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# Inflation Dynamics in Uganda: The role of disequilibria in the money and traded goods markets

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## Abstract

This paper models inflation dynamics in Uganda using a error correction model. The long-run equilibrium relationships in the money market and external sector are estimated, and the two error-correction terms integrated into a short-run single equation error correction model. Consistent with the predictions of a small open economy model, money supply, exchange rate, foreign inflation, terms of trade and real output have a cointegrating relationship with inflation.. In the short- run, inflation is driven by changes in real output, monetary aggregates, the exchange rate, and foreign prices. The disequilibria in the money and traded goods markets is significant but the adjustment process is slow. The significance of the interest rate differential in the money-demand equation implies some degree of monetary policy effectiveness in influencing aggregate demand.

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## 1 Introduction

It is now widely recognized that the primary objective of monetary policy is price stability. This agreement in part reflects the general consensus that has emerged over the past decades that there is no medium-term trade-off between inflation and growth. In fact, empirical evidence has found that inflation impedes an economy from realising its medium-term growth potential by distorting relative prices, increasing risk and uncertainty, and redistributing wealth from creditors to debtors. Effective monetary policy formulation, however, requires a thorough understanding of inflation dynamics and the process of expectations formation. Policymakers therefore need to assess the ongoing stochastic changes in the structure and functioning of the economy. This provides the Central Bank with an insight into inflationary pressures and the likely inflation outlook which are crucial in the design of a counter-cyclical monetary policy.

This paper models inflation dynamics in Uganda during the period 2000 – 2015. Following Juselius [1], Durevall and Njuguna [2], Nachega [3], Oral and Olumuyiwa [4] and Diouf [5], among others, we start by specifying and estimating long-run equilibria in the money and traded goods markets. This is consistent with a small open economy assumption, where inflation is usually assumed to originate from disequilibria in the two markets. The two error-correction terms are then integrated into a short-run model to specify a single equation error-correction model (ECM) for inflation in Uganda. The stability of the model is estimated using recursive estimation, and diagnostic tests are applied to the omitted variables.

Consistent with the predictions of a small open economy model, the results indicate that in the long-run money supply, exchange rate, foreign inflation, terms of trade and real output determine inflation in Uganda. In the short run, inflation is driven by changes in real output, monetary aggregates, the exchange rate, and foreign prices. The disequilibria in the money and traded goods markets is significant but the adjustment process is slow. In spite of the fact that inflation has exogenous determinants, such as foreign inflation, there is scope for the central bank to limit the impact of such shocks on inflation by pursuing a tight monetary policy stance. The significance of the interest rate differential in the money-demand equation implies some degree of effectiveness of the monetary policy.

The rest of the paper is structured as follows. Section 2 discusses the institutional framework for the external payments regime and the conduct of monetary policy in Uganda. In addition, it also it also provides an overview of inflation developments in Uganda. Section 3 provides the theoretical background for the empirical model and also reviews the empirical literature on inflation dynamics in Uganda. The analytical and empirical framework for investigating inflation dynamics in Uganda is presented in section 4, while empirical results are discussed in section 5. Finally, the conclusion and policy implications are presented in section 6.

# 2 Institutional Framework and Macroeconomic Developments

## 2.1 External payments regime and the Foreign Exchange Market

The external payments regime and the structure and operations of the foreign exchange market are critical determinants of exchange rate dynamics in a small open economy like Uganda. The extent and speed with which financial shocks emanating either from the interest rates or portfolio changes are transmitted to the real domestic economy through the exchange rate channel depends on the degree of openness of the economy to cross-border financial transactions and the exchange rate regime in place. A clear understanding of the external payments regime and the structure and the operation of the foreign exchange market is therefore crucial to understanding the evolution of the exchange rate and the institutional framework for the conduct of monetary policy.

Uganda pursued a fixed exchange rate regime in the 1960s and 1970s. A parallel foreign exchange market however emerged in the 1970s following the acute shortage of foreign exchange in the economy resulting from the collapse of the export sector. The premium between the official exchange rate and the parallel market rate rose steadily, and by 1981, the exchange rate in the parallel market was more than 30 times the official exchange rate. In an effort to restore macroeconomic stability, a first reform programme was initiated in 1982, and a *managed float* exchange rate regime was introduced. In 1983, a dual exchange rate regime was introduced, but this was short-lived as the two windows were merged in May 1984, before reverting back to a fixed exchange rate regime in 1986. In May 1987, a currency reform was effected, which saw a 77 percent devaluation of the exchange rate to try to correct the external sector imbalances.

In 1990, the parallel foreign exchange market was legalised and foreign exchange bureaux licensed to serve as money shops. The legalization of the parallel exchange market gave way to introduction of a weekly Dutch auction of donor funds at BOU. In order to eliminate the segmented nature of the exchange system and to bring about a convergence of the exchange rates, an inter-bank foreign exchange market system was introduced in November 1993. The liberalization of the external payments system was completed with the liberalization of the capital account in July 1997 (see Kasekende and Atingi-Ego [6]. Currently, IMF [7] classifies Uganda's exchange rate regime as a "floating exchange rate regime". BOU's involvement in the foreign exchange market is limited to occasional interventions to dampen excessive exchange rate volatility. This allows for the possibility that monetary policy actions in Uganda can be transmitted to the economy through the exchange rate channel, since the exchange rate is an endogenous variable.

