Channels of Monetary Policy Transmission in Kenya[1]

Benjamin O. Maturu[2]

Abstract

This study confronts the monetary policy transmission mechanism problem using structural vector auto-regression analysis to adduce evidence that while the traditional money channel has sustained some of its potency, the interest rate and the exchange rate channels are unambiguously important channels of monetary policy transmission in Kenya. There is therefore potential for signaling monetary policy using the repo interest rate and the Central Bank of Kenya should adopt explicit inflation targeting for effective control of inflation. The monetary policy transmission lag is estimated at 13 to 19 months when monetary policy is measured in terms of a repo interest rate shock. If reserve money shock is used, instead, the transmission lag is longer, 23 to 36 months.

1. Introduction

While economists are largely agreed that money supply is the ultimate determinant of the general level of prices and that, therefore, by extension, excess money supply is the ultimate cause of inflation, the monetary policy transmission mechanism, which is the sequence of events starting with a change in the value of the monetary policy instrument and culminating in a change in real output and inflation, is not clear in many countries. For most of these countries, Bernanke and Gertler (1995)'s characterization of the monetary policy transmission mechanism as "a black box" remains true.

It is however imperative that a central bank should answer the monetary policy transmission mechanism problem. A central banks needs to know the elasticity of inflation with respect to monetary policy shocks in order to determine the amount by which it should change the value of the policy instrument so as to obtain a desired amount of change in inflation. It should also know the average amount of time taken for the full impact of a monetary policy shock on inflation to materialize. Together with knowledge of the elasticity, this enables the central bank to take timely measured policy actions aimed at controlling inflation. Generally, knowledge that the impact of policy on inflation comes with long and varied distributed lags explains why banks embrace forward-looking monetary policy management strategies, for instance, explicit inflation targeting policy operating frameworks. Most importantly, a central bank should know the channels of monetary policy transmission that are operational in the country so as to choose suitable policy instruments and intermediate policy targets.

A number of studies have been carried out about various aspects of the monetary policy transmission mechanism in Kenya. Using a structural vector auto-regression model, Kevin (2006) shows that the exchange rate and the interest rate channels were operational in Kenya over the study period. A monetary policy shock expressed in terms of a positive one standard deviation innovation in the repo interest rate which is therefore interpreted to be monetary

---

[1] A paper for presentation during the 12th African Econometric Society Conference in Cape Town, South Africa; 4th-6th, July 2007. An earlier version of this paper was presented during the "*Transmission Mechanism of Monetary Policy*" Seminar organized by COMESA Secretariat in Lusaka, Zambia, on 9th-11th, October 2006.
[2] An Assistant Director, Research Department, Central Bank of Kenya, maturubo@centralbank.go.ke

tightening results in deceleration of headline inflation starting in the 5th month through the 11th month following inception of the shock. The peak impact occurs in the 10th month and this implies that the policy transmission lag is 10 months. The influence of a monetary policy shock on real output does not however tally with theoretical predictions that when commodity prices are rigid monetary policy induces sluggish price adjustments and the balance of the adjustment process is felt in real output. Thus, monetary policy influences real output temporarily while price adjustment lasts. Lack of significant impact of monetary policy shocks on real output would owe to inadequate high frequency real output data.

Earlier on, Baffie (2003) had shown that Kenya, among other sub-Saharan Africa countries, pursued self-defeatist monetary policy. As the countries strove to absorb excess liquidity using open market operations, interest rate differentials rose thereby attracting even larger net capital inflows that entailed further monetary tightening to start the vicious circle all over again. Similar concerns had been raised by Ndung'u (1996) in which a policy of "doing nothing" in the face of short-term capital inflows was recommended. The CBK commits to the 5% inflation objective and tightens monetary policy when necessary. Analyzing whether Kenya pursued macroeconomic policies supportive of creation and sustenance of decent jobs, UNDP (2006) apparently questions the appropriateness of pursuing a 5% inflation objective when the growth and hence employment optimizing rate of inflation among developing countries was about 10%. Similarly, UNDP wonders whether Kenya should not adopt a counter-cyclical monetary policy strategy in the management of inflation instead of the pro-cyclical strategy that exacerbated inflation instead of controlling it. A pro-cyclical strategy calls for monetary tightening when a country is faced with an adverse supply shock believing that that will curtail demand and bring in line with the reduced food production and supply and therefore circumvent inflation. Counter-cyclical inflation will entail monetary easing in order to stimulate production and supply of foodstuffs and in so doing check loss of jobs. The aftermath of monetary policy management in Kenya is a never-ending tide of net capital inflows that has supported a strengthening Kenya shilling exchange rate that threatens competitiveness of Kenya's produce.

Though not addressing the monetary policy transmission mechanism problem head-on and comprehensively, there are other studies including Rotich, Kathanje and Maana (2006), Ouma *et al.* (2006), Kiptui et al. (2006), and Maturu, Kethi and Maana (2006) that adduce useful evidence regarding monetary policy transmission mechanism in Kenya. Rotich, Kathanje and Maana (2006) and Ouma *et al.* (2006) attempt to characterize the setting of monetary policy instruments in Kenya. According to Rotich, Kathanje and Maana (2006), the CBK conducted monetary policy in such a manner that it did not target the shilling exchange rate. They also conclude that monetary policy was not accommodative of inflation considering that any increase in the inflation gap (i.e. inflation less the value of the inflation target) was met with a more than proportionate increase in the repo rate. In contrast, Ouma *et al.* (2006) characterize monetary policy management has having been inconsistent with attainment of macrocosmic policy objectives including price stability, real economic growth and a strong external balance of payments position. One however notes the monetary policy reaction function is set up within the context of an inadequately set up structural vector auto-regression model. One cannot therefore tell whether monetary policy implementation was indeed inconsistently managed or that the conclusion about inconsistent monetary policy management was largely a creation of a weak analytical framework when monetary policy management was after all consistent and in keeping with best practice. At any rate, the authors fail to report plausible results for the estimated monetary policy reaction function.

Studying the exchange rate pass-through effect to domestic prices in Kenya, Kiptui et al. (2006) show that there is partial exchange rate pass-through to domestic prices and that therefore importers did not shift forward to domestic consumers the full exchange rate effect on import prices. The exchange rate pass-through is estimated at 20% and 70% in the short- and in the long-run, respectively. The results show that a necessary condition for an operational exchange rate channel holds. As a sufficient condition, and therefore further to the existence of a strong exchange rate pass-through to domestic prices, the elasticity of the exchange rate with respect to a monetary policy shock should be consistent and sufficiently large. The latter aspect was beyond the scope of Kenya, Kiptui et al. (2006).

Maturu, Kethi and Maana (2006)'s analysis of the inflationary process in Kenya uses the New Keynesian Phillips curve hybrid model to adduce evidence that prices were rigid. The proportion of firms adjusting prices is small and one would therefore expect that monetary policy shocks influence real output as long as it takes commodity and factor prices to adjust fully in response to the monetary policy shock. One would also expect that following a monetary policy shock, prices will adjust sluggishly consistent with the finding that the impact of monetary policy on inflation is not instantaneous but features long varied distributed lags. Since 60% of the firms that adjust prices use forward-looking expectation formation models in which firms' expected stream of real marginal cost mattered, there was scope for monetary policy transmission through the expectations channel. Accordingly, the CBK could secure monetary policy objectives by policy signaling and therefore anchoring economic agents' expectations about future inflation. This would therefore complement the rather overworked traditional monetary policy instrument, the open market operations, that hardly achieve monetary aggregate targets in Kenya.

Since the early 1990s to date, the CBK has been using a monetary aggregate targeting policy operating framework. Reserve money comprising currency in circulation (i.e. currency held outside commercial banks and the CBK) and bank reserves held with the CBK and cash in till among commercial banks is the operating target while extended money supply, M3, is the intermediate target. Low stable headline inflation is the ultimate policy objective with a 5% implicit inflation target.

Underpinning this monetary policy operating framework is the conviction that a stable money demand function exists and that the CBK has sufficient control over money supply. The CBK can therefore provide for monetary expansion just enough to accommodate a desired rate of real economic growth and the implicit inflation target. Thus, monetary tightening in terms of reduced reserve money, given a stable money multiplier consistent with a stable money demand function, induces a corresponding reduction in money supply that in turn reduces the general level of prices.

Precisely how monetary tightening is disinflationary, how quickly the disinflationary effect is fully realized, and what the order of magnitude of impact of monetary policy on inflation is within the Kenyan context is an empirical problem this study sought to shed some light on. This study therefore confronts measurement and identification problems involving measurement of the monetary policy shock and monetary policy shock's dynamic effects on macroeconomic variables including inflation. Based on results of the monetary policy shock's dynamic effects on macroeconomic variables, we identify channels of monetary policy transmission that are operational in Kenya.

In a nutshell, the results show that while the traditional money channel has sustained its potency, the interest rate and exchange rate channels are unambiguously important channels of monetary policy transmission in Kenya.

Following a brief review of the literature in section 2, we explain the conceptual framework and specify the estimable model in section 3. The empirical results are presented and discussed in section 4 upon which we conclude the study with a summary of the main findings, conclusions and policy implications in section 5.

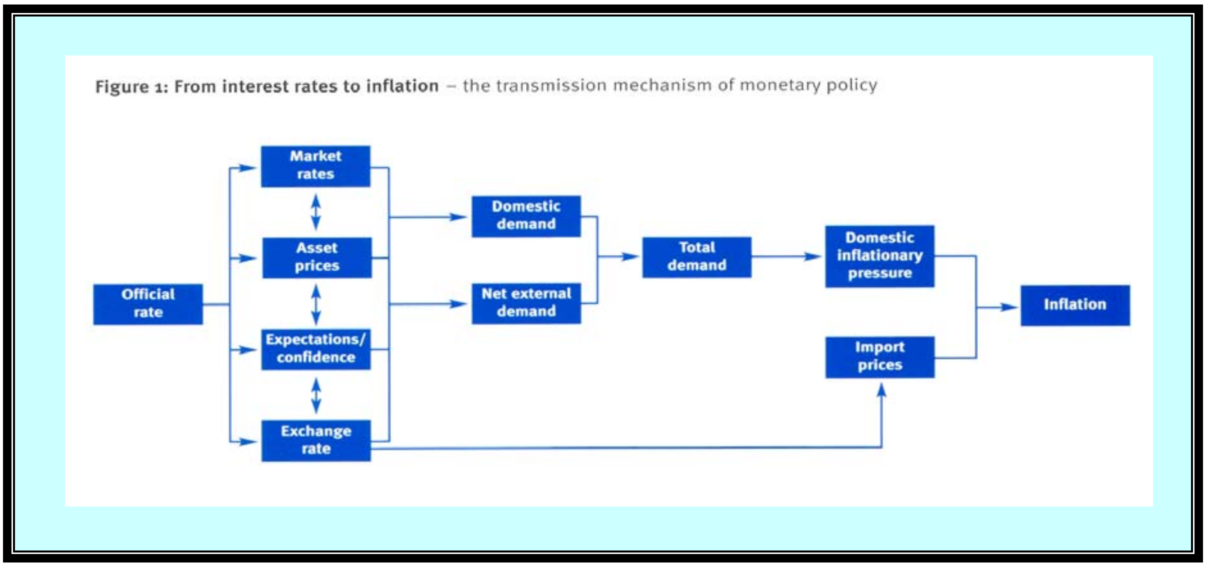
2. Review of the Literature

We can think of a channel of monetary policy transmission as a set of sequential causal effects linking up a monetary policy shock with real output and inflation. The set of channels that are operational in a country defines the country's monetary policy transmission mechanism. Meltzer (1995) and Mishkin (1995) provide succinct discussions of channels of monetary policy transmission. Commonly cited channels include the traditional money channel, the interest rate channel, the exchange rate channel, the broad credit channel comprising the balance sheet and the bank lending channels, the asset price channel, and the expectations channel.

