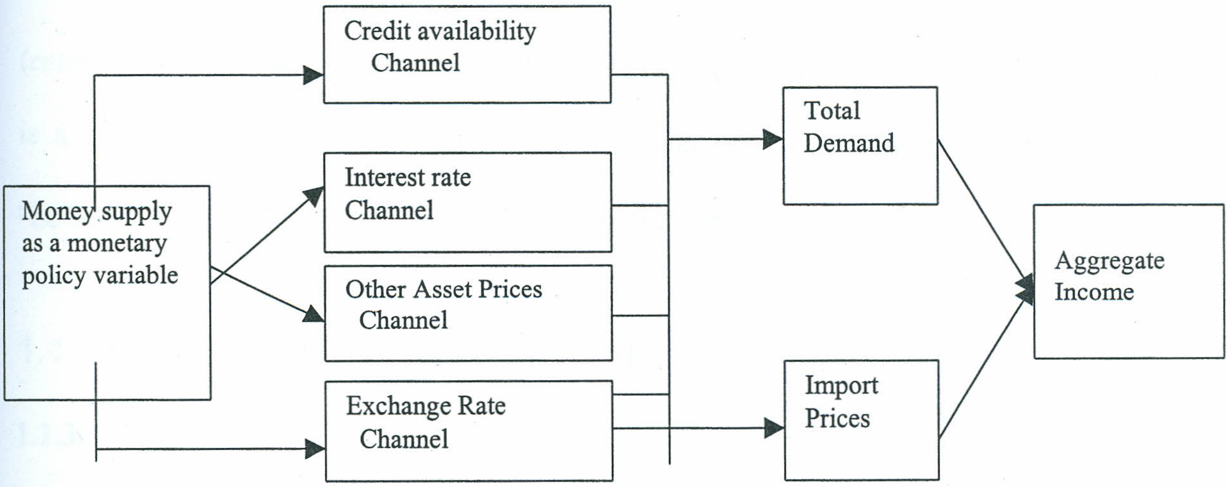
(c) Asset Price Channel

Domestic asset prices including bonds and stock prices, and real estate prices are inversely related to the long-term interest rates. So a rise in the long-term interest rates lowers the bond prices and vice versa. Other things being constant, higher long-term interest rates also lower other security prices. This is because expected future returns are discounted by a larger factor, so the present value of any given future stream of income falls. A rise in the price of any physical asset - the mortgage rate - reduces the remaining disposable income of those affected and so, for any given gross income reduces the flow of funds available to spend on goods and services reducing aggregate demand hence aggregate incomes. Higher interest rates on unsecured loans have a similar effect.

(d) Exchange Rate Channel

The exchange rate channel is set in motion when monetary policy affects the external value of the shilling, thus opening up the potential for differential effects across countries. A reduction in money supply, *ceteris peribus*, will raise the domestic interest rates relative to the foreign interest rates leading to capital inflows that in turn leads to the appreciation of the domestic currency. This in turn leads to cheaper imports and costly exports hence loss of competitiveness. Term of trade as a result of an appreciation imply a gain in real income but the loss of competitiveness may result into a decline in output and employment.

(e) The links between the Transmission Channels in Kenya



The Central Bank of Kenya currently uses money supply as the monetary policy-programming target to anchor the evolution of the price level. The interest rate channel works when a reduction in money supply increases the Treasury bill (T/bill) rates. The T/bill rates increase the market interest rates (overnight rates, base lending rate, and deposit rates) which reduces aggregate demand for investments hence reducing aggregate incomes.

The credit availability channel works when a reduction in money supply through increased reserve requirement by the Central Bank reduces the availability of reserves at the disposal of commercial banks to give credit through credit creation. This affects aggregate demand which reduces aggregate incomes.

Other asset prices channel works when higher market interest rates lower the prices of securities such as bonds and equities and real estates. This is because the expected future returns are discounted by a larger factor, so that the present value of any future income streams falls. This reduces the demand for investment in securities reducing aggregate incomes.

Lastly, a reduction in money supply due to a contractionary monetary policy affects incomes through the exchange rate channel in that, it increases T/bill rates leading (*ceteris peribus)* to an appreciation of the exchange rate. This reduces net exports which is a component of aggregate demand. A reduction in money supply may also affect aggregate incomes directly through the demand for imports.

1.1.3 Government Policy Statements

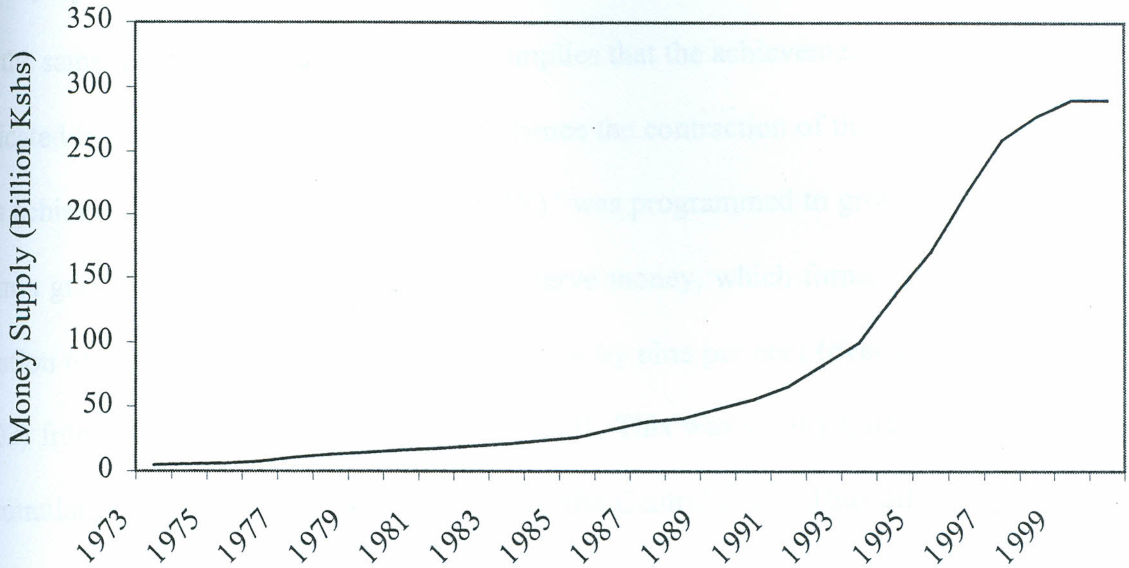
1.1.3(a) Monetary Policy

Monetary policy in Kenya, like in other countries, ultimately seeks to promote economic well being of the country's citizens by striving to achieve high and sustainable non- inflationary rate of economic growth and employment as well as a viable balance of payments position. Prior to July 1991 when the open market operations were introduced, the Central Bank of Kenya had been using four main instruments for implementing monetary policy. These were the minimum liquid asset ratio, the minimum cash balances, interest rate controls and credit controls. Currently monetary policy management requires right reserve money forecasting.

Reserve money is the anchor of the money supply process. Reserve money comprising of currency in circulation, and balances that commercial banks and the non-banking financial institutions (NBFIs) must hold both in their vaults and as cash balances at the Central Bank. This definition of reserve money times the money multiplier gives the M3 measure of money supply (CBK, 2000 b).

As indicated in CBK (2000b p. 6), the Central Bank of Kenya currently uses M3 as the principal concept of money in conducting monetary policy. It has been a monetary aggregate programming target and indicates the stance of monetary policy followed under the Central Bank's monetary aggregate anchor. There are three fundamental monetary regime options that a country can adopt; an exchange rate anchor, a monetary aggregate anchor and an inflation target anchor. An exchange target anchor uses an exogenously determined trajectory of the exchange rate as a nominal anchor, a monetary anchor relies on a pre- committed path for the money supply to anchor inflation rate, and in inflation targeting, the anchor for inflation is the publicly announced inflation target itself. Money supply measured by M3 has been expansionary over the years to 1996 when it started declining (Figure1.1)

Figure 1.1 Money supply Growth in Kenya (1973-2000)



SOURCE: CBK quarterly bulletin (1996)

The decline in money supply as a monetary policy variable from 1997 was due to the Central Bank's recognition of the role of inflation on income and employment determination after the 1993 inflation. In this year inflation reached a high of 46 per cent after the massive monetary expansion in 1992 to finance the first multiparty elections. Hence there was a need to come up with measures to reduce money supply. The Central Bank in 1996 came up with the first monetary policy statement in pursuant of section 4B of the Central Bank of Kenya (Amendment) Act of 1996, which conferred autonomy on the Central Bank. The autonomy mandated CBK to specify the monetary policy objectives, the means through which these polices would be achieved and the reason for undertaking them. In this statement the Central Bank 's major target was to reduce inflation to single digit levels. In the third policy statement (1999), inflation was targeted at five per cent; money supply was targeted to expand by not more than 10 per cent, and domestic credit to expand by not more than 9.3 per cent.

In the Ninth Monetary policy statement (December 2001), the annual average underlying inflation for the month of February 2002 was 4.7 per cent and overall inflation for the same month was –0.6 per cent. This implies that the achievements of the targets as indicated in the previous policy statements, hence the contraction of the monetary policy, was achieved. Projected money supply (M3X) [1] was programmed to grow at 6.1 per cent from a growth of eight per cent in 2001. Reserve money, which forms the basis for the creation of money supply, was projected to grow by nine per cent (over the year to June 2002) from a growth rare of 9.8 per cent in 2001. This was wholly built up through the accumulation on foreign exchange reserves of the Central Bank. Thus all projections of the monetary policy aggregates are aimed at tightening monetary policy. All these are indications of a contractionary monetary policy (CBK, 1996-2001)

1.1.3(b) Exchange Rate Policy

The use of exchange rates as an instrument of monetary policy, during the first twenty years of Kenya 's independence was minimal. A fixed exchange regime where the exchange rate is fixed at given levels by the monetary authorities was adopted between 1966 and 1982. During this period the shilling exchange rate was adjusted only three times in 1967, 1975 and 1981 in order to maintain competitiveness of exports. The fixed exchange rate system was replaced in 1983 by a crawling peg exchange rate. In the crawling peg regime, the exchange rate is pegged at desired levels according to economic and trade situations prevailing with the major trading partners. It is different from the fixed regime in that, in the fixed regime, the fixed rate is not adjusted when economic and trade situations in the world economy change. A floating exchange rate, where the market forces are left to determine the rates, was finally adopted in October 1993. Since then the

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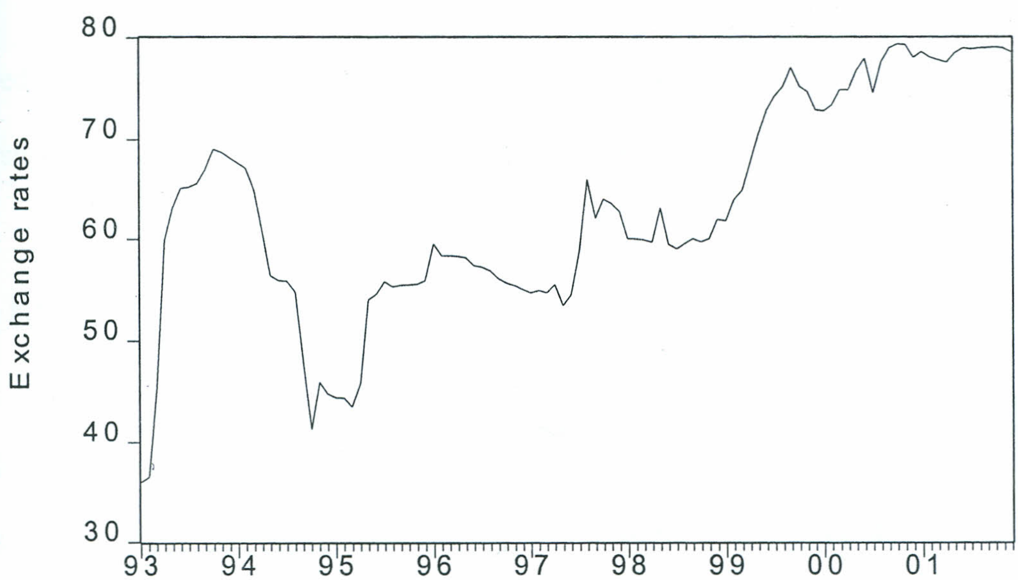
[1] M3X includes M3 and residents foreign currency denominated deposits held with the commercial banks

shilling has remained largely market driven with the Central Bank only intervening to correct erratic movements in the rate. (CBK, 2000(b)).

After the liberalization of the foreign exchange market in the 1993, the exchange rates have been left to the market forces. Therefore there is no overt monetary policy objective to manage them except indirectly through such instruments as the Central Bank's foreign exchange holdings which were for instance increased from US$ 791m in December, 1999 to US$ 802m at the end of June, 2000 to strengthen the weakening shilling. No mention is made in the Ninth monetary policy statement about exchange rates showing that the Bank has no direct policy on it (CBK, 1996-2001). The figure below shows the trends in exchange rates from 1968 when the rates were fixed through to the crawling peg regime in the 1980s up to the year 2000 in the floating regime.

Figure 1.2 - Exchange Rate Trends in Kenya



SOURCE: CBK quarterly bulletin (1996)

1.2 Statement of the Problem

The Central Bank of Kenya's policy of running a contractionary monetary policy whose objectives is to maintain inflation levels to a target of five per cent is aimed at maintaining price stability and certainty of money value (CBK, Jan. 2002). The argument for the policy does not consider the effects of the same on aggregate incomes. Using a priori (Dornbusch 1976, Marrinan 1989, Dellas 2002), a contractionary monetary policy leads to exchange rate overshooting in the short- run. Through the exchange rate channel of the monetary policy transmission mechanisms, exchange rate overshooting, reduces competitiveness of the domestic exports through its workings in increasing domestic interest rates and making domestic goods more expensive to foreigners. With reduced exports and increased interest rates, aggregate incomes decrease hence the monetary objective of increasing incomes is defeated. This is a policy paradox.

Secondly several studies have been done on exchange rate determination and related areas in Kenya but none has so far captured the aspect of exchange rate overshooting. This clearly indicates a knowledge gap that calls for a study such as this one.

1.3 Research Questions

From the statement of the problem, it is clear that there are several policy questions that raise policy concerns as regards the current monetary policy stance of the CBK. The following questions therefore emanate from the research problem.

i) Is there any empirical evidence for exchange rate overshooting in Kenya? More specifically, at what lag horizon does exchange rate peak after a monetary policy shock?

ii) If there has been exchange rate overshooting, do both money supply and output prices cause exchange rate overshooting in Kenya?

iii) How does exchange rate overshooting influence economic activity specifically aggregate output through the foreign exchange channel of the monetary policy transmission mechanisms?

iv) Considering the effects of exchange rate overshooting on aggregate output as in (i), (ii), and (iii) above, what are the policy directions for an effective monetary policy to fit the Kenya's exchange rate regime.

1.4 Objectives of the Study

1.4.1 General Objective

In line with the research questions, the general objective of this study is to investigate exchange rate overshooting and its transmission to the economic system in Kenya.

1.4.2 Specific Objectives

i) To establish whether exchange rate overshoots in Kenya.

ii) To quantify the magnitude of influence of both the sticky prices and monetary shocks on exchange rate overshooting.

iii) To investigate how exchange rate overshooting is transmitted in the economy through the exchange rate channel of the monetary policy transmission mechanism.

iv) To recommend a suitable monetary policy direction and monetary regime to anchor the price level.

1.5 Hypothesis

The following null hypothesis would be tested to achieve the objectives this study:

i) In Kenya exchange rates do not overshoot.

ii) If (i) is not true, then sticky output prices and money supply do not influence exchange rate overshooting in Kenya.

iii) Exchange rate overshooting has no affects on aggregate output levels.

iv) A contractionary monetary policy in the monetary aggregate anchor is not appropriate for the Kenyan floating exchange environment.

1.6 Significance of the Study

This study has been motivated by the fact that, there seems to be some theoretical relationship between the final aggregate output and exchange rate overshooting through the monetary policy transmission mechanisms which acts via the restrictive monetary policy. This study is important because no study has so far been done on exchange rate overshooting in Kenya and more specifically on its role on the aggregate output through the monetary policy transmission mechanisms. It would be interesting to know the effectiveness of the restrictive monetary policy stance currently being pursued by the Central Bank of Kenya if the exchange rate actually overshoots in Kenya. This will be useful to policy makers and academic researchers in designing monetary policies that would be in line with the findings of this study to help improve aggregate incomes and employment in Kenya.

1.7 Scope and Limitations of the Study

The scope of this study in time horizon is to establish for overshooting in the period between 1993 to 2001. The rationale for the choice of this time horizon is the fact that it is the period when exchange rates were liberalized. Some of the limitations of this study include:

(i) The long run equilibrium in this study is taken to be the period of adjustment of the short run model disturbances back to the initial point before the disturbance. This initial point may not necessarily be an equilibrium point due to other external disturbances from equilibrium, which might have not fully adjusted to the long run equilibrium when the other shocks are introduced.

ii) One of the major premises of this study is that the purchasing power parity (PPP) holds in the long run. The PPP theory postulates that, in the long run, identical products and services in different countries should cost the same in different countries. This is based on the belief that exchange rates will adjust to eliminate the arbitrage opportunity of buying a product or service in one country and selling it in another. The theory makes some assumptions that don't hold in the real world, such as ignoring the effects of transportation costs and tariffs. If the assumption of long-run PPP does not hold, since there are also many reasons why PPP may not hold (Officer, 1976), then the basis of analysis would be on shaky grounds.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The theoretical and empirical literature on the evidence of exchange rate overshooting indicate that most research on the subject have mostly been done for the developed world. Not much has been published on establishing for the evidence for exchange rate overshooting in Africa outrightly except only mentions of overshooting in passing in between other studies.

2.1 Theoretical Literature

Modern exchange rate theories emphasize financial -asset markets, rather than the traditional view of exchange rates adjusting to equilibrate international trade in goods and services. Because goods prices adjust slowly relative to the financial asset prices, and financial assets are traded continuously each business day, the shift in emphasis from goods market to asset markets are important. Most exchange rate overshooting theories so far developed take this stand.

2.1.1 Exchange Rate Overshooting models

(a) Classical Monetary Models (CLMM)

The classical model of exchange rate is based firmly in the quantity theory of money and of fully flexible prices and wages. Therefore the labor markets always clear in the long- run and that real output is supply determined and including the non- traded goods in addition to the two freely traded bundles of commodities. For the home country, the general price level, P is specified to be a linear homogenous function of traded and non-traded good prices P_t and P_n, respectively. This is expressed as:

$$P= P_t^{1-v} P_n^{v} \tag{2.1}$$

where v is the expenditure share of non- traded goods on home country output. The foreign country also has a traded and a non traded sector and it is assumed for ease of exposition that the proportion of the traded goods sector to total expenditure in the foreign economy is the same as for the home country. Hence the foreign average price level is also a linearly homogenous function of traded and non traded goods prices and can be written as:

$$P^* = P_T^{*1-v} P_N^{*V} \tag{2.2}$$

The relationship between the two economies now depends only upon the traded goods price parity, that is;

$$E= P_t / P^*_t \tag{2.3}$$

where E is the nominal exchange rate.