## 2.2 Institutional Framework for Conduct of Monetary Policy

Following the enactment of the Bank of Uganda Act [8], monetary policy in Uganda is formulated within a framework of central bank autonomy and a flexible exchange rate regime, the primary objective being price stability. Prior to July 2011, the Reserve Money Program (RMP)[3], which is premised on a strong underlying relationship between base money, broader monetary aggregates, economic growth and inflation, was used to guide monetary policy decisions. Under the RMP, the overall macroeconomic objectives on desired real GDP growth, inflation, and balance of payments were defined. Broad money (M2) growth was projected consistent with these macroeconomic objectives, given assumptions on velocity. The growth of the monetary base, the operating target[4,] was then projected in line with growth in broader monetary aggregates and inflation. Other things being equal, the direction of monetary policy stance was determined by the gap between the outturn and desired levels of base money. Monetary policy was eased if base money was below desired, tightened if base money was above desired, and left unchanged/neutral if base money was in line with the desired levels. In 2009, the RMP was modified, and flexible version of the RMP adopted with Net Domestic Assets (NDA) as the operating target.

The structural transformation of the economy and developments in the financial sector over the last two decades however weakened the underlying relationship between base money, broader monetary aggregates, and inflation as the money multiplier became very unstable. This necessitated the reform of the

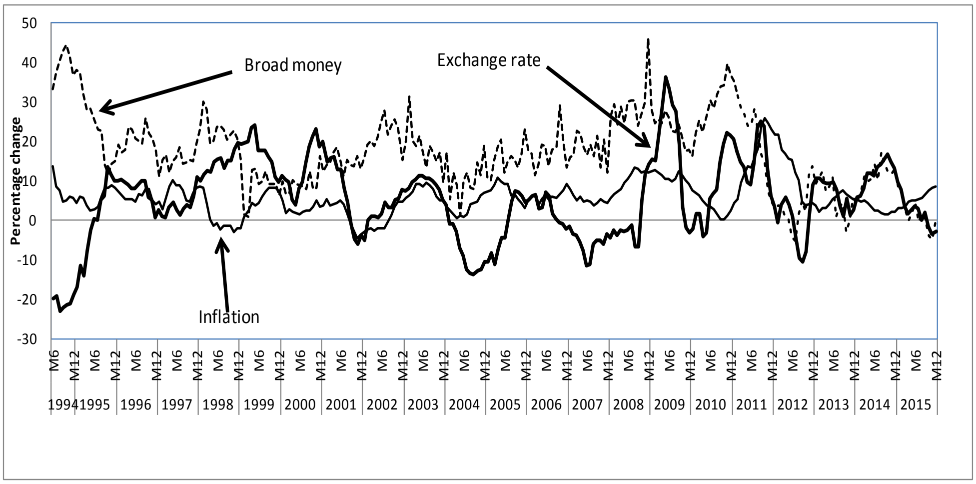
[3] The relationship between broad money (M2) and the money base is relayed through the multiplier effect of financial intermediation and the propensity of people to hold cash.

[4] Base money was adopted as the operating target since data on base money was available with a shorter lag than data on broader Monetary aggregates.

monetary policy framework. Consequently, an inflation targeting-lite (ITL) monetary policy framework was adopted in July 2011. Under the ITL framework, BoU sets the Central Bank Rate (CBR) consistent with the desired monetary policy stance for the month and regulates liquidity conditions in the interbank money market to ensure that the 7-day interbank money market rate is consistent with the CBR for the month.

## 2.3 Evolution of Inflation, exchange rate and monetary aggregates

The analytical framework in this paper is based on the premise that in a small open economy like Uganda, inflationary pressures emanate from disequilibria in the money market and traded goods sector. Consequently, this section discusses inflation dynamics in Uganda and relates this to broad money and exchange rate developments. During the 1970s and 1980s Uganda experienced high and volatile inflation, with annual headline inflation reaching a peak of about 200 in 1987. The high inflation rate during this time was attributed to structural weaknesses in the economy that led to acute shortages and the monetization of fiscal deficits. The economic recovery program (ERP) introduced in late 1987 culminated in enhanced fiscal discipline and a remarkable reduction in inflation. The Government consistently pursued fiscal discipline in its budgetary operations and the overall objective was to contain the fiscal deficit to levels that would be financed on a sustainable basis while at the same time reducing government indebtedness to the banking sector. Despite the huge weather-related shocks to prices, depicted by the trend of the Headline inflation, Bank of Uganda managed to keep core inflation (i.e. price changes that exclude food crop prices) very stable at around 5 percent per annum during most of the 1990s and early 2000s. Nonetheless, inflation remained remarkably variable as shown in Figure 1.




Source: Bank of Uganda

Figure 1: Evolution of Annual inflation and exchange rate and broad money changes

Towards the end of the last decade however, and in line with most economies in the region, domestic inflation rose sharply and substantially above the Bank of Uganda' medium term target of 5 percent per annum. Annual headline and core inflation which rose to 15.6 percent and 13.4 percent, respectively in August 2008, declined to single digit levels for most of 2010 before rising to peak at 30.4 percent and 30.8 percent, respectively in October 2011. These inflationary pressures were in part generated by supply-side factors, most notably the increases in international oil and food prices. In November 2011, a disinflation process started, with both headline and core inflation declining to and stabilising at the Bank of Uganda's medium-term target of 5.0 percent by the close of 2012. The disinflation process is largely attributed to the tight monetary policy stance pursed by the Bank of Uganda.

# 3 Literature Review

## 3.1 Theoretical literature

Inflation, which is defined as a sustained increase in the general price level in an economy can be caused by *"demand-pull"* factors, *"cost-push"* factors, inflation expectations or inertial factors. Demand-pull inflation occurs when the level of aggregate demand or spending in the economy is growing at an unsustainable rate leading to increased pressure on scarce resources and a positive output gap. An increase in aggregate demand could result from higher consumer spending, perhaps because money supply has increased and interest rates have fallen[5], taxes have been cut or simply because there is a greater level of consumer confidence in the economy. Aggregate demand could also supersede aggregate supply if firms are investing more under the expectation of future economic growth or if there is high government expenditure on non-tradables.

