INFLATION IN KENYA: AN EMPIRICAL ANALYSIS

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Abstract

The paper analyses the dynamics of inflation in Kenya by assessing the relative importance of monetary and external factors. This is done through a multivariate Granger-noncausality tests and the decomposition of the forecast error variance into variable specific innovations

Using Granger-noncausality tests the study finds that monetary base growth, exchange rate movements, real income growth, the foreign rate of inflation and interest rate movements have significant effects on inflation. The monetary base growth, interest rate' and exchange rate movements have strong feedback effects with inflation. This implies that a shock on any of this variables, including the rate of inflation will not peter out rapidly (not transitory) but will have permanent effects. Broad money, M3, on the other hand, is driven by inflation without feedback effects. These results point to the differential impact of the two money supply aggregates on the rate of domestic inflation.

Using variance decomposition, the exchange rate was found to be the most important variable accounting for half of the innovations in the price level. The paper thus concludes that exchange rate movements are more important than money supply growth in explaining Kenya's inflationary process.

1. Introduction

A review of the literature on inflation in Kenya reveals a striking similarity of conclusions drawn. Practically all studies are unanimous on the importance of both monetary and foreign factors (see Adongo, 1978, Killick,1984, Nganda,1985, Killick and Mwega, 1989, Kiptui,1989, Mwega,1990, World Bank, 1990, Barber, 1990, Chhibber, 1991 and Ndung'u, 1994). Killick(1984), for instance, states that "No single factor could be taken as the major cause of inflation in Kenya". Killick and Mwega(1989), on the other hand, conclude that "Despite variations in model tests, all studies in Kenya are unanimous in finding monetary expansion among the most important variables explaining inflation in Kenya". On a broader perspective, Chhibber(1991), analysing a group of African countries, argues that inflation emanates from four major sources:

I) Cost-push factors from discrete currency devaluations;
ii) Demand-pull forces when there is excess demand created by excessive credit expansion in the economy;
iii) Balance of payments crises, and,
iv) Controlled prices widely deviating from market prices and whose re-adjustment creates an inflationary shock.

In Ndung'u (1994) a monetarist model of inflation is estimated. The results showed that money supply growth (broadly and narrowly defined), interest rate changes, real income growth, lagged inflation and dummies were important in explaining movements in the rate of inflation in Kenya. This paper adds to the analyses by enlarging the information set, incorporating the foreign sector and hence get a more realistic model.

The purpose of this paper is to analyse the dynamics of inflation in Kenya for the period 1971-1995. We are, in particular, interested in the following questions: What is the relative importance of the monetary and the external factors in explaining inflation? Are there differences in impacts on inflation between changes in the exchange rate and foreign prices? Does the monetary base have a larger explanatory power, as often assumed, than a broad measure of money, like M3? What is the role of the interest rate?

We depart from earlier studies in two respects. First, unlike Mwega (1990), Killick and Mwega (1989) and others, we separate the influence of the foreign sector by having the exchange rate and foreign price level enter individually in the analysis. Second, by comparing the performance of the two different measures of money supply, we investigate which of them drives and is driven by the rate of inflation.

In analyzing these issues we first carry out multivariate Granger-noncausality tests (Granger 1969, 1980). There are very few studies on Kenya that have used this approach. Killick and Mwega (1989) report causality tests for money supply growth and the rate of inflation. They conclude that money supply causes inflation with no feedbacks. Canetti and Green (1991) use a three variable system; inflation, exchange rate changes and monetary expansion. They show that exchange rate changes and monetary expansion predict the rate of inflation with reverse effectcs.
Three aspects distinguish our study from the earlier ones. First, since all variables of interest are nonstationary, we use the Johansen approach to test whether they form stationary linear relations, that is, if the variables are cointegrated. Since we find cointegration, the cointegrating vectors are identified and included in the statistical model as error correction terms. The variables then enter the model in log-differences. When carrying out the Granger-noncausality tests for a particular variable, we consider that in addition to entering the model in rates of change, it is also part of one or several error correction terms. By following this procedure

we pay attention to the long run information in the data, get more efficient estimates and make sure that the standard distributions for statistical inference are valid since all variables are stationary (see Cuthbertson et al. 1992 pp 133, and Charemza and Deadman 1992, pp 143).

Second, we use the estimated vector autoregressive (VAR) model to decompose the innovations in the price level into portions that can be attributed to innovations in the other macroeconomic variables. This framework provides a basis for comparing the relative importance of the various factors that cause inflation.

