Impact of Selected Macroeconomic Indicators on Inflation in Kenya

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Abstract: Price inflation has continued to manifest itself on the macroeconomic scene becoming an area of concern to many policy makers. This study analyzes the impact of money supply, exchange rate, oil prices and interest rate on inflation using Vector Error Correction Model and monthly data for the period 2003-2013. Johansen Co-integration Analysis was conducted to establish the presence of cointegration. Causality between the variables was ascertained using Granger causality tests. According to the VECM model estimated, all the variables except exchange rate have positive and significant effects on the fluctuation of the Consumer Price Index (CPI) in long run. Considering the short run effects of these variables on inflation, only interest rate and money supply are statistically significant. In reference to granger causality, it was observed that changes in CPI granger cause changes in crude oil prices and changes in interest rates granger cause changes in CPI. On the basis of the findings, the study concludes that inflation in Kenya is triggered by both demand and supply side factors but crude oil prices and money supply are most critical. Several policy implications have been provided to mitigate the effects of interest rate, exchange rate, oil price shocks and money supply on inflation.

Keywords: Inflation, Vector Error Correction Model, Causal relationship, Interest rates, money supply.

1. Introduction

Inflation is a complex economic phenomenon that still has extensive attention of macroeconomists, policymakers and central bankers in both developing and developed countries. It is also a main subject of the macroeconomics and one of the principal concerns of the policymakers and the public. The three major explanations of inflation include fiscal, monetary, and balance of payments aspects (Sargent, 1982). Inflation is a major macroeconomic indicator in the Kenyan economy. A study done by Ndung’u reported that during the 1970s, and the first half of the 1980s, average inflation was fairly stable, although there were large fluctuations between the quarters. Around 1986 a change occurred when both its level and variance decreased markedly. Inflation then slowly rose again, and in the beginning of the 1990s it had returned to its pre-1986 level. During 1992 inflation was hit by several shocks raising it to over 30% per year. In the beginning of 1994 it declined abruptly, probably as a consequence of the stabilization programme, and there was actually a period of deflation (Ndung’u, 2001).

Kenya is still experiencing swings in inflation even in the recent years. Inflation accelerated from 3 percent at the beginning of 2007 to 16 percent by mid 2008, and after having fully reversed by mid 2010, climbed again to almost 20 percent by end 2011 as indicated in figure 1.2. This was due political crisis that followed the December 2007 general elections, the significant impact of sharp oil price fluctuations on domestic prices, and the impact of the global financial crisis that initially dampened Kenya’s external demand, curtailing export growth, tourism receipts, remittances and private capital flows. To curb the inflation crises the government increased central bank lending rate in 2011 hence reducing money supply and inflation (Andrew et al, 2013).

Given the advances in the econometrics methodology, different methods of analyses have yielded different results. Therefore, there was need to understand how these macroeconomic variables impact on inflation which required an understanding of the links among these macroeconomic variables. Hence, the study embarked on bridging this knowledge gap by exploring the relationship between interest rate, crude oil prices, money supply and exchange rate and to what extent they affect inflation.

2. Previous Research

Ndung’u (1993) estimated a six-variable VAR (money supply, domestic price level, exchange rate index, foreign price index, real output, and the rate of interest) in an attempt to explain the inflation movement in Kenya. He observed that the rate of inflation and exchange rate explained each other. A similar conclusion was also reached in the extended version of this study (Ndung’u 1997).

Ndung’u (1999) analyzed the dynamics of inflation in Kenya during 1974-1996, a period characterized by external shocks and internal disequilibrium. Using the error-correction model, he found that the exchange rate, foreign prices and terms of trade have long-run effects on inflation while the money supply and interest rate only have short run effects.

Odusola and Akinlo (2001) use a six variable VAR (official exchange rate, parallel exchange rate, prices, income, money supply and interest rate) for Nigeria and reveals that positive shocks of official exchange rate are followed by significant increase in prices. Berument and Pasaogullari (2003) estimate several VAR models for Turkey and found that the real exchange rate movements are an important factor in the variability of output and inflation.