Suppose that in the short run, the prices of non-tradable goods are sticky, the increase in money supply say by x per cent will have to raise the price of non tradable goods by more than x per cent if the average domestic price levels are to rise by x per cent. The exchange rate will depreciate in the long run to maintain PPP of traded goods. With domestic economy unchanged, relative prices are also unchanged. Hence an excess supply of traded goods and a corresponding excess demand for non-traded goods. Thus the prices of non-tradable goods will rise over time until their relative price is established in the long run. This results into an appreciation of the exchange rate following its over-depreciation in the short run.

This model hence, exhibits exchange rate overshooting in the short run because of stickiness of non- traded good prices. This result can be generalized in that any rigidities in the economy may produce relative price shifts and hence exchange rate overshooting in the short run. This overshooting is independent of capital flows and of expectations about the future level of the exchange rate. It results solely from the stickiness of prices of non- traded goods.

(b) Currency Substitution Monetary Model (CSMM)

Here domestic residents hold both domestic and foreign currencies. In these models, bond market is not explicitly represented and so there are no interest rates. They however try to integrate the current and capital accounts of the balance of payments through wealth effects. According to Pentecost (1993), this model follows papers by Calvo and Rodriguez (1977) and Frankel and Rodriguez (1982). The asset market equilibrium in this class of model is made up of the wealth identity and equilibrium conditions in both home and foreign money markets. Domestic residents real wealth, w, in terms of foreign currency is defined as: $w = M/E + M*$ (2.4)

where E is the nominal exchange rate, M is the domestic money supply and $M*$ is the foreign money supply. The asset market equilibrium condition is expressed as a ratio of home to foreign money: $\left[M/(EM*)\right] = L/L* = \left(\dot{E}/E\right)$ (2.5)

where L -is the demand for domestic assets, and $\dot{E}$ - is the growth in the nominal exchange rate.

Equation (2.5) shows that the desired ratio of home to foreign currency declines as the rate of depreciation of the home currency increases. Considering a monetary change in the context of this model, for an increase in money m, the nominal exchange rate e, depreciates overshooting its long -run level. At this depreciated level, however, real wealth w, has fallen, but because the non-traded goods market must clear, the real exchange rate q, must rise to maintain the model on $q(w)$ space. The major limitation of this model is that it considers only instantaneous adjustments in the stock levels and ignores any delays in the stock adjustment process.

(c) Mundell-Fleming's Fixed Price Overshooting Model - Sticky Price Keynesian model (SPKM)

The model developed by Fleming (1962) and Mundell (1963) of the open economy with unemployed resources has had a tremendous impact on international monetary economics. As was the *modus operadi* then, they assumed fixed prices so that nominal exchange rate changes are in the real exchange rates. In this model, perfect capital mobility is assumed so that uncovered interest parity holds. Assuming a perfect foresight situation, the expected change in the exchange rate next period based on information available in this period is, exactly the change, which occurs. That is:

$$E(e) = \mu(\bar{e} - e) \tag{2.6}$$

Where e is the nominal exchange rate

So that the covered interest parity condition is:

$$r - r^* + \mu(\bar{e} - e) \tag{2.7}$$

where r is the domestic interest rate, and $r*$ is the foreign interest rate.

Equation (2.7) shows that r can now deviate from r^* if e is not at its equilibrium level.

The model assumes that the money market clears instantaneously while the goods market only clears slowly according to the size of the coefficient of partial adjustment. Therefore the exchange rate will overshoot its final equilibrium position in the short - run as it jumps to clear the money market before output has time to rise. This overshooting in the short- run is caused by the different speeds of adjustment between the goods market, which clears only slowly and the money market, which clears instantaneously.

(e) Overshooting in the Portfolio Balance Monetary Model (PBMM)

The portfolio balance approach of exchange rate determination stems from the work on portfolio theory and the demand for money by Markowitz (1952) and Tobin (1958). The central feature in this model of exchange rate determination is that domestic and foreign non-money assets are assumed to be imperfect substitutes rather than perfect substitutes as in the monetary and Mundell-Fleming approaches. In this theory, the total domestic residents' wealth W, is made up of domestic residents holdings of domestic bonds B, and domestic residents holdings of foreign currency assets F*. Therefore the domestic non-bank private sector wealth is measured in domestic currency as:

$$W = M + B + EF^* \tag{2.8}$$

where: E - is the nominal exchange rate.

The asset market equilibrium condition is given by:

$$M = m\left(r, r^*, +E(e)^*\right)W \tag{2.9}$$

$$B = b\left(r, r^*, +E(e)^*\right)W \tag{2.10}$$

$$EF^* = f\left(r, r^*, +E(e)^*\right)W \tag{2.11}$$

where: E(e)- is the expected change in the exchange rate, r - is the domestic interest rates and r^*-foreign interest rates. Since equation (2.7) and (2.9) are independent owing to the wealth constraint, linearized versions of (2.7) and (2.9) give solutions for e as follow:

$$e = \theta[(EF^*/W),(M/W)] \quad (2.12)$$

This is the PBMM overshooting model with W as the overshooting parameter.

where: W - is the domestic nominal wealth, e - is the real exchange rate, F*- domestic residents holdings of foreign currency assets, E - is the nominal exchange rate defined in terms of domestic price of foreign currency and M - is the domestic resident's holdings of domestic bonds.

An increase in money supply, so that, $\Delta M = -\Delta B$, will shift the e curve to the right implying that the exchange rate initially depreciates and then appreciates down the saddle path to the new long run equilibrium. The initial steep depreciation leads to undershooting giving rise to a trade surplus as domestic residents accumulate foreign assets thereby appreciating the exchange rate towards its equilibrium level.

This result is consistent with the overshooting hypothesis of the monetary and Mundell-Fleming models.

(f) Dornbusch Sticky- Price Overshooting Model (SPMM)

The first alternative to the fixed- price-overshooting model is the Dornbusch overshooting model (1976) whereby, although the price level is sticky in the short-run, in the long run it is flexible in response to excess demand in the goods market. In what has become a classical paper, Dornbusch (1976) proposed that, rather than output adjusting to equate demand and supply in the goods market, the supply of output could be assumed fixed just like in the classical approach. And that the general level of prices could rise (fall) in response to excess demand (supply).

With asset market clearing instantaneously and the goods market adjusting only slowly (sticky prices), the expectation of a future appreciation of exchange rates (e)

allows interest rates (r) to fall below its initial value hence overshooting of the exchange rate. As goods market prices rise, the exchange rate appreciates back towards its long-run equilibrium value. The extent of this short-run exchange rate overshooting is given by totally differentiating the price level equation, noting that $\partial e = \partial m = \partial p$, gives $\partial e / \partial m = (1 + 1/\mu\beta)$, where $0 < \mu\beta < 1$. That is a one per cent rise in the money supply has a larger than one per cent effect on the exchange rate. Moreover the extent of exchange rate overshooting depends upon the interest elasticity for the demand for money, β, and the regressive expectation coefficient, μ. Thus if the interest elasticity of the money demand is low, any change in the money supply will result in a relatively large change in the interest rate and will be mirrored by a large overshoot of the exchange rate.

2.2 Empirical Literature

2.2.1 General Literature

Driskill (1981) using the Swiss-US Dollar exchange rate and three-monthly data utilized the single equation procedure to estimate the quasi-reduced form for the Swiss-Franc-US Dollar exchange rate for the period 1973-1977. His approach was to convert the continuous time, two country theoretical model into a discrete time, two country empirical model. The model is reduced to two dynamic equations, one for the price level and the other for the exchange rate. To convert the Dornbusch model into a two-country model for the prices and the exchange rate, Driskill defines all variables in relative terms.

The empirical model for exchange rate is attained by using the uncovered interest parity equation combined with regressive expectations where the long-run equilibrium exchange rate $\bar{e}$ is replaced by the relative money supply $\hat{m}_t$. Driskill used the relationship below to establish for exchange rate overshooting:

$$e_t = b_0 + b_1 e_{t-1} + b_2 \hat{m}_{t-1} + b_3 \hat{m}_{t-1} + b_4 \hat{p}_{t-1} + b_5 \hat{y}_t + b_6 \hat{y}_{t-1} + b_7 \hat{g}_{t-1} + v_t \qquad (2.13)$$

The Dornbusch model implies that the following four restrictions are valid: $b_1<0$, $b2>0$, $b_4<0$, and $b_1+b_2+b_3+b_4=1$. The sign and size of b_2 indicates the short-run overshooting and the constraint that the sum of the first four b s sum to unity is equivalent to long-run PPP. Furthermore since the price level rises only after the exchange rate has overshot its long–run equilibrium level, prices rise as the exchange rate appreciates back towards equilibrium and so b_4 must be negative. The terms in government expenditure are not strictly part of the Dornbusch model and so are excluded in the estimated version of the model. The income terms also had to be omitted because the proxies used for the Swiss income data were insignificant. Driskill's results offer strong evidence for exchange rate overshooting with $b_2 > 0$ and strongly significant.

Demey (1984) re-estimated the model, using the same data set, by maximum likelihood method to obtain efficient estimates of the parameters and to test the implied cross-equation restrictions, not tested by Driskill. Demey's estimates are rather different from Driskill for two reasons. First, Demey uses a moving average error process as implied by the theoretical model, and not an autoregressive error process as used by Driskill. Secondly, the oil dummy included in Driskill is not included in Demey's test for technical reasons. Demey's coefficients differ considerably in magnitude and sign from those of Driskill; in particular, in the unrestricted form, the coefficient of b_2 is less than unity, suggesting exchange rate overshooting.

Demey explicitly tests two restrictions using the likelihood ratio procedure. He tests for the validity of other restrictions, which includes the test for PPP, which however again exceeds its critical value leading to the rejection of the restrictions. Therefore contrary to Driskill's results, it seems that overshooting is not an important feature in the case of Swiss- US Dollar exchange rate.

Papell (1988) tests the Dornbusch model using constrained maximum likelihood techniques which incorporate cross- equation restrictions, and the assumption of rational expectations for the effective exchange rates indices of Germany, Japan, the UK and USA using quarterly data from 1973 quarter two (Q2) to 1984 quarter four (Q4). In this model, most of the structural parameters have plausible values, but the critical parameter for the overshooting is δ_2 , the coefficient of the price level in the exchange rate equation. If δ_2 is positive then, there is exchange rate overshooting, but if it is negative, then undershooting prevails. The results obtained shows that half the coefficients are positive and half are negative. The only country where overshooting seems a credible hypothesis is West-Germany, while Japan seems to display the characteristics of undershooting. For the UK, the results are weak, with insignificantly different from zero.

Papell (1984) estimates a two-country version of the Dornbusch overshooting model, assuming rational expectations and postulates endogenous money supplies. Monetary policy in both countries is assumed to be responsive to exchange rate and price level changes. The estimated model consists of six equations which are estimated structurally using constrained maximum likelihood techniques and quarterly data for the USA, and West Germany for the period 1973 quarter three (Q3) to 1981 quarter four (Q4). The strongest result is that, while the US monetary policy is strongly accommodating of prices, Germany's monetary policy is sufficiently offsetting for the combined monetary policies not to be able to induce exchange rate undershooting. Thus exchange rate overshooting is a strong result to emerge from this extended Dornbusch model.

Faust and Rogers (2000) in an attempt to assess the instantaneous overshooting hypothesis by Dornbusch and testing for the validity of PPP and UIP, used the US monthly data for the period 1974:1 to 1997:12. They used an extension of the Bayesian simulation method to produce the error bands on the impulse response and values drawn from the reduced standard form parameters. They found out that the delayed overshooting result is sensitive to dubious identifying assumptions. They found little evidence that the large UIP deviations are the main source of the forward premium anomaly. They also found that monetary policy shocks might explain less exchange rate variance than previously believed. Their results allow for an early peak in the exchange rate, which might give a role for the conventional overshooting model. However, the bulk of the variance of the exchange rate after policy shocks, is due to large deviations from UIP. This they concluded is inconsistent with Dornbusch overshooting model.

2.2.2 Literature Specific to Developing Countries

Literature on developing countries on the evidence for exchange rate overshooting is scant. Studies that touch on anything on exchange rate overshooting in Kenya and Africa in general did not undertake to establish for the evidence of overshooting as one of the main objectives of their studies. It only comes in during data analysis (see Sichei 2002, Ndung'u 2000, and Alwendo 1999)

Bahmani (2000), in an effort to test for overshooting of the Turkish Lira, used the error correction model to test for the short run and the long run overshooting using Turkish monthly data covering January1987 to December 1998.

By combining the concepts of PPP theory and the Quantity Theory of Money, he developed a log linear model of exchange rate determination given by;

$$Logs = (LogM_T - LogM_{US}) - (LogY_T - LogY_{US}) + (LogV_T - LogV_{US})$$

Where variables with the T subscript are domestic (Turkish) variables while the ones in US subscript denote the foreign variables and V is the velocity of money from the quantity theory of money. The study proxied the velocity of money using inflationary differentials and the interest rates since he argued that money velocity are determined by the two factors to come up with the error correction model given by;

$$\Delta s_t = a_0 + \sum_{j=1}^{n} b_j \Delta s_{t-1} + \sum_{j=1}^{n} c_j \Delta m_{t-1} + \sum_{j=1}^{n} d_j \Delta y_{t-j} + \sum_{j=1}^{n} f \Delta i_{t-1} + EC_{t-1}$$

The study found out that the values for the coefficients of *Δm* variable were positive up to the second lag order but negative from the third lag order onwards implying that the Lira depreciates first due to a monetary policy shock, and then it appreciates in the long run. This showed overshooting in the short run though with most of the coefficients insignificant.

The error correction term, EC_{t-1} in this study was positive; implying that there was overshooting in the long run.

2.3 Overview of Literature

This chapter has reviewed some of the developments in modeling of exchange rate overshooting models in the context of the Mundell (1963) and Fleming (1962) tradition of fixed or sticky prices. This type of models extend the income -expenditure approach to include international capital flows, where domestic and foreign assets are assumed to be perfect substitutes. In the Mundell-Fleming (SPMM) model, goods market is assumed to be slowly clearing while the asset market is in continuous equilibrium. This may give rise to exchange rate overshooting as in the CLMM although for different reasons. In this case it is the differential adjustment speeds of the assets and the goods markets whereas in the CLMM, it is the stickiness in the non-tradable goods prices which gives rise to exchange rate overshooting.

However, some of the limitations of the CLMM are its ignoring of international capital flows and future expectations of exchange rate movements, which are major determinants of exchange rates. The SPKM (Mundell- Fleming) model, therefore has an advantage over the modern monetary approaches in that overshooting can occur and hence real exchange rate changes can take place, at least in the short run (Pentecost, 1993).

Dornbusch (1976) model also had methodological limitations when examined from a micro-foundations point of view (Were et al, 2001). The model lacks choice theoretical foundations particularly the micro-foundations of aggregate supply. Its specification of the price determination is *ad hoc*. The model is also ill equipped to capture current account dynamics (Obstfelt, and Rugoff, 1996). In addition it does not explicitly model the implicit bond market (Were et al. 2001).

The portfolio balance approach which emphasizes the link between the balance of payments and the adjustments in the asset stocks (Were et al. 2001), assumes that domestic and foreign assets are not perfect substitutes, and therefore the UIP do not hold (Isard, 1995). Empirical tests of the portfolio balance models based on earlier works of

Meesse and Rugoff (1983) incorporating cumulative trade and current account balances have become widely adapted (see Hooper and Morton, 1983, Were et al. 2001).

It is therefore important when establishing for the evidence for exchange rate overshooting to incorporate the different aspects of these models to capture all their salient futures.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.0 Introduction

The previous chapter reviewed some of the theoretical foundations of exchange rate overshooting. These theories include the classical theory, the portfolio balance approach (Keynesian approach), Mundell-Fleming model (Fixed price models) and the Dornbusch flexible price model. Each of these models has its assumptions, which in most cases limit their applicability in the developing countries. To develop an encompassing exchange rate overshooting model, it is possible in principle to integrate these approaches into a unified model, thus the different models can be viewed as complementary and not necessarily competing (Rugoff 2002).

3.1 Theoretical model for exchange rate overshooting

In this study, the classical exchange rate overshooting theory will be used as a baseline for empirical model development. In the classical exchange rate overshooting model, the money stock is assumed to be proportionate to the price levels and the exchange rate. A monetary policy change therefore, will change the exchange rates and prices in the same direction and magnitude (Pentecost 1993). An over-reaction of the exchange rates due to a monetary policy change is interpreted as either an exchange rate overshooting or undershooting depending on the direction of change. On the other hand, a disproportionate change in prices as monetary policy change implies that the prices are sticky. This means that, prices will not move instantaneously with movements in the exchange rates. This theory is called the money neutrality hypothesis. The classical model has the following assumptions.

First the classical theory is firmly based on the quantity theory of money with fully flexible prices. The quantity theory of money is given by:

$$M = \frac{PY}{V} \tag{3.1}$$

Equation (3.1) is referred to as the money demand equation, where M is the money stock level, P is the general price level, Y is the income level and V is the money velocity. Since V, the velocity of money is not observable, Bahmani (2000) argues that it can be substituted by its major determinants such as the interest rates (R) and the inflationary expectations (Π). Equation (3.1) above then becomes:

$$M = \frac{PY}{R\Pi} \tag{3.2}$$

Equation (3.2) above may be linearized by taking its logarithms, which gives:

$$m = p + y - r - \pi \tag{3.3}$$

where: $m = \log(M)$; $p = \log(P)$; $y = \log(Y)$; $r = \log(R)$; *and* $\pi = \log(\Pi)$.

This representation means that all prices including the wage rates are perfectly flexible, thereby establishing full automatic employment of resources.

The second assumption of the classical model is that the velocity of money is constant so that money is neutral in its effects to the real economy in the long run. That is:

$$\Delta m = \Delta p = \Delta e \tag{3.4}$$

where (Δm) is the monetary policy change, Δp is the change in the price level and Δe is the appreciation or depreciation of the exchange rates. This means that, a monetary policy change (Δm) would lead to a proportionate change in the price levels and the exchange rates in the long run.

The third proposition of the classical theory is that the domestic and foreign prices are linked through the nominal exchange rates. This means that according the classical theorists, the exchange rate is the purchasing power of the domestic currency in terms of the foreign currency. This relationship can be expressed as:

$$E = \frac{P^d}{P^f} \tag{3.5}$$

where E is the nominal exchange rate, P^d is the nominal domestic price level and P^f are the nominal foreign prices. Taking the logarithms of equation (3.5) above gives:

$$e = p^d - p^f \tag{3.6}$$

where $e = \log(E)$; $p^d = \log(P^d)$, and $p^f = \log(P^f)$. This relationship is what Keynes called the Purchasing Power Parity (PPP).

The proponents of the classical theory also argue that the change in the expected depreciation of the home currency will be equal to the excess of the domestic nominal interest rates over the foreign nominal rates. That is:

$$r^d - r^f = \theta(\bar{e} - e) \tag{3.7}$$

where θ is the expectations operator, $\bar{e}$ is the equilibrium nominal exchange rates in logs, e is the current nominal exchange rates in logs, r^d are the domestic nominal interest rates in logs and r^f are the foreign nominal interest rates in logarithms. This relationship represents the uncovered interest rate parity (UIP) condition. The UIP represents a situation of perfect capital mobility. This means that the bonds apart from their currency denominations are perfect substitutes and that international portfolios such as foreign securities are adjusted instantaneously.