We observe from Figure 1 that monetary policy can influence inflation through many channels. In Figure 1, the directional arrows point to the flow of the effect of a monetary policy shock unleashed as a change in the policy instrument, which is in this case provided as the policy rate. Within the Kenyan context, the policy instrument is reserve money, instead.

Generally, a change in the monetary policy instrument such as a policy rate initially impacts financial market prices including market interest rates and the exchange rates. Economic agent's expectations are also influenced. These changes would have feedback effects among themselves thereby magnifying the initial direct effect of the monetary policy shock on one of the financial market prices. How long the influence of a monetary policy shock lingers on and how long feedback effects obtain among the financial market prices takes will depend on the extent of asymmetrical receipt and processing of the monetary policy information. Thus, the monetary policy shock will be expected to impact financial market prices with distributed and varied lags. The policy-induced changes in financial market prices will then be transmitted to the commodity market and thence to commodity prices.

For instance, policy induced changes in the exchange rate will then impact import prices and, in turn, domestic commodity prices and by extension inflation. This is the direct exchange rate channel of monetary policy transmission. Indirectly, however, the exchange rate changes will cause demand-switching effects that will impact net external demand and therefore total demand that will bid up or down domestic inflationary pressure and finally inflation will accelerate or decelerate depending on whether domestic inflationary pressure was bid up or down.



Source: http://www.bankofengland.co.uk/images/from_int_inf2.gif).

Generally, it follows from Angeloni et al. (2002), Bank of England (Undated) and Peersman and Smets (2001) that the interest rate, the exchange rate and the expectations channels are most effective in developed countries while the exchange rate channel is particularly important in small open economies as shown in Cushman and Zha (1997) and Parrado (2002). Also operational in developing countries to varied extents is the credit channel and the equity market price channel. Sichei (2005) provides evidence showing that the bank-lending channel is operational in the Republic of South Africa. There is also evidence on the credit channel for the Republic of South Korea in Cho and Kang (1999) and Ferri and Kang (Undated).

Possibly because of relatively more developed and stable financial systems in industrialized countries, monetary policy transmission is more efficient in the industrialized countries. Accordingly, the magnitude of effect of monetary policy shocks on inflation is larger and the influence of monetary policy shocks travels faster to hit inflation. Well-anchored inflation expectations also shorten the monetary policy transmission mechanism lag, which is generally estimated to be one to one and a half years. The interest rate shock arising from a positive one-standard deviation innovation is 0.45% to 0.75% in the Euro Area and 0.3% in the USA compared with less than 0.3% in many developing countries.

In contrast, accelerator factors like the external finance premium impair monetary policy transmission in developing countries to the extent that monetary policy transmission lags are elongated. The accelerator factors continue to influence inflation long after the initial monetary policy shock dissipates and in the process not only elongate the transmission lag but also cause a magnification effect whereby the overall effect on inflation arising from a monetary policy shock is more than proportionate to the initial corresponding monetary policy shock.

Moreover, prevalent financial sector vulnerabilities in developing countries inhibit policy transmission. Banks with inadequate capital seek to build up the capital to comply with prudential requirements. Monetary easing aimed at stimulating bank credit amid shortfalls in core capital among banks hardly works because instead increasing their respective loan portfolios, banks use available free reserves to acquire additional capital assets. Banks with strong financial positions can also frustrate monetary policy tightening considering that the banks have the capacity to raise additional financial resources to extend loans well above desired levels of bank credit consistent with the prevailing monetary policy stance (Bernanke, 1983). This is particularly applicable in countries whose financial sectors are predominant in foreign banks that take recourse to offshore assets to circumvent liquidity tightness.

Baffie (2003) shows that when countries practice flexible foreign exchange rate systems amid open capital accounts in the balance of payments, monetary tightening is self-defeatist. Higher real interest rate differentials accompanying monetary tightening attracts net capital inflows that boost the net foreign assets of the banking system including those of central bank. Consequently, the monetary base increases and unless the central bank is successful in sterilizing injected liquidity, money supply expands further and the folly of further monetary tightening results even in larger capital inflows. It follows from Ndung'u (1996) that a central bank is better off doing nothing and therefore not tightening monetary policy.

Normally, the impact of monetary policy on inflation is permanent and proportionate to the corresponding initial change in money supply. Conversely, monetary policy influences real output quicker because of sluggish price adjustment. When prices adjust fully so that the effect on inflation is proportionate to the initial change in money supply, the monetary policy shock's effect on real output dies out consistent with the neutrality assumption about money. Thus, monetary policy affects real output temporarily and it is therefore futile using monetary policy to target long term growth in real output. Some Banks, however, including the Reserve Bank of New Zealand, optimize price stability subject to smoothing the real business cycle.

A lesson learnt from past studies on transmission mechanism of monetary policy is that small open economies are susceptible to external shocks, which complicate policy management. For instance, Hoffmaister, Roldos and Wikham (1998) show that terms of trade shocks influence output and exchange rates especially among countries practicing a fixed exchange rate system. The results support the view that a floating exchange rate system insulates a country from such external shocks thereby enabling the country to practice independent monetary policy.

Owing to the susceptibility of small open economies to external shocks, measurement of monetary policy shocks assumes slightly different treatment from measurement of monetary policy shocks in large relatively closed economies in which the standard recursive identification method performs as evidenced in Christiano and Eichenbaum (1992). It is observed from Kim and Roubini (1995), Cushman and Zha (1997) and Parrado (2002) that a structural vector auto-regressive approach including a wide range of foreign economic variables performs better than standard recursive identification for small open economies.

For instance, Cushman and Zha (1997) explain, citing Grilli and Roubini (1995), that monetary policy transmission mechanism study results for small open economies were afflicted with inconsistencies with theoretical postulates because of failure to include enough relevant foreign variables in the analyses. By including trade flow variables in their structural autoregressive model of monetary policy transmission mechanism in Canada, a country whose economy Cushman and Zha considered small and open relative to the USA, the authors obtained results that were devoid of the exchange rate puzzle reported in Grilli and Roubini (1995).

3. Analytical Framework

It follows from section 2 that structural vector auto-regression model is particularly useful in studying the monetary policy transmission mechanism problem and this is the approach followed in this study. Upon outlining vector auto-regression modeling in 3.1, we describe the data in 3.2 and then proceed to specify the estimable model in 3.3.

3.1 A General Vector Auto-regression Model

A standard vector auto-regression model expresses a set of endogenous variables as a system of equations each of which depends on own lags and lags of the rest of the variables as represented in (1). The vector auto-regressive model in (1) has a moving average representation (2).

$$\mathbf{y}_t = \sum_{s=1}^{L} \mathbf{\Phi}_s \mathbf{y}_{t-s} + \mathbf{u}_t \quad (1)$$

$$\mathbf{y}_t = \mathbf{x}_t \mathbf{ß} + \sum_{s=0}^{\infty} \psi_s \mathbf{u}_{t-s} \quad (2)$$

Whereby, $\forall$ s$\neq$t, E($\mathbf{u}_t\mathbf{u}_s$)=0, E($\mathbf{u}_t\mathbf{u}_t^T$)=$\mathbf{\Sigma}_u$ is the variance covariance matrix of $\mathbf{u}_t$; $\forall$ i=1,2,3, …, n being the ith equation in the VAR and $\forall$ i$\neq$n, E($\mathbf{u}_{it}\mathbf{u}_{nt}$) $\neq$ 0 and hence $\mathbf{\Sigma}_u \neq$ **Đ** (**Đ** denotes a diagonal matrix); The first term on the right hand side of (2) is the deterministic component of $\mathbf{y}_t$ and the second term is the stochastic component; and u is an N-variate innovation process for **y**.

The stochastic part in (2) is particularly useful in the analysis of the dynamic responses, formally called impulse responses, of y to any of the N innovations **u**. The time-varying influences of the innovations, **u**, on **y**, are captured by ψ_s for all s=0, 1,2, …, k whereby k is the chosen time horizon for tracing the impulse responses. The impulse responses at time s are captured in the NxN matrix of impulse responses ψ_s.

The problem, however, is that for any ith equation ψ is does not represent a pure ith innovation effect at time s because E($\mathbf{u}_{it}\mathbf{u}_{jt}$) $\neq$ 0 for i$\neq$j and therefore the innovations are contemporaneously correlated across equations in the VAR. This poses the difficulty of not being able to isolate the unique effect of any one shock, including the monetary policy shock, on the economic variables. Unleashing a shock to any equation simultaneously changes some, if not all, of the other innovations with which it is contemporaneously correlated. There will therefore be simultaneity of shocks impacting the economy at any one time making it impossible to tell what the effect of any one of those shocks is. This is the shock identification problem.

Solving the identification problem basically entails normalizing $\mathbf{u}_{it}$ to obtain $\mathbf{v}_{it}$ such that E($\mathbf{v}_{it}\mathbf{v}_{jt}$)=0 and $\mathbf{\Sigma}_u$ becomes $\mathbf{\Sigma}_v$ which is a diagonal matrix **Đ** whose principal diagonal elements show the variance of the orthogonal innovations. With this normalization of **u**, ψ_s is also normalized to yield φ_s. Thus, the relevant innovations and impulse responses to draw policy implications from are $\mathbf{v}_{it}$ and φ_s.