Nguyen and Seiichi (2007) examined the impact of real depreciation on economic performance in Vietnam using
VAR approach, the study shows that devaluation shock may affect inflation and output growth via raising money supply and improving balance of trade. However, the real exchange rate changes do not have significant effect on output in the long run.

Akpan (2009) analyzed the relationship between oil price shocks and the Nigerian economy using the VAR approach. The study pointed out the asymmetric effects of oil price shocks; for instance, positive as well as negative oil price shocks significantly increase inflation and also directly increases real national income through higher export earnings, though part of this gain is seen to be offset by losses from lower demand for exports generally due to the economic recession suffered by trading partners.

Alain (2012) carried out a study to identify the main factors underlying inflation in Uganda; he used a single equation Error Correction Model (ECM) based on the quantity theory of money including both external and domestic variables. Over the long run, monetary aggregate, world food prices, and domestic supply and demand effects in agricultural sector are main determinants of inflation in Uganda. While money growth, world food prices, and energy prices, combined with domestic food prices have short term impact on inflation.

3. Material and Methods

3.1 Data Collection

The study used secondary data for time series analysis on the macroeconomic factors that affect inflation in Kenya. Sources of reliable data on these variables included government sources and reliable international sources like CBK and KNBS. Inflation was measured by Consumer Price Index (CPI), interest rate was measured by 91 days Treasury Bill Rate, money supply was measured by M2, Foreign exchange rate was measured in Kenya Shilling to US dollar nominal Exchange rate and oil prices was given by crude oil prices.

3.2 Theoretical Framework

According to Mishkin (1996)

\[ M \downarrow \Rightarrow r \uparrow = I \downarrow = Y \uparrow \]

The schematic diagram is a representation of how a monetary tightening is transmitted to the real economy. Where \( M \) indicates a contractionary monetary policy, leading to a rise in real interest rates \( r (\uparrow) \), which in turn raise the cost of capital thereby causing crowding out of local investments, \( I (\downarrow) \) thereby leading to a decline in aggregate demand and a fall in output \( Y (\uparrow) \)

\[ MV = PY \]

Classical economists by the name of Irvin fisher came up with a relationship between quantity of money to nominal income.

Where: \( M \) = Quantity of money
\( P \) = Price level
\( Y \) = Real output=real income
\( V \) = Velocity

Working on the assumption that \( Y \) is at full employment and that \( V \) is constant in the short run,

\[ MV = pY \]

The equation above now states that, a change in \( M \) will cause an equal change in \( P \).

\[ M = \left( \frac{1}{v} \right)PY \text{ assuming that } \frac{1}{v} = \text{ a constant represented by } k \]

and that when the money market is in equilibrium, \( M = M_d \) and so, our equation becomes:

\[ M_d = kPY \]

With the Keynes model of money demand, as demand for real quantity of money (real balances) i.e.,

\[ \frac{M_d}{P} = f(i, Y) \]

In equilibrium, supply of real money balances is equal to demand of real money balances

\[ \frac{M_d}{P} = \frac{M_d}{P} = f(i, Y) \]

but with inclusion of some other variables such as Tb rates, exchange rates crude oil prices and gdp or income(Y) it becomes

\[ \frac{M_d}{P} = f(Tb \text{ rates}, \text{ crude oil prices, exchange rate and GDP}) \]

The monetarist views inflation as always and everywhere a monetary phenomenon (Friedman 1963). Further, macroeconomic theory proposes that growing the money supply in excess of real growth causes inflation. This is also the result from the Friedman model, which assumes “that prices adjust to excess money supply in the money market.” It is on the basis of this assumption that it is possible to invert the real money demand equation as a price equation:

\[ P = f(M, y, i) \]

Where \( P \) is the price level, \( M \) is the nominal money supply, \( y \) is real GDP, and \( i \) is the nominal interest rate.