Finally, the other major proposition of the classical theorists is that the domestic and the foreign money markets are in equilibrium and the conditions in the world market (foreign markets) directly affect the exchange rates so that:

$$m^d = m^f \tag{3.8}$$

where m^d is the domestic nominal money stock and m^f is the foreign nominal money stock. Given the relationship from equation (3.3), the domestic and the foreign money demand functions are represented below:

$$m^d = p^d + y^d - r^d - \pi^d \tag{3.9}$$

$$m^f = p^f + y^f - r^f - \pi^f \tag{3.10}$$

Moreover, from equation (3.6) the log of the domestic prices is given as:

$$p^d = p^f + e$$

Using the above equations to solve for e gives the following expression:

$$e = \left(m^d - y^d + r^d + \pi^d\right) - \left(m^f - y^f + r^f + \pi^f\right) \tag{3.11}$$

After collecting like terms equation (3.11) becomes:

$$e = \left(m^d - m^f\right) + \left(y^f - y^d\right) + \left(r^d - r^f\right) + \left(\pi^d - \pi^f\right) \tag{3.12}$$

Equation (3.12) gives the classical exchange rate determination model, which is basically a monetary side model because it does not consider the supply side of the economy.

This becomes the major criticism of the classical model, that is, the supply side is not incorporated in the model (Mundell 1968). To include the supply side, the Keynesian economists came up with the portfolio balance monetary model (Rugoff 2002). In this model they suggested that including current account flows and net capital inflows in the classical model would capture the supply side. Empirical application of the portfolio balance model is based on the assumption that currency composition of financial portfolios could be measured by incorporating the cumulative current account (Were et al. 2001). Based on the interpretations of Mussa and Rugoff (1983) that trade and current account balances are terms that allow for changes in the long run exchange rate, the relationship can be represented by a general equation as:

$$e = \alpha + \beta\, cab + \eta \inf + u \tag{3.13}$$

where: $\beta\, cab$ is the component part of the current account balance that affects the exchange rates, $\eta \inf$ is the influence of the net capital inflows on the exchange rates and u is the disturbance term. Incorporating these two supply side variables into the classical model gives:

$$e = \left(m^d - m^f\right) + \left(y^f - y^d\right) + \left(r^d - r^f\right) + \left(\pi^d - \pi^f\right) + cab + \inf \tag{3.14}$$

To capture the sticky price aspect of the exchange rate overshooting theory, price levels are used to proxy inflationary expectations in the model. The rationale for using price levels is that, inflation is the percentage change in the price levels two periods apart (Bahmani 2000). That is:

$$\theta\left(p^d_{t-1} - p^d_t\right) = \pi^d \qquad and \quad \theta\left(p^f_{t-1} - p^f_t\right) = \pi^f \tag{3.15}$$

where θ is the expectations operator, $p^d{}_t$ *and* $p^d{}_{t-1}$ are the domestic prices in time t *and* $t-1$ respectively and p^f_t *and* p^f_{t-1} are the foreign price levels in time t *and time* $t-1$ respectively.

From equation (3.14), an empirical model may be derived such as the following:

$$e_t = \beta_0 + \beta_1\left(m^d_t - m^f_t\right) - \beta_2\left(y^f_t - y^d_t\right) + \beta_3\left(r^d_t - r^f_t\right) + \beta_4\left(p^d_t - p^f_t\right) + \beta_5 cab + \beta_6 \inf + w_t \tag{3.16}$$

where: cab is the current account balance, inf is the net external capital inflows and w_t is the error term. The expression in equation (3.16) is a hybrid of the classical and the portfolio balance models since it incorporates the characteristics of both models.

When there is a contractionary monetary policy, m^d in the equation (3.16) falls. As a consequence, difference $(m_t^d - m_t^f)$ also falls. Following the money neutrality theory, the expectation is that exchange rate (e_t) will change in the same direction and magnitude as the monetary policy (money supply). If β_1 is positive then this implies that a monetary policy change leads to an overreaction (overshooting) of the exchange rates. On the other hand a negative β_1 implies an under reaction (undershooting) of the exchange rates due to a monetary policy change.

3.2 Assumptions of the model

i. The first assumption of this study is that purchasing power parity (PPP) holds in the long run. When PPP holds, the national aggregate price levels are linked through the nominal exchange rates. Since the price of each nominal money is the reciprocal of the average price levels, the exchange rate is sometimes referred to as the relative price of domestic money in terms of foreign money, that is the purchasing power of the domestic currency compared to foreign currency.

ii. The second assumption is that of perfect substitutability of the foreign and domestic assets so that the uncovered interest parity (UIP) holds in the long run. This condition says that the expected depreciation of the home currency will be equal to the excess of the domestic nominal interest rate over the foreign nominal rate.

iii. Money is neutral in the long run. This implies that a permanent change in money supply, m, leads to a proportionate change in both prices p, and exchange rates, e.

3.3 Theoretical model for the transmission mechanism

The exchange rate channel of the monetary policy transmission mechanism examines the relationship between exchange rates and the aggregate demand and supply. (Sichei, 2002). Exchange rate influences net exports through its impacts on interest rates, and domestic price levels. A contractionary monetary policy for instance, reduces money supply (M) leading to an increase in the domestic interest rates r_t, relative to the foreign interest rate r_t^f. This widens the interest rate differential $\hat{r}_t$ inviting increased capital inflows. The increased capital inflows appreciate the domestic currency (e) as more foreign currency comes into the country chasing the few domestic currency. This would increase the domestic price levels (p) since exchange rate is the relative price of domestic to foreign money. Increased domestic prices reduce the demand for domestic goods relative to foreign goods. This impacts negatively on net exports (NX) by reducing them hence reducing aggregate income (Y). A schematic presentation of this chain of reaction can be given as;

$$\downarrow M \Rightarrow \uparrow r_t \Rightarrow \uparrow \hat{r}_t \Rightarrow \downarrow e \Rightarrow \uparrow p \Rightarrow \downarrow NX \Rightarrow \downarrow Y \qquad (3.17)$$

where $\hat{r}_t$ is the interest rate differential between domestic and foreign rates and $\downarrow e$ signifies an appreciation of the domestic currency. Therefore,

$$\text{NX} = \text{f}(m, r_t, e, p). \qquad (3.18)$$

3.4 Empirical Model and Estimation Technique

3.4.1 Estimation Procedure for Overshooting

Meaningful econometric estimation of a model using time series data requires that the data be stationary. According to Granger and New bold (1974), econometric estimation using non-stationary time series data often leads to spurious results. Spurious results arise when the regression of non-stationary series which are known to be unrelated, indicates that the series are correlated (Adam, 1992).

Since the overshooting hypothesis is a short-run phenomenon, an appropriate method to test it would be to employ the error correction modeling and cointegration techniques (Barmani and Orham, 2000). Engel and Granger (1987) for instance argues that if two variables are cointegated, that is, if there is a long term relationship between them, then the short-run dynamics of the model can be described by an error correction model.

This paper will adopt an approach similar to that of Bahrain (2000). First it explores the existence of a cointegration relationship among the variables in the regression equation. If the variables are cointegrated then, a long run relationship among them can be established, and it can be estimated using the two-step procedure introduced by Engle and Granger. The information in the error term of the long run relationship is then used to develop an error correction model, which is capable of describing the short-term dynamics of the variables.

The first step in applying the techniques is to determine the order of integration of each variable. The variables in the model are subjected to unit root tests using Augmented Dickey Fuller tests (ADF) and Phillip-Perron tests.

Let $\hat{m}_t = (m^d{}_t - m^f_t), \hat{y}_t = (y^d{}_t - y^f_t), \hat{r}_t = (r^d{}_t - r^f_r), \hat{p} = (p^d{}_t - p^f_t)$, then the long run equation can be written from equation (3.16) as:

$$e_t = \alpha_0 + \alpha_1 \hat{m}_t + \alpha_2 \hat{y}_t + \alpha_3 \hat{r}_t + \alpha_4 \hat{p}_t + \alpha_5 cab + \alpha_6 \inf + u_t \qquad (3.19)$$

Equation (3.19) is a static model by its nature. Due to the dynamic relationships of the variables in the model, it is reasonable to assume an autoregressive distributed lag (ARDL) model with *n* lags as:

$$\begin{aligned} e_t = \alpha_0 + \sum \alpha_{1i} e_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \hat{m}_{t-i} + \sum_{i=1}^{n} \alpha_{3i} \hat{y}_{t-i} + \sum_{i=1}^{n} \alpha_{i4} \hat{r}_{t-i} + \\ \sum_{i=1}^{n} \alpha_{5i} \hat{p}_{t-i} + \sum_{i=0}^{n} \alpha_{6i} cab_{t-i} + \sum_{i=0}^{n} \alpha_{7i} \inf_{t-i} + \mu_t \end{aligned} \qquad (3.20)$$

where n is the number of lags.

As discussed earlier, if a set of variables, are cointegrated, then the short run dynamics of the long run equilibrium given in equation (3.19), can be described by an error correction model as:

$$\begin{aligned} \Delta e_t = \beta_0 + \sum_{j=1}^{n} \beta_{1i} \Delta e_{t-j} + \sum_{j=1}^{n} \beta_{2i} \Delta \hat{m}_{t-j} + \sum_{j=1}^{n} \beta_3 \Delta \hat{y}_{t-j} + \sum_{j=1}^{n} \beta_4 \Delta \hat{r}_{t-j} + \\ \sum_{j=1}^{n} \beta_5 \Delta \hat{p}_{t-j} + \sum_{j=1}^{n} \beta_6 cab_{t-j} + \sum_{j=1}^{n} \beta_7 \inf_{t-j} + \beta_8 ECT_{t-1} + v_t \end{aligned} \qquad (3.21)$$

where: $ECT_{t-1} = e_{t-1} - \alpha_0 + \alpha_1 \hat{m}_{t-1} - \alpha_2 \hat{y}_{t-1} - \alpha_3 \hat{r}_{t-1} - \alpha_4 \hat{p}_{t-1} - \alpha_5 cab_{t-1} - \alpha_6 \inf_{t-1}$ (3.22)

ECT_{t-1} is the lag of residuals estimated from equation (3.19), Δ represents the difference operator; and v_t is a disturbance term. The error correction term ($\beta_8 ECT_{T-1}$) represents the short-term response necessary to move the system back towards long run equilibrium.

Before interpreting the results of the error correction model, a series of diagnostic tests on the variable and the equation itself would be performed. Using the Box-Pierce and Ljung-Box q statistic and LM tests, the presence of serial correlation among variables will be tested. The ARCH test would be used to test for heteroskedasticity in the disturbance term. A linear combination of the lagged values of all the variables is denoted by an error correction term, ECT_{t-1} in the ARDL model. If cointegration is established, the model is then re-estimated using an appropriate lag selection model. Cointegration will be established using the residual based test by Engel and Granger.

Concentrating on the sign of the lagged Δm variable (and depending on the number of lags), it would be possible to establish overshooting of the exchange rate. If the coefficient of the first lag order of Δm is negative, this implies that the exchange rate first of all appreciates and if the latter lag orders of Δm coefficients are positive, then it means the exchange rate latter (after appreciating) depreciates. This would support the overshooting hypothesis in the short-run. If the lagged error term, (ECT_{t-1}) that is suppose to have a negative coefficient, carries a positive coefficient, then this is interpreted as exchange rate overstaying above its long run equilibrium value in other words it overshoots itself in the long run (Bahmani 2000).

3.4.2 Vector autoregression analysis (VAR) Estimation

To analyze the dynamic relationship among variables in the exchange rate channel of the monetary policy transmission mechanism, this paper will utilize the vector autoregression (VAR) model. The use of VAR is justified since it is possible to simulate the response over time of any variable in a set to either an own innovation or innovations to any other variable in a system of equations (Sichei, 2002). VAR econometrics analysis entails estimating regression equations in which the current value of each variable is expressed as a function of lagged values of itself and of each of the selected variables

(Orden 1986). No variable is assumed to be exogenous a priori and no variable is excluded from the autoregressive equation for any of the variables in the system.

There are three different VAR models; the reduced form VAR, the recursive form VAR, and the structural form VAR. The recursive and the structural VARs have the same form at the level of matrix equations. These two VARs allow for explicit contemporaneous interactions among the variables of the system, that is, they allow the contemporaneous variables to be simultaneously determined (Stock and Watson 2001).

The reduced form VAR approach sidesteps the need for structural modeling, by modeling every endogenous variable in the system as a function of the lagged values of itself and of all of the endogenous variables in the system (Engel and Granger 1987). The reduced form and the recursive VAR models are statistical models that utilize no economic structure beyond the choice of variables. The reduced form VAR model is a system of n equations, which is written in matrix form as;

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + . \quad . \quad . + A_p Y_{t-p} + \varepsilon_t \tag{3.23}$$

where A_0 is a n×1 vector of constant terms, $A_1, A_2, . . . A_p$ are n×n matrices of coefficients, Y_t is a n×1 vector of the endogenous variables and ε_t is a vector of serially uncorrelated error terms that are assumed to have a mean of zero and a covariance of matrix Ω.

This paper will utilize a system of equations in the reduced form VAR to test for the transmission mechanism through the exchange rate channel. A five variable VAR with the variables in the relationship (3.17) can then be specified in a functional form as:

$$e = f(m, r_t, e, NX, p) \tag{3.24}$$

where: m is the domestic money supply, r is the domestic interest rates, e is the domestic spot exchange rates NX the domestic net exports and p is the domestic price levels.

The complete estimatable VAR (p) model can then be written as:

$$\Delta NX_t = C_{10} + \sum_{j=1}^{p} \alpha_{11}^{(j)} \Delta NX_{t-j} + \sum_{j=1}^{p} \beta_{12}^{(j)} \Delta m_{t-j} + \sum_{j=1}^{p} \eta_{13}^{(j)} \Delta r_{t-j} + \sum_{j=1}^{p} \gamma_{14}^{(j)} \Delta e_{t-j} + \sum_{j=1}^{p} \mu_{15}^{(j)} \Delta p_{t-j} + \varepsilon_{1t} \quad (3.25a)$$

$$\Delta m_t = C_{20} + \sum_{j=1}^{p} \alpha_{21}^{(j)} \Delta NX_{t-j} + \sum_{j=1}^{p} \beta_{22}^{(j)} \Delta m_{t-j} + \sum_{j=1}^{p} \eta_{23}^{(j)} \Delta r_{t-j} + \sum_{j=1}^{p} \gamma_{24}^{(j)} \Delta e_{t-j} + \sum_{j=1}^{p} \mu_{25}^{(j)} \Delta p_{t-j} + \varepsilon_{2t} \quad (3.25b)$$

$$\Delta r_t = C_{30} + \sum_{j=1}^{p} \alpha_{31}^{(j)} \Delta NX_{t-j} + \sum_{j=1}^{p} \beta_{32}^{(j)} \Delta m_{t-j} + \sum_{j=1}^{p} \eta_{33}^{(j)} \Delta r_{t-j} + \sum_{j=1}^{p} \gamma_{34}^{(j)} \Delta e_{t-j} + \sum_{j=1}^{p} \mu_{35}^{(j)} \Delta p_{t-j} + \varepsilon_{3t} \quad (3.25c)$$

$$\Delta e_t = C_{40} + \sum_{j=1}^{p} \alpha_{41}^{(j)} \Delta NX_{t-j} + \sum_{j=1}^{p} \beta_{42}^{(j)} \Delta m_{t-j} + \sum_{j=1}^{p} \eta_{43}^{(j)} \Delta r_{t-j} + \sum_{j=1}^{p} \gamma_{44}^{(j)} \Delta e_{t-j} + \sum_{j=1}^{p} \mu_{45}^{(j)} \Delta p_{t-j} + \varepsilon_{4t} \quad (3.25d)$$

$$\Delta p_t = C_{50} + \sum_{j=1}^{p} \alpha_{51}^{(j)} \Delta NX_{t-j} + \sum_{j=1}^{p} \beta_{52}^{(j)} \Delta m_{t-j} + \sum_{j=1}^{p} \eta_{53}^{(j)} \Delta r_{t-j} + \sum_{j=1}^{p} \gamma_{54}^{(j)} \Delta e_{t-j} + \sum_{j=1}^{p} \mu_{55}^{(j)} \Delta p_{t-j} + \varepsilon_{5t} \quad (3.25e)$$

In this VAR model, each variable is regressed on a constant variable C_{ij}, p lags of itself, and p lags of each of the other variables in the model and the disturbance term ε_t. All the variables are in logarithms except the net exports.

The choice of p (the number of lags) would be determined using the Akaike information criteria (AIC), and the Schwatz criteria (SC). However, given the data limitations, lag length determination becomes a major challenge. While longer lag lengths are appropriate since they fully capture the dynamics of the system being modeled and increasing the parameters to be estimated, they reduce degrees of freedom and increase data requirements. Due to the degrees of freedom and data limitation problems, it would be important to have a trade-off between having a sufficient number of lags and a sufficient number of parameters to estimate.

3.4.3 Impulse Response Analysis (IRA)

The coefficient estimates of the VAR are however meaningless because of the lack of theoretical underpinning. The coefficient estimates can however be used in the derivation of impulse responses and forecast error decomposition. Impulse response analysis links the current value of the error term to the future values of Y_t or equivalently, the current and past values of the error term to the current values of Y_t. Forecast error decomposition measures how important the error in the j^{th} equation is for explaining unexpected movements in the i^{th} variable (Stock 2001).

Since impulse response analysis traces the systems response to a shock in one of the endogenous variables, it can be captured through Vector autoregression moving average (VARMA). The coefficients of the VARMA representation describe how a shock to a particular variable at one moment in time shifts the expected time path of each variable in the model compared with its expected evolution had the shock not occurred. Enders (1995) show that equation (3.25) can be written as a VARMA (∞) of the form:

$$\Delta NX = D_{10} + \sum_{j=0}^{\infty} \varphi_{11}^{(j)} \varepsilon_{1t-j} + \sum_{j=0}^{\infty} \varphi_{12}^{(j)} \varepsilon_{21t-j} + \ . \ . \ . + \sum_{j=0}^{\infty} \varphi_{15}^{(j)} \varepsilon_{5t-j} \tag{3.26a}$$

$$\Delta m = D_{20} + \sum_{j=0}^{\infty} \varphi_{21}^{(j)} \varepsilon_{1t-j} + \sum_{j=0}^{\infty} \varphi_{22}^{(j)} \varepsilon_{21t-j} + \ . \ . \ . + \sum_{j=0}^{\infty} \varphi_{25}^{(j)} \varepsilon_{5t-j} \tag{3.26b}$$

$$\Delta r = D_{30} + \sum_{j=0}^{\infty} \varphi_{31}^{(j)} \varepsilon_{1t-j} + \sum_{j=0}^{\infty} \varphi_{32}^{(j)} \varepsilon_{2t-j} + \ . \ . \ . + \sum_{j=0}^{\infty} \varphi_{35}^{(j)} \varepsilon_{5t-j} \tag{3.26c}$$

$$\Delta e = D_{40} + \sum_{j=0}^{\infty} \varphi_{41}^{(j)} \varepsilon_{1t-j} + \sum_{j=0}^{\infty} \varphi_{42}^{(j)} \varepsilon_{2t-j} + \ . \ . \ . + \sum_{j=0}^{\infty} \varphi_{45}^{(j)} \varepsilon_{5t-j} \tag{3.26d}$$

$$\Delta p = D_{50} + \sum_{j=0}^{\infty} \varphi_{51}^{(j)} \varepsilon_{1t-j} + \sum_{j=0}^{\infty} \varphi_{52}^{(j)} \varepsilon_{2t-j} + \ . \ . \ . + \sum_{j=0}^{\infty} \varphi_{55}^{(j)} \varepsilon_{5t-j} \tag{3.26e}$$

where D_{i0}, are constant terms, $\varphi_{i1}^{(j)}$ are impact multipliers which denotes the response of each variable to innovations in each of the corresponding error terms on impact, and ε_{it-j} are innovations.