It follows therefore that u should be factorized into its orthogonal part, **v**, and non-orthogonal part using the factorization matrix **G** as shown in (3) and (4). By definition, and following the factorization of **u**, (5) and (6) obtain for v being the orthogonal innovations and φ_t the matrix of impulse responses uniquely identified with the orthogonal innovations at time t.

$$\mathbf{G}^{-1}\boldsymbol{\Sigma}_u\mathbf{G}^{T(-1)} = \boldsymbol{\Sigma}_v \qquad (3)$$

$$\mathbf{y}_t = \mathbf{x}_t\boldsymbol{\beta} + \sum_{s=0}^{\infty}\psi_s\mathbf{G}\mathbf{G}^{-1}\mathbf{u}_{t-s} \qquad (4)$$

$$\mathbf{v}_{t-s} = \mathbf{G}^{-1}\mathbf{u}_{t-s} \qquad (5)$$

$$\varphi_s = \psi_s\mathbf{G} \qquad (6)$$

Re-organizing (3) and generalizing (5) using **A** and **B** matrices yields (7) and (8).

$$\mathbf{G}^{-1}\mathbf{G}^{T} = \boldsymbol{\Sigma}_v \qquad (7)$$

$$\mathbf{A}u_t = \mathbf{B}\mathbf{v}_t \qquad (8)$$

Whereby, $\mathbf{G} = \mathbf{B}\mathbf{A}^{-1}$

The shock identification problem involves generating $\mathbf{v}_t$ for the monetary policy instrument equation(s) in the system. As (7) and (8) stand, there is no sufficient information to solve for $\mathbf{v}_t$. All that we know is $\mathbf{u}_t$ and $\boldsymbol{\Sigma}_u$. We must therefore make a sufficient number of identifying restrictions on the elements of **A**, **B**, and $\boldsymbol{\Sigma}_u$.

Assuming, as we have already done, that $\boldsymbol{\Sigma}_u$ is a diagonal matrix (i.e. $\boldsymbol{\Sigma}_u$ = **Đ**) and that **A** is an identity unity matrix (i.e. **A**=**IA**), whereby also the elements in the principal diagonal of the **B** matrix are normalized to unity, we need 8*(8-1)/2=28 free parameters in the **B** matrix in order for the 8-endogenous variables SVAR model to be just identified and therefore solvable. Invoking relevant theory, we can impose restrictions on some of the elements of **B** so that we are left with the 28 free parameters. This approach is the structural factorization. Alternatively, we just assume that the 8 endogenous variables are neatly recursively related so that the **B** matrix is lower- triangular. This is the recursive factorization approach.

The required restrictions on the **B** matrix will depend on the specific vector of endogenous variables. We therefore need to describe the relevant data and state the vector of endogenous variables upon which we impose a sufficient number of identifying restrictions.

3.2 Data

We need to establish how monetary policy shocks influence the level of macroeconomic performance in Kenya. We therefore require four sets of variables: measures of the level of macroeconomic performance, measures of monetary policy stance, variables indicative of channels of monetary policy transmission, and variables capturing external economic shocks. The commonly used measures of macroeconomic performance are real output (hereafter denoted by OUTPUT) and measured in terms of the real gross domestic product at 1997 constant prices, and the general levels of prices (denoted by PRICES) measured in terms of Kenya’s New Consumer Price Index (CPI) with 1997:10=100.

Under the monetary aggregate targeting policy operating framework, nominal reserve money, RMONEY, is the monetary policy operating target while extended money, M3, hereafter denoted by MONEY is the intermediate target. The ultimate target is the twelve-month percentage change in the consumer price index (CPI). Under the monetary aggregate targeting policy operating framework, a change in RMONEY impacts MONEY m-fold whereby m is the money multiplier. The monetary policy shock would then take a multiplicity of paths to culminate in influencing the general level of prices.

A working assumption is that monetary policy is transmitted through many channels including, the money channel (MONEY), the credit channel and hence through bank credit to the private sector (CREDIT), the interest rate channel and hence through the bank deposit interest rate (DEPOSITRATE) and bank lending interest rate (LENDRATE), the exchange rate channel and hence through the Kenya shilling exchange rates represented by the nominal effective exchange rate (NEER) or the Kenya shilling-USA dollar nominal bilateral exchange rate (DOLLAR) as it influences exports and imports, EXPORTS and IMPORTS, respectively and thence to influencing OUTPUT and the asset market price channel including the foreign exchange, bond and the equity market prices. Further to the Shilling exchange rates, monetary policy is expected to be transmitted under the asset market price channel through the Government Securities interest rate represented by the 91-day Treasury bill interest rate (TB91RATE), and the returns on shares for companies listed at the Nairobi Stock Exchange market (NSE).

Kenya's economy is susceptible to being hit by external economic shocks including terms of trade (TOT) shocks measured in terms of shocks to the international price of oil expressed in USA dollars per barrel and the international financial market interest rate shocks measured in terms of the USA Federal Reserve Bank System Funds Rate (FEDRATE). Considering the small open economy assumption, TOT and FEDRATE are exogenous and hence independent of economic developments in Kenya. In order to analyze the effect of shocks to these external variables on Kenya's economy, the variables should however be included in the SVAR model as endogenous variables with plausible identifying restrictions.

All the data is applied in their log-transformed indices, 1997:10=100. Transformation of all data series into indices focuses the analysis on variability of the data over time beginning 1997:10 as well as scaling the data similarly for efficient model estimation (Davidson and McKinnon, 1993). Log-transformation of the indexed data maintains the need for scaling the data similarly while providing for interpretation of impulse responses as elasticities thereby facilitating easier interpretation of the results.

3.3 The Structural Vector Auto-regression Model

For efficient estimation of the free parameters in **B**, we need adequate degrees of freedom. Instead of attempting to estimate a large SVAR that spans all the sixteen (16) variables, all at once, we start with a benchmark SVAR model aligned as closely as possible to the monetary aggregate targeting policy operating framework in Kenya. The balance of the variables is then incorporated, in turns, into the analysis under robustness test exercises.

The main elements of the monetary aggregate targeting policy-operating framework are: OUTPUT, PRICES, MONEY, RMONEY, REPORATE and NEER. Including external shock variables, the set of endogenous variables in the benchmark model is: OIL, FEDRATE, OUTPUT, PRICES, MONEY, RMONEY, REPORATE and NEER. We therefore consider an eight-variate benchmark SVAR model and hence **B** is 8x8 and N=8.

Considering the eight endogenous variables, the SVAR model is stated according to (9).

$$
\begin{bmatrix} u^{OIL} \\ u^{FEDRATE} \\ u^{OUTPUT} \\ u^{PRICES} \\ u^{MONEY} \\ u^{RMONEY} \\ u^{REPORATE} \\ u^{NEER} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b2 & 0 & 1 & b3 & 0 & 0 & b4 & b5 \\ b6 & 0 & b7 & 1 & b8 & 0 & 0 & b9 \\ 0 & b10 & b11 & b12 & 1 & 0 & b13 & b14 \\ 0 & 0 & b15 & b16 & b17 & 1 & 0 & b18 \\ 0 & b19 & b20 & b21 & b22 & 0 & 1 & b23 \\ b24 & b25 & b26 & b27 & 0 & 0 & b28 & 1 \end{bmatrix} \begin{bmatrix} v^{OIL} \\ v^{FEDRATE} \\ v^{OUTPUT} \\ v^{PRICES} \\ v^{MONEY} \\ v^{RMONEY} \\ v^{REPORATE} \\ v^{NEER} \end{bmatrix} \quad (9)
$$

In (9), OIL depends contemporaneously on other variables other than those captured in the SVAR and therefore responds to its own shocks. Under the small open economy assumption, the FEDRATE is independent on economic developments in Kenya. However, OIL is assumed to be a major factor influencing world inflation including inflation in the USA. Accordingly, we assume that the USA Federal Reserve Bank System directs monetary policy at the oil price shock by tightening monetary policy in order to check incipient inflation. Hence the free parameter b1 that is expected to be positive, b1>0.

In the long run, money is neutral to the real economy. All monetary aggregate shocks do not therefore influence OUTPUT. It is only the real interest rate and the real effective exchange rate shocks that exert lasting influence on OUTPUT. We therefore retain free parameters attaching to $v^{REPORATE}$, v^{NEER}, v^{PRICE}, and v^{OIL}. We therefore control for inflation in Kenya via PRICES and inflation in the rest of the world via inclusion of OIL. Effectively therefore we consider real interest rate and real effective exchange rate as the determinants of real output growth in Kenya according to (10).

$$u^{OUTPUT} = CONSTANT + b2*v^{OIL} + b3*v^{PRICES} + b4*v^{REPORATE} + b5*v^{NEER} \quad (10)$$

whereby, b2<0, b3<0, abs(b2)= abs(b5) and abs(b3)= abs(b4).

PRICES is driven by both supply side and demand side factors thereby capturing the cost-push inflation and demand-pull inflation elements. While the cost-push inflation is captured by b6, b7 and b9, demand-pull inflation is captured by b8. Oil is a major intermediate input in the production and distribution of goods and services in Kenya and hence a constituent part of the unit cost of production among firms in the Kenya. Since oil is imported, depreciation of the Kenya shilling exchange rate will increase the Kenya shilling price of oil and the unit cost of production. We therefore expect b6=b9>0.

In view of the threshold relationship between inflation and real output growth whereby the threshold is about 10 percent, or so, and inflation in Kenya in 1997:10-2006:09 fluctuated about 10 percent, we cannot tell the direction of effect of PRICES on OUTPUT and hence b7≠0. Since monetary expansion supports increased demand, should supply of goods and services fall short of demand for goods and services while monetary expansion continued, the excess monetary expansion will be inflationary and hence b8>0.

Money stock coincides with demand for money so that the MONEY equation is a demand for money function. Typical determinants of money demand functions include: a scale variable OUTPUT, opportunity cost of holding MONEY, instead of real goods and services (i.e. expected inflation proxied by PRICES), own real rate of return represented by the REPORATE and a host of competing returns on alternative financial assets including

Government securities (TB91RATE), foreign currency denominated assets (i.e. NEER) and equities (i.e. NSE). This explains the free parameters b11, b12, b13, and b14. Holding foreign currency denominated assets instead of MONEY will consider not only exchange rate developments but also offshore interest rates represented by FEDRATE. This is why there is a free parameter b10.

Since RMONEY is the monetary policy operating target, it captures supply of money. Hence, we formulate a monetary policy reaction function in which the Central Bank considers MONEY, PRICES or OCPIK, OIL and NEER as lead indicators of inflation and adjusts the monetary policy instrument (i.e. RMONEY). We also bear in mind that under financial programming, a target for OUTPUT is considered when defining the time path for RMONEY. Accordingly, we have the free parameters b15>0 (representing the pro-cyclical monetary policy implementation in Kenya), b16<1, b17<0, and b18<0 so that monetary policy is not accommodative of inflation.

The REPORATE is a potential short-term monetary policy instrument and therefore formulated a Taylor-like monetary policy reaction function. Hence b19>0, b21>0, b22>0 and b23>0 so that monetary policy is not accommodative of inflation. While the NEER is modeled to respond to all variables in SVAR model, we need to impose two more parameter restrictions in order for the SVAR model (i.e. equations (9)) to be solvable. We therefore reasoned that the effect of monetary aggregate shocks on NEER could sufficiently be represented, indirectly through, by the REPORATE's effect on NEER. Hence the two restrictions in the last row in **B**.

4. Results

4.1 The Factorization Matrix

While estimates of the free parameters in the factorization matrix **B** are not particularly important, the coefficients should be theoretically consistent for the results to be upheld. The results presented in Table 1 show that virtually all the coefficients have standard errors that are less than one and that therefore the coefficients are efficient and form a reasonably good basis for measuring the monetary policy shocks, among other shocks. That b(23) is estimated to be nil, would mean that the CBK was not targeting the shilling exchange rate during the estimation sample and this is consistent with its policy of leaving the exchange rate to be market determined.