Therefore,

\[ P = f(Int, Exe, Cap, m2) \]

Where:

\( P \) = dependent variable (CPI)
\( Int \) = independent variable (exchange rate)
\( Exe \) = independent variable (interest rate)
\( m2 \) = independent variable (money supply)
\( Cap \) = independent variable (crude oil prices)

3.3 Model Specification

This study has used the Augmented Dickey–Fuller (ADF) which attempts to retain the validity of test based on white noise errors in the regression model by ensuring that the errors are indeed white-noise. The ADF test the null hypothesis that \( |\beta| = 0 \) against an alternative that \( |\beta| < 0 \) in the autoregressive equations:

1. ADF without intercept and trend

\[ \Delta y_t = \rho y_{t-1} + \delta \Delta y_{t-1} + \epsilon_t \quad \text{(3.2)} \]

2. ADF with an intercept but no trend

\[ \Delta y_t = \alpha + \rho y_{t-1} + \delta \Delta y_{t-1} + \epsilon_t \quad \text{(3.3)} \]

3. ADF with both intercept and trend

\[ \Delta y_t = \alpha + \rho y_{t-1} + \delta \Delta y_{t-1} + \epsilon_t \quad \text{(3.4)} \]
(Dickey and Fuller, 1979).

Cointegration test was used to identify equilibrium or a long-run relationship among the variables. The Johansen and Juselius (1990) approach was based on maximum likelihood estimates and gives maximum Eigen Value and Trace Value test statistics for detecting number of cointegration vectors. This procedure provides framework for cointegration test in the context of vector autoregressive approach. Johansen method is explained as follows:

\[ X_t = \delta_0 + \sum_{i=1}^{k} \delta_i X_{t-i} + \varepsilon_t \]  

(3.5)

Where \( \delta_0 \) is an \((n \times 1)\) vector of constants, \( X_t \) is an \((n \times 1)\) vector of non stationary I(1) variables, \( k \) is the number of lags, \( \delta_i \) is a \((n \times n)\) matrix of coefficients and \( \varepsilon_t \) is assumed to be a \((n \times 1)\) vector of Gaussian error terms.

According to Engel and Granger (1987), if the variables are integrated of order I(1) and are cointegrated, then there must exist at least one way causation. If the variables are cointegrated, the existence of an error-correction representation may take the following form:

\[ \Delta Y_{t} = \alpha_0 + \sum_{i=1}^{k} \alpha_i (i) \Delta Y_{t-i} + \sum_{j=1}^{k} \alpha_j (j) \Delta Y_{t-j} + \delta ECM_{t-1} + \varepsilon_t \]  

(3.6)

\[ \Delta X_{t} = \alpha_0 + \sum_{i=1}^{k} \alpha_i (i) \Delta X_{t-i} + \sum_{j=1}^{k} \alpha_j (j) \Delta X_{t-j} + \gamma ECM_{t-1} + \varepsilon_t \]  

(3.7)

where ECM explains the error-correction mechanism term and \( \alpha_0, \alpha_i, \gamma \) are constant terms. This ECMt-1 is the one period lagged value of the estimated error of the cointegration regression obtained from OLS (Ordinary Least Squares) estimation. The logic behind this model is that generally a long-run equilibrium relationship between two economic variables exists. But, in the short run there can be disequilibrium. Therefore, the error correction mechanism corrects a proportion of disequilibrium in the next period. So, the error correction process is an instrument of reconciling short-run and long-run behavior. In the error correction model \( \Delta X_t \) and \( \Delta Y_t \) are the short-run dynamic coefficients and \( \delta, \gamma \) is the long-run coefficient, \( \varepsilon_t \) are white-noise residuals. The absolute value of \( \delta, \gamma \) determines how quickly the equilibrium is restored.