Finally, in addition to the price level, the exchange rate and two measures of the money stock, we include the foreign price level, the treasury bill discount rate, and output in our study. By using an extended data set we reduce the risk of obtaining spurious results (see Surrey, 1989).

It is worth noting that noncausality tests are carried out in a VAR model. They can, therefore, be given (at least) two different interpretations. One interpretation is that a particular variable precedes another in time and thus Granger-causes it. In this study we use Granger-noncausality (GNC) to establish 'facts' about the data, after which competing models are formulated and estimated. The other interpretation is based on the fact that a VAR model can be viewed as an unrestricted reduced form related to several structural models (Spanos, 1990). Hence, by testing for Granger-noncausality it is possible to draw conclusions about the appropriateness of structural models used in the literature. For instance, if a variable is shown to Granger-cause another variable, that variable must enter as an explanatory variable, directly or indirectly, in the structural model (see Durevall, 1993).

The paper is organized as follows: Section two presents the logic behind the GNC tests, the problems likely to be encountered, and the solutions this study intends to adopt. Section three starts by outlining the data to be used in the analysis. The cointegration tests and the results are presented in subsection two. In subsection three the results of the GNC tests are reported. The section ends with the variance decomposition of the price level. The final section is devoted to a summary of the findings and the conclusions that can be drawn from the analysis.

2. Granger-Noncausality Tests

In carrying out the GNC tests, two rules are assumed to apply, that is; strict causality (in Granger's sense) can only occur with the past causing the present or the future, and it is only meaningful to analyse causality for a group of stochastic variables (see Harvey, 1990 and Maddala, 1988). The question asked in GNC tests is whether, with the relevant information, adding more information improves the predictability of some certain outcome. The initial information is usually composed of lags of the dependent variable. This can be illustrated by using nominal money supply, M, and the price level, P. We would like to use the GNC test to investigate the relation;

$$P_t = \sum_{i=1}^{k} \alpha_{1i} P_{t-i} + \sum_{i=1}^{m} \alpha_{2i} M_{t-i} + \eta_t \qquad ($$

From equation (1), the added information in predicting prices is contained in lagged values of money supply, M_t, and η_t is the error term, which is taken to be a white noise process. The significance of the α_i's can be tested using F-tests. If all the α_{2i}'s are identically zero, then the price level is predicted solely from its own past values and the stochastic component η_t. GNC test in the reverse direction can be tested by conditioning money supply on lagged prices. These investigations produce a series of F-statistics which may fall on one or two of the following outcomes; one variable Granger-causes another, both variables Granger-cause each other, that is there is feedback between them and finally, the variables do not predict each other (no Granger-causality).

There are several criticisms that have been raised against the GNC tests. First, the true data generating process (DGP) is generally unknown and additional information becoming available might lead to different F-statistic values so that the test statistic becomes sensitive to the information set used (see Maddala, 1988). There is no clear-cut solution to this problem. However, if the selection of variables is based on economic theory, the problem of the information set could be minimized drastically.

A second criticism centers on the possibility of getting spurious results because one variable might seem to Granger-cause another simply because it precedes it in time. For example, a third variable might drive both money and prices in equation (1), and one of them reacts faster than the other. If this were the case, erroneous conclusions would be drawn if analysis is confined to money and prices only. This problem can also be reduced greatly by expanding the information set and then testing for GNC tests in a multivariate setting (see Surrey, 1989).

Finally, the GNC tests have been shown to be sensitive to specification of the statistical model. These issues include the non-stationarity of the data, whether deterministic trends are included or not, and the lag length to be used in the analysis (see Geweke, 1984, Kang, 1985, Stock and Watson, 1989, among others). In this study the decision on the lag length will be determined by using autocorrelation tests on each equation, where we test whether the residuals are innovations for a particular lag length. The nonstationarity and the trend will be handled via the Johansen Procedure (Johansen, 1988, Johansen and Juselius, 1990). The Johansen Procedure tests for the number of cointegrating vectors in nonstationary time series, in a multivariate setting. If the variables of interest are cointegrated, it implies that there exist stationary linear combinations. This information helps us in determining when the standard critical values apply for the F-statistics. It should be noted that finding cointegration among a set of variables implies Granger-causality at least in one direction (Engle and Granger, 1987).