4.2 Impulse Responses

Having measured the monetary policy shocks according to $\mathbf{v}^{RMONEY}$ and alternatively according to $\mathbf{v}^{REPORATE}$ as per the estimable model, equation (9), we proceed to estimate and plot the dynamic effects of the shocks on macroeconomic variables. The results are presented in Figure 1. Wanting to assess the robustness of the results before proceeding to interpret them, we derived comparative results that are presented in Figure 2 through Figure 5.

Unlike the results in Figure 1, those in Figure 2 are derived upon exclusion from the analysis the world oil price and interest rate developments in international financial markets represented by the Fed Funds Rate. The benchmark model results in Figure 1 are not robust to exclusion of the two variables and in comparative terms, the results in Figure 2 are parsimonious with clearly delineated and theoretically consistent dynamic economic impacts. Two results vindicate those in Figure 2 compared to those in Figure 1. It is theoretically inconsistent that a real output shock should be accompanied with decreasing demand for money as shown in Figure 1 panel (5,3). We would also expect that given the high level of unemployment in the country, increased real output would initially, at least, ameliorate the inflation problem as idle resources are engaged in gainful employment. In the long run, continued real output growth can only be achieved with increasing pressure on wages that could then cause some cost-push inflation. The results in Figure 2 panel (2,1) are therefore data coherent and consistent with the Kenyan experience while those in Figure 1 panel (4,3) are not. The results in Figure 2 panel (3,2) show that inflation hardly influences demand for money contrary to available evidence that inflation is one of the most dominant determinants of demand for money in Kenya (Maturu, 2007). The results in Figure 1 panel (5,3) are consistent. Moreover the impact of a nominal effective exchange rate shock on real output and inflation are very clear from the results in Figure 1 compared to the results in Figure 2. A positive exchange rate innovation significantly increases real output while reducing inflation during the first six months. It is however inflationary between seventh through the 16th month following the onset of the exchange rate shock.

Based on the results in Figure 2, the monetary policy shock measured in terms of a one-standard deviation innovation to reserve money and which therefore is interpreted to be monetary loosening is 3.5 basis points as shown in panel ((4,4). The reserve money shock is permanent as it declines only to remain steady at 1.7 basis points beginning in the 3rd month. It is shown in Figure 2 panel (3,4), that within two months, the reserve money shock leads to significant and appreciable monetary expansion that persists well beyond one and a half years. Following from the results in Figure 2 panel (2,3) showing that a positive money demand, and by extension money supply, shock is strongly inflationary within five months, the reserve money shock induced monetary expansionary will be inflationary consistent with the monetary aggregate targeting policy framework. It is also shown in Figure 2 panel (1,3) that real output is neutral to a money supply shock. Real output however responds by temporarily falling following a positive reserve money shock possibly because of expectations for monetary tightening. It follows from these results that the traditional money channel is operational in Kenya considering that the link between reserve money to extended money and finally to inflation is complete and strong.

One gets an alternative view about how monetary policy shocks influence inflation by considering the effect of a short-term interest rate shock, the repo interest rate shock in this case. Shown in Figure 2 panel (5,5) at 2.5 basis points, the interest rate shock representing monetary tightening is basically equal, in absolute terms, to the reserve money shock. The interest rate shock persists clearly lasting ten months. Consistent with expectations, it temporarily reduces real output during the first four months, see Figure 2 panel (1,5), and permanently reduces money demand/supply and inflation as shown in Figure 2 panels (3,5) and (2,5), respectively. Although inflationary during the first two months, the interest rate shock interpreted as monetary tightening significantly and permanently reduces headline inflation beginning in the 5th month. Thus, the link between the repo rate as a presumed monetary policy instrument with inflation is also complete and strong and that therefore the interest rate channel is operational in Kenya.

We hasten to add that the results in Figure 2 are devoid of the exchange rate puzzle that afflicts many past studies. This is in spite of foreign variables not being included in model underlying the results. As shown in panel (6,5), a positive interest rate shock leads to strong and appreciable appreciation of the shilling nominal effective exchange rate beginning two months following the shock. The peak impact occurs after about ten months.

Thus, monetary policy measured in terms of a short-term interest rate shock transmits efficiently to the shilling exchange rate. To establish the existence of the exchange rate channel of monetary policy transmission, we should demonstrate the demand switching effect of exchange rate changes as well as the direct effect on inflation arising from exchange rate shocks.

Unlike the results in Figure 1, the results in Figure 2 are largely insignificant concerning the dynamic economic effects of the shilling exchange rate. This is because ordinarily, exchange rates respond to net capital flows that in turn depend on real interest rate differentials. While the results in Figure 1 provide for real interest rate differentials as they incorporate the role of interest rates in the rest of the world as represented in the Fed Funds Rate, the results in Figure 2 do not and it is not therefore surprising that they are not nice. In the further analysis of the exchange rate channel, we invoke the more relevant results in Figure 1.

Firstly, notice that a positive interest rate shock leads to an appreciation of the shilling nominal exchange rate as shown in panel (7,6). The peak impact however occurs slightly earlier, in the 6^{th} month. As shown in Figure 1 panel (8,8), a positive one standard deviation innovation in the shilling nominal exchange rate, which is depreciation, represents an exchange rate shock measuring 0.5 basis points and which lasts for two months only.

In spite of the small magnitude of the exchange rate shock, its direct effect on inflation is phenomenal. As shown in Figure 1 panel (4,8), the 0.5 basis point exchange rate shock reduces inflation on impact by 0.8 basis points. The peak reduction in inflation amounting to 1.2 basis points occurs in the 2^{nd} month upon which it dies out in the 3^{rd} month. Between 6 to 15 months, the exchange rate shock is inflationary. It is reasonable to conclude that a depreciation of the shilling exchange rate has a direct inflationary effect.

The indirect exchange rate channel is also operational considering that the results in panel (3,8) imply that the exchange rate shock boosts net exports that in turn increase real output by 2 basis points on impact. Thereafter the increase in real output reverses gradually lasting 4 months. Thus, the demand-switching effects of a change in the real effective exchange rate hold.

In order to account fully for the indirect exchange rate channel of monetary policy transmission, we should demonstrate the effect of a real output shock on inflation. The expectation is that a positive real output shock increases the real output gap that then pressures up the cost of production and by extension the general level of prices. Consistently, the one standard deviation negative innovation to real output shown in Figure 1 panel (3,3) will on impact induce acceleration in inflation as shown in panel (4,3). The results in Figure 2 panel (2,1) tally since a one standard deviation positive innovation to real output decelerates inflation significantly on impact. We therefore conclude that the indirect exchange rate channel is also operational since the chain reaction starting with an interest rate shock runs through the exchange rate, real output and inflation as discussed.

Table 1: Estimated B-Factorization Matrix

Variable	Coefficient	Std Error	T-Statistic	Significance
b1	-0.0371	0.0804	-0.4620	0.6441
b2	-0.0893***	0.0489	-1.8257	0.0679
b3	2.8254*	0.7544	3.7451	0.0002
b4	-0.0091	0.0220	-0.4133	0.6794
b5	1.2782**	0.5440	2.3497	0.0188
b6	-0.0308	0.0309	-0.9965	0.3190
b7	0.6187*	0.2204	2.8077	0.0050
b8	-0.2328	0.5128	-0.4540	0.6450
b9	-0.6802**	0.3022	-2.2506	0.0244
b10	0.0278	0.0250	1.1151	0.2648
b11	-0.0692	0.1289	-0.5370	0.5913
b12	0.0229	0.1983	0.1152	0.9083
b13	0.0001	0.0097	0.0151	0.9880
b14	-0.0521	0.1682	-0.3095	0.7569
b15	0.0926	0.1681	0.5507	0.5819
b16	0.4978	0.3664	1.3589	0.1742
b17	-1.0515*	0.3604	-2.9177	0.0035
b18	0.3273	0.2636	1.2413	0.2145
b19	-0.3722	0.5531	-0.6729	0.5010
b20	2.0246	1.7695	1.1442	0.2526
b21	-3.4929	3.3421	-1.0452	0.2960
b22	-0.0031	4.8852	–0.0006	0.9995
b23	0.0000	0.0000	0.0000	0.0000
b24	-0.0453	0.0513	-0.8831	0.3772
b25	-0.0378	0.0626	-0.6035	0.5462
b26	0.5296	0.4160	1.2730	0.2030
b27	-1.1146	0.9980	-1.1169	0.2640
b28	-0.0315	0.0246	-1.2792	0.2008

Note: Function Value = 124; *, **, *** denotes coefficients that are Significantly different from zero at the 1%, 5% and 10% significance levels, respectively.

Table 2: Estimated **B**2-Factorization Matrix

Variable	Coefficients	Standard Errors	T-Statistics	Significance
rf(1)	-0.037147832	0.080462229	-0.46168	0.64431055
rf (2)	-0.049116939	0.042699244	-1.15030	0.25002034
rf (3)	-0.038765722	0.060666276	-0.63900	0.52282324
rf (4)	-0.021699137	0.014543166	-1.49205	0.13568593
rf (5)	0.004248065	0.020833001	0.20391	0.83842353
rf (6)	0.300406102	0.038879196	7.72665	0.00000000
rf (7)	0.015335859	0.017567027	0.87299	0.38266789
rf (8)	0.027482343	0.024920530	1.10280	0.27011434
rf (9)	-0.132577489	0.057636729	-2.30023	0.02143543
rf (10)	-0.070327186	0.125466808	-0.56052	0.57512192
rf (11)	0.068137793	0.052944615	1.28696	0.19810697
rf (12)	-0.099582510	0.075105750	-1.32590	0.18487372
rf (13)	0.043160125	0.145548204	0.29653	0.76682160
rf (14)	0.429661973	0.338376067	1.26978	0.20416426
rf (15)	-1.079863508	0.356091073	-3.03255	0.00242498
rf (16)	0.470682785	0.381247054	1.23459	0.21698412
rf (17)	-0.314446697	0.540141943	-0.58216	0.56046183
rf (18)	0.179410244	1.400195273	0.12813	0.89804427
rf (19)	-2.882021674	3.038127465	-0.94862	0.34281505
rf (20)	0.432349804	2.782360245	0.15539	0.87651419
rf (21)	0.060107260	0.818666406	0.07342	0.94147115
rf (22)	-0.014378841	0.024979601	-0.57562	0.56486981
rf (23)	-0.014501878	0.035929729	-0.40362	0.68649379
rf (24)	0.050031577	0.085636033	0.58424	0.55906215
rf (25)	-0.018690272	0.185794321	-0.10060	0.91987072
rf (26)	-0.058229622	0.176774281	-0.32940	0.74185263
rf (27)	0.070695484	0.056161868	1.25878	0.20810950
rf (28)	-0.010032715	0.007406399	-1.35460	0.17554474