The monetarists contend that excessive growth in money is the main determinant of *"demand-pull"* inflation. Assuming a natural equilibrium level, increases in money supply shift the aggregate demand curve outwards, followed by an increase in income or a decline in the unemployment rate and wage increases, which would in turn shift the aggregate supply curve leftwards, until a new equilibrium is achieved. The new equilibrium presents a higher price level. Friedman [10] stated that: *"Inflation is always and everywhere a monetary phenomenon"*. Indeed, the monetarist school argues that any change of money supply will lead to a change the price level. This follows from Fisher's equation of exchange, $MV = PQ$, where $M$ is the nominal quantity of money, $V$ is the velocity of money in final expenditures, $P$ is the general price level and $Q$ is an index of the real value of final expenditures. This view rests on two important assumptions: $V$ and $Q$ are constant. This has however been challenged by Keynesian, who argue that $V$ is not necessarily constant and stable and that there

[5] See Stein [9].

is a time lag between changes in $M$ and changes in $P$, given that $P$ is sticky, especially in the short-run (see Friedman [11], Cagan [12], Friedman and Schwartz [13], Brunner [14], Friedman [15], and Dornbusch and Fischer [16], among others).

The Keynesians argue that inflation can be caused by both “demand-pull” and “cost-push” factors. The inflationary gap arises when the aggregate demand exceeds aggregate supply at the full employment level of output. The larger the gap between aggregate demand and aggregate supply, the more rapid the inflation. The original Keynesian Model assumed that the Aggregate supply curve has two ranges. At low levels of output with massive unemployment and excess capacity, firms would react to changes in demand by increasing output and not prices, thus the aggregate supply curve is horizontal. Under these circumstances, the problem facing policy makers would be unemployment. Once the economy reaches full employment, the aggregate supply becomes vertical and firms only increase prices in response to increases in aggregate demand. On the other hand, *“cost-push inflation”* occurs when the general price level rises due to increases in the costs of production in the economy that are independent of demand. This forces firms to increase prices in order to maintain profitability. *“Cost-push inflation”* implies that producers will pass increases in costs to consumers through high consumer prices. Increases in production costs could originate from increases in wages, prices of raw materials, import prices, and indirect taxes or a reduction in government subsidies (see Keynes [17], Tobin [18], Modigliani and Papademos [19], and Blinder [20], among others).

Gordon’s [21] “triangle model” stipulates that in addition to *“demand-pull”* and *“cost-push”* factors, inflation can also be caused by *“built-in”* factors. Inflation expectations and price stickiness as well as possible indexation have also been identified as the main determinants of inertial inflation (Taylor [22], Clarida, Gali and Gertler [23], and Lane [24]). Researchers have also considered international transmission of inflation on domestic price stability. Canzoneri and

Gray [25] and Turnovsky, Basar and d’Orey [26] developed models in which expansionary policies abroad could cause the home country to inflate even in a flexible exchange rate regime.

Structural factors, such as weather conditions, transport bottlenecks and protective industrial and trading policies of the government have also been identified as potential causes of inflation. These policies are believed to create monopolistic and oligopolistic structures, which usually set prices well above border prices. Weather conditions, crop failures or drought are some of the structural factors that are also believed to have a direct impact on the inflation rate given the weight of food items in the consumption basket (Prebisch [27]). Recent theories of inflation also emphasise the role of political factors and policy credibility in explaining inflation. Nordhaus [28] and Lindbeck [29] for example argue that central banks administer expansionary monetary policy in the period leading up to an election in order to add to the governing party’s chances for re-election. Empirical evidence confirming the political business cycle hypothesis has been mixed, with both McCallum [30] and Alesina [31] rejecting the hypothesis.

## 3.2 Empirical Literature

There are a number of studies that have attempted to examine the long-run determinants and inflation dynamics in Uganda. These studies in general suggest a link between money supply, exchange rate depreciation, interest rate, economic activity, fiscal deficit, terms of trade, domestic supply shocks and inflation in Uganda. For example, Nachega [3] investigates the long-run determinants of inflation and inflation dynamics in Uganda using quarterly data for the period 1982-Q4 – 1998-Q4. He estimates the long-run equilibrium relationships in the monetary, tradable and asset markets and examines how deviations from the steady state relations in the three markets affect inflation using a single-equation error-correction model (ECM). His findings indicate that during this period, inflation in Uganda was influenced by both monetary and external factors. Disequilibria in the monetary and financial sector and the traded goods sector had a lasting inflationary impact in Uganda. Changes in the return of foreign securities, in the exchange rate, and in import prices were found to have a positive inflationary impact in the short run. He also found that certain policy variables, such as positive real interest rates, strict money growth, and exchange rate stability, can be effective in controlling inflation in the short run.

Kihangire and Mugyenyi [32] use an autoregressive distributed lag (ARDL) model to investigate the long-run relationship and inflation dynamics in Uganda. They examine the relation between inflation and a vector of explanatory variables including broad money (M2), exchange rate, interest rate, real GDP, fiscal deficit, terms of trade and domestic supply shocks. Their results suggest that excessive monetary growth, fiscal deficits, terms of trade and exchange rate depreciation determine both the long-run trend and short-run inflation dynamics in Uganda. Good rains were also found to be associated with a decline in inflation although the measured effects were inelastic and at times insignificant. The impact of real economic activity and real interest rate on inflation was however found to be quite inelastic.