3. Empirical Implementation

3.1 The Data

The period of investigation covers 1971 through to 1995, using quarterly series. The variables of interest in this study include: the domestic price level; this is proxied by the (weighted) Consumer Price Index (P). The second variable is a measure of money stock. We use two measures of money supply, the monetary base, MB, (defined as currency held by the public plus the banks' liquid assets) and, M3, (which is composed of currency outside the banking system plus demand and time deposits and the deposits of the non-bank financial institutions).

These two money supply measures have different susceptibility to government control. This is reflected by the fact that in the 1970s and 1980s, there was a sudden increase of the Non-Bank Financial Institutions, (NBFIs), as a result of government's liberal policy of issuing licences. The NBFIs operate at the short end of the market, taking deposits, offering consumer finance, residential mortgages and business term loans, but are not allowed to transact in foreign exchange. The NBFIs were not subject to statutory reserve requirements, and could lend at higher rates than the commercial banks (see World Bank, 1992). This selective enforcement of monetary control instruments thus makes M3, which includes the deposits of NBFIs, less controllable than monetary base.

The World Bank(1990) argue in favour of using M3 in an inflation model. The interest rate used is the annualised Treasury Discount Rate (TR). Mwega(1990) has argued that since the treasury bills have been sold through a tendering system to the highest bidder, the relevant interest rate is the Treasury Discount Rate. This interest rate can, therefore, be taken as the best reflection of the money market conditions. Data for the above variables were collected from the Kenya Central Bureau of Statistics' annual publications and Central Bank of Kenya Quarterly and Annual reports. For the external sector we have calculated a multilateral nominal exchange rate index, in domestic currency, weighted by import shares of the major trading partners (EX)[1]. The foreign price is proxied by the wholesale price index of Kenya's main trading partners using the same weights as for the multilateral exchange rate (WP)[2]. Data for both variables were collected from the International Financial Statistics (lines ae for the exchange rate and lines 63 and 63a for the wholesale/industrial prices). Finally, the income series, (RY), used is gross national income which is GNP (from National Accounts) adjusted for terms of trade and interpolated from annual to quarterly series.

3.2 Cointegration Tests

The basic idea behind cointegration analysis is that although macrovariables may tend to move up or down over time groups of variables may drift together. If stationary linear relationships hold amongst a group of variables over time, then cointegration analysis helps us to find them. The analysis begins by specifying a general vector autoregressive, VAR, model, (see Johansen, 1988 and Johansen and Juselius, 1990);

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + \mu + \psi D_t + \epsilon_t, \qquad (2)$$

The import weights constructed are as follows: United Kingdom 23%, West Germany 12%, Italy 6%, Netherlands 5%, Japan 10%, United States and Oil price imports 40% (since oil prices are quoted in dollars and hence the bilateral exchange rate between say Iran or Saudi Arabia with Kenya do not determine the going oil prices)

Except in this case United States has a share of 9% and oil prices 31%.

where X_t is a vector of the variables of interest, μ represents a vector of constants, and D_t represents deterministic components, and ϵ_t is an independently identically distributed vector of residuals with zero mean and covariance matrix Ω. The vector X contains nonstationary variables, we assume that they are integrated of order one and thus become stationary in first differences. In order to obtain the long run, or cointegrating matrix, the VAR is rewritten as a reduced form error correction model:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \mu + \psi D_t + \epsilon_t, \tag{3}$$

where $\Pi = \Pi_1 + \Pi_2 + .. + \Pi_k - I$ and $\Gamma_i = \Pi_1 + \Pi_2 + \ldots + \Pi_i - I$ $i = 1, \ldots, k-1$; and I is an identity matrix.

The rank, denoted r, of Π, the long run matrix, defines the number of cointegrating relations in the data. The cointegrating relations are estimated as the eigenvectors corresponding to the r nonzero eigenvalues in the system. The statistical problem is to discriminate between the zero and the nonzero eigenvalues. This is done with a likelihood ratio test statistic for r which is given by the trace statistic;

$$Q_r = -T \sum_{i=r+1}^{p} \ln(1-\lambda_i) \tag{4}$$

where λ_i is the i^{th} estimated eigenvalue and T is the number of observations. The distribution of the test statistic can be found in Osterward-Lenum(1992).

Tables 1a and 1b report on tests for misspecification, these are essentially tests on the residuals from the equations, they are; the Box-Pierce Q test for autocorrelation, the Arch test for autoregressive heteroscedasticity, and the Jarque-Bera test for normality.