Figure 1: Structural Factorization; Impulse Responses

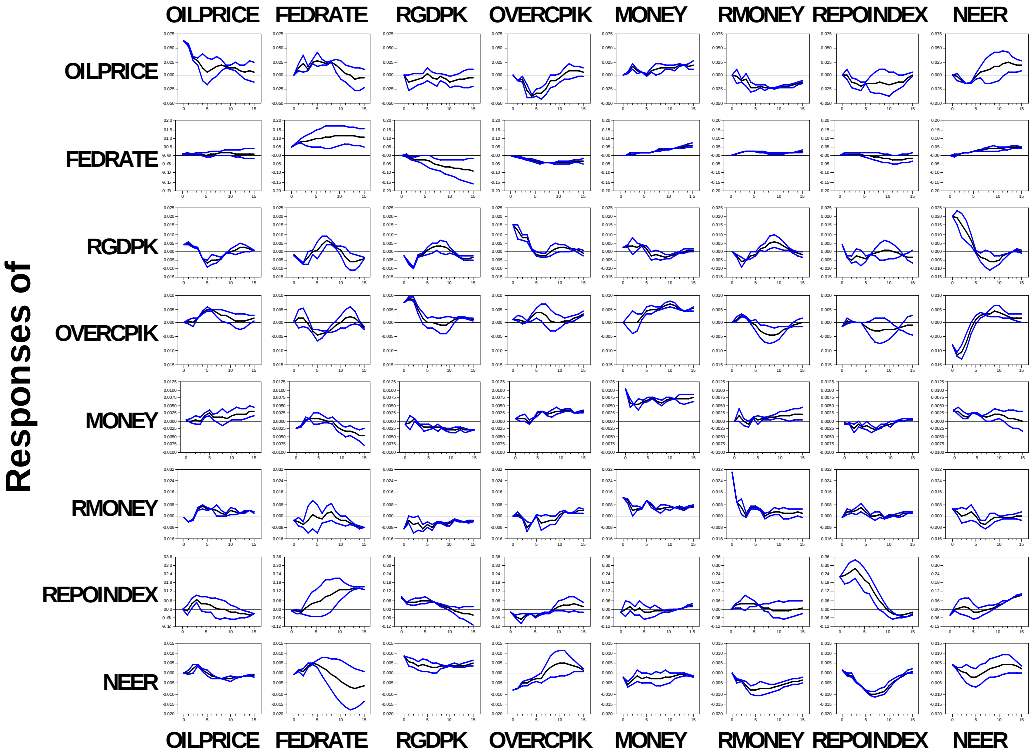


Figure 2: Structural Factorization; Impulse Responses

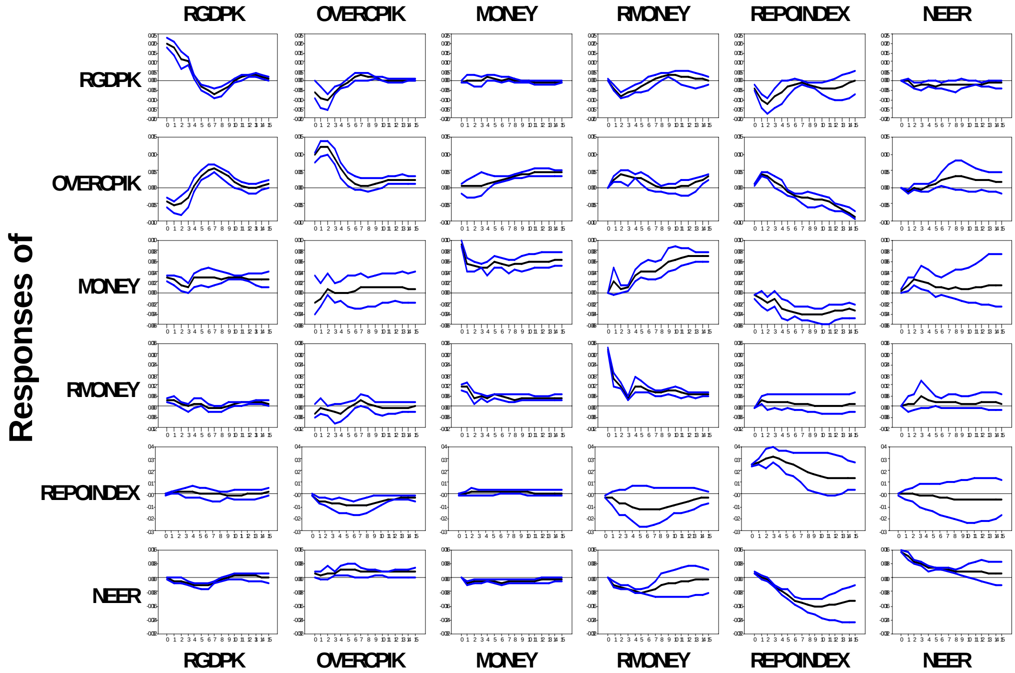


Figure 3: Recursive Factorisation Impulse Responses

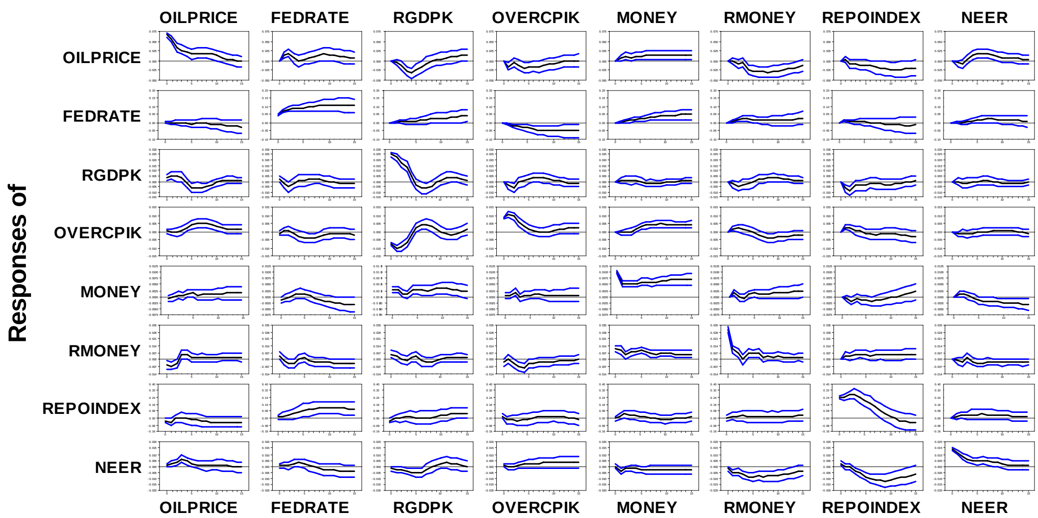


Figure 4: Recursive Factorisation Impulse Responses

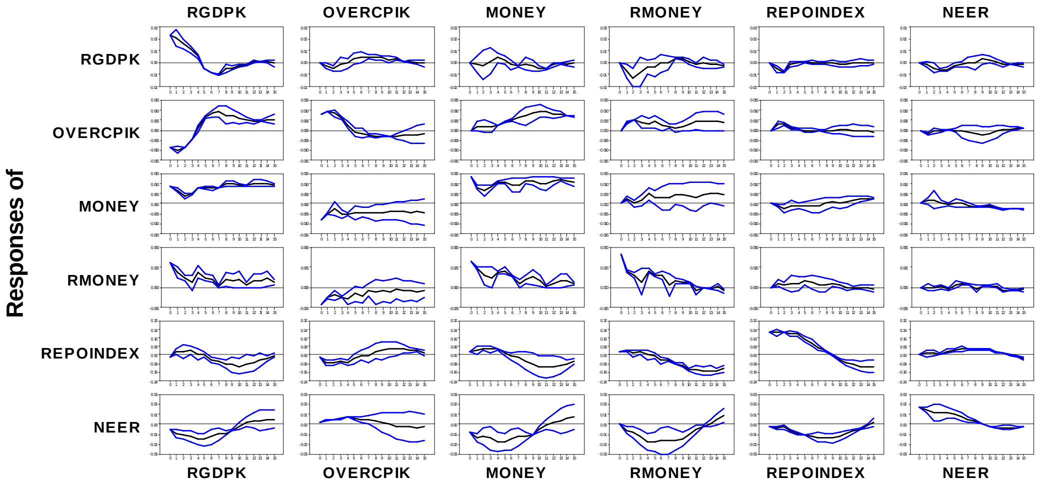
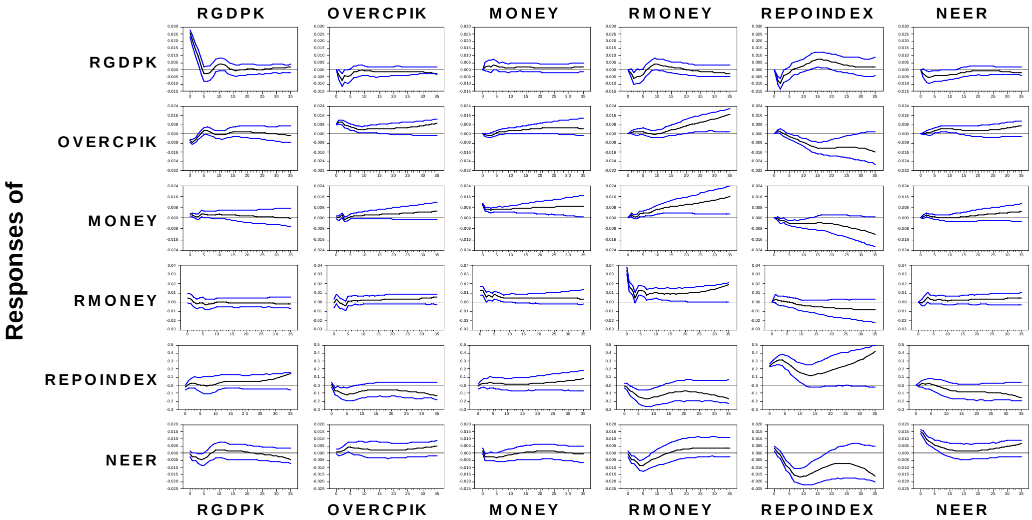


Figure 5: Recursive Factorization; Impulse Responses



Note: Recursive Factorization under the Benchmark Model when the estimation sample is 1998:02-2005:10

4.3 Variance Decomposition

The variance decomposition results are derived on the basis of the benchmark structural VAR model and they are presented in Tables 3 through 8. The results presented in Table 3 show the relative role of monetary policy shocks, among other shocks, in explaining the out-of-sample forecast error of inflation. Consistent with expectations, the money supply shocks' influence on inflation builds up over time starting with only 9% on impact the rising to 11% in the 10th month. The peak impact occurs in the 29th month beyond which it peters off. The bulk of the forecast error in inflation is however accounted for by real output shocks. On impact, real output shocks account for 34% of the forecast error. The role of the real output however diminishes steadily as the role of money supply increases. The bulky of the forecast error in inflation during the short run, within 12 months is accounted for by real output shocks. In the long run, money supply is important.