Kabundi [33] uses monthly data to estimate a single-equation ECM which includes both domestic and foreign variables to assess the determinants of inflation dynamics in Uganda. His findings indicate that over the long-run both domestic and foreign variables are important determinants of inflation in Uganda. Monetary aggregates portray an equilibrium relationship with inflation, which means that expanding money supply is inflationary in the long-run. In addition, agricultural supply shocks are identified as crucial determinants of inflation in Uganda. Constraints to agricultural production together with high demand for food from both the domestic and regional market tend to hike domestic food prices, which in turn lead to an increase in the overall price level. External factors, such as international food price and energy prices are also important determinants of inflation in Uganda. He also finds evidence of inflation inertia, possibly as a result of persistence in inflation expectations.

# 4 Methodology

## 4.1 Theoretical Framework

Following conventional theories and the structure of the economy, inflation in Uganda can be explained by developments in the money market and the traded goods sector of the economy. This reflects the standard assumption that inflation in an open economy could possibly originate from disequilibria in the money and traded goods markets. As a starting point, assume that the general price level is a weighted average of the prices of tradeables $\left(p_t^T\right)$ and non-tradables $\left(p_t^N\right)$. This relationship is specified in equation (1).

$$p_t = \lambda p_t^T + (1-\lambda) p_t^N \tag{1}$$

where $0 < \lambda < 1$ is the share of traded goods in the consumption basket and lower case letters indicate that the variables are expressed in logs. In a small open economy, the price of tradables is determined in the world market and depends on the foreign price level ( $p_t^F$ ) and the exchange rate ( $s_t$ ) as specified in equation (2).

$$p_t^T = s_t + p_t^F \tag{2}$$

The price of non-tradables is assumed to be determined in the domestic money market, and is assumed to move in line with the overall demand in the economy. Assuming equilibrium condition in the domestic money market as specified in equation (3),

$$m_t - p_t = m_t^d - p_t \tag{3}$$

where $(m_t - p_t)$ and $(m_t^d - p_t)$ denote real money supply and real money demand, respectively. The price of non-tradables can thus be specified as follows:

$$p_t^N = \delta\left(m_t - \left(m_t^d - p_t\right)\right) \tag{4}$$

where $(\delta)$ is a parameter which represents the relationship between aggregate demand and the demand for non-tradables. If the actual supply of money exceeds real demand for money balances, then there will be an upward pressure on prices. Real money demand is modelled as a function of real income $(y_t - p_t)$, inflation expectations $(E(\pi))$ and the relative rate of return between domestic and foreign financial assets $\left(R_t^D - R_t^F\right)$. This money demand function is specified in equation (5).

$$m_t^d - p_t = \beta_0 + \beta_1(y_t - p_t) + \beta_3\left(R_t^D - R_t^F\right) + \beta_4 E(\pi) \tag{5}$$

Assuming for simplicity that inflation expectations depend only on past inflation and the realization of past inflation forecasts, that is, $E(\pi) = \Delta P_{t-1}$, and substituting equation (5) into equation (4) yields:

$$p_t^N = \delta\left(m_t - \left(\beta_0 + \beta_1(y_t - p_t) + \beta_3\left(R_t^D - R_t^F\right) + \beta_4 \Delta p_{t-1}\right)\right) \tag{6}$$

Substituting equation (2) and equation (6) into equation (1) yields a reduced form equation of the form:

$$p_t = f\left(p_t^F, s_t m_t, (y_t - p_t), (R_t^D - R_t^F), \Delta p_{t-1}\right) \tag{7}$$

Ideally $\left(p_t, p_t^F, s_t m_t, (y_t - p_t), (R_t^D - R_t^F), \Delta p_{t-1}\right)$ could be estimated as a single system, and if the test reveals the existence of cointegrating vectors, then a vector error correction model (VECM) could be estimated as a short-run model. However, the application of Johansen's procedure to the whole system may not determine the existing co-integrating relationships due to the small sample size, a large variety potential determinants of inflation and difficulties in interpreting the cointegrating space and getting the coefficients close to the theoretical priors

(Leheyda [34]). In addition, it is difficult to disentangle causes from consequences in a system in which all endogenous variables are contemporaneously determined. Moreover, it is the “relative” correlation between the independent variables and inflation and not the “absolute” association between the independent variables and inflation that is important for policy design.[6] Thus, we follow Juselius [1] , Durevall and Njuguna [2], Nachega [3], Oral and Olumuyiwa [4] and Diouf [5], among others and first estimate the respective long-run equilibrium relationships in the money and traded goods markets.

## 4.2 Empirical framework

### 4.2.1 Cointegrating relationships

The basic premise underlying cointegration is that if, in the long-run, two or more series move closely together, even though the series themselves are trended, the difference between them is constant. It is therefore possible to consider these series as defining a long-run equilibrium relationship, since the difference between them is stationary (Hall and Henry [35]). Absence of cointegration implies that such variables have no long-run relationship and in principal can wander arbitrarily far away from each other (Dickey et. al. [36]). The study employs Johansen and Juselius [37] and Johansen [38] maximum likelihood framework to cointegration. This systems approach sets up a non-stationary time series as a vector autoregressive process of order k in a re-parameterized form as given in equation (8).

$$X_t = \alpha + \prod_1 X_{t-1} + \ . \ . \ . + \prod_k X_{t-k} + \varepsilon_t \tag{8}$$

[6] From a policymaker’s perspective, what is more important is knowledge of the extent to which the deviation of money supply from the desired level causes inflation (relative association) and not knowledge of the association between inflation and money supply (absolute association).