The reported result in table 4-1 reveals that the hypothesis of a unit root can’t be rejected in all variables in levels. However, the hypothesis of a unit root is rejected in first differences at 0.05 level of significant which indicates that all variables are integrated of degree one. That means all the variables achieve stationarity only after first difference.

4.2 Co-integration Test

Table 4.2: Co-integration Test Results

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.344794</td>
<td>08.7480</td>
<td>69.81889</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.233739</td>
<td>05.0175</td>
<td>47.585613</td>
<td>0.0091</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.087331</td>
<td>1.24030</td>
<td>29.79707</td>
<td>0.3428</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.061545</td>
<td>0.634858</td>
<td>15.49471</td>
<td>0.3099</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.012271</td>
<td>0.568054</td>
<td>3.841466</td>
<td>0.2105</td>
</tr>
</tbody>
</table>

4.3 Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
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</tr>
</tbody>
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4.4 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
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<tr>
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<td>3.841466</td>
<td>0.2105</td>
</tr>
</tbody>
</table>

4. Results

Data was analyzed using EViews Version 7. The results of these statistical tests aided in the fulfillment of the study objectives by answering the research questions.
At 5 per cent significance level, the trace test indicates 2 cointegrating equations while the maximum eigenvalue test indicates 2 cointegrating equation among the variables. As the maximum eigenvalue test is usually preferred for trying to pin down the number of cointegrating vectors (Enders 2004), we conclude that there are 2 cointegrating equation among the variables based on this test.

4.3 The Long Run Estimation

The long run equation is given by:
\[ CPI_{t-1} = \alpha_0 + \alpha_1 COP_{t-1} + \alpha_2 EXC_{t-1} + \alpha_3 M2_{t-1} + \alpha_4 INT_{t-1} + \mu_t \]  

\[ CPI_{t-1} = 36.88 + 0.036 COP_{t-1} + 0.006 EXC_{t-1} + 6.14 M2_{t-1} + 0.71 INT_{t-1} + \mu_t \]  

The long run equation suggests that money supply and interest rate have significant positive impact on consumer price index in the long run at 95% confidence level, with exception of crude oil price which has significant positive impact in the long run at 90% confidence level and exchange rate which has insignificant positive impact in the long run at 95% confidence level. As expressed in equation (4.2) above, the results show that in the long run an increase of 1% of crude oil prices will increase inflation by 0.036%. The growth of exchange rate with 1% increases the inflation by 0.006%. An increase in money supply by 1% increases inflation insignificantly by 6.14% and 1 percentage point increase in the interest rate increases the inflation with 0.71%.

4.4 Error Correction Model

The short run equation is given by:
\[ \Delta CPI_t = \beta_0 \Delta COP + \beta_1 \Delta EXC + \beta_2 \Delta M2 + \beta_3 \Delta INT + \gamma \varepsilon_{t-1} + \mu_t \]  

\[ \Delta CPI_t = 0.0689 \Delta COP + 0.0199 \Delta EXC + 2.74 \Delta M2 + 0.15 \Delta INT - 0.07 \varepsilon_{t-1} + \mu_t \]  

The short run equation suggest that oil price and exchange rate have insignificant positive short run relationship with inflation. However, interest rate and money supply have significant positive impact on inflation in the short run at 95% confidence level. The error term coefficient is significant which implied that inflation adjusted 7.4% percent in one month to the long-run equilibrium.

4.5 Residual Diagnostic Tests

The null hypothesis in this test states that error term is homoscedastic. The results from table 4-5 indicate that the p-value is greater than 10%, therefore we cannot reject the null hypothesis. The error term is homoscedastic, meaning that it has a constant variance of errors.

Table 4.5: Heteroskedasticity Test Results

<table>
<thead>
<tr>
<th>Heteroskedasticity Test: ARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Prob. F(1,127)</td>
</tr>
<tr>
<td>Obs*R-squared</td>
</tr>
<tr>
<td>Prob. Chi-Square(1)</td>
</tr>
</tbody>
</table>

The null hypothesis in this test states that error term is homoscedastic. The results from table 4-5 indicate that the p-value is greater than 10%, therefore we cannot reject the null hypothesis. The error term is homoscedastic, meaning that it has a constant variance of errors.