It is notable that world oil price shocks significantly influence inflation in 9 to 21 months. It generally accounts for 11% of the forecast error in inflation during the period. In the very long run, world financial market interest rates become increasingly crucial accounting for about 11% in the 24th month and builds up to 38% after 5 years.

It is also notable that inflation is predominantly self-driven as own innovations account 58% of its forecast error initially diminishing only gradually to 29% after 12 months.

Overall, real output and inflation shocks accounts for 92% of the forecast error in inflation a month ahead. Over 50% of the one year and two year ahead inflation forecast error is accounted for by real output and inflation shocks. The import of these results is that monetary policy was accommodative of money demand and by extension inflation.
Apart from own shocks, the forecast error in real output is largely explained by inflation and nominal interest rate shocks and hence real interest rate. The two factors account for 10% in the 12 months and 11% in the 24th month. See the results in Table 4.

The results in Table 5 confirm that money supply is predominantly driven by demand for money. Within a period of one year, the crucial money demand factors are real output and inflation. Thereafter, real interest rate differentials adjusted for exchange rate depreciation become increasingly important. This shows that over a long time horizon, money supply is driven by net capital inflows and this raises concern about the capacity that the CBK has in controlling money supply and inflation. As shown in the same table, reserve money shocks play a negligible role in determination of money supply and this diminishes the importance of reserve money as a monetary policy operating instrument. It therefore implies that an interest rate policy instrument will perform better than the reserve money. This is because interest rates have a capacity to influence net capital inflows, which account for the bulky of the money supply.

That the repo interest rate is potentially more useful as policy instrument than reserve money is demonstrated in the results in Tables 5 and 6. Reserve money is not entirely exogenous as it is driven by money supply, international financial market interest rates and the exchange rate. In contrast, it is shown in Table 6 that the repo rate is predominantly self-driven and hence more of an exogenous variable than reserve money is. It accounts for 95% and 40% of its own forecast errors over a period of one month and 60 months ahead, respectively.

The importance of the interest rate channel is re-enforced by the fact that real interest rate differentials account for much of the variation in the shilling exchange rate movements as shown in Table 7. The importance of the repo rate rises from a mere 4% in one month ahead to a peak of 44% 14 through 16 months ahead. The importance of the repo rate predominates the role of international financial market interest rates that account for only 16% of the forecast error of the shilling nominal interest rate from 32 to 43 months. Thus, monetary policy action in terms of the repo rate cannot be nullified by external financial market developments.

An important conclusion from these results is that the indirect exchange rate channel works more through the capital and financial account of the external balance of payments than through the traditional current account.

4.4 Transmission Lag

For lack of a clear cut measure of the policy transmission lag to inflation and real output, we conceptualized the transmission lag as coinciding with the period when the monetary policy shock exerts its largest impact on real output and inflation. The impact is measured in terms of the proportion of the forecast variance explained by the monetary policy shock.

Accordingly we plotted Figure 6 to show that the monetary policy transmission lag to inflation is 13 to 19 months when monetary policy shock is measured in terms of the repo rate. In this period, the monetary policy shock accounts for 4% of the inflation forecast error. In terms of reserve money, however, the transmission lag is much longer, 23 to 36 months during which monetary policy accounts for 17% of the inflation forecast error.

In contrast and consistent with expectations, the monetary policy transmission lag to real output is shorter than to inflation. As shown in Figure 7, it is 10 months whence reserve money shocks accounts for 4% of the real output forecast error. The largest proportion of the real output forecast error that is explained by the repo interest rate shock is 6% and sets in after 19 months. Consistent with the neutrality of money assumption, the proportion of the real output forecast error explained by money supply shock is negligible both in the short- and long-run time horizons.

Table 3:Decomposition of Variance for Series Real Output (OUTPUT)

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	reporate	neer
1	0.021509	2.291	0.000	94.293	1.278	0.000	0.000	0.644	1.493
2	0.029915	2.943	0.982	89.175	2.846	0.270	0.430	2.271	1.082
3	0.035123	2.637	2.846	81.344	4.777	0.553	1.974	4.650	1.218
4	0.037297	2.732	2.759	81.267	4.484	0.492	2.382	4.509	1.374
5	0.037697	3.060	2.726	80.444	4.406	0.491	2.625	4.903	1.345
6	0.038365	5.108	2.720	78.088	4.454	0.536	2.597	5.174	1.322
7	0.039307	6.486	2.783	76.102	4.662	0.956	2.646	5.049	1.317
8	0.040353	7.843	2.977	74.069	4.880	1.204	2.762	4.948	1.317
9	0.041079	8.807	3.088	72.247	5.001	1.541	3.085	4.960	1.272
10	0.041428	8.967	3.059	71.112	5.033	1.838	3.594	5.081	1.315
11	0.041630	8.924	3.040	70.476	4.987	1.936	3.906	5.271	1.460
12	0.041884	8.817	3.107	70.022	4.947	1.957	4.060	5.365	1.725
13	0.042177	8.755	3.318	69.575	4.955	1.930	4.128	5.365	1.974
14	0.042415	8.732	3.608	69.119	5.027	1.930	4.133	5.323	2.128
15	0.042566	8.731	3.865	68.716	5.106	1.955	4.132	5.288	2.207
16	0.042661	8.728	4.034	68.412	5.161	1.998	4.136	5.308	2.224
17	0.042757	8.703	4.105	68.240	5.184	2.032	4.138	5.382	2.216
18	0.042880	8.660	4.112	68.172	5.174	2.041	4.138	5.499	2.204
19	0.043018	8.610	4.094	68.164	5.149	2.034	4.136	5.621	2.192
20	0.043141	8.568	4.072	68.171	5.124	2.023	4.131	5.729	2.181
21	0.043230	8.547	4.058	68.158	5.107	2.015	4.125	5.818	2.173
22	0.043287	8.547	4.054	68.119	5.099	2.013	4.117	5.884	2.167
23	0.043324	8.562	4.061	68.057	5.100	2.015	4.110	5.932	2.164
24	0.043353	8.582	4.077	67.981	5.105	2.018	4.108	5.968	2.161
36	0.043659	8.552	4.117	67.165	5.066	2.511	4.242	6.041	2.306
48	0.044002	8.556	4.281	66.128	5.032	3.008	4.265	6.227	2.502
60	0.044270	8.601	4.548	65.339	5.128	3.253	4.229	6.275	2.627

Table 4: Decomposition of Variance for Series OVERCPIK

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	reporate	neer
1	0.009638	0.081	0.000	34.214	57.825	7.841	0.000	0.000	0.039
2	0.015897	0.080	0.465	37.652	51.722	7.312	0.596	1.645	0.526
3	0.019616	0.064	0.653	38.713	49.800	7.113	1.188	2.022	0.447
4	0.021121	0.362	0.597	39.662	48.880	6.703	1.359	1.822	0.615
5	0.021692	1.951	1.637	37.913	48.230	6.381	1.357	1.735	0.795
6	0.022564	4.857	3.303	36.203	45.218	6.624	1.287	1.680	0.828
7	0.023861	7.558	5.036	35.334	40.650	7.387	1.580	1.691	0.764
8	0.025232	9.852	6.117	34.424	36.440	8.409	2.348	1.727	0.684
9	0.026331	11.548	6.425	33.105	33.581	9.630	3.303	1.768	0.641
10	0.027104	12.401	6.320	31.643	31.985	10.902	4.286	1.830	0.634
11	0.027657	12.633	6.121	30.398	31.315	11.948	4.994	1.935	0.657
12	0.028136	12.505	5.920	29.444	31.179	12.685	5.461	2.106	0.699
13	0.028570	12.243	5.745	28.663	31.341	13.181	5.751	2.355	0.721
14	0.028969	11.982	5.607	27.890	31.628	13.563	5.918	2.702	0.710
15	0.029379	11.745	5.542	27.177	31.799	13.908	6.000	3.134	0.695
16	0.029871	11.510	5.600	26.690	31.662	14.210	6.013	3.579	0.736
17	0.030482	11.264	5.825	26.494	31.170	14.471	5.953	3.950	0.874
18	0.031192	11.004	6.234	26.470	30.433	14.731	5.835	4.187	1.106
19	0.031945	10.739	6.805	26.432	29.637	15.030	5.675	4.276	1.406
20	0.032686	10.478	7.494	26.238	28.933	15.385	5.488	4.246	1.739
21	0.033391	10.225	8.251	25.842	28.384	15.783	5.290	4.141	2.085
22	0.034064	9.984	9.043	25.277	27.983	16.184	5.091	3.999	2.439
23	0.034725	9.758	9.853	24.596	27.684	16.553	4.899	3.850	2.807
24	0.035396	9.549	10.686	23.847	27.427	16.866	4.720	3.708	3.197
36	0.046100	9.337	23.021	14.643	22.415	16.960	2.939	3.338	7.346
48	0.057434	10.474	31.901	9.449	20.642	14.381	2.016	3.315	7.822
60	0.068391	10.835	38.024	6.684	20.910	11.694	1.935	2.585	7.333

Table 5: Decomposition of Variance for Series MONEY

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	eporate	neer
1	0.008713	0.000	2.600	9.781	13.927	72.828	0.000	**0.009**	0.854
2	0.010257	0.003	2.729	13.669	12.914	67.724	2.178	**0.161**	0.622
3	0.011358	0.129	2.361	13.042	16.922	63.438	1.846	**1.640**	0.623
4	0.012164	0.152	2.353	11.880	15.703	65.754	1.831	**1.783**	0.543
5	0.013232	1.010	2.253	13.645	14.565	63.475	1.748	**2.180**	1.125
6	0.014549	1.847	1.944	14.090	14.054	60.701	1.850	**2.698**	2.816
7	0.015670	1.847	1.711	14.192	13.915	58.916	1.805	**3.284**	4.330
8	0.016660	1.948	1.821	14.330	13.994	57.057	1.758	**3.543**	5.549
9	0.017687	2.041	2.433	14.266	13.465	56.154	1.724	**3.487**	6.429
10	0.018862	2.132	3.328	14.486	12.660	55.120	1.704	**3.231**	7.338
11	0.020121	2.378	4.377	14.653	11.917	53.785	1.784	**2.866**	8.240
12	0.021370	2.643	5.451	14.466	11.283	52.816	1.805	**2.541**	8.996
13	0.022574	2.929	6.453	14.028	10.781	51.908	1.850	**2.319**	9.733
14	0.023772	3.261	7.391	13.363	10.404	50.990	1.945	**2.230**	10.416
15	0.024967	3.550	8.289	12.567	10.121	50.106	2.069	**2.259**	11.039
16	0.026161	3.815	9.196	11.745	9.942	49.102	2.204	**2.397**	11.600
17	0.027357	4.081	10.138	10.939	9.818	48.018	2.329	**2.615**	12.062
18	0.028560	4.351	11.106	10.191	9.711	46.901	2.422	**2.882**	12.436
19	0.029778	4.646	12.084	9.514	9.613	45.724	2.490	**3.179**	12.752
20	0.031009	4.963	13.060	8.903	9.526	44.533	2.525	**3.483**	13.008
21	0.032243	5.289	14.022	8.354	9.454	43.357	2.528	**3.782**	13.213
22	0.033470	5.620	14.961	7.855	9.408	42.207	2.505	**4.074**	13.370
23	0.034684	5.942	15.867	7.399	9.390	41.108	2.464	**4.351**	13.479
24	0.035878	6.248	16.737	6.979	9.407	40.064	2.409	**4.608**	13.547
36	0.048572	8.930	25.020	4.019	11.323	30.760	1.535	**5.527**	12.888
48	0.059989	10.178	31.370	2.785	13.948	24.622	1.094	**4.431**	11.571
60	0.072155	10.629	36.995	2.015	16.033	19.597	1.044	**3.359**	10.328