Where $X_t$ is an $(n \times 1)$ vector of endogenous variables that are integrated of order one, commonly denoted as I(1), and $\varepsilon_t$ is an $n$x1 vector of innovations. This VAR can be re-written as given in equation (9).

$$\mathbf{\Delta}X_{\mathbf{t}} = \mathbf{\Pi}X_{\mathbf{t-1}} + \sum_{\mathbf{i=1}}^{\mathbf{k-1}} \mathbf{\Gamma_1 \Delta}X_{\mathbf{t-i}} + \mathbf{\Phi d_t} + \boldsymbol{\varepsilon}_{\mathbf{t}} \quad (9)$$

Where each of the $(n \times n)$ matrices $\mathbf{\Gamma}_i$ and $\mathbf{\Pi}$ comprise coefficients to be estimated; $i = 1,...,k-1$ is the number of lags included in the system; $\mathbf{d_t}$ is a vector of deterministic terms (constants, linear trends, 'spike' and/or intervention dummies); $\Delta$ is a difference operator; $\boldsymbol{\varepsilon}_{\mathbf{t}}$ is a well-behaved vector of structural innovations, with zero mean, i.e. $E(\varepsilon_t) = 0$, a time-invariant positive definite covariance matrix $\mathbf{\Sigma}$, and are serially uncorrelated, i.e. $E(\varepsilon_t \varepsilon'_{t-k}) = 0$ for $k \neq 0$. The vector $\mathbf{\Pi}$ is a matrix of long-run coefficients, defined as a multiple of two $(n \times r)$ vectors, $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}'$. If the coefficient matrix $\mathbf{\Pi}$ has reduced rank $r < n$, then there exist $(n \times r)$ matrices $\boldsymbol{\alpha}$ and $\beta$, each with rank $r$, such that: $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$ and $\boldsymbol{\beta}' y_t$ is stationary. $r$ is the number of cointegrating relationships, the elements of $\boldsymbol{\alpha}$ are the adjustment parameters in the vector error correction model and each column of $\beta$ is a cointegrating vector.

Johansen [39], Johansen [40] and Johansen and Juselius [37] propose two statistics, the trace statistic and maximum eigenvalue test statistic. The trace test $(\lambda_{trace})$ and maximum eigenvalue $(\lambda_{\max})$ are shown in equations (10a) and (10b), respectively.

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_{\mathrm{i}}\right) \quad (10a)$$

$$\lambda_{\max} = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \quad (10b)$$

Where $T$ is the sample size and $\hat{\lambda}_{r+1},...,\hat{\lambda}_{n}$ are the smallest characteristic roots. If the statistic is bigger than the critical value, the null hypothesis of at most $r$ cointegrating vectors is rejected.

#### 4.2.2 Short-run Error-correction Model

The long-run relationships in the money market and traded goods market are first estimated using the cointegration framework. Once established, a single-equation error correction model (ECM) for inflation specified in equation (11) is estimated.

$$\begin{aligned}\Delta p_t &= \alpha_o + \sum_{i=1}^{k-1}\alpha_{1i}\Delta p_{t-i} + \sum_{i=1}^{k-1}\alpha_{2i}\Delta m_{t-i} + \sum_{i=1}^{k-1}\alpha_{3i}\Delta s_{t-i} + \sum_{i=1}^{k-1}\alpha_{4i} p_t^F + \sum_{i=1}^{k-1}\alpha_{5i} r_t \\ &+ \sum_{i=1}^{k-1}\alpha_{6i}\Delta(y_t - p_t) + \sum_{i=1}^{k-1}\alpha_{7i}\left(R_t^D - R_t^F\right) + \phi_1 ECM(1)_{t-1} + \phi_2 ECM(2)_{t-1} + \mu_t\end{aligned} \tag{11}$$

Where and $\Delta$ is a difference operator and $\mu_t$ is a white noise process. The two error correction terms (ECMs), the deviations from long-run equilibrium in the money market and traded goods market are defined as given in equations (12) and (13).

$$ECM(1) = \left(m_t - \left(\beta_0 + \beta_1(y_t - p_t) + \beta_3\left(R_t^D - R_t^F\right) + \beta_4\Delta p_{t-1}\right)\right) \tag{12}$$

$$ECM(2) = p_t - s_t - p_t^f - tot \tag{13}$$

where $tot$ are terms of trade and all other variables as previously defined. Equation (11) combines both the short-run and long-run determinants of inflation. The coefficients of the two error correction terms ($\phi_1$ for the money market and $\phi_2$ for the traded goods market) show the strength of adjustment or the amount of disequilibria transmitted to inflation in each period. The short-run part of the model is accounted for by including variables in their first differences.

## 4.3 Data and Sample Characteristics

The study uses quarterly data for the period 2000-Q1 – 2015-Q4. Inflation, the variable of interest, is defined as the quarterly change of the logarithm of the consumer price index (CPI). During the last decade, inflation was fairly low and stable, although there were fluctuations between quarters. Inflation however, rose markedly during the third quarter of 2011 but has since receded to low and single-digit levels. Real quarterly GDP is used as a measure of real income while $M2$, which includes currency outside the central bank plus demand, savings and time deposits is used as a measure of broad money. The nominal exchange rate used is the average Ushs/US dollar rate while the foreign price level is computed as a weighted average of wholesale price indices of Uganda's major trading partners. The interest rate differential is computed as the difference between the three months time deposit rate and the three months US dollar deposit rate. All variables save for interest rates are in logarithms. Centred seasonal dummies are used in the estimations instead of pre-adjusting the series for seasonality.