Misspecification Tests

Table 1a) With Monetary Base

EQUATION (3 lags)	BOX-PIERCE Q $\chi^2(17)$	ARCH TEST $\chi^2(2)$	NORMALITY TEST $\chi^2(2)$
ΔMB	15.80	2.68	1.15
ΔP	9.51	3.94	5.28
ΔRY	12.36	1.44	2.24
ΔTR	10.88	1.92	6.02
ΔEX	15.55	6.22	5.50
ΔWP	15.62	.84	7.31
95% Level	27.60	5.99	5.99

Table 1b) With M3

EQUATION (3 lags)	BOX-PIERCE Q $\chi^2(17)$	ARCH TEST $\chi^2(2)$	NORMALITY TEST $\chi^2(2)$
ΔM3	10.63	.54	.19
ΔP	9.91	1.45	11.45
ΔRY	25.74	.23	.51
ΔTR	10.12	.37	10.82
ΔEX	20.42	6.05	5.88
ΔWP	16.85	.007	11.67
95% Level	27.60	5.99	5.99

The misspecification tests follow a χ^2 distribution with the degrees of freedom given in the parentheses. The critical values at the 5% level are shown in the last row.

Except for the foreign price, interest rate and exchange rate equations in Table 1a and M3, domestic price, interest rate, exchange rate and the foreign price level in Table 1b where, respectively, the Normality test and the ARCH test are significant at the 5% level, the rest of the equations have statistics that are below the critical values. The most critical test is probably the Box-Pierce Q-test for autocorrelation, which is not significant in any equation. We proceed under the assumption that the residuals are a white noise process.

Table 2: **Cointegration Tests**

	MB	M3	
r=	T(r)	T(r)	TRACE TEST 95%
0	190.70	190.32	94.15
1	106.49	99.84	68.52
2	47.04	46.12	47.21
3	19.05	12.85	26.68
4	5.19	2.69	12.41
5	2.52	.160	3.76

In table 2 the trace statistics testing for the rank of the long run matrices and the 95% level critical values are reported. For both measures of money supply we find three cointegration vectors, that is r = 2. Table 3 reports the stationarity and exclusion tests, all of which follow a χ^2 distribution with 3 degrees of freedom. As can be seen from this table, when we use MB and M3 in the equations, respectively, all the variables are non-stationary. The exclusion tests show that all the variables are important in the cointegration analysis.

Table 4 reports on the final (restricted) cointegration vectors. The first vector is identified as a money demand relationship, where money, the domestic price level, real income and the interest rate cointegrate.

Table 3: Testing for Stationarity and Exclusion

VARIABLE (3 Lags)	STATIONARITY $\chi^2(3)$	EXCLUSION $\chi^2(3)$	VARIABLE (3 Lags)	STATIONARITY $\chi^2(3)$	EXCLUSION $\chi^2(3)$
MB	24.40	23.43	M3	25.59	30.24
P	21.69	40.00	P	21.85	33.74
RY	22.18	26.65	RY	23.53	31.44
TR	17.85	23.80	RR	22.12	25.96
EX	22.40	54.38	EX	23.13	50.18
WP	22.46	58.04	WP	24.51	76.31
95% Level	7.81	7.81		7.81	7.81

The second cointegrating vector consist of the domestic price level, the multilateral nominal exchange rate and the foreign price index. The third vector could not be identified, but shows a long run relationship between money, the price level and the rate of interest.

Cointegrating vectors using monetary base:

$ECM1 = MB_t - P_t - 1.8\ RY_t + 5.24\ TR_t$; [P-Value = .11]
α's (-.169) (.035) (.021) (-.047)

$ECM2 = EX_t - 1.513\ P_t + 1.73\ Wp_t$; [P-Value = .62]
α's (-.357) (.140) -

$ECM3 = MB_t - 2.01\ P_t + 5.24\ Tr_t$; [P-Value = .39]
α's (.007) (.017) (.030)

Cointegrating vectors using M3:

$ECM1 = M3_t - P_t - 1.95\ RY_t + 3.02\ Tr_t$; [P-Value = .88]
α's (-.132) (.013) (.080) (-.076)

$ECM2 = EX_t - 1.66\ P_t + 1.94\ Wp_t$; [P-Value = .80]
α's (.-296) (.043) -

$ECM3 = M3_t - 2.08\ P_t + 8.07\ TR_t$; [P-Value = .41]
α's (-.016) (.002) (-.035)

Tests for identifying restrictions on these vectors follow a χ^2 distribution, we report the probability values in the brackets. The α's are the corresponding error correction coefficients which show the short run speed of adjustment for the respective variables. The three cointegrating vectors are used to reparameterize our general model into an error correction form, which is shown as equation (5) below.