Table 6: Decomposition of Variance for Series RMONEY

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	reporate	neer
1	0.027682	0.000	0.000	2.265	0.004	11.667	83.088	0.000	2.977
2	0.030621	1.167	0.454	2.653	0.469	15.336	75.167	1.044	3.709
3	0.032041	1.382	2.458	2.424	0.960	15.973	71.168	1.308	4.327
4	0.033788	3.433	3.213	2.444	1.564	19.461	64.003	1.843	4.038
5	0.036146	5.403	2.826	2.199	2.892	22.632	57.263	2.698	4.087
6	0.037912	5.875	2.569	2.148	2.634	25.421	53.370	3.082	4.901
7	0.039084	5.939	2.499	2.349	2.482	26.953	51.252	3.171	5.354
8	0.039850	6.003	2.708	2.929	2.389	27.659	49.401	3.528	5.382
9	0.040575	6.112	2.888	3.196	2.314	28.283	47.787	3.962	5.458
10	0.041361	6.220	3.219	3.140	2.227	29.115	46.169	4.321	5.588
11	0.042171	6.387	3.697	3.023	2.147	29.578	44.598	4.658	5.912
12	0.042932	6.584	4.286	2.945	2.092	29.752	43.111	5.039	6.191
13	0.043660	6.779	4.880	2.884	2.040	29.807	41.713	5.460	6.437
14	0.044409	6.973	5.463	2.842	1.997	29.715	40.352	5.971	6.687
15	0.045152	7.124	6.001	2.794	1.991	29.573	39.083	6.496	6.938
16	0.045843	7.196	6.511	2.727	2.037	29.378	37.963	7.034	7.154
17	0.046478	7.229	6.990	2.655	2.133	29.119	36.977	7.575	7.322
18	0.047068	7.246	7.431	2.589	2.261	28.839	36.103	8.084	7.446
19	0.047622	7.260	7.834	2.530	2.417	28.551	35.319	8.531	7.558
20	0.048147	7.282	8.214	2.475	2.597	28.255	34.606	8.899	7.671
21	0.048640	7.318	8.586	2.426	2.792	27.967	33.954	9.179	7.779
22	0.049104	7.367	8.958	2.381	2.989	27.689	33.352	9.382	7.882
23	0.049546	7.431	9.332	2.343	3.184	27.427	32.788	9.518	7.977
24	0.049968	7.503	9.706	2.310	3.377	27.186	32.257	9.598	8.063
36	0.054170	8.449	13.721	2.030	5.651	25.411	27.486	8.889	8.362
48	0.058897	9.033	18.314	1.846	7.886	23.582	23.350	7.636	8.351
60	0.065026	9.411	24.046	1.575	10.133	20.828	19.297	6.444	8.266

Table 7: Decomposition of Variance for Series REPORATE

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	reporate	neer
1	0.193956	0.000	0.452	3.940	0.365	0.008	0.000	95.168	0.066
2	0.278895	0.060	0.516	2.327	0.603	1.612	0.583	94.257	0.042
3	0.357667	0.640	0.607	1.657	0.420	3.259	0.701	92.557	0.158
4	0.428491	1.387	0.984	1.168	0.638	3.619	0.897	91.162	0.144
5	0.477101	1.403	2.266	0.945	0.562	3.877	0.909	89.759	0.278
6	0.511938	1.297	3.878	0.842	0.511	3.723	0.956	88.359	0.434
7	0.535934	1.187	5.564	0.776	0.468	3.501	0.972	86.916	0.615
8	0.552566	1.154	7.721	0.731	0.451	3.308	0.985	84.848	0.802
9	0.564905	1.263	9.948	0.706	0.473	3.170	0.995	82.488	0.958
10	0.574995	1.495	12.121	0.751	0.506	3.094	1.010	79.958	1.064
11	0.584511	1.814	14.127	0.931	0.530	3.048	1.029	77.388	1.134
12	0.594313	2.160	15.870	1.321	0.534	2.998	1.047	74.916	1.154
13	0.604715	2.487	17.318	1.917	0.521	2.923	1.077	72.614	1.142
14	0.615557	2.774	18.506	2.619	0.503	2.826	1.118	70.539	1.115
15	0.626470	3.020	19.499	3.318	0.491	2.730	1.177	68.684	1.081
16	0.637135	3.226	20.363	3.920	0.495	2.660	1.261	67.028	1.047
17	0.647329	3.396	21.143	4.378	0.518	2.643	1.376	65.531	1.014
18	0.656972	3.531	21.859	4.696	0.564	2.696	1.525	64.145	0.985
19	0.666105	3.628	22.516	4.901	0.632	2.831	1.706	62.827	0.959
20	0.674784	3.689	23.104	5.027	0.722	3.054	1.914	61.554	0.936
21	0.683073	3.714	23.611	5.106	0.835	3.364	2.142	60.310	0.918
22	0.691036	3.709	24.028	5.158	0.969	3.758	2.381	59.090	0.906
23	0.698721	3.681	24.349	5.198	1.121	4.229	2.624	57.896	0.903
24	0.706169	3.636	24.578	5.231	1.286	4.766	2.864	56.731	0.908
36	0.783984	2.986	23.548	5.144	2.531	11.539	5.543	47.092	1.617
48	0.841596	2.642	21.403	4.871	2.489	15.142	7.654	43.183	2.617
60	0.882142	2.562	19.904	4.780	2.311	18.174	8.535	40.475	3.260

Table 8:Decomposition of Variance for Series NEER

Month	Std Error	oilprice	fedrate	output	overcpik	money	rmoney	reporate	neer
1	0.012028	0.356	0.280	0.024	1.565	0.000	0.000	3.802	93.973
2	0.016059	0.457	0.781	0.670	1.085	2.428	3.366	2.138	89.075
3	0.017998	1.570	0.894	1.140	0.870	2.740	5.527	1.818	85.442
4	0.020567	4.584	2.687	1.897	0.945	2.361	9.615	3.928	73.983
5	0.023325	4.176	4.188	2.945	1.305	2.948	14.922	7.045	62.471
6	0.026389	3.265	4.460	3.755	1.713	3.742	18.470	12.230	52.365
7	0.029250	2.826	3.902	3.930	1.824	4.430	19.377	17.821	45.889
8	0.031881	2.748	3.295	3.347	1.926	5.007	20.397	22.531	40.747
9	0.034293	2.792	2.886	3.049	1.982	5.468	20.887	26.424	36.512
10	0.036544	2.696	2.709	3.241	1.979	5.746	21.312	29.366	32.951
11	0.038441	2.569	2.696	3.828	1.938	6.010	21.553	31.266	30.141
12	0.039998	2.481	2.773	4.461	1.947	6.229	21.624	32.497	27.987
13	0.041204	2.463	2.956	4.832	2.004	6.459	21.563	33.293	26.430
14	0.042130	2.509	3.251	4.947	2.111	6.736	21.440	33.697	25.309
15	0.042846	2.605	3.633	4.900	2.255	7.039	21.254	33.827	24.486
16	0.043421	2.716	4.098	4.798	2.419	7.344	21.025	33.748	23.852
17	0.043898	2.800	4.640	4.697	2.582	7.649	20.764	33.529	23.338
18	0.044313	2.841	5.252	4.609	2.734	7.941	20.495	33.224	22.903
19	0.044691	2.841	5.930	4.535	2.864	8.219	20.229	32.861	22.520
20	0.045048	2.814	6.676	4.469	2.970	8.479	19.967	32.456	22.169
21	0.045399	2.773	7.481	4.412	3.053	8.714	19.708	32.021	21.838
22	0.045752	2.731	8.333	4.366	3.117	8.927	19.452	31.561	21.514
23	0.046110	2.692	9.209	4.337	3.167	9.121	19.199	31.085	21.190
24	0.046477	2.657	10.081	4.332	3.208	9.303	18.952	30.601	20.864
36	0.051105	2.485	16.189	5.408	3.496	12.241	17.385	25.339	17.456
48	0.055578	2.139	16.119	5.526	3.521	16.584	17.891	22.385	15.834
60	0.059314	2.012	14.766	5.282	3.237	20.196	18.033	21.362	15.113

Figure 6: Determining the Monetary Policy Transmission Mechanism Lag to Inflation