Table 1: Unit root tests

| Augmented Dickey-Fuller (ADF) tests and Phillips-Perron (PP) tests | | | | | |
|---|---|---|---|---|---|
| Variable | Levels | | Variable | First differences | |
| | ADF | PP | | ADF | PP |
| $p$ | -1.556 | -1.553 | $\Delta p$ | -5.589** | -5.578** |
| $p^F$ | -2.451 | -1.707 | $\Delta p^F$ | -5.984** | -5.576** |
| $s$ | -1.521 | -1.620 | $\Delta s$ | -5.585** | -5.429** |
| $m2$ | -2.465 | -2.576 | $\Delta m2$ | -8.699** | -8.687** |
| $y-p$ | -1.321 | -2.856 | $\Delta(y-p)$ | -9.285** | -15.549** |
| $R^D-R^F$ | -2.332 | -2.332 | $\Delta(R^D-R^F)$ | -9.186** | -9.273** |
| $tot$ | -3.214 | -3.352 | $\Delta tot$ | -7.441** | -7.495** |

The superscripts ** and * denote rejection of the null of a unit root at 1% and 5% significance levels, respectively

Source: Authors Computations

It is important to establish the time series properties of the data before conducting cointegration analysis. All variables appear to contain a deterministic trend. The time series properties are also investigated using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The null hypothesis under both tests is that the time series are generated by unit root processes. As shown in table 1, all variables appear to have at least one unit root and become stationary after first differencing.[7]

# 5 Empirical Results

Having established the time series properties of the variables, the I(1) variables in each market are entered into the cointegrating vector to establish the existence of a long-run relationship between the variables. The appropriate lag structure of the VAR is determined using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). After determining the lag structure of the VAR, diagnostic tests of the preferred lag are conducted.

## 5.1 Long-run equilibrium

### 5.1.1 Money Market

The results of the Johansen [38] [41] maximum likelihood procedure are presented in Table 2. The VAR model consists of 3 lags on $m2$, $p$, $(y-p)$ and $(R^D - R^F)$. A dummy variable is included as an exogenous variable to capture the impact of the financial crisis of 2008. Since $p$ contains a unit root and is stationary in first differences, $\Delta p_{t-1}$ is not included in the longrun relationship.

[7] We reject the null of a unit root against a one-sided alternative if the test statistic is less than the critical value.

However, it can enter the short-run inflation model directly since it is stationary. As shown in table 2, both the maximal eigen statistic and the trace statistic reject the null of *"no cointegrating vector"* in favour of one cointegrating relationship.

Table 2: Co-integration Analysis of the Monetary Sector

| Cointegration Analysis (Johansen Maximum likelihood procedure) | | | | |
|---|---|---|---|---|
| Eigenvalue | 0.4392 | 0.3143 | 0.1626 | 0.0151 |
| Null hypothesis[2] | r=0 | $r \leq 1$ | $r \leq 2$ | $r \leq 3$ |
| $\lambda_{max}$[3] | 31.018 | 18.457 | 9.328 | 0.882 |
| $\lambda_{trace}$[3] | 59.684 | 28.666 | 10.209 | 0.882 |
| 95% critical value[4] | 27.58 (47.85) | 21.13 (29.79) | 14.26 (15.49) | 3.84 (3.84) |
| Standardized eigenvector β' | | | | |
| Variable | *m2* | *y-p* | *p* | $R^D$-$R^F$ |
| | 1 | -1.41 | -0.92 | -0.36 |
| | -0.70 | 1 | 0.65 | 0.26 |
| | -1.09 | 1.55 | 1 | 0.39 |
| | -2.78 | 3.91 | 2.53 | 1 |
| Adjustment coefficient α | | | | |
| | m2 | *y-p* | *p* | $R^D$-$R^F$ |
| Δ*m2* | -0.439 | 0.6202 | 0.017 | 0.016 |
| Δ*(y-p)* | -0.065 | 0.092 | 0.003 | 0.002 |
| Δ *p* | 0.158 | -0.223 | -0.006 | -0.005 |
| Δ ($R^D$-$R^F$) | 1.804 | -1.055 | -0.499 | -0.464 |
| Weak exogeneity tests[5] | | | | |
| Variable | *m2* | *y-p* | *p* | $R^D$-$R^F$ |
| $\chi^2(1)$ | 6.808** | 1.496 | 5.417* | 6.862 |
| P-value | 0.008 | 0.221 | 0.019 | 0.081 |
| Testing significance of a given variable[5] | | | | |
| | *m2* | *y-p* | *p* | $R^D$-$R^F$ |
| $\chi^2(1)$ | 12.268** | 10.416** | 7.824** | 11.149** |
| p-value | 0.00 | 0.00 | 0.021 | 0.00 |

1. Cointegration with m2, y-p, p and $R^D$-$R^F$ as endogenous variables. A dummy is entered as an exogenous variable to capture the impact of the financial crisis.
2. r is the number of cointegrating vectors.
3. The statistics $\lambda_{max}$ and $\lambda_{trace}$ are respectively the Johansen maximal and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of r (the number of cointegrating vectors), and rejection of r=0 is evidence in favour of at least one cointegrating vector.
4. The critical value in parenthesis is for the trace statistic. The critical values for both the maximal and trace statistics are taken from Osterwald-Lenum [42].
5. ** and * denote 1% and 5% significance levels, respectively.

Source: Authors Computations

The estimated cointegrating vector normalised in $m2$ is reported in the first line of the Standardized eigenvector in table 2. The resulting long-run money demand function can thus be specified as:

$$m2_t = 1.41(y - p)_t + 0.92 p_t + 0.36(R_t^D - R_t^F) \quad (12)$$

This equation has the properties of a money demand function. All coefficients in equation have signs consistent with economic theory. The income elasticity of demand for money is 1.41, which is positive and significant in explaining the demand for real money balances. This is consistent with economic theory, which postulates that an increase in real income increases the level of transactions, and consequently the demand for real money balances to finance the high level of transactions in an economy. When the unit income homogeneity restriction was imposed, the $x^2$-statistic was found to be 0.084 with a p-value of 0.6323, which suggests that the unit income elasticity cannot be rejected for the long-run relationship.

The price elasticity of demand for real money balances of 0.92 indicates that an increase in the general price level increases the demand for money. The semi-elasticity of the difference between the deposit rate and the foreign interest rate is positive and statistically significant in explaining the demand for money. An increase in the differential between the two rates increases the demand for money as agents restructure their wealth portfolio in favour of the high yielding assets[8].