3.3 Granger Noncausality Tests

The statistical model to be estimated now involves all the variables in differences, the three error correction terms and dummies;

$$X_t = \delta_o + \sum_{i=1}^{3} \delta_{1i} \Delta P_{t-i} + \sum_{i=1}^{3} \delta_{2i} \Delta MB_{t-i} + \sum_{i=1}^{3} \delta_{3i}$$

$$+ \sum_{i=1}^{3} \delta_{4i} \Delta TR_{t-i} + \sum_{i=1}^{3} \delta_{5i} \Delta EX_{t-i} + \sum_{i=0}^{3} \delta_{6i} \Delta$$

$$+ \alpha_1 ECM1_{t-1} + \alpha_2 ECM2_{t-1} + \alpha_3 ECM3_{t-1} + \psi_i D_{it} + \varepsilon$$

where X_t = { ΔP, ΔMB(ΔM3), ΔTR, ΔEX }
We have used a number of dummies, D_i, which include three dummies for the exchange rate, corresponding to the three devaluations in 1973, 1975 and 1981. The price level has several dummies corresponding to 1975, 1981, 1982, 1990 and 1991. The 1975 dummy captures the effects of the first oil-price hikes and deterioration in the terms of trade in the period 1973-5. The 1981 and 1982 dummies catch the effects of deteriorating economic conditions, notably the scarcity of goods preceding and following the political turmoil in 1982, while the 1990/1 dummies cater for a multiplicity of factors. The interest rate and real income have one dummy each in 1983 and 1976, which, respectively cater for the interest rate shifts and the commodity boom. Money supply, M3, has two dummies in 1978, which reflect the effects of the commodity boom. The general model in (5) has the rate of inflation, money supply growth, interest rate and exchange rate changes alternating as dependent variables.

The GNC tests are reported in Tables 4a and 4b, with MB and M3 used in the statistical model, respectively. In these tables, the lower the probability value, the stronger the level of causation. Looking at the inflation equation, when we use the monetary base growth, there is a feedback effect between the rate of inflation and monetary base growth. That is the rate of inflation is seen to Granger-cause and to be Granger-caused by the monetary base growth. All the other variables are important in predicting the rate of inflation. The error correction terms, on the other hand, are seen to be important in predicting the rate of inflation. Monetary base growth, on the other hand, is predicted by the rate of inflation at 96.3%, real income growth at 94.5%, and interest rate changes at 95% while its own lagged values are also important (the probability values of other variables are interpreted in the same way). This equation, therefore, shows that the rate of inflation, interest rate changes and real income growth predict the monetary base growth while none of the other variables have any significant effect.

The interest rate equation, on the other hand, shows that it is solely predicted by the monetary base growth, the rate of inflation, real income growth, its own past values and the first and third error correction terms. There is a feedback effect between the monetary base growth and interest rate changes, on the one hand and the rate of inflation and interest rate changes, on the other. Exchange rate changes and the foreign rate of inflation do not predict changes in the rate of interest. The final equation looks at the exchange rate changes, where the domestic and foreign inflation rates are important, besides the past values of the exchange rate changes. The reverse causality between domestic rate of inflation and exchange rate changes is also strong.

Granger Non-Causality Tests

~~Table (4a) Using~~ Monetary Base (F-tests, Probability Values)

Dep.Var⇒	lags	ΔP	ΔMB	ΔTR	ΔEX
ΔP,ECM1,ECM2,ECM3	1-3	.009	.037	.000	.000
ΔMB,ECM1,ECM3	1-3	.021	.025	.000	.258
ΔTR,ECM1,ECM3	1-3	.006	.052	.000	.167
ΔRY,ECM1	1-3	.004	.055	.006	.164
ΔEX,ECM2	1-3	.000	.533	.207	.000
ΔWP,ECM2	0-3	.034	.374	.269	.000
ECM1	1	.016	.118	.002	-
ECM2	1	.000	-	-	.000
ECM3	1	.013	.330	.000	-

The tests show that the monetary base growth, real income and the interest rate do not predict exchange rate changes. The respective error correction term is also important in predicting exchange rate changes.