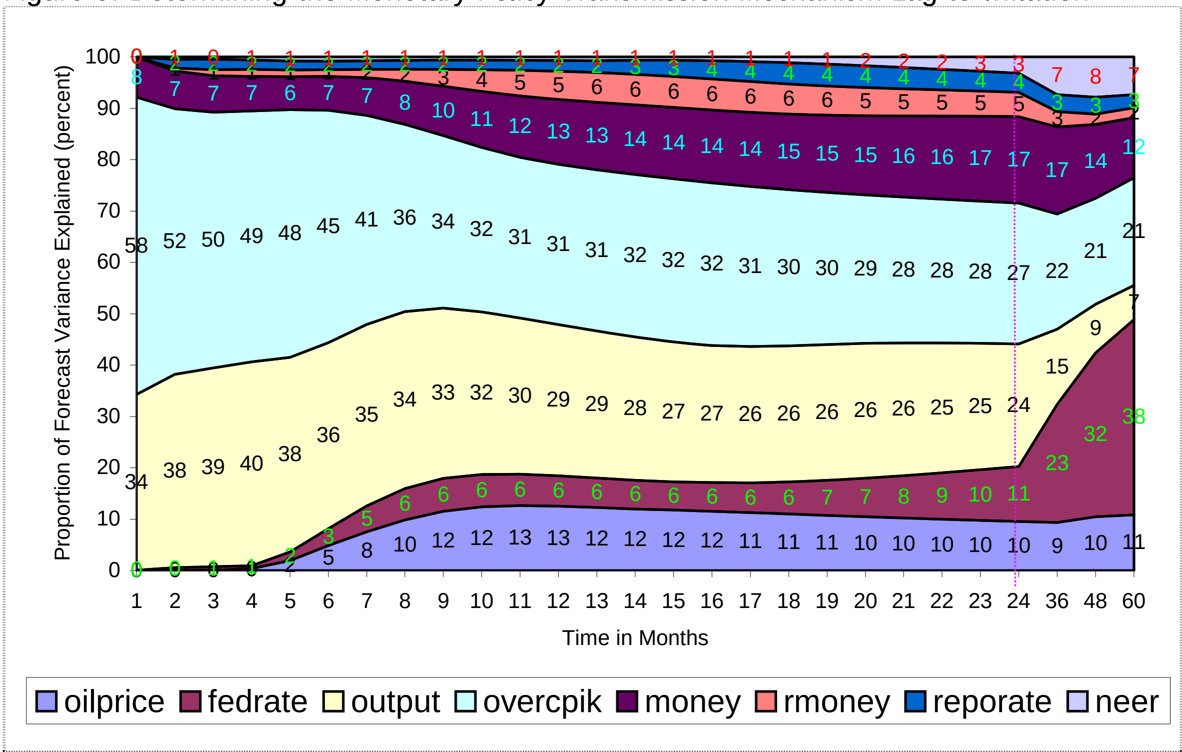
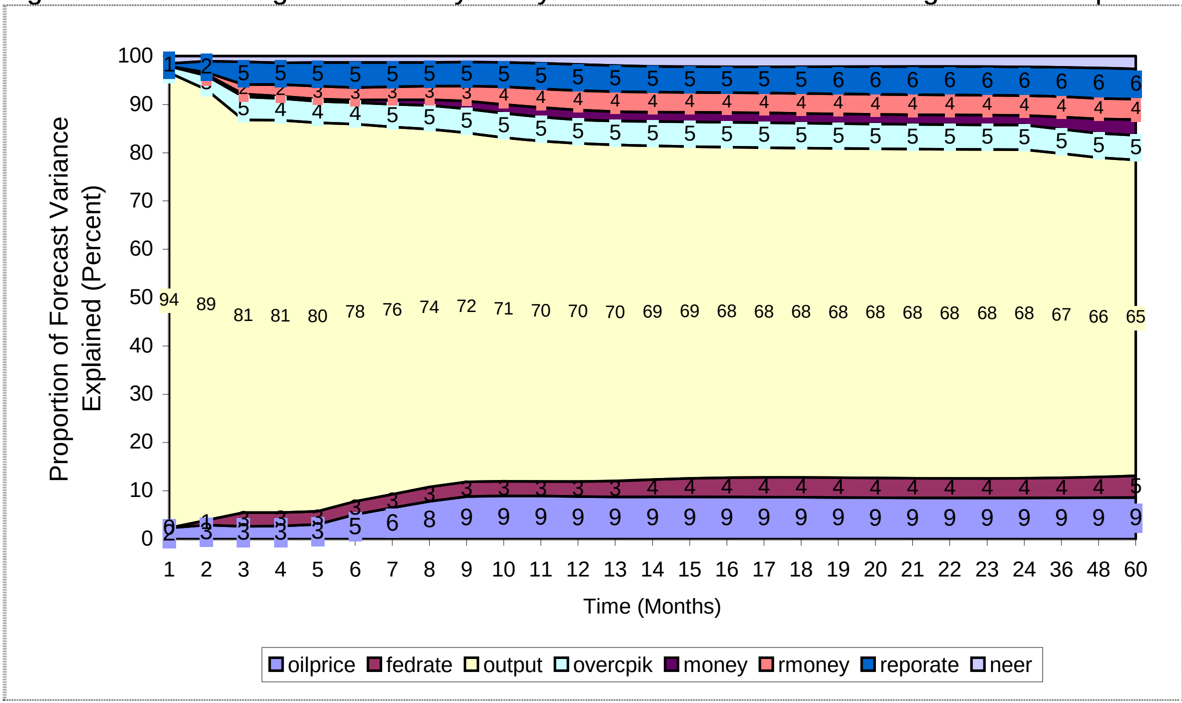


Figure 7: Determining the Monetary Policy Transmission Mechanism Lag to Real Output



5. Conclusions

This study has argued that for effective monetary policy management, it is imperative that a central bank tackles the monetary policy transmission mechanism problem by finding adequate answers to three basic questions, namely, what is the elasticity of inflation with respect to monetary policy shocks? What is the average amount of time taken for the full impact of a monetary policy shock on inflation to materialize? What are the channels of monetary policy transmission that are operational in the country?

Taking the view that these questions have not been addressed adequately in past studies within the Kenyan context, we confronted the monetary policy transmission mechanism problem using structural vector auto-regression analysis to adduce evidence that the monetary policy transmission lag to inflation is 13 to 19 months when monetary policy shock is measured in terms of the repo rate. In this period, the monetary policy shock accounts for 4% of the inflation forecast error. In terms of reserve money, however, the transmission lag is much longer, 23 to 36 months during which monetary policy accounts for 17% of the inflation forecast error.

In contrast and consistent with expectations, the monetary policy transmission lag to real output is shorter than to inflation. It is 10 months whence reserve money shocks accounts for 4% of the real output forecast error. The largest proportion of the real output forecast error that is explained by the repo interest rate shock is 6% and sets in after 19 months. Consistent with the neutrality of money assumption, the proportion of the real output forecast error explained by money supply shock is negligible both in the short- and long-run time horizons.

The results show also that while the traditional money channel has sustained some of its potency, the interest rate and exchange rate channels are unambiguously important channels of monetary policy transmission in Kenya. There is potential therefore for policy signaling using the repo interest rate and in so doing complimenting the overworked and hardly effective open market operations as a monetary policy instrument. In the whole, CBK should consider adopting an explicit inflation targeting policy operating framework.

References

Angeloni, I., A. Kashyap, B. Mojon and D. Terlizzese, 2002, "Monetary Transmission in the Euro Area: Where do we Stand?", European Central Bank Working Paper Series, Working Paper No. 114,

Baek, Ehung Gi , 1999, "Effects of Financial Uncertainty on the Korean Business Cycle," in Economic Papers, Vol. 2, No. 1, March, pg. 20-67.

Bank of England, (undated), "The Transmission Mechanism of Monetary Policy" prepared by the Bank of England staff for the Monetary Policy Committee in response to suggestions by the Treasury Committee of the House of Commons and the House of Lords Select Committee on the Monetary Policy Committee of the Bank of England. The report is available at www.bankofengland.co.uk.

Bernanke, B., 1983, "Non-monetary Effects of the Financial Crisis in the Propagation of the Great Depression," American Economic Review, June, pg. 257-276.

Bernanke, B., 1993, "How Important is the Credit Channel in the Transmission of Monetary Policy: A Comment", in Carnegie-Rochester Conference Series on Public Policy, Vol.39, (December), 47-52.

Bernanke, B., and M. Gertler, 1995, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission", in The Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn), 27-48.

Brzoza-Brzezina, M., (Undated), "Estimating the Natural rate of Interest: A SVAR Approach", Macroeconomic and Structural Analysis Department, National Bank of Poland and Monetary Policy Chair, Warsaw School of Economics.

Cho, S. and Kang, J., 1999, "The Impact of Monetary Policy on Bank Lending Behavior," in Economic Papers, Vol. 2 No. 1, March, pg. 1-19.

Cushman, D. O. and T. Zha, 1997, "Identifying Monetary Policy in a Small Open Economy Under Flexible Exchange Rates", Journal of Monetary Economics, 39, pg. 433-448.

Davidson, R., and J. G. Mackinnon, 1993, *Estimation and Inference in Econometrics*, Oxford University Press, Oxford.

Ferri, G., and T. S. Kang, (Undated), "The Credit Channel at Work: Lessons from the Republic of Korea's Financial Crisis".

Gerlach, S., and L. E. O. Svensson, 2003, "Money and Inflation in the Euro Area: A Case for Monetary Indicators?", Journal of Monetary Economics, Vol. 50, No. 8, pg. 1649-1672.

Guay, A., and F. Pelgrin, 2004. "The US New Keynesian Phillips Curve: An Empirical Assessment", Bank of Canada Working Paper 2004-35, September.

Keshyap, Anil K., Jeremy C. Stein and David W. Wilcox, 1993, "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance," *American Economic Review* 83, March, 78-98.

Keshyap, Anil K., Jeremy C. Stein and David W. Wilcox, 1996, "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance: Reply," *American Economic Review* 86 (1), March, pg. 310-314.

Kashyap, Anil K. and Jeremy C. Stein, 1994, "The Impact of Monetary Policy on Bank Balance Sheets," National Bureau of Economic Research (NBER) 4821, August.

Maturu, B.O., K Kethi and I. Maana, 2006, "A New Keynesian Phillips Curve for Kenya", Central Bank of Kenya Working Paper Series, Working Paper WP/06/02, at http://www.centralbank.go.ke/publications/swp/index.html.

Marques, C. R., P. D. Neves and L. M. Sarmento, 1999, "Evaluating Core Inflation Indicators," *Bank of Portugal Economic Bulletin* (December), pg. 39-48.

Meltzer, A., 1995, "Monetary, Credit and (Other) Transmission Processes: A Monetarist Perspective", in The Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn), 49-72.

Morris, C. S, and Gordon H. Sellon, Jr., 1995, "Bank Lending and Monetary Policy: Evidence on a Credit Channel," *Economic Review* 80 (2), Federal Reserve Bank of Kansas City, 59-75.

Peersman, G., and F. Smets, 2001, "The Monetary Transmission Mechanism in the Euro Area: More Evidence from VAR Analysis", *European Central Bank Working Paper Series*, Working Paper No. 91, (December).

Nualtaranee, J. (Undated), "Transmission of Monetary Policy: Literature Survey and Theoretical Discussion." Downloaded on 5th June, 2006 from http://wb-cu.car.chula.ac.th/papers/ransmission.htm.

Parrado, E., 2002, "Effects of Foreign and Domestic Monetary Policy in a Small Open Economy: The Case of Chile", Central Bank of Chile Working Papers, Working Paper No. 108.

Peersman, G., and F. Smets, 2001, "The Monetary Transmission Mechanism in the Euro Area: More Evidence from VAR Analysis", European Central Bank Working Paper Series, Working Paper No. 91, (December).

Ramey, V., 1993, "How Important is the Credit Channel in the Transmission of Monetary Policy? in *Carnegie-Rochester Conference Series on Public Policy*, Vol. 39, (December), pg. 1-45.

Ribon, S. 2004. "A New Phillips Curve for Israel", Bank of Israel Discussion Paper No. 11, October.

Sichei, M . M., 2005, "Bank-lending Channels in South Africa: Bank-Level Dynamic Panel Analysis", University of Pretoria Working Paper Series, Working Paper 2005-10 at www.up.ac.za/up/web/en/academic/economics/index.html.

Sims, C. A., 1980, "Macroeconomics and Reality", Econometrica 48, 1-48.

Woodford, M., 2005, "Firm-Specific Capital and the New Keynesian Phillips Curve", International Journal of Central Banking, Vol. 1, Number 2 (September), pg. 1-46.