As part of model specification, the orthogonal ordering of the right hand variables is very important. The ordering imposes recursive causality on the variables selected for the analysis. An alteration of the ordering affects the estimates of the dynamic relationships.

3.5 Definition of Terms and Variables

The variables used in this study include:

e_t -Spot exchange rate defined as a number of Kenya Shillings per US dollar.

m_t^d -is the domestic currency defined as currency held by the non-bank public, plus demand deposits, time and savings deposits held by the commercial banks and other non-banking financial institutions (NBFI).

m_t^f, is the US M3 component of money supply comprising institutional money funds, time deposits with commercial banks, time deposits at thrift institutions and the overnight and long term repurchase agreements.

$\hat{m}_t$ -Logarithm of ($m^f - m^d$).

r_t^d - is the (domestic) 90-day treasury bill rate used for the domestic rate of interest.

r_t^f -is the (foreign) 3-month US treasury bill rate

$\hat{r}_t$ - is the logarithm of the difference $r^f - r^d$

$y^d{}_t$ - Domestic nominal Gross Domestic Product (GDP) at current prices

y_t^f – US GDP at current prices

$\hat{y}_t$ - Logarithm of the differential of $y^f - y^d$

p_t^d -Domestic Consumer Price Index (CPI)

p_t^f -US consumer Price Index for all urban consumers

$\hat{p}_t$ -Logarithm of the difference ($p^f{}_t - p_t^d$)

cab -current account balance (the account in the balance of payments that records transactions of goods and services, income and current transfers)

inf -Net external inflows (the difference between the official inflows and outflows)

NX - net exports (is the total exports less total imports).

Note: In the VAR estimation, $m, r, e,$ and p denote domestic levels of money supply, interest rates, exchange rates and prices.

3.6 Concluding remarks

This chapter presented the theoretical and empirical model used in the study. The theoretical model presented is derived from the quantity theory of money and is extended to incorporate the supply side of the economy through the portfolio balance approach to exchange rate determination. An Error Correction Model (ECM) will be used to determine exchange rate overshooting both in the long run and in the short-run. A reduced form VAR of five variables will be used to trace the transmission of exchange rate overshooting in the economy. The next chapter presents data analysis and the model estimation results based on empirical model above.

CHAPTER FOUR

MODEL ESTIMATION AND ANALYSIS OF RESULTS

4.0 Introduction

This chapter presents the set of data used in the study and empirical results based on the theoretical model developed in Chapter 3. Data transformation was done before estimation and time series properties of the data determined using Augmented Dickey Fuller (ADF) test. Non-stationary series in the data were made stationary by differencing. Cointegration was established using the Engel-Granger two-stage method. The cointegrated variables were then used to form an error correction model, which was used to establish for exchange rate overshooting both in the short-run and in the long run. A five-variable VAR was used to trace the transmission of exchange rate overshooting in the economy.

4.1 Data Type and Sources

To achieve the objective of this study, monthly and quarterly time series data for the period 1993:1 to 2001:12 was collected for the purpose of the study. Quarterly data was used to establish for overshooting and monthly data to trace its transmission to the economy. The different data sources include:

- Central Bank of Kenya Quarterly Bulletin (1996) – quarterly domestic data on money supply, interest rates, and net external inflows.
- Central Bank of Kenya Monthly Economic Reviews (1996-2002) – Monthly domestic data on money supply, interest rates, and net external inflows.

- World Bank Africa database 2002 CD ROM –Monthly and quarterly domestic and foreign data on exchange rates, current account balance, Gross Domestic Product (GDP), and exports and imports (net exports).

- US Federal Reserve Bank at http://www/stls.frb.org - Monthly and quarterly foreign data on money supply, interest rates, and net external inflows.

Overshooting variables included all quarterly foreign variables and quarterly domestic variables including exchange rates, interest rates, prices, money supply, current account balance, net capital inflows, and Gross Domestic Product. Transmission variables were all domestic monthly variables including exchange rates, interest rates, money supply, prices and net exports.

4.1.1 Data interpolation

Data on domestic income or GDP is only available in annual frequency. Therefore data on GDP was interpolated using the SAS/ETF technique (SAS Institute Inc., 1993) described below. It is assumed that the quarterly series to be estimated (y) satisfy a multiple regression relationship with p related series $x_1 \ldots x_p$. During the sample period of 4n quarters, the relationship is $y = x\beta + \mu$.

(4.1)

where: y is $4n$ x 1, x is $4n$ x p β is the parameter to be estimated and μ is a random vector with mean of zero and a covariance matrix V.

The problem is to estimate a vector z of m observations on the dependent variables, where z would be identical with y in the cases of interpolation and distribution and would consist of observations outside the sample period in the case of extrapolation. A linear unbiased estimator of z satisfies for some m x n matrix A, $z = Ay = A(x\beta + \mu)$.

To find the best linear unbiased estimator z, we form a Langrange equation and minimize it with respect to A subject to the m x p matrix equation using an m x p matrix.

Solving the Langrange equation for A gives:

$$Ay = z = X_z \beta + \left(V_z V^{-1}\right)\hat{\mu} \tag{4.2}$$

where: $\beta = \left(X'V^{-1}X\right)^{-1} X'V^{-1}y$ (4.3)

is the least squares estimate of the regression coefficients using the n quarterly observations in the sample and;

$$\hat{\mu} = \left[I - X\left(X'V^{-1}X\right)\right]^{-1} y \tag{4.4}$$

$= y - X\beta$ is the nx1 vector of the residuals in the regression using quarterly data. $X_z\beta$ in the equation (4.2) applies the estimated regression coefficient β to the yearly observations if the explanatory variable X_z is associated with the vector z to be estimated. The estimator in (4.2) is the one used in the interpolation of yearly series into quarterly series since it is related to the yearly series but is unbiased and efficient. This estimator, due to its linear, best and unbiasedness produces quarterly estimates whose annual totals equals the observed values, for by (4.2) and with $V = E\mu\mu' = VC'$,

$$C\hat{y} = CX\beta + CVC'V^{-1}\hat{\mu} \tag{4.5}$$

$$= X\beta + \hat{\mu} = y$$

Equation (4.5) is estimated using the GLS to get the quarterly series.

4.2. Time Series Properties

4.2.1 Unit Root Tests

Figure 4.1 (a-f) shows the quarterly movements over the years from 1993 to 2001 of the model variables including exchange rates, money supply, prices, interest rates, incomes, current account balance and net exports. A look at the trends of the variables in equation (3.21) suggests that some of the variables are characterized by fluctuations and volatility.

Figure 4.1 (a) Exchange rates

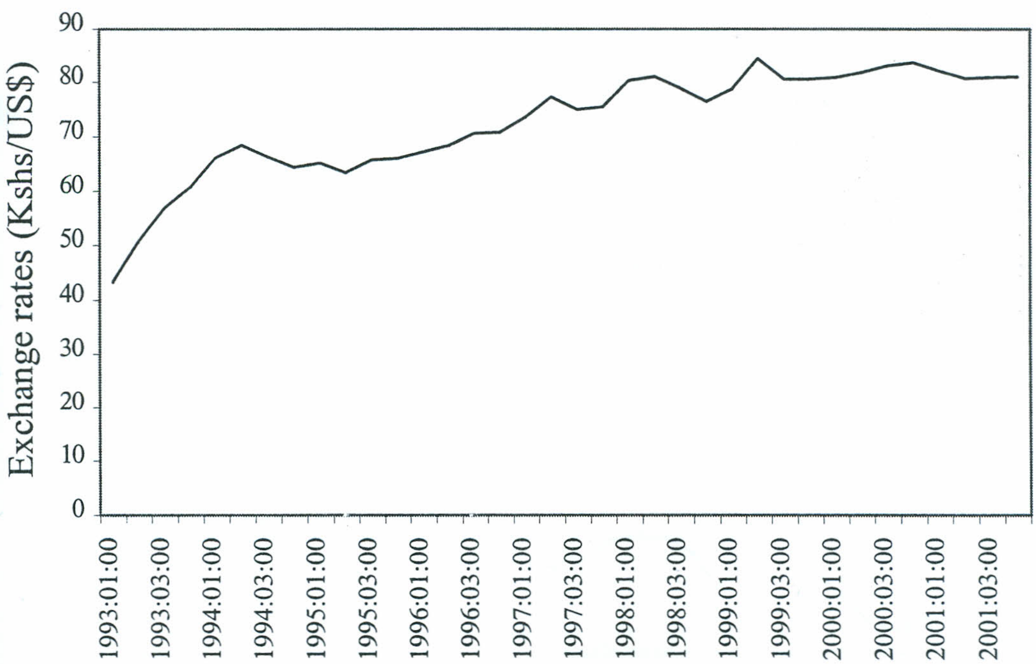


Figure 4.1-(b) money supply

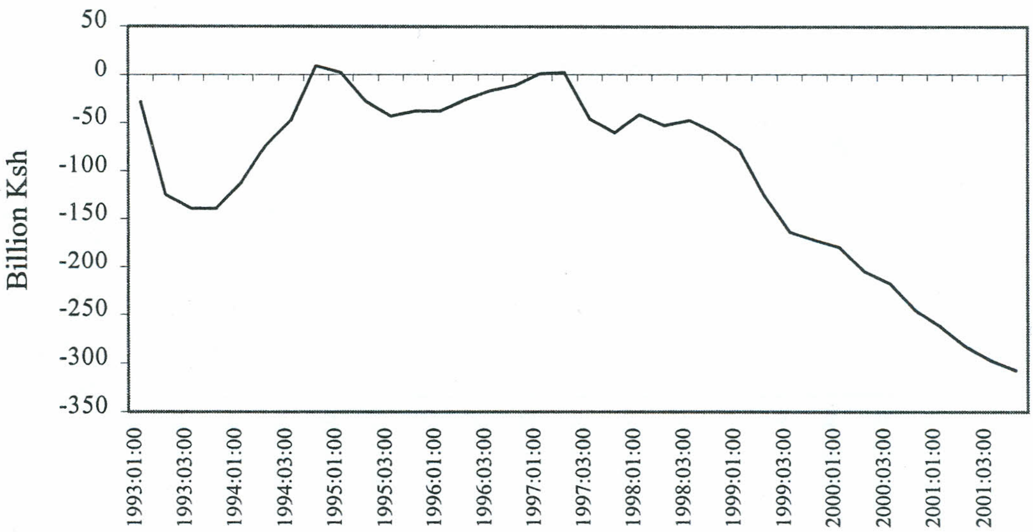


Figure 4.1 (c) Interest rates

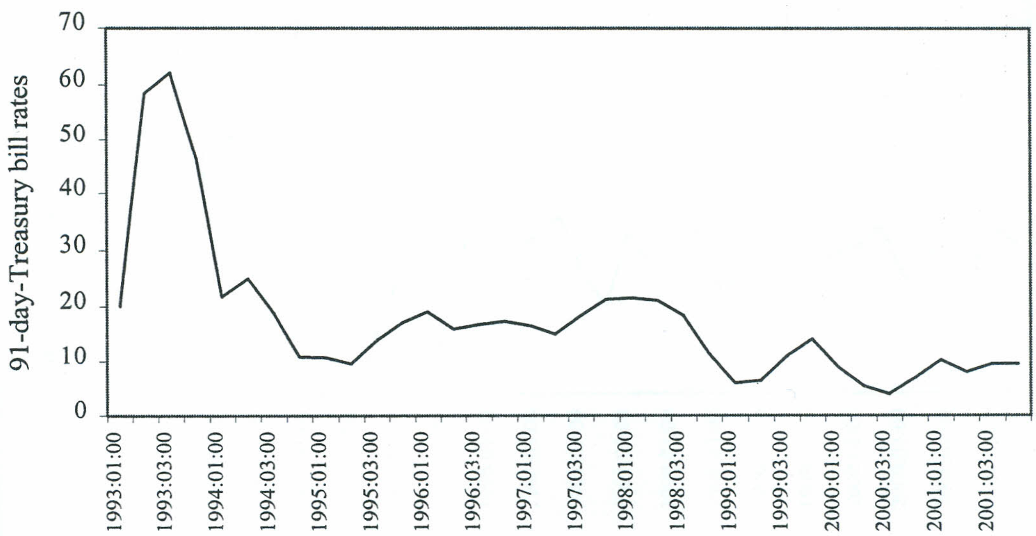


Figure 4.1 (d) Gross Domestic Product

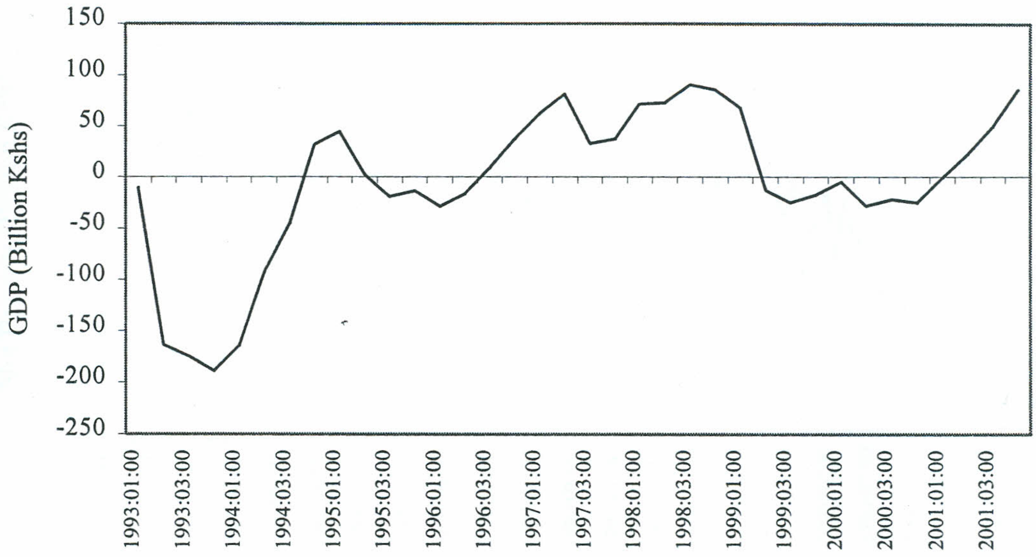


Figure 4.1 (e) Current Account Balance

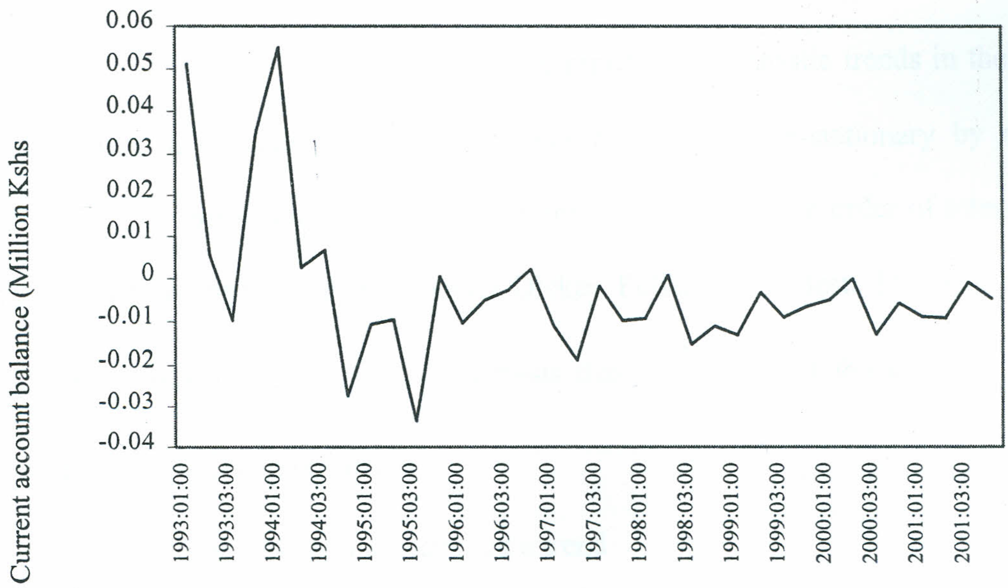


Figure 4.1 (f) Net Exports

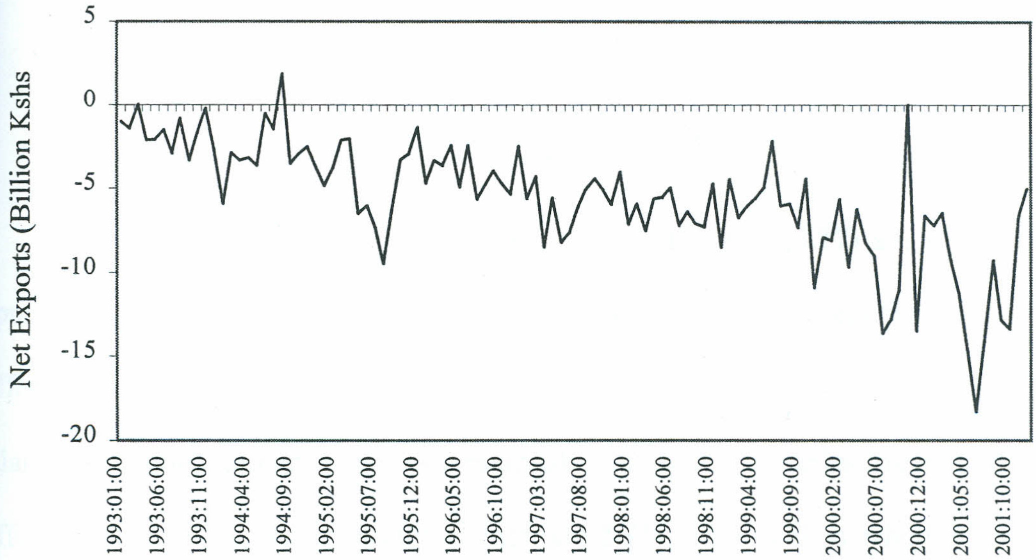


Figure 4.1 (a-f) suggest that all the variables seem to exhibit non-constant means and variance, which is evidence for either deterministic or stochastic trends in the data. However basing a decision on whether or not a series is non-stationary by casual inspection may be misleading. An appropriate method of testing the order of integration (testing for stationarity) is the Augmented Dickey Fuller (ADF) test. The Augmented Dickey–Fuller (ADF) tests the null hypothesis that $|\rho|=0$ against the alternative that $|\rho|<0$ in the autoregressive equations:

i) ADF without an intercept and a trend

$$\Delta y_t = \rho y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-1} + u_t \tag{4.6}$$

ii) ADF with an intercept but no trend

$$\Delta y_t = \alpha + \rho y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-1} + u_t \quad (4.7)$$

iii) ADF with both the intercept and trend

$$\Delta y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-1} + u_t \quad (4.8)$$

The unit root tests of the variables in the relationship (3.17) are reported in the Appendix A-1.The results of the unit root show that domestic exchange rates, price differentials, and money supply income levels, capital inflows and current account balance are non-stationary. The tests establish that all the variables are stationary after differencing once, which implies that they are I (1). To establish whether these non-stationary variables cointegrated, an appropriate test is used. The next section presents the cointegration test results.