In Table 4b we compare the results with those in Table 4a, when M3 growth is used in the statistical model. The results are somewhat different. The rate of inflation is predicted only by real income growth and exchange rate changes. M3 growth is only predicted by the rate of inflation, real income growth and the first error correction term. Another different outcome is that changes in the rate of interest do not predict M3 growth, while M3 growth, the rate of inflation, real income growth and the third error correction term predict changes in the rate of interest.

Table 4b) Using M3 (F-tests, Probability Values)

~~Dep.Var⇒~~	lags	ΔP	ΔM3	ΔTR	ΔEX
ΔP,ECM1,ECM2,ECM3	1-3	.694	.002	.060	.000
ΔM3,ECM1,ECM3	1-3	.319	.233	.077	444
ΔTR,ECM1,ECM3	1-3	.334	.168	.001	.138
ΔRY,ECM1	1-3	.013	.021	.024	.178
ΔEX,ECM2	1-3	.009	.903	.561	.000
ΔWP,ECM2	0-3	.206	.598	.294	.000
ECM1	1	.731	.026	.943	–
ECM2	1	.107	–	–	.000
ECM3	1	.956	.868	.003	–

The rest of the results are the same as in those in Table 5a.

The GNC tests have established that the rate of inflation is affected by monetary base growth, interest rate changes and exchange rate changes with strong reverse effects. The feedback effects between the rate of inflation and interest rate changes are dependent on the measure of money supply used in the equations. Thus, while the monetary base growth is used, there is a feedback effect between the rate of inflation and interest rate changes, on one hand, and between the monetary base growth and interest rate changes, on the other. When M3 growth is used, interest rate changes do not affect, but are affected, by M3 growth. The rate of inflation affects M3 growth with no reverse effects. This shows that the two measures of money supply have different effects on the rate of inflation.

These results support those of Killick and Mwega (1989), where M3 growth is used. Our results are also similar to those of Canetti and Green (1991), in that the rate of inflation and exchange rate changes affect each other.

3.4 Dynamic Analysis

In this section we analyse the dynamics in the system of variables by computing variance decompositions. These are based on moving average representation, which expresses the current value of each variable as a distributed lag of past innovations in all the variables in the system plus the dependent variable's own innovations.

The analysis begins by specifying the non-deterministic part of the model which is of the form; (see Sims, 1980),

$$B(L)X_t = \mathbf{v}_t \qquad (6)$$

where X_t = { P, MB(M3), TR, EX, WP } and real income and the dummies form a set of deterministic variables in the system. B(L) is a 5×5 matrix with the lag operator L, $B_0=I$. The **v**s are the innovation process for X, with $E(\mathbf{v}_t\mathbf{v}'_t) = \Sigma$ and $E(\mathbf{v}_t\mathbf{v}_{t-i}) = 0$ for $i\neq0$. Once (6) is estimated, it is then inverted so that each variable is expressed as a linear combination of its own innovations and the lagged innovations of all other variables;

$$X_t = [B(L)]^{-1}\mathbf{v}_t \qquad (7)$$

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

$$\boldsymbol{\mu}_t = G\mathbf{v}_t \qquad (8)$$

Such that $G\Sigma G' = I$, where I is an identity matrix. This ensures that the innovations $\mathbf{v}_t$ will be mutually orthogonal. The orthogonalised residuals in (8) eliminate the covariances among the shocks to each explanatory variable, thereby isolating the relative impacts of each variable in the system. The problem that arises is that for a given Σ there is no unique way of choosing G, the orthogonalized moving average representation of the system. In this study, we adopt Sims recursive Choleski decomposition of Σ, where the matrix G is taken to be triangular with positive elements on the diagonal. The correlation matrices (in the appendix) shows that the correlations between the variables are low and hence may not alter the conclusions, if a different method of decomposition was adopted.

The decomposed forecast error variance (that is the difference between actual values of the variable and those forecast from known values of the system) is dependent on the parameters and actual innovations of the estimated reduced form model. Therefore, by decomposing the forecast error variance of the price level into the percentage contribution of the innovations in the explanatory variables, the relative influence of each on the domestic price level can be assessed. Since the variables in the system were found to be cointegrated, we perform the decomposition in log-levels in order to capture the long run dynamics which otherwise would have been lost if we instead used an error correction model and hence kept the cointegrating vectors constant. Asymptotically the estimation in log-levels is the same as the estimation of an error correction model (see Sims, Stock and Watson, 1990).