Table 2 also contains the adjustment matrix, which contains the weight with which the cointegrating vectors enter the equation in the system. Each nonzero column measures the speed of short-run response to disequilibrium in the endogenous variables of the VAR. Specifically, the first column measures the speed at which ***m2,*** the dependent variable in the first equation of the VAR moves towards restoring long-run equilibrium. The coefficient (–0.439) is the estimated feedback coefficient for the money demand equation. It shows that 43.9 percent of the adjustment is achieved in the first quarter. The negative coefficient signifies that lagged excess money induces smaller holdings of current money.

Weak exogeneity tests are also conducted to establish the direction of long-run causality. In a system of error-correction equations, a variable is said to be weakly exogenous if the error-correction term in the equation of that particular variable is statistically insignificant. Thus, weak exogeneity is investigated by testing whether the coefficient on the error-correction term, that is, the corresponding element in $\alpha$, is zero. As indicated in table 2, while weak exogeneity is rejected for $m2$ and $p$, it cannot be rejected for $(y-p)$ and $(R^D - R^F)$. These results indicate that if an external shock causes the system to deviate from its long-run path, money and prices will adjust over time to restore long-run equilibrium. This implies that if a simultaneous equation model is used, the error-correction mechanism should be introduced in the equations for money and prices.

[8] An increase in the deposit rate increases the relative interest rate whereas an increase in the foreign interest rate reduces the relative rate.

### 5.1.2 External Sector

The results of the Johansen [39; 40] maximum likelihood procedure are presented in Table 3. The VAR model consists of 4 lags on $s$, $p$, $p^f$ and $tot$. A dummy variable is included as an exogenous variable to capture the impact of the financial crisis of 2008. As shown in Table 3, both the maximal eigen statistic and the trace statistic reject the null of no cointegrating vector in favour of one cointegrating relationship.

Table 3: Co-integration Analysis for the External Sector

| Cointegration Analysis (Johansen Maximum likelihood procedure) | | | | |
|---|---|---|---|---|
| Eigenvalue | 0.55501 | 0.365951 | 0.16884 | 0.00067 |
| Null hypothesis[2] | r=0 | $r \leq 1$ | $r \leq 2$ | $r \leq 3$ |
| $\lambda_{max}$[3] | 36.43667 | 20.50334 | 8.321986 | 0.030153 |
| $\lambda_{trace}$[3] | 65.292 | 28.855 | 8.352 | 0.030 |
| 95% critical value[4] | 27.58 (47.85) | 21.13 (29.79) | 14.26 (15.49) | 3.84 (3.84) |
| Standardized eigenvector β' | | | | |
| *Variable* | *s* | *p* | $p^f$ | *tot* |
| | 1 | -1.068 | 0.771 | 0.248 |
| | -0.935 | 1 | -0.721 | -0.326 |
| | 1.297 | -1.386 | 1 | 0.452 |
| | 2.870 | -3.067 | 2.212 | 1 |
| Adjustment coefficient α | | | | |
| | *s* | *p* | $p^f$ | *tot* |
| $\Delta s$ | -0.960 | 0.577 | -0.660 | -0.334 |
| $\Delta p$ | 0.359 | -0.964 | 0.995 | 0.125 |
| $\Delta p^f$ | 0.313 | -0.842 | 0.869 | 0.109 |
| Δtot | 0.288 | -0.774 | 0.799 | 0.101 |
| Weak exogeneity tests[5] | | | | |

| Variable | *s* | *p* | $p^f$ | *tot* |
|---|---|---|---|---|
| $\chi^2(1)$ | 6.781** | 14.914** | 2.417 | 0.570 |
| P-value | 0.00 | 0.00 | 0.219 | 0.45 |
| Testing significance of a given variable[5] | | | | |
| | *s* | ***p*** | $p^f$ | ***tot*** |
| $\chi^2(1)$ | 15.631** | 14.612** | 10.180** | 4.798** |
| p-value | 0.00 | 0.00 | 0.00 | 0.02 |

1. Cointegration with m2, y-p, p and $R^D$-$R^F$ as endogenous variables. A dummy is entered as an exogenous variable to capture the impact of the financial crisis.
2. r is the number of cointegrating vectors.
3. The statistics $\lambda_{max}$ and $\lambda_{trace}$ are respectively the Johansen maximal and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of r (the number of cointegrating vectors), and rejection of r=0 is evidence in favour of at least one cointegrating vector.
4. The critical value in parenthesis is for the trace statistic. The critical values for both the maximal and trace statistics are taken from Osterwald-Lenum [42].
5. ** and * denote 1% and 5% significance levels, respectively.

Source: Authors Computations

The estimated cointegrating vector normalised in $s$ is reported in the first line of the Standardized eigenvector in Table 3. The unconstrained long-run relationship can thus be specified as:

$$s_t = 1.068 p_t - 0.771 p_t^f - 0.248 tot \qquad (13)$$

The unconstrained coefficients on prices are very close to unity. This is consistent with the predictions of economic theory. The restricted cointegrating vector can thus be written as:

$$s_t - p_t + p_t^f = 0.216tot \tag{14}$$

Weak exogeneity tests suggest that foreign prices and terms of trade are weakly exogenous and that adjustment to the long-run equilibrium is achieved either through the exchange rate or the domestic price level.

## 5.2 Short-run Dynamics

A single equation error correction model for inflation is estimated to ascertain the determinants of inflation in Uganda. The general model was estimated with two lags of each variable in first differences and two error correction terms, representing the longrun relationships in the monetary and external sectors. A general-to-specific modelling strategy is used to arrive at a parsimonious model that explains inflation dynamics in Uganda. The results of the parsimonious model are presented in Table 4.