4.2.2 Cointegration test

The procedure for testing for cointegration is similar to that of testing for the order of integration. The residual based cointegration test introduced by Engel and Granger by analogy of equation (4.6) involves testing the significant of the coefficient $|\rho|$ in the OLS regression of:

$$\Delta u = \rho u_t + \varepsilon_t \quad (4.9)$$

where u_t is the residual. The test postulates that if the residuals from the OLS estimation of the non-stationary variables are stationary, then the series are cointegrated. It is observed from the results that the residuals of the series are not stationary implying that they are not cointegrated as shown in Appendix B-1.

Given that the residuals do not exhibit a stationary trend, implies that the error correction model cannot be run. Instead estimation would be done on the variables at their first difference, but this means that the long run characteristics of the data are lost.

4.2.3 Unit Root tests and Cointegration Results for the data used in the Transmission model

The unit root tests results for the variables used in the transmission model are reported in the Appendix A-2. All the variables were tested for stationarity at levels. The results show that, nominal exchange rate, domestic price levels, interest rates, and money supply and net exports are all non-stationary. Moreover, it was found out that all the variables that were non-stationary at levels become stationary after the first difference, which means that they are I (1) series.

After establishing that some variables in the model are integrated of order one I(1), it is necessary to test for the long run relationship of these variables using cointegration tests. Again, this is done by using an ADF test on the residuals (from the regression of the non-stationary variables). The residuals seems not to be stationary as is seen from the residual graph in the Appendix B Figure B-2. Unit root test was then done on the residuals (results presented in the Appendix Table B-2) and it was further found that the variables are not cointegrated. This means that there is no long run relationship between the vari2ables.

4.3 Estimation of the Exchange Rate Overshooting model

4.3.1 Lag Selection

The initial regression involves estimating an overparametized (general) model to choose the appropriate number of lags to use in the final estimation (specific model). Initially unrestricted model of the equation (3.21) with three lags of each variable of the model was estimated and compared with restricted model of zero lags. The choice of the preferred model to be estimated proceeded with the elimination of those lags of each variable that seemed to be not significant. The overparametized model was reduced to specific model by comparing the critical F-ratios with the computed F ratios. The null hypothesis was rejected in the cases where the computed F-ratio was greater than the critical F-ratio and thus choosing the unrestricted model. After several procedures, a model with one lag was then selected for use in the estimation.

4.3.2 Estimation Results

The model selected from 4.3.1, that is the model with one lag, was estimated and results are reported in the Appendix Table C-1. It was found that there is high correlation between current account balance and income and income and interest rates. It was therefore necessary to drop income from the model. But given its importance in the analysis, interest rates and current account balance were dropped instead. Results of the estimation without both interest rates and current account balances are presented in the Appendix C-2. Elimination of variables that were least significant continued until the preferred model was reached. Three lags of both money supply and prices were added to capture both exchange rate overshooting and sticky prices respectively. The preferred model results that was estimated are reported in Table 4.1 below:

Table 4.1 Estimation Results for the Overshooting model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013491	0.009662	1.396327	0.1754
DM	8.42E-07	4.78E-07	1.761465	0.0909
DM1	1.73E-06	6.94E-07	2.496572	0.0198
DM2	-1.57E-06	6.37E-07	-2.461782	0.0214
DP1	-8.47E-05	3.43E-05	-2.472743	0.0209
DP2	3.28E-05	2.06E-05	1.592957	0.1243
DY	-6.14E-07	3.10E-07	-1.979459	0.0593
DY1	5.61E-07	4.85E-07	1.157827	0.2583
INF1	1.153459	0.835004	1.381381	0.1799
R-squared	0.576631	Mean dependent var		0.010854
Adjusted R-squared	0.435508	S.D. dependent var		0.032642
S.E. of regression	0.024525	Akaike info criterion		-4.351240
Sum squared resid	0.014436	Schwarz criterion		-3.943102
Log likelihood	80.79547	F-statistic		4.086012
Durbin-Watson stat	1.844787	Prob(F-statistic)		0.003437

Where:

DP – Change in prices
DY- Change in income
INF- net capital inflows
DM- Change in money supply

The coefficients of the overshooting model in Table 4.1 represents the short run dynamics of the model. The theoretical expectation was that the coefficient of money supply was supposed to be negative. The coefficient however is positive on impact upto to the second lag. It turns negative in the second period. This implies that exchange rates overshoot following a monetary policy contraction and stays overshot for two quarters (eight months) when it starts to trace back its long run path. The price coefficient is negative in the first quarter, which is contrary to the theoretical expectations since it was expected to be positive. The coefficient turns positive in the second quarter. It is worth noting that the coefficient is positive on impact (Table C-2 in the Appendix) with a coefficient of 0.0000615. This implies that prices do not respond significantly on impact but only react after the first quarter. This supports the price stickiness hypothesis, implying that prices are sticky in the short run in Kenya.

In conclusion, this section set out to establish for empirical evidence of exchange rate overshooting in the short run and in the long run in Kenya. The results give support to exchange rate overshooting in the short-run but no empirical investigation was done to establish for the evidence for exchange rate overshooting in the long run since the data series was found not to be cointegrated. Having established that exchange rate overshoot in the short-run, the next policy concern would be that is exchange rate overshooting relevant in Kenya after all? That is, is exchange rate transmitted to the other economic activities and how is it transmitted? This analysis forms the basis of the next section.

4.4 Estimation of the Transmission Mechanism Model

4.4.1 Lag Selection

Before estimating the model, a decision has to be reached as regards to the number of lags to include in estimating the VAR model specified in equation (3.25a-e). This study uses the lag selection criteria namely: the Schwartz information criteria (SC) and the Akaike Information Criteria (AIC). These information criteria provide a measure of information that strikes a balance between a measure of goodness of fit and the parsimonious specification of the model. The results of these selection criteria are reported in Table 4.3. The decision rule is to choose the model with the lowest value of the information criteria. This ensures that the error term is not mispecified (Enders 1995).

Table 4.2 Results of the VAR Lag Selection at first difference

Lag Length	SC	AIC
4	6.1139	3.4280
3	5.3027	3.2685
2	4.860	3.4698
1	4.68	3.9300

The results of the AIC lag selection in Table 4.2 above points to the use of 3 lags as the most appropriate lag length that would minimize the value of the selection criteria. On the other hand the SC suggests the use of one lag. Since the two criteria gave different results, the AIC results will be chosen since the use of only one lag is believed not to be able to capture the transmission dynamics of the model.

4.4.2 VAR (5) Estimation

The VAR (5) estimation results are presented in Appendix D. One important result from the VAR (5) estimation is that the present values of domestic prices (Δp_t) are significantly affected by the past changes in exchange rates (Δe_t) with a four-month lag. Also, the present price levels (Δp_t) react to the changes in the past values of money supply (Δm_t) significantly with a two-month lag. This delayed response of price changes in as money supply and exchange rates change gives evidence that domestic prices in Kenya are sticky in the short run. That is the change money supply and exchange rates are not proportional to price changes in the short run. This means that the change in prices due to changes in exchange rates and money supply is not instantaneous but is sticky in the short run. With this evidence for sticky prices and instantaneous adjustment of exchange rates and money stock levels, the result is the overshooting of exchange rates. These findings are consistent with the assumptions of the Dornbusch (1976) overshooting Model used in this study that prices are sticky in the short run but flexible in the long run.

The major findings in this section have been that, exchange rates overshoot in the short run. Its also established that exchange rate adjust instantaneously to monetary policy shocks while prices are sticky in the short run but flexible in the long run. To simulate the dynamics of these findings in the economy, impulse analysis is used.

4.5 Impulse Response Analysis Results

As discussed in Section 3.4.3, impulse response analysis traces the effects of a one standard deviation shock to the innovation on current and future values of all the endogenous variables of the system. A shock to the j^{th} variable affects directly the same variable and is also transmitted to all the other endogenous variables in the system through the dynamic structure of the VAR.

One challenging issue when generating the impulse responses is the ordering of variables in the VAR. The ordering is important in that the assumption in generating the responses is that the innovations (error terms) in the endogenous variables are all uncorrelated. One of the disadvantages of this assumption is that changing the ordering of the equations may dramatically change the impulse responses. Unfortunately, there in no economic theory on the appropriate ordering of the variables in general. The ordering used in this paper is based on the schematic relationship presented in equation (3.17) in Chapter 3. This order is also consistent with the variance decomposition analysis postulation that the variation to own shocks are more pronounced in the initial periods of the shock and the influence reduces with the lags as the percentage variation of the other variables of the model increase. The impulse response of each variable to a one standard deviation positive shock was generated over a twenty-four-month period with the ordering as: M R E P NX. Figure (4.3) below shows the plots of the impulse response:

The plots and the impulse response summarize the results of the shock evaluation, indicating the responses of each variable over the twenty-four-month horizon to an initial one standard deviation positive shock to each of the five VAR variables. The graphs of impulse responses clearly indicate the effectiveness of the exchange rate channel in the transmission of monetary policy effects in the economy. The results also support the earlier findings in section 4.3 on the evidence for exchange rate overshooting in the first two quarters of the shock.

The graph of the response of exchange rates to money supply changes in Figure 4.3 (a) column 1 row 2 gives evidence for exchange rate overshooting in the short run. The graph shows that the impact of a monetary policy contraction on exchange rates is instantaneous. The instantaneous impact of a one standard deviation shock of money supply on exchange rates is negative, implying that the nominal value of the exchange rate reduces on impact from a monetary contraction. That is less of the Kenya shilling will now be needed to buy one unit cf the US dollar, which is an appreciation of the exchange rates. The exchange rate appreciates for four months reaching a peak then the change turns positive.

Figure 4.3 Impulse Responses

Figure 4.3 (a): Response to One S.D. Innovations to M3 .

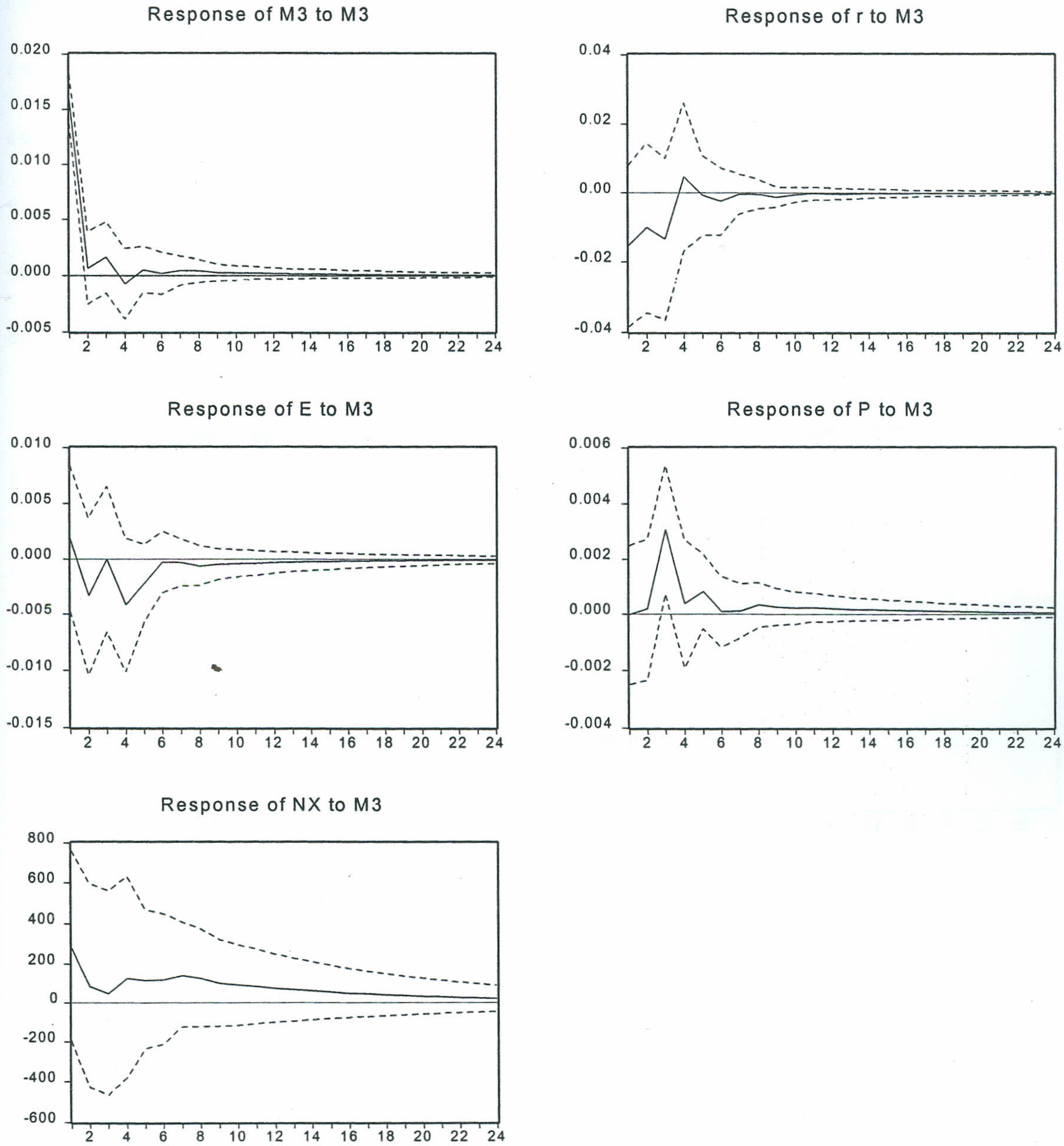


Figure 4.3 (b): Response to One S.D. Innovations to r

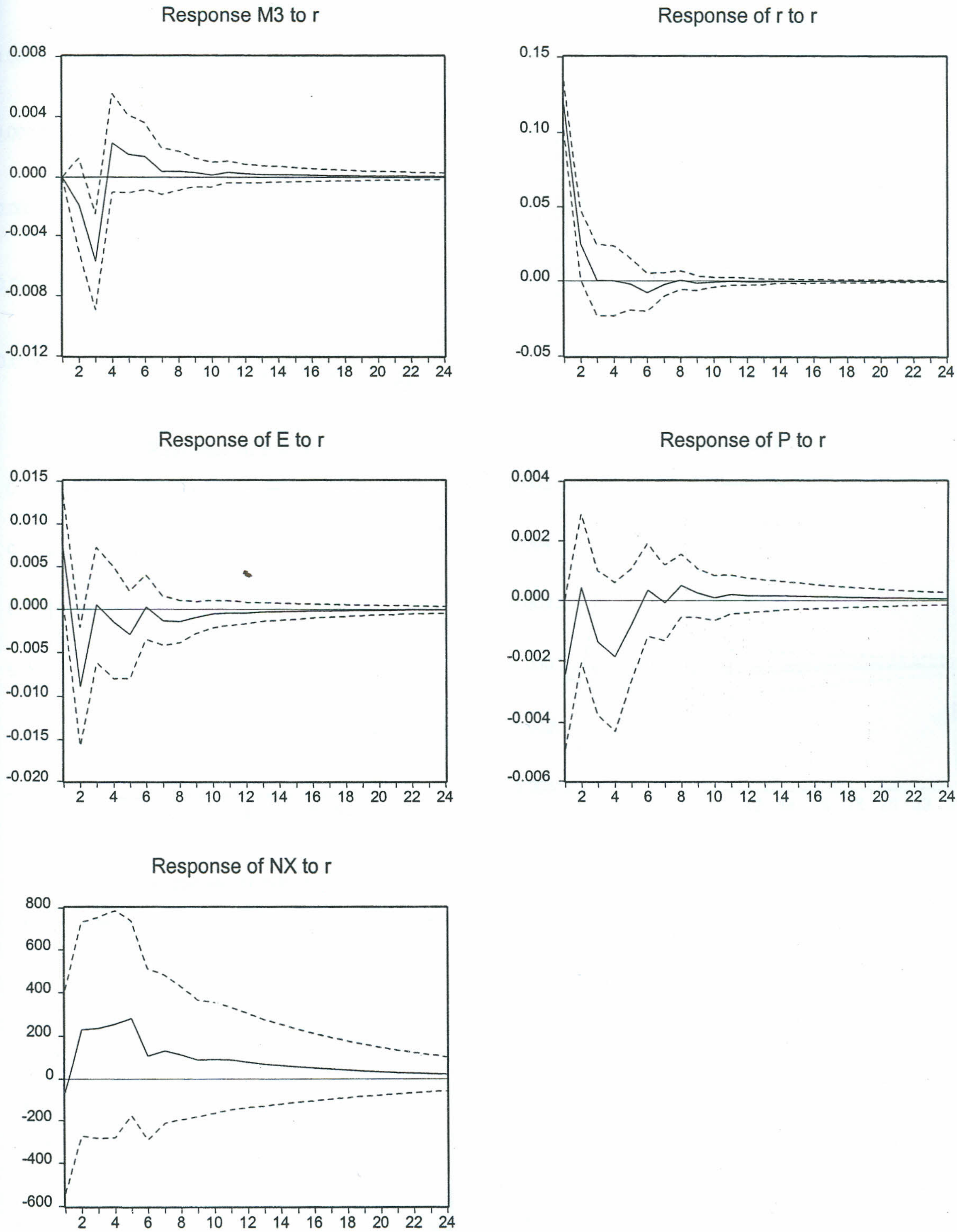
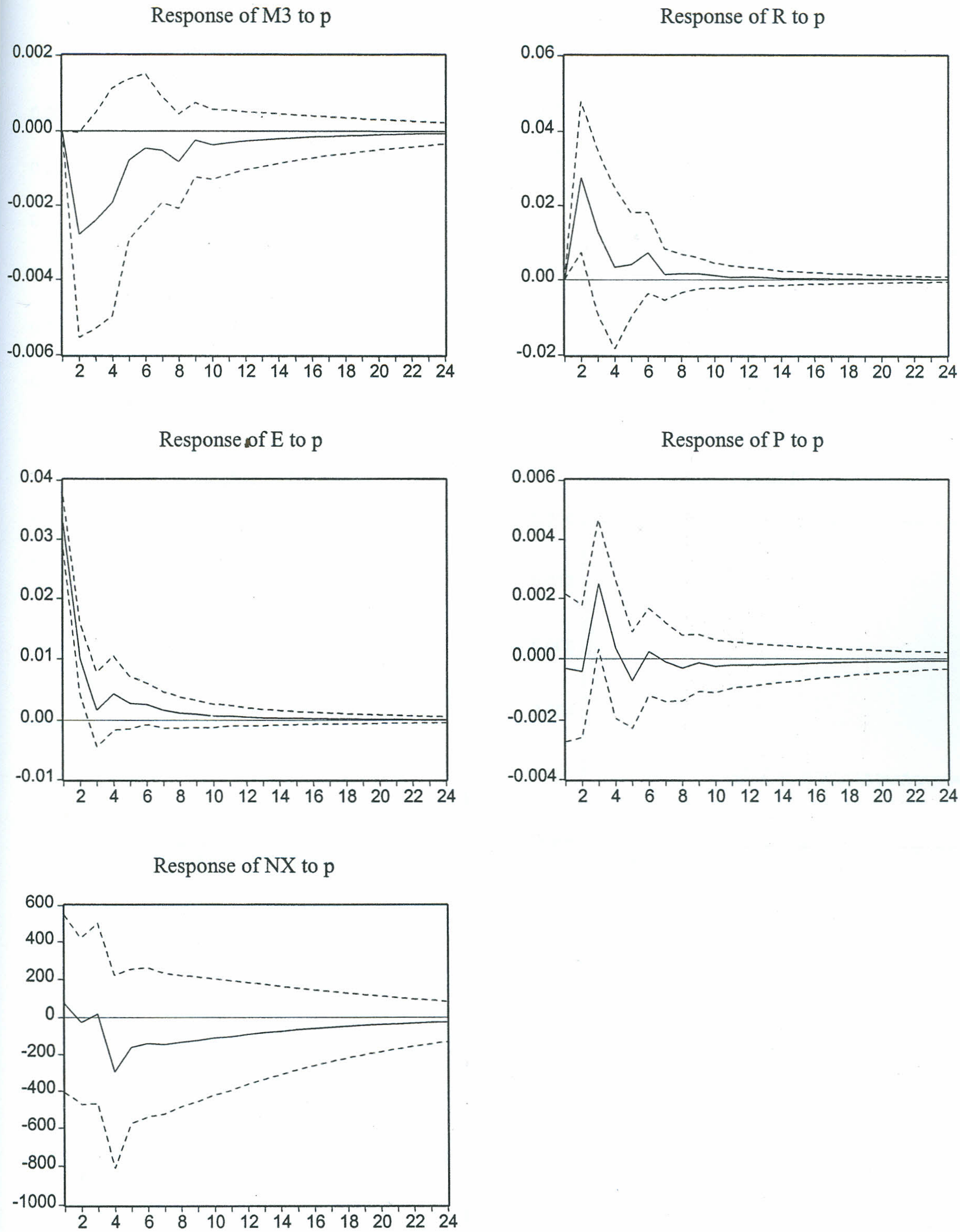