The results, using 48 quarters horizon, are summarised in Tables 5 and 6 when we use monetary base and M3 in the equations, respectively. Since the results might be sensitive to a particular ordering of the variables, we tried a number of combinations. The results were almost similar in that the largest portion of the forecast error in the price level was accounted for by the exchange rate followed by the rate of interest, monetary base and the foreign price, when we use monetary base in the system. When M3 is used in the system, the results were the same except that M3 and the rate of interest switch position. We therefore report the ordering where the foreign price level was put first[3] followed by money supply, the exchange rate and interest rate, and the price level was put last.

In table 5 the price level accounts for 79% of its own innovations in the first quarter, which declines drastically to 59% in the fourth quarter and further to less than 5% by the 30th quarter. The exchange rate, on the other hand, accounts for only about 7% of the innovations in the price level in the first quarter, which increases to 10% in the 4th quarter. By the 30th quarter, the share rises to 43% and to about 52% by the end of the simulation period, 48th quarter.

The second most important variable in accounting for the forecast error in the price level is the rate of interest followed by the monetary base and the foreign price level. The proportion of the foreign price level rises from 5% in the first quarter to 25% in the 12th quarter, but declines drastically thereafter. By the end of the simulation period, the price level accounts for only about 3% of its own innovations, the rest being shared out by the exchange rate, 52%, interest rate, 28%, monetary base about 10% and the foreign price level about 7%.

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3 The foreign price was always put first in any of the orderings tried, it was assumed to be weakly exogenous. In the equation formulation, the foreign price level was made to depend only on its own lagged values.

Table 6 shows slightly different results when instead we use M3 in the analysis. The price level accounts for over 80% of its own innovations in the first quarter, which declines to 69% in the 4th quarter. By the 30th quarter this proportion has declined to 13%.

Table 5 Using Monetary Base in the Equations

STEPS	WP	MB	EX	TR	P
1	5.33	7.23	7.92	.28	79.24
4	4.25	7.53	10.71	17.57	59.95
8	21.25	4.32	12.82	44.72	16.88
12	25.28	4.70	22.62	34.55	12.84
16	24.80	6.79	27.50	31.36	9.55
20	22.65	7.07	31.54	31.68	7.06
24	19.00	8.08	37.81	28.97	6.13
30	12.91	9.14	43.18	30.08	4.69
36	8.91	9.96	48.23	28.99	3.91
42	6.83	10.32	50.59	29.01	3.25
48	6.74	10.50	51.75	28.18	2.83

The exchange rate, on the other hand, accounts for 14% of the innovations in the price level in the first quarter. This proportion increases to about 16% in the 4th quarter, to about 47% in the 30th and to 48% at the end of the simulation period. M3 accounts for the second largest proportion of the forecast error in the price level. This proportion increases from about 10% when we use monetary base to about 19% when we use M3. Similary, the proportion of innovations accounted for by the rate of interest declines from 28% when we use monetary base to 14% when we use M3 in the analysis. By the end of the simulation period, the price level accounts for only about 9% of its own innovations, the rest are shared out by the exchange rate. 48%, M3 19%, the rate of interest, 14% and the foreign price level at 10%. In both cases involving the monetary base and M3, the price level was weak in accounting for its own innovations.

Table 6 Using M3 in the Equations

STEPS	WP	M3	EX	TR	P
1	.96	1.44	14.06	1.80	81.74
4	.63	9.54	16.49	4.01	69.33
8	18.13	4.84	19.34	25.10	32.40
12	21.79	6.11	27.07	18.63	26.40
16	18.87	9.07	33.29	17.18	21.58
20	15.15	11.12	38.38	17.40	17.95
24	11.06	14.24	43.01	15.94	15.76
30	6.78	16.93	47.23	15.79	13.27
36	5.84	18.52	49.07	15.00	11.57
42	7.32	18.94	49.03	14.39	10.31
48	10.04	18.83	48.02	13.71	9.40

In Tables 8 and 8a (in the Appendix) we report results when we the ordering is reversed. That is when the price level is put after the world price level, followed by money supply, exchange rate and the rate of interest is put last. This is intended to test the robustness of the results in Tables 5 and 6.

In Table 8, the results when we use the monetary base in the equations are reported. We see that except for the increase in the proportion for the price level, accounting for about 8% of its own innovations, which is higher than that of the foreign price level, the rest of the results were not drastically changed. The order of importance in accounting for innovations in the price level for other variables was maintained. That is the exchange rate accounted for the largest portion followed by interest rate and the monetary base. In Table 8a, the results for M3 in the equations are reported. The largest portion of the forecast error in the price level is still accounted for by the exchange rate followed by M3. However, the results are slightly reversed for the other variables. The price level now accounts for 19% of its own innovations at the end of the simulation period, followed by the rate of interest with about 16%, and finally the foreign price level at 10%. Even though the price level accounts for a slightly increased share of its own innovations when the order is reversed, this does not alter the previous conclusions.