4.5.2 Test of serial correlation

The Breusch-Godfrey test for higher-order serial correlation was used.

Table 4.6 Serial Correlation Test Results

<table>
<thead>
<tr>
<th>Breusch-Godfrey Serial Correlation LM Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Prob. F(2,116)</td>
</tr>
<tr>
<td>Obs*R-squared</td>
</tr>
<tr>
<td>Prob. Chi-Square(2)</td>
</tr>
</tbody>
</table>

The serial correlation test indicates that there was no serial correlation, meaning that when one error term occurs it does not influence the outcome of the next error term in our model.

4.5.3 Test of Normality

The Jargue-Bera Test was used to test the model on whether the residual was normally distributed. Results from figure 1 indicate that the p-value is more than 5%; we cannot reject the null hypothesis which states the error terms are normally distributed. Therefore, the error terms are normally distributed.
positive effect of money supply to changes in prices result effects on the fluctuation of price level in long run. The variables except exchange rate have positive and significant exert a significant lagged influence on the inflation. All the According to the VECM model estimated in the study, crude

5. Conclusions and Recommendation

According to the VECM model estimated in the study, crude oil prices, interest rates and money supply were found to exert a significant lagged influence on the inflation. All the variables except exchange rate have positive and significant effects on the fluctuation of price level in long run. The positive effect of money supply to changes in prices result conformed to our a priori expectation as a unit rise in the money supply in the economy was supposed to result in a rise in the inflation since increases in money supply lead to increase in the aggregate demand. Given the higher coefficient of money supply, it seems that money supply is more relevant in price determination in Kenya than crude oil prices and interest rate. Considering the short run effects of these variables on inflation, only interest rate and money supply are the significant variable. The impact is positive as increase in interest rate results in increased cost of production that lead to decrease in the supply of goods in the market. The limited goods have to compete with the available money in circulation and thus increase in inflation. Exchange rate may not directly control inflation in the short run and long run, but it helps to restructure the price mechanism of both import and export, such that Shilling depreciation subtly tends to moderate prices in Kenya, especially imported price inflation. The findings presented in this study demonstrate that oil price shocks do not have direct substantial effects on inflation in the short run but in the long run.

Following the analysis and the findings of this research work, these recommendations are made to curb inflation in the Kenyan economy:

a) In order to ensure that the Kenya Bank’s Reference Rate KBRR is effective in managing the cost of borrowing, the level of government borrowing from the domestic market should be lowered, commercial banks should be compelled to ensure that their computations of the variable K is as realistic as possible and where they disregard the law, proper action should be taken and any reference rate must have proper oversight to prevent abuses and errors.

b) On the determining power of money supply (M2), greater efforts should be made to make available, short, medium and long term loans to productive investments like small scale industries/businesses as they constitute an integral part of the growth and transformation process of an agro based economy like that of Kenya.

c) Exchange policy should be designed to bridge the savings investment gap, enhance government revenue and reduce the fiscal gap through the curtailment of deficits and guarantee of external balance in the long run.

d) Focus should also be given to develop indigenous energy sources like gas hydrates, shell gas, coal-bed methane, underground coal gasification, wind, solar, nuclear energy etc to prevent the negative macroeconomic consequences of oil price fluctuations, which is expected to rise further with the recent unrest in oil-reach countries.

e) The study recommended that further study should be carried out using different sets of macro-economic variables and other econometric models to understand the inflation determinants in Kenya.

5. Conclusions and Recommendation

According to the VECM model estimated in the study, crude oil prices, interest rates and money supply were found to exert a significant lagged influence on the inflation. All the variables except exchange rate have positive and significant effects on the fluctuation of price level in long run. The positive effect of money supply to changes in prices result

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