Figure 4.3 (c): Response to One S.D. Innovations to p



. **Figure 4.3 (d): Response to One S.D. Innovations to r**

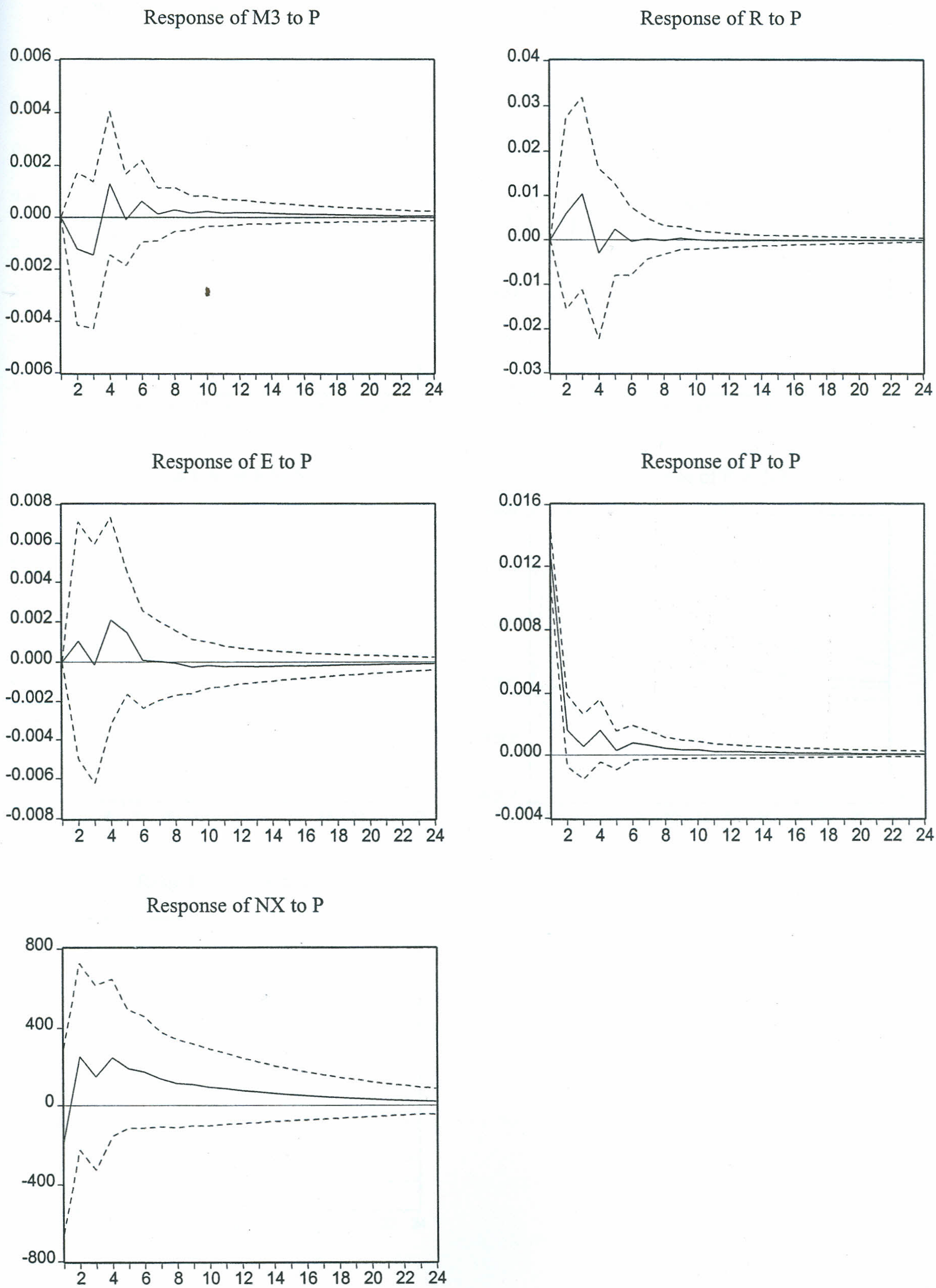
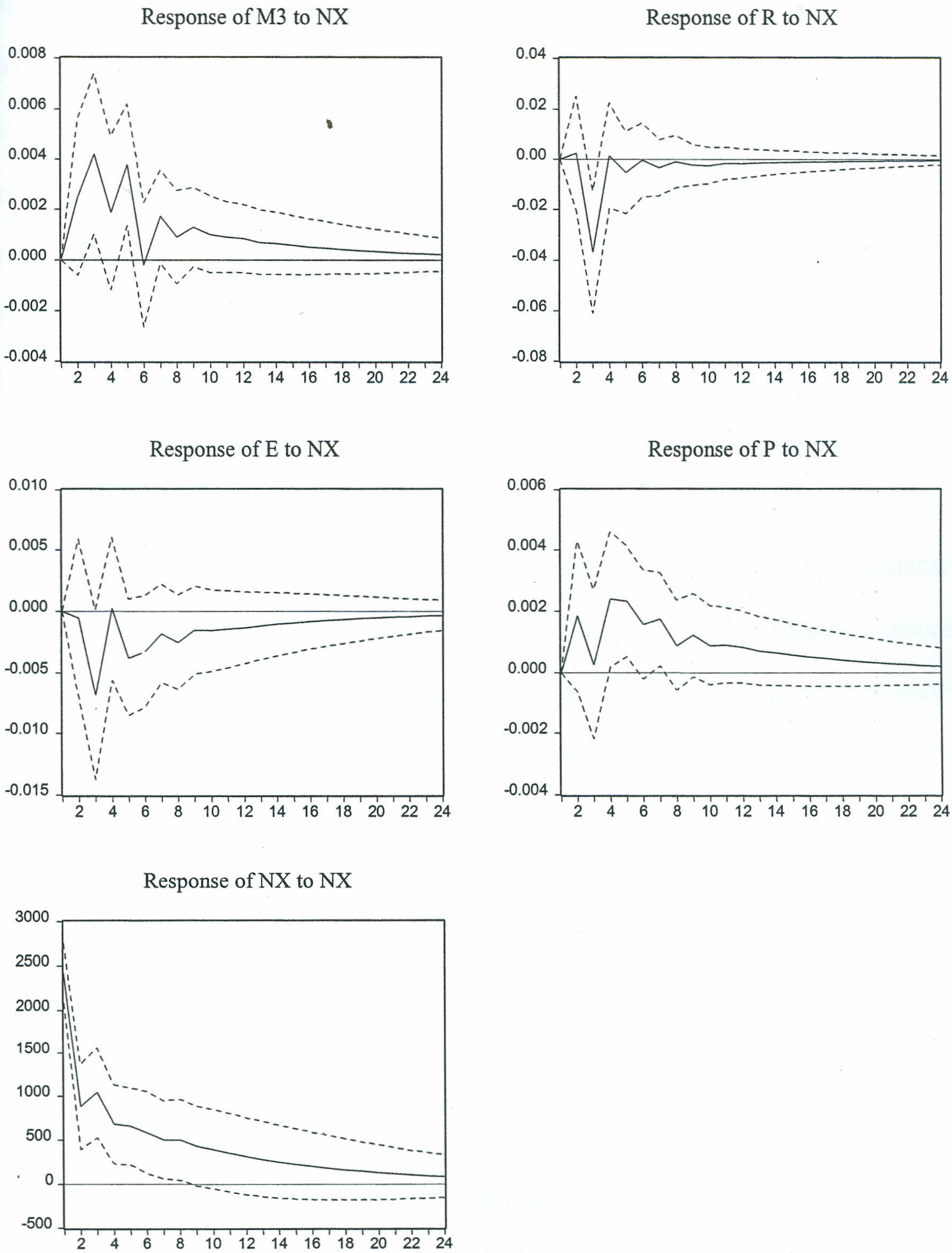


Figure 4.3 (e): Response to One S.D. Innovations to NX



The positive sign by analogy of the discussion of appreciation above, is a depreciation of the exchange rates. The exchange rates as can be seen from the graphs appreciate from the third month onwards converging towards the long run equilibrium path. These results are consistent with the findings of existence of overshooting in the short run from the error correction model results in section 4.2.4 with the first two coefficients of the lagged money supply being negative. The graph also shows the convergence of the short run exchange rate path towards the long run path supporting exchange rate overshooting in the long run. From the graph, the exchange rates converge back to its initial equilibrium path after eight months.

The response of interest rates to money changes in the graph in column 1 row 1 apart from being consistent with the exchange rate channel of the monetary policy transmission mechanism is consistent with economic theory that a contractionary monetary policy increases domestic interest rates. Money supply contraction reduces Treasury bill rates on impact. This effect is felt for the next two months apparently coinciding with the period when exchange rates overshoot. The interest rates start to converge back to its long run equilibrium path after three months again coinciding with the peak of exchange rate overshooting. This shows that the interest rate variable in the channel is an effective path through which exchange rate overshooting is transmitted in the economy in Kenya.

The graph that shows the impulse response of prices to a monetary policy change in Figure 4.3 (a) column 2 row 2 supports the sticky price assumption of the exchange rate overshooting hypothesis. The price levels remain constant for a period of two months given a monetary policy disturbance. They don't move instantaneously. Prices only react to monetary changes from the second month, which shows the relevance of price levels in this channel in transmitting monetary policy effects in the economy. Price levels remain above equilibrium for one month then starts to decline towards the initial long run path. It converges back to its long run path after twelve months. This supports the earlier findings that prices are flexible in the long run.

The flexibility of prices, exchange rates and money supply in the long run, supports one of the major assumptions of this study that in Kenya money is neutral in the long run. That is a change in monetary policy will in the long run result to no changes in the initial levels of exchange rates, money stock and the price levels. In other words the changes are proportionate in the long run.

The impulse response analysis shows that the exchange rate channel of monetary policy transmission mechanism is effective in Kenya. These findings point to very vital policy concerns. The Central Bank of Kenya doesn't recognize the exchange rate channel in the transmission of monetary policy as important. The only channel that the bank seems to recognize is the credit channel whose importance in Kenya some studies have doubted (see Sichei et al (Forthcoming) and Geda et al. (Forthcoming)). This would imply that the Central Bank's reaction function might have been formulated using irrelevant weights of monetary variables. Factoring of exchange creates into the CBK's reaction function will in this case improve the effectiveness of monetary policy in Kenya.

4.3.6 Variance Decomposition Analysis (VDA)

It is plausible thus far to conclude that evidence has been found for exchange rate overshooting in Kenya and that the channel through which it is transmitted to the other economic variables is effective. A further step of establishing what percentage of the variation in a series is due to its own shocks and which percentage is due to shocks of the other model variables at a given time is necessary. This is done by the variance decomposition analysis (VDA). VDA determines the proportion of a variance in a series that is due to its own shock, the other variable shocks and other identified institutional shocks. In the VDA analysis in this paper, the variations in the other variables in the exchange rate channel brought about by the changes in monetary policy are analyzed. The plots of variance decomposition are shown in Figure 4.6 below.

Figure 4.6 (a) shows that all variations in money supply are due to own shocks at 100% in the first month. The variation of own shocks in money supply reduces to 94% in the second month and even lower as the forecast horizon increases. It is noted that the variations in the money supply shock in the first period brought about by the other variables is zero implying that, on impact the variation money supply are totally own shocks. However the effects of these other variables in the system increase with the increase in the lag horizon. This means that monetary changes have feedback effects in this channel and are multidirectional.

VDA graphs above add support to the effectiveness of the exchange rate channel of the monetary policy transmission mechanism. The Figure showing the decomposition of exchange rate (Figure 4.6-c) shows that the variations in exchange rates are dominated by all the other model variables. This means that interest rate, prices, money supply and net exports all contribute significantly to the variations in the exchange rate levels. Prices, interest rates and net exports also contribute significantly to the variations in money supply (Figure 4.6-a) This shows evidence for the multidirectional transmission of monetary policy effects in the exchange rate channel, which provides further support for its effectiveness.

Figure 4.6 Variance Decomposition Graph

Figure 4.6 (a): Variance Decomposition due to Money supply shocks

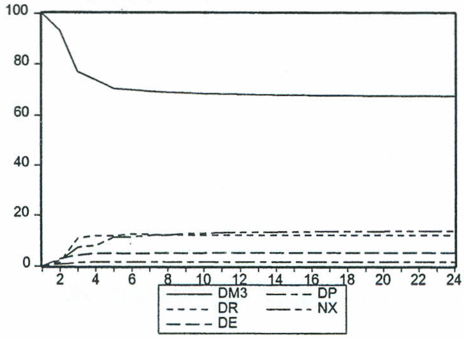


Figure 4.6 (b): Variance Decomposition due to interets rate shocks

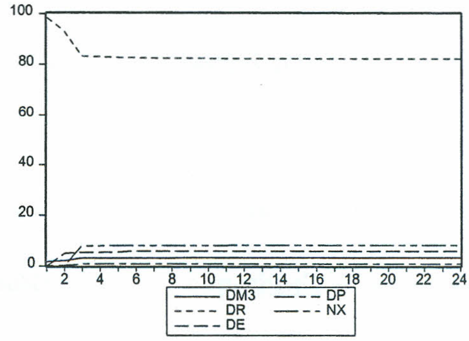


Figure 4.6 (c): Variance Decomposition due to exchange rate shocks

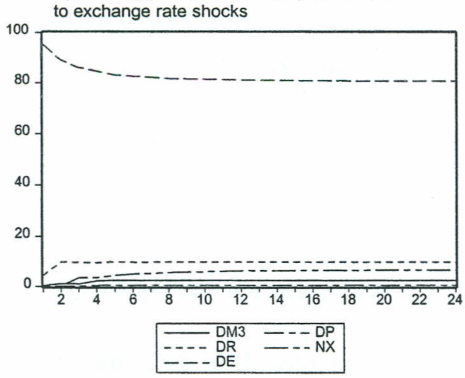


Figure 4.6 (c): Variance Decomposition due to price shocks

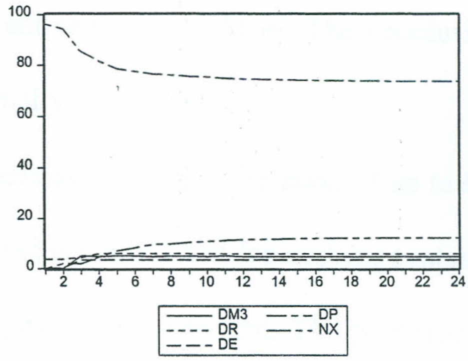
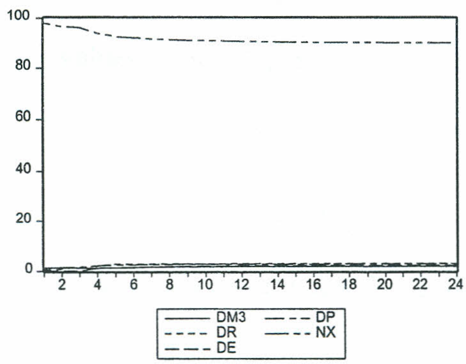


Figure (d) : Variance Decomposition due to net export shocks



In summary, the variance decomposition analysis of the innovations in the system provide further support for the effectiveness of the channel implying that a monetary policy contraction leads to reduced aggregate output.

4.4 Diagnostic tests

The Jarque-Bera normality test, the Whites heteroskedasticity test, and the Langrage-multiplier (LM) serial correlation tests were performed on the error correction model (ECM) equation (3.21). The diagnostic test results are shown in Appendix D: From the probability values presented from the tests, the null hypothesis of the Jarque-Bera test that the residuals of the series are normally distributed is rejected except for money supply, which is not rejected at one per cent significance level. The conclusion here is that residuals from all the series are not normally distributed.

The LM tests indicate that the null hypothesis of no serial correlation of up to the third lag is rejected for price levels and net exports but is not rejected for exchange rates at one per cent and both interest rates and money supply at five per cent. The presence of serial correlation was expected given the high correlation between the variables and their lagged values. The null hypothesis of the Whites test of no heteroskedasticity is only rejected for the exchange rate variable. This implies that the errors are not homoskedastic and are dependent on the regressors. These results show that regression results using the least square methods are invalid and should not be used for inference. The use of stationary data in the error correction model estimated in this study sorted some of these problems particularly that of serial correlation.