Table 4: Coefficient Estimates for the Error Correction Inflation Equation

| **Dependent Variable ($\Delta p$)** | | | |
|---|---|---|---|
| **Regressor** | **Coefficient** | **t-values** | **p-values** |
| **Constant** | -0.017908 | -3.163842 | 0.0033 |
| $\Delta p_{t-1}$ | 0.475749 | 3.440730 | 0.0016 |
| $\Delta p_{t-2}$ | 0.199381 | 2.015419 | 0.0521 |
| $\Delta m2$ | 0.407642 | 7.007121 | 0.0000 |
| $\Delta m2_{t-1}$ | 0.164372 | 2.521646 | 0.0167 |
| $\Delta m2_{t-2}$ | 0.108896 | 2.878522 | 0.0070 |
| $\Delta (y-p)_{t-1}$ | 0.312164 | 4.081569 | 0.0003 |
| $\Delta (y-p)_{t-2}$ | 0.280963 | 3.329549 | 0.0021 |
| $\Delta p^f$ | 0.213644 | 3.679405 | 0.0008 |
| $\Delta p^f_{t-1}$ | 0.200905 | 2.966696 | 0.0056 |
| | 0.120765 | 3.477619 | 0.0014 |

| | | | |
|---|---|---|---|
| $\Delta S_{t-2}$ | 0.057044 | 1.847789 | 0.0736 |
| **ECM (Money)$_{t-1}$** | -0.113584 | -3.533815 | 0.0012 |
| **ECM(External)$_{t-1}$** | -0.053968 | 1.417968 | 0.0256 |

| | | | |
|---|---|---|---|
| R-squared: | 0.949797 | Adjusted R-squared: | 0.774088 |
| F-statistic: | 11.5434[0.002] | Durbin-Watson statistic: | 1.903743 |
| A: Normality: Jaque-Bera | $\chi^2(2)$=1.55[0.471] | B: Serial Correlation $\chi^2(1)$ = 8.49[0.152] | |
| C: Heteroscedasticity: | $\chi^2(1)$=3.57[0.471] | D: Functional Form: $\chi^2(1)$=8.56[0.351] | |

The coefficient on the long-run disequilibrium in the money market is highly significant in the inflation equation, suggesting that disequilibrium in the money market matters for inflation. The speed of adjustment is however slow, in that, a 1 percent excess demand for money is likely to raise the rate of inflation by about 0.11 percent. The coefficient on the error-correction term from the external sector is also significant but the speed of adjustment is slow in that a 1 percent disequilibrium in the external sector leads to a 0.5 percent increase in the rate of inflation. Short-run dynamics in inflation depend on changes in past inflation (partly reflecting inflation inertia), real monetary aggregates, exchange rate, real output and foreign prices. The diagnostic tests of the estimated models indicate that the residuals are normal, and free of serial correlation and heteroscedasticity. The stability tests also indicate the structural stability of the estimated error correction models. The estimated and actual inflation are shown in Figure 2.

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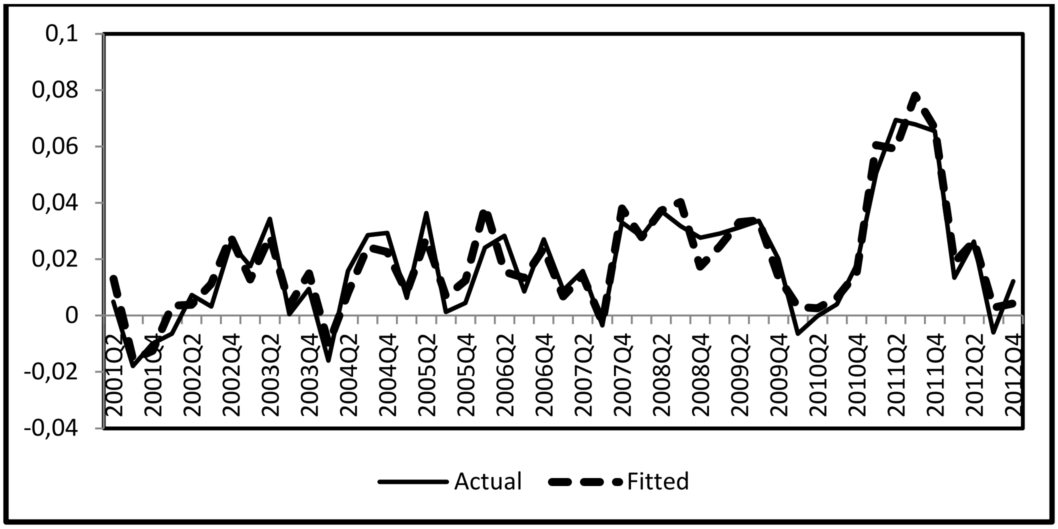
## Appendix 3: Actual and Predicted Inflation




## A.1 Conclusion and Policy Implications

The objective of this paper was to examine inflation dynamics in Uganda using a single equation error correction model. The results indicate that the proximate determinants of inflation in the long-run are money supply, exchange rate, foreign inflation, terms of trade and real output. This result is consistent with the predictions of a small open economy model, where exchange rate movements and changes in foreign prices affect the domestic price level. The results further suggest that in the short run, inflation is driven by changes in real output, monetary aggregates, the exchange rate, and foreign prices. Disequilibrium in the money and traded goods markets, captured by the two error-correction terms is also significant but the adjustment process is slow. In spite of the fact that inflation has exogenous determinants, such as foreign inflation, there is scope for the central bank to limit the impact of such shocks on inflation by pursuing a tight monetary policy stance. The significance of the interest rate differential in the money-demand equation implies some degree of effectiveness of the monetary policy.