4 Conclusions

The objective of this chapter was to investigate the relative importance of monetary and foreign factors in explaining Kenya's inflation. It was also intended to asssess the explanatory power of the monetary base compared to that of a broader money supply definition, M3. The investigations used both the Granger-noncausality tests and the variance decomposition.

Using GNC tests, it was found that the monetary base growth, exchange rate changes, real income growth, interest rate changes, the foreign rate of inflation and the error correction terms all have significant effects on the rate of inflation. The monetary base growth, interest rate and exchange rate changes were found to have strong reverse effects with the rate of inflation. This implies that a shock to any of these variables will be transmitted back and forth to the rate of inflation and will thus have lasting effects on the rate of inflation, that is, the observed rate of inflation will be an accumulation of shocks that have had permanent effects. Similary a shock on the rate of inflation will have permanent rather than transitory effects. M3 growth, on the other hand, was found to be affected by the rate of inflation, with no reverse effects. This result points to the differential impact on inflation of the the two money supply measures. Using variance decomposition of the price level, the exchange rate was found to be the most important variable accounting for half of the innovations in the price level.

In summary, we find that the exchange rate is more important than monetary factors in explaining Kenya's inflationary process. From a policy perspective, this implies that the exchange rate management is crucial in stabilizing domestic prices. This is particulary important when the exchange rate ceases to play the role of a norminal anchor that can tie prices down. There is need to establish an anchor that can control price movements. One such candidate is exchange rate targeting (or an exchange rate band). Given our results, it is unlikely that inflation can be stabilized with a flaoting exchange rate in operation, which at times is influenced by factors outside the fundamentals and furthermore would require appropriate accompanying monetary and fiscal policies. Currently, fiscal adjustment has been the most problematic to achieve and the most fragile of the structural adjustment policies. Part of the problem has been debt overhang and internal shocks hitting the economy. Monetary expansion will reflect this underlying fiscal pressure. This paper is thus pessimistic that the combination of monetay and fiscal policies alone can create a favourable environment of price stability currently. In addition, since the liberalization steps taken in 1993, the recurring policy pronouncements has been to target real exchange rate, low inflation and conduct a strict monetary stance. However, these targets do not have an equal number of instruments, thus unachievable. This strengthens the argument of a nominal anchor.

APPENDIX: Tables

Table 7 Correlation Matrix (MB)

	P	TR	MB	EX	WP
P					
TR	.059				
MB	–.283	.074			
EX	.268	.063	.090		
WP	–.102	.029	.093	–.109	

Table 7a Correlation Matrix (M3)

	P	TR	M3	EX	WP
P					
TR	.090				
M3	–.120	–.273			
EX	.356	.034	.183		
WP	–.080	.005	.003	–.186	

Table 8 Responses to the Price Level in Reverse Order

STEPS	WP	P	MB	EX	TR
1	5.33	94.67	.00	.00	.00
4	4.25	77.90	.44	1.92	15.49
8	21.25	23.49	4.35	7.55	43.36
12	25.28	19.35	6.32	15.61	33.44
16	24.80	15.22	9.85	19.79	30.34
20	22.65	12.37	10.70	23.55	30.73
24	19.00	11.71	12.65	28.62	28.03
30	12.91	10.33	14.57	33.09	29.11
36	8.91	9.77	16.13	37.18	28.00
42	6.83	9.15	16.84	39.16	28.01
48	6.73	8.70	17.22	40.13	27.20

Table 8a Responses to the Price Level in Reverse Order

STEPS	WP	P	M3	EX	TR
1	.96	99.04	.00	.00	.00
4	.63	89.12	4.73	2.10	3.42
8	18.13	42.84	2.63	7.99	28.42
12	21.79	37.95	6.16	12.58	21.52
16	18.87	32.76	10.81	17.25	20.31
20	15.15	28.78	13.85	21.50	20.72
24	11.06	26.76	17.91	25.03	19.23
30	6.78	24.09	21.39	28.60	19.14
36	5.83	22.16	23.41	30.46	18.27
42	7.32	20.51	23.95	30.67	17.56
48	10.04	19.18	23.80	30.23	16.75

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