4.5 Concluding Remarks

This chapter presented the results of this study. The results from the short-run overshooting model showed that exchange rates overshoot in Kenya in the short-run. Due to lack of cointegration among the model variables, it was not possible to analyze the long run dynamics of the overshooting model using the error correction model. However, the results from the impulse response analysis show a convergence path of the exchange rates (after a monetary policy change) towards the long run path. The path converges after eight months implying that exchange rates do not overshoot in the long run in Kenya.

CHAPTER FIVE

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

5.0 Summary and Conclusions

This study was motivated by the fact that there seemed to exist a relationship between exchange rate overshooting and reduced output through restrictive monetary policy. Exchange rate overshooting in a floating exchange rate regime is transmitted in the economy through the exchange rate channel of the monetary policy transmission mechanisms.

Kenya having floated the exchange rate in 1993 operates under the floating exchange rate regime. With the floating exchange rate regime, it was suspected, the exchange rate channel of monetary policy transmission mechanism is effective in Kenya. If exchange rates overshoot, and this channel is effective in Kenya, then both would impact negatively on aggregate incomes.

This paper therefore set out to establish how the effects of exchange rate overshooting are transmitted into the macroeconomic variables in Kenya. Before this analysis was done it was worth establishing whether there is any empirical evidence to prove that exchange rates actually overshoot in Kenya before its effects in the economy can be traced.

This paper therefore estimated two models. The first one aims at establishing for the evidence of exchange rate overshooting in Kenya under the floating exchange rate regime using quarterly data from 1993:1 to 2001:4. The second model tries to trace the transmission of exchange rate overshooting to the other macroeconomic variables in the system using monthly data from January 1993 to December 2001.

To establish the evidence of exchange rate overshooting, the short run equation was estimated using the ordinary least squares (OLS) method after making the variables stationary. The ECM was not used due to the non-existence of cointegration in the overshooting variables. It was therefore only possible to estimate the short run equations but not the long run equations.

The second part of the analysis was concerned with tracing the transmission of exchange rate overshooting in the economy. To do this, vector autoregression (VAR) analysis was used. The justification for the use of VAR analysis is that it is possible to simulate the response over time of an own disturbance of a variable and also the disturbance on the other variables in a system of equations.

The results of the short run overshooting equation show evidence for exchange rate overshooting in Kenya in the short run. The lags of money supply in the preferred model are positive up to the second quarter. This means that exchange rates overshoot on impact and reaches the overshooting peak at the end of the second quarter then starts to trace back its long run path. The short run path and the long run path converge after eight months (second quarter). This analysis rejects the first null hypothesis of this study that exchange rates do not overshoot in Kenya.

Having established that exchange rates overshoot in Kenya in the short run, the study proceeded to trace its transmission into the economic system. A VAR (5) model with three lags (p=3) was estimated and the results analyzed using impulse response analysis and variance decomposition analysis. The results from impulse response analysis show that exchange rate channel of monetary policy transmission mechanism is effective in Kenya and the tightening of monetary policy though this channel reduces aggregate output. This result addresses the third objective of this study and leads to the rejection of the third null hypothesis of this study that exchange rate overshooting has no effects on aggregate output levels.

It is found that prices are sticky in the short run and flexible in the long run while exchange rates and money supply adjustments from a monetary policy change are instantaneous. This leads to exchange rate overshooting its long run path in the short run. These results address the second objective of this study. Therefore sticky prices and money supply are the major causes of exchange rate overshooting in Kenya. Exchange rates, money supply and prices however all adjust from the short run disequilibrium towards the long run path. They are in other words, flexible in the long run. This supports one of the major assumptions of this study that money is neutral in the long run. That is, a change in monetary policy will leave the initial paths of exchange rate, money supply and the price levels unchanged in the long run. From the analysis a monetary policy change is neutralized after eight months. This gives evidence to the fact that exchange rates do not overstay their long run path but will converge back to the long run path after eight months. Therefore exchange rates do not overshoot in Kenya in the long run.

Variance decomposition analysis further provides support for the effectiveness of the exchange rate channel of the monetary policy transmission mechanism. It is found out that interest rates, price levels, money supply and net export which are the variables of the exchange rate channel, contribute significantly to the variations in the exchange rates. The multidirectional influences of the variables in this channel further point to the effectiveness of this channel. It is realized that even though the initial shocks come from money supply, the own variation in money supply is only felt in the first month at 100%.

This reduces to 94% in the second month and even lower as the forecasting horizon is extended. Extending the forecast period from one-month horizon onwards introduces feedback effects on the variations of money supply changes.

5.2 Policy Recommendations

This study found that the exchange rate channel of the monetary policy transmission mechanism is effective in Kenya, it is important to point out policy issues that accompany it. First the government does not recognize the effectiveness of this channel in the transmission of monetary policy effects. In CBK (2000(b)) p. 65, when the bank explains how its policies are transmitted in the economy and what magnitude of importance should be given to the monetary policy variables when formulating monetary policy, no mention is made of the exchange rate channel. A lot of importance is given to the interest rates in the credit channel. Other studies on the monetary policy transmission mechanisms in Kenya have doubted the effectiveness of this channel arguing that private investments are not driven by the interest rates (see for instance Sichei, 2002). Therefore manipulating interest rates may not have significant effects on aggregate output.

This therefore may call for the inclusion of exchange rates in the government's monetary policy formulation, and formulating a reaction function that is consistent with the relative importance of macroeconomic variables. This may be done by constructing a monetary policy conditions index (MCI). The MCI can be constructed by looking at the relative importance of the monetary variables like the term structure of the interest rates, the domestic debt and the exchange rates in influencing aggregate incomes. This will be a recognition of the fact that, having taken the step to float exchange rates, exchange rate overshooting cannot be avoided and the only way to absorb its effects is by including the exchange rates in the monetary policy formulation framework. On the other hand in the absence of an MCI, an expansionary rather than a contractionary monetary policy is desirable, as it would improve aggregate incomes rather than reduce it when exchange rates overshoot.

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APPENDICES

Appendix A- Unit root tests

Table A-1: ADF Unit Root tests of the overshooting data at levels

Variable	Lags	Intercept only	Critical value-5%	Intercept and trend	Critical value-1%	Results
Exchange Rates	0 2 4	-2.1452 -1.9803 -1.4536	-2.888 -2.889 -2.888	-2.3928 -2.6717 -2.5643	-3.4519 -3.4527 -3.4535	Non-stationary
Price differential	0 2 4	-0765 -0.5440 -1.252	-2.888 -2.888 -2.888	-1.6782 1.7402 -1.3467	-3.4535 -3.4527 -3.4519	Non-stationary
Money Supply differential	0 2 4	-1.7656 -2.2547 -3.2339	-2.9472 -2.9527 -2.9591	-1.3459 -1.2349 -2.3452	-3.5426 -3.5514 -3.5614	Non-stationary
Interest Rates differential	0 2 4	-1.1231 -2.2352 -3.6543	-2.8884 -2.889 -2.8895	-1.2454 -2.2341 -2.6573	-3.4519 -3.4527 -3.4535	Non-stationary
Capital inflows	0 2 4	-5.5315 -4.0892 -1.7050	-2.9472 -2.9527 -2.9591	-6.2037 -4.9014 -2.4126	-3.5426 -3.5514 -3.5614	Stationary
GDP	0 2 4	-1.4108 -3.1008 -2.6581	-2.9472 -2.9527 -2.9591	-2.0559 -3.2928 -2.5150	-3.5429 -3.5514 -3.5614	Non-stationary
Current account balance	0 2 4	-7.3634 -6.1515 -7.9173	-2.888 -2.888 -2.5809	-7.9641 -7.4175	-3.4519 -3.4527 -3.4535	Stationary
Interest differential	0 2 4	-1.3764 -4.953 -0.4928	-2.9472 -2.9527 -2.9591	-2.2483 -3.4051 -2.6254	-3.5426 -3.5514 -3.5614	Non-stationary
Price differential	0 2 4	-3.2392 -2.2244 -6.5589	-2.9472 -2.9527 -2.9591	-3.2034 -2.3626 -2.4645	-3.5426 -3.5514 -3.5562	Non-stationary

Table A-2: ADF Unit Root tests of the Transmission data at levels

Variable	Lags	Intercept only	Critical value-5%	Intercept and trend	Critical value-1%	Results
Exchange Rates	0 2 4	-2.1722 -1.7503	-2.888 -2.889	-2.3928 -2.6717	-3.4519 -3.4527 -3.4535	Non-stationary
Prices	0 2 4	-0.983 -0.990 -1.252	-2.888 -2.888 -2.888	-1.8282 1.7402 -1.6957	-3.4535 -3.4527 -3.4519	Non-stationary
Money Supply	0 2 4	-1.4256 -2.4347 -3.2339	-2.9472 -2.9527 -2.9591	-1.9229 -1.6129 -2.4162	-3.5426 -3.5514 -3.5614	Non-stationary
Interest Rates	0 2 4	-1.0651 -2.0952 -3.0863	-2.8884 -2.889 -2.8895	-1.1034 -2.0501 -2.8763	-3.4519 -3.4527 -3.4535	Non-stationary
Net exports	0 2 4	-4.9084 -2.9906 -2.4685	-2.8884 -2.888 -2.888	-7.8410 -5.0827 -4.2379	-3.4519 -.3.4527 -3.4535	Stationary

Appendix B: Cointegration Tests

Table B: 1 Cointegration test for the overshooting data (Unit root test of the Residuals)

Test	Lags	Intercept only	Critical value-5%	Intercept and trend	Critical value-1%	Results
Phillip-Perron	0	-3.9798	-4.71	-3.932	-4.42	Non-Stationary
	2	-3.966	-4.71	-3.901	-4.42	
	3	-4.004	-4.71	-3.932	-4.42	
ADF	0	-3.979	-4.71	-3.932	-4.42	Non-Stationary
	2	-2.602	-4.71	-2.632	-4.42	
	3	-2.714	-4.71	-2.705	-4.42	

Table B: 2 Cointegration test for the Transmission data

Test	Lags	Intercept only	Critical value-5%	Intercept and trend	Critical value-1%	Results
Phillip-Perron	0	-3.9798	-4.71	-3.932	-4.42	Non-Stationary
	2	-3.966	-4.71	-3.901	-4.42	
	3	-4.004	-4.71	-3.932	-4.42	
ADF	0	-3.979	-4.71	-3.932	-4.42	Non-Stationary
	2	-2.602	-4.71	-2.632	-4.42	
	3	-2.714	-4.71	-2.705	-4.42	

Note: Asymptotic Critical values are from Davidson and Mackinon (1993)

Figure B: 1 Residuals of the overshooting data

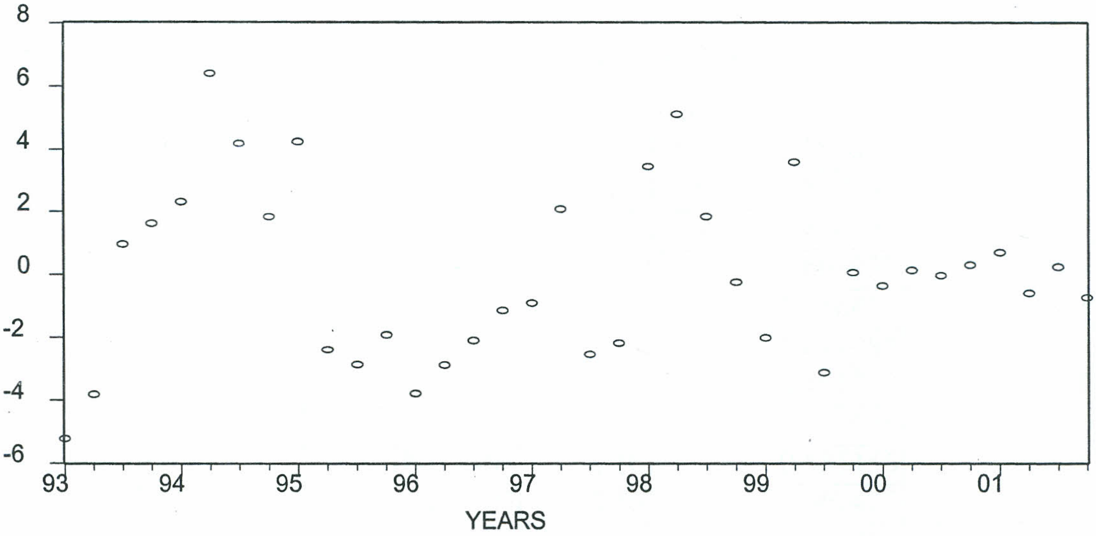
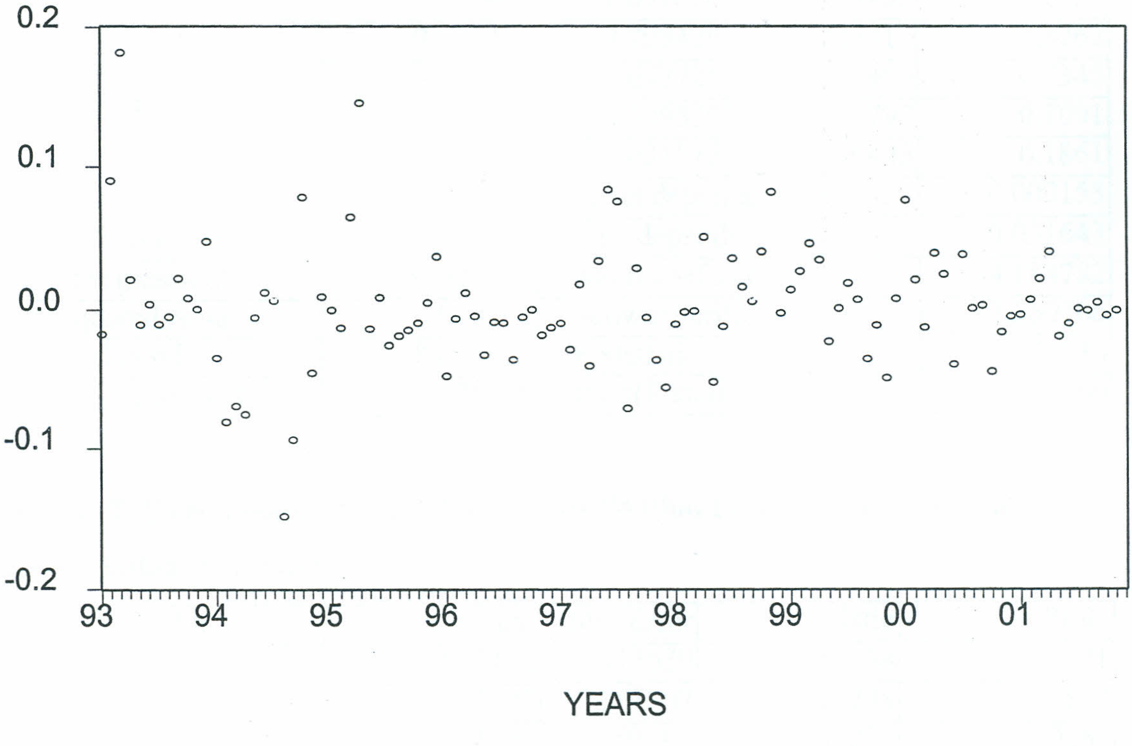


Figure B: 2 Residuals of the Transmission data



Appendix C - Overshooting Estimation Results

Table C-1: Overshooting Estimation Results (At one lag)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006479	0.034552	0.187502	0.8540
DE1	0.137443	0.254125	0.540849	0.5971
DM	5.60E-07	1.03E-06	0.544598	0.5946
DM1	6.45E-07	1.06E-06	0.608937	0.5523
DM2	-1.52E-06	1.12E-06	-1.358817	0.1957
DM3	9.65E-07	9.27E-07	1.041488	0.3153
DP	3.00E-05	6.49E-05	0.461718	0.6514
DP1	-7.25E-05	4.74E-05	-1.530639	0.1481
DP2	2.45E-05	4.18E-05	0.585156	0.5678
DP3	-3.44E-05	3.56E-05	-0.967429	0.3497
DY	-8.83E-07	8.60E-07	-1.027256	0.3217
DY1	9.96E-07	7.05E-07	1.411713	0.1799
INF	-0.397852	1.133057	-0.351132	0.7307
INF1	1.838418	1.657070	1.109439	0.2859
CAB	0.177951	0.795429	0.223717	0.8262
CAB1	-0.222360	0.642721	-0.345966	0.7345
DR	0.011256	0.029559	0.380797	0.7091
DR1	-0.043122	0.031013	-1.390443	0.1861
R-squared	0.701627	Mean dependent var		0.009153
Adjusted R-squared	0.339317	S.D. dependent var		0.031643
S.E. of regression	0.025720	Akaike info criterion		-4.184782
Sum squared resid	0.009261	Schwarz criterion		-3.360306
Log likelihood	84.95651	F-statistic		1.936536
Durbin-Watson stat	2.425676	Prob(F-statistic)		0.108686

Table C-2: Overshooting Estimation Results (Without interest rates and current account balance variables).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.015402	0.015639	0.984834	0.3371
DM	-1.33E-07	9.26E-07	-0.143798	0.8872
DM1	2.03E-06	7.69E-07	2.638206	0.0162
DM2	-1.55E-06	7.59E-07	-2.046540	0.0548
DM3	4.62E-07	8.11E-07	0.570315	0.5751
DP	6.15E-05	4.89E-05	1.257306	0.2239
DP1	-0.000101	3.86E-05	-2.613956	0.0171
DP2	3.17E-05	2.50E-05	1.268391	0.2200
DP3	-1.95E-05	2.69E-05	-0.723062	0.4784
DY	-1.20E-06	5.50E-07	-2.175161	0.0425

DY1	7.67E-07	5.39E-07	1.424336	0.1706
INF	-1.159086	0.973269	-1.190920	0.2484
INF1	1.992634	1.202880	1.656552	0.1140
R-squared	0.614241	Mean dependent var		0.009153
Adjusted R-squared	0.370604	S.D. dependent var		0.031643
S.E. of regression	0.025104	Akaike info criterion		-4.240414
Sum squared resid	0.011974	Schwarz criterion		-3.644959
Log likelihood	80.84663	F-statistic		2.521129
Durbin-Watson stat	2.028510	Prob(F-statistic)		0.034784

Appendix D: VAR (5) Estimation Results

Table D: VAR (5) Estimation Results

Equation	(4.3)	(4.4)	(4.5)	(4.6)	(4.7)
	DE	DR	DP	DM3	NX
DE(-1)	0.308147	0.844932	-0.013164	-0.088372	-1333.076
	(0.09352)	(0.33148)	(0.03543)	(0.04450)	(6824.19)
	(3.29497)	(2.54897)	(-0.37161)	(-2.98587)	(-0.19535)
DE(-2)	0.010908	-0.016838	0.077099	-0.038842	-1194.630
	(0.09929)	(0.35193)	(0.03761)	(0.04725)	(7245.29)
	(0.10985)	(-0.04784)	(2.04989)	(-0.82210)	(-0.16488)
DE(-3)	0.094282	-0.152724	0.005800	0.016697	-12342.18
	(0.09808)	(0.34765)	(0.03715)	(0.04667)	(7157.00)
	(0.96126)	(-0.43931)	(0.15612)	(2.35777)	(-1.72449)
DR(-1)	-0.092610	0.170121	0.007661	-0.011911	2748.172
	(0.03097)	(0.10976)	(0.01173)	(0.01474)	(2259.74)
	(-2.99050)	(1.54987)	(0.65307)	(-0.80829)	(1.21615)
DR(-2)	0.038462	0.017661	-0.020902	-0.052978	858.9007
	(0.02892)	(0.10250)	(0.01095)	(0.01376)	(2110.17)
	(1.33001)	(0.17230)	(-1.90815)	(-3.85003)	(0.40703)
DR(-3)	-0.028725	0.005179	0.001097	0.024541	1848.029
	(0.03035)	(0.10759)	(0.01150)	(0.01444)	(2214.91)
	(-0.94633)	(0.04814)	(0.09539)	(1.69911)	(0.83436)
DP(-1)	0.080453	0.485721	0.137190	-0.083372	25392.91
	(0.26712)	(0.94678)	(0.10118)	(0.12710)	(19491.4)
	(0.30119)	(0.51302)	(1.35587)	(-0.65594)	(1.30277)
DP(-2)	-0.065303	0.310597	0.004595	-0.091893	4243.557
	(0.24897)	(0.88246)	(0.09431)	(0.11847)	(18167.2)
	(-0.26229)	(0.35197)	(0.04872)	(-2.77567)	(0.23358)
DP(-3)	0.265915	-0.070697	0.142119	0.111353	6488.184
	(0.22807)	(0.80839)	(0.08639)	(0.10853)	(16642.4)
	(1.16593)	(-0.08745)	(1.64503)	(2.02605)	(0.38986)
DM3(-1)	-0.328512	-0.582001	0.006902	0.022224	1551.601
	(0.22703)	(0.80469)	(0.08600)	(0.10803)	(16566.1)

	(-1.44702)	(-0.72326)	(0.08025)	(0.20572)	(0.09366)
DM3(-2)	0.094231	-0.256217	0.164194	0.000854	-1772.012
	(0.19591)	(0.69441)	(0.07421)	(0.09322)	(14295.8)
	(0.48098)	(-0.36897)	(2.21252)	(0.00916)	(-0.12395)
DM3(-3)	-0.338088	0.307357	-0.012947	-0.061403	5204.466
	(0.19277)	(0.68326)	(0.07302)	(0.09173)	(14066.3)
	(-1.75385)	(0.44984)	(-0.17731)	(-0.66941)	(0.36999)
NX(-1)	-2.43E-07	9.39E-07	7.58E-07	1.03E-06	0.361648
	(1.5E-06)	(5.2E-06)	(5.5E-07)	(7.0E-07)	(0.10685)
	(-0.16565)	(0.18089)	(1.36652)	(2.47477)	(3.38455)
NX(-2)	-2.31E-06	-1.53E-05	-2.92E-07	1.39E-06	0.274577
	(1.6E-06)	(5.5E-06)	(5.9E-07)	(7.4E-07)	(0.11367)
	(-1.48246)	(-2.77260)	(-0.49493)	(1.88135)	(2.41546)
NX(-3)	9.81E-07	1.17E-05	6.87E-07	-5.25E-07	0.054761
	(1.6E-06)	(5.7E-06)	(6.1E-07)	(7.6E-07)	(0.11699)
	(0.61171)	(2.06314)	(1.13180)	(-0.68810)	(0.46809)
C	-0.007930	-0.033732	0.009566	0.019760	-2024.838
	(0.01269)	(0.04499)	(0.00481)	(0.00604)	(926.184)
	(-0.62480)	(-0.74978)	(1.98968)	(3.27168)	(-2.18622)
Adj. R-squared	0.098168	0.082901	0.344320	0.253727	0.416839
F-statistic	1.700749	1.581919	4.380552	3.188694	5.601469
Akaike AIC	-3.626393	-1.095618	-5.567904	-5.111746	18.76921
Schwarz SC	-3.194137	-0.663362	-5.135647	-4.679490	19.20147

Where: De – is the change in exchange rates
DR- Change in interest rates
DP – Change in prices
DM3- Change in money supply
NX- Net exports

Appendix E: Diagnostic test results

Table E: Diagnostic test results

Test		ΔDR	ΔDE	ΔP	NX	ΔM3
Jarque-Bera	F-test	43.5431	66.98	72.2291	73.4341	7.8638
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0196
Langrange Multiplier test	F-test	1.6130	3.0603	6.2637	12.2636	0.4105
	Prob.	0.1911	0.0317	0.00061	0.000001	0.7457
White test	F-test	1.1052	3.4185	0.4489	0.9777	0.9746
	Prob.	0.3663	0.0016	0.8885	0.4580	0.4603

Appendix F- Basic Data

Table F-1: Basic Overshooting Data

YEAR	Current account balance- Kshs (cab)	Exchange rate (e) Kshs/US$	Net capital inflows- Kshs (inf)	Domestic Prices (p) Kshs	US wholesale prices- Kshs (P^f)	Treasury bill rates (r)	US treasury bil ratesr^f
1993:1	0.051021	43.40616	0.001648	62.13	29287.09	23.02667	2.99
1993:2	0.005410	50.57580	0.002505	72.94	9045.907	61.48667	2.98
1993:3	-0.009588	56.82919	0.002499	82.27333	9543.92	65.15667	3.02
1993:4	0.034943	60.66443	0.002942	88.42667	10008.13	49.52	3.08
1994:1	0.054935	66.22712	-0.009435	97.15	9762.363	24.95	3.25
1994:2	0.002625	68.60391	-0.008727	101.2767	8522.403	29.00333	4.04
1994:3	0.006622	66.48332	-0.007831	99	7878.803	23.24667	4.51
1994:4	-0.027274	64.45356	-0.006456	96.45	6586.77	16.06	5.28
1995:1	-0.010582	65.28686	0.006082	98.49	6660.853	16.43667	5.78
1995:2	-0.009564	63.35951	-0.002469	96.44667	7841.933	15.17667	5.62
1995:3	-0.033684	65.78449	-0.008481	100.5633	8490.28	19.19	5.38
1995:4	0.000440	66.07713	-0.003796	101.4967	8551.097	22.35	5.27
1996:1	-0.010240	67.28279	-0.002762	104.2833	9109.43	23.96	4.95
1996:2	-0.005017	68.58003	0.005960	107.3267	9074.3	20.95	5.04
1996:3	-0.002679	70.75182	-0.003111	111.34	8931.1	21.81667	5.14
1996:4	0.002099	70.98404	0.003848	112.5067	8776.437	22.27667	4.97
1997:1	-0.010692	73.84175	-0.003490	117.83	8741.83	21.51333	5.06
1997:2	-0.018720	77.39411	-0.000845	123.9833	8725.417	19.96667	5.07
1997:3	-0.001826	75.20985	-0.006517	120.9633	10017.84	23.33	5.06
1997:4	-0.009677	75.65301	-0.006905	122.1567	10237.18	26.32667	5.09
1998:1	-0.009172	80.44815	-0.006876	130.2433	9709.517	26.53	5.08
1998:2	0.000650	81.23309	0.000550	131.81	9888.213	26.02667	5.01
1998:3	-0.015132	79.17101	-0.005176	129.3667	9729.473	23.21667	4.88
1998:4	-0.010970	76.67282	0.005186	125.72	9929.99	15.56	4.31
1999:1	-0.012965	79.00860	-0.016214	130.0533	10456.36	10.26667	4.42
1999:2	-0.003137	84.51043	-0.004178	134.1067	11696.78	10.75333	4.46
1999:3	-0.008818	80.76162	-0.015394	135.0633	12625.28	15.49667	4.7
1999:4	-0.006355	80.79599	-0.002964	135.95	12495.79	18.98	5.06
2000:1	-0.004936	81.02227	-0.006787	137.69	12524.08	14.36333	5.54
2000:2	-4.19E-05	82.06898	-1.18E-06	140.9467	13138.81	11.08667	5.78
2000:3	-0.012786	83.13793	-0.005024	143.9167	13338.39	9.936667	6.01
2000:4	-0.005570	83.77253	-0.013344	145.7933	13730.76	12.81333	6.04
2001:1	-0.008712	82.33271	-0.007100	144.6567	13734.87	14.98	4.9
2001:2	-0.009046	80.95821	-0.004993	143.73	13910.54	11.52333	3.68
2001:3	-0.000906	81.04755	-0.000601	144.0733	14035.65	12.72333	3.27
2001:4	-0.004536	81.30827	-0.014512	144.1333	13983.47	11.33	1.95

Table F-1: Basic Overshooting Data (Cont..)

YEAR	Money supply-Kshs (m)	US money supply-Kshs (m^f)	Domestic income-Kshs (y)	Foreign income - Kshs (y^f)
1993:1	409157	16877.21	136385.7	264026.4
1993:2	419209	27137.72	139736.3	277066.3
1993:3	418248	28631.76	139416	290059.2
1993:4	462291	30024.39	154097	303180.9
1994:1	512159	29287.09	170719.7	316464.9
1994:2	520043	25567.21	173347.7	330223.3
1994:3	542914	23636.41	180971.3	344892.6
1994:4	601379	19760.31	200459.7	360123.7
1995:1	586851	19982.56	195617	374885.3
1995:2	605872	23525.8	201957.3	388446.5
1995:3	629425	25470.84	209808.3	400312.1
1995:4	657125	25653.29	219041.7	410954.3
1996:1	713946	27328.29	237982	422159.4
1996:2	750750	27222.9	250250	435927.1
1996:3	771949	26793.3	257316.3	454241.8
1996:4	785534	26329.31	261844.7	476902.9
1997:1	828870	26225.49	276290	501142
1997:2	843985	26176.25	281328.3	524522.8
1997:3	842505	30053.52	280835	545018.5
1997:4	846756	30711.53	282252	561732.5
1998:1	874955	29128.55	291651.7	575462.8
1998:2	873997	29664.64	291332.3	587530.1
1998:3	887145	29188.42	295715	599270.2
1998:4	907623	29789.97	302541	611105.3
1999:1	931489	31369.07	310496.3	622668.5
1999:2	928573	35090.35	309524.3	633792.1
1999:3	921418	37875.84	307139.3	644462.8
1999:4	917630	37487.38	305876.7	654887.1
2000:1	928066	37572.24	309355.3	665712.4
2000:2	935644	39416.44	311881.3	677731.4
2000:3	934590	40015.16	311530	691879.8
2000:4	928991	41192.29	309663.7	708998.6
2001:1	926440	41204.62	308813.3	729579.6
2001:2	925220	41731.62	308406.7	754452.4
2001:3	922440	42106.95	307480	784852
2001:4	955760	41950.41	318586.7	821545.9

Sources: Central Bank of Kenya (CBK)- quarterly Bulletins and monthly Economic Reviews, World bank, Africa Database 2002 CD ROM, US Federal Reserve Bank at http://www.stls.frb.org

Table F-2: Basic Transmission Data

YEAR	Exchange rates (e)	Money supply (M3)	Net Exports NX	Prices (P)	Treasury bill rates (r)
1993:01	35.92000	133756.0	-991.0000	58.35000	17.17000
1993:02	36.46000	135576.0	-1437.000	63.02000	17.10000
1993:03	45.53000	139825.0	37.00000	65.01000	34.81000
1993:04	59.87000	145890.0	-2117.000	69.44000	48.94000
1993:05	63.18000	136492.0	-2098.000	71.96000	64.88000
1993:06	65.14000	136827.0	-1500.000	77.42000	70.64000
1993:07	65.25000	135670.0	-2879.000	78.84000	67.97000
1993:08	65.56000	138629.0	-806.0000	81.55000	65.59000
1993:09	66.96000	143949.0	-3311.000	86.44000	61.91000
1993:10	69.06000	147022.0	-1685.000	87.33000	60.51000
1993:11	68.75000	153684.0	-170.0000	88.26000	48.71000
1993:12	68.16000	161585.0	-2648.000	89.69000	39.34000
1994:01	67.67000	165572.0	-5905.000	94.26000	23.09000
1994:02	67.13000	171766.0	-2845.000	97.27000	23.32000
1994:03	64.86000	174821.0	-3326.000	99.92000	28.44000
1994:04	60.77000	174599.0	-3167.000	102.6000	27.56000
1994:05	56.46000	173524.0	-3631.000	101.5600	29.08000
1994:06	55.96000	171920.0	-486.0000	99.67000	30.37000
1994:07	55.91000	174951.0	-1459.000	100.4000	26.28000
1994:08	54.81000	181552.0	1899.000	99.06000	20.86000
1994:09	48.01000	186411.0	-3501.000	97.54000	22.60000
1994:10	41.27000	195497.0	-2918.000	98.05000	13.69000
1994:11	45.95000	200064.0	-2489.000	95.68000	16.59000
1994:12	44.84000	205818.0	-3726.000	95.62000	17.90000
1995:01	44.47000	196546.0	-4832.000	97.61000	16.92000
1995:02	44.44000	193838.0	-3765.000	98.64000	16.95000
1995:03	43.55000	196467.0	-2111.000	99.22000	15.44000
1995:04	45.89000	197611.0	-2061.000	98.84000	14.18000
1995:05	54.04000	199664.0	-6483.000	99.68000	15.25000
1995:06	54.63000	208597.0	-6048.000	99.82000	16.10000
1995:07	55.83000	206446.0	-7360.000	99.85000	17.94000
1995:08	55.32000	211099.0	-9476.000	100.3900	18.78000
1995:09	55.47000	211880.0	-6013.000	101.4500	20.85000
1995:10	55.50000	210225.0	-3279.000	101.2900	23.50000
1995:11	55.58000	220765.0	-2936.000	100.9900	22.65000
1995:12	55.94000	226135.0	-1366.000	102.2100	20.90000
1996:01	59.53000	234674.0	-4672.000	103.4000	21.94000
1996:02	58.39000	235677.0	-3312.000	103.8900	25.89000
1996:03	58.39000	243595.0	-3624.000	105.5600	24.05000
1996:04	58.33000	246998.0	-2415.000	105.9300	21.15000

1996:05	58.20000	248699.0	-4893.000	106.6500	20.84000
1996:06	57.42000	255053.0	-2438.000	109.4000	20.86000
1996:07	57.23000	257638.0	-5658.000	110.9000	20.53000
1996:08	56.92000	258873.0	-4733.000	111.2800	20.65000
1996:09	56.11000	255438.0	-3937.000	111.8400	24.27000
1996:10	55.69000	257127.0	-4689.000	112.0900	23.42000
1996:11	55.40000	260579.0	-5334.000	112.3200	21.80000
1996:12	55.02000	267828.0	-2463.000	113.1100	21.61000
1997:01	54.71000	269591.0	-5592.000	114.8000	21.63000
1997:02	54.94000	276319.0	-4300.000	116.4300	21.55000
1997:03	54.70000	282960.0	-8451.000	122.2700	21.36000
1997:04	55.49000	280459.0	-5583.000	123.1800	20.79000
1997:05	53.45000	282505.0	-8209.000	125.2100	20.15000
1997:06	54.46000	281021.0	-7608.000	123.5600	18.96000
1997:07	58.91000	280975.0	-6152.000	120.9200	19.25000
1997:08	65.92000	287361.0	-5073.000	120.0600	23.58000
1997:09	62.03000	274169.0	-4414.000	121.9100	27.16000
1997:10	63.99000	274920.0	-5044.000	122.0700	27.20000
1997:11	63.54000	277784.0	-5950.000	121.6700	26.51000
1997:12	62.68000	294052.0	-4020.000	122.7300	26.27000
1998:01	60.04000	293415.0	-7110.000	127.7300	26.28000
1998:02	59.99000	293473.0	-5922.000	130.7700	26.41000
1998:03	59.89000	288067.0	-7492.000	132.2200	26.90000
1998:04	59.71000	286955.0	-5587.000	131.7400	26.96000
1998:05	63.06000	295810.0	-5535.000	130.9800	26.00000
1998:06	59.48000	291232.0	-4944.000	132.7100	25.12000
1998:07	59.05000	293659.0	-7201.000	135.0400	24.45000
1998:08	59.54000	297334.0	-6374.000	126.2900	23.20000
1998:09	60.04000	296152.0	-7088.000	126.7800	22.00000
1998:10	59.73000	301627.0	-7286.000	126.0900	19.82000
1998:11	60.05000	302246.0	-4730.000	125.2800	15.79000
1998:12	61.91000	303750.0	-8449.000	125.7900	11.07000
1999:01	61.75000	307155.0	-4446.000	126.3300	10.59000
1999:02	63.92000	310641.0	-6708.000	130.0600	10.97000
1999:03	64.91000	313693.0	-6074.000	133.7600	9.240000
1999:04	67.72000	309808.0	-5585.000	133.6000	9.270000
1999:05	70.50000	308966.0	-4933.000	133.6800	9.590000
1999:06	72.91000	309799.0	-2175.100	135.0500	13.40000
1999:07	74.23000	313380.0	-6010.130	134.2900	14.81000
1999:08	75.17000	305056.0	-5916.920	134.9400	14.94000
1999:09	77.07000	302982.0	-7308.000	135.9600	16.74000
1999:10	75.19000	302723.0	-4389.120	136.3800	17.79000
1999:11	74.66000	302791.0	-10921.34	135.6400	18.69000
1999:12	72.93000	312116.0	-7881.070	135.8300	20.46000

2000:01	72.81000	310630.0	-8072.940	137.2900	18.92000
2000:02	73.40000	308033.0	-5647.200	137.4700	12.27000
2000:03	74.87000	309403.0	-9654.800	138.3200	11.90000
2000:04	74.86000	315792.0	-6224.590	139.1100	12.09000
2000:05	76.70000	309497.0	-8200.900	140.5900	11.16000
2000:06	77.95000	310355.0	-8992.500	143.1400	10.01000
2000:07	74.56000	313562.0	-13667.30	143.2500	9.520000
2000:08	77.61000	312424.0	-12787.60	142.9200	9.700000
2000:09	78.99000	308604.0	-11059.30	145.5800	10.59000
2000:10	79.36000	305717.0	0.000000	145.3200	10.81000
2000:11	79.30000	308608.0	-13502.20	146.1000	14.16000
2000:12	78.04000	314666.0	-6620.700	145.9600	13.47000
2001:01	78.62000	310520.0	-7204.000	145.5800	15.12000
2001:02	78.08000	307020.0	-6464.600	144.6500	15.40000
2001:03	77.82000	308900.0	-9215.400	143.7500	14.42000
2001:04	77.55000	312480.0	-11235.20	144.1800	11.80000
2001:05	78.52000	307140.0	-14788.30	143.5500	10.34000
2001:06	78.99000	305600.0	-18281.34	143.4600	12.43000
2001:07	78.88000	306680.0	-14127.11	143.4800	12.94000
2001:08	78.97000	304340.0	-9271.260	144.6000	12.84000
2001:09	79.02000	311420.0	-12876.52	144.1400	12.39000
2001:10	79.08000	315480.0	-13376.70	144.3000	11.63000
2001:11	78.97000	317960.0	-6643.900	144.2000	11.51000
2001:12	78.60000	322320.0	-5031.380	143.9000	10.85000

Sources: Central Bank of Kenya (CBK)- quarterly Bulletins and monthly Economic Reviews, World bank, Africa Database 2002 CD ROM, US Federal Reserve Bank at http://www.stls.frb.org