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An Empirical Investigation of Inflation Dynamics in Kenya

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Abstract:
This study examined inflation dynamics in Kenya using quarterly data covering 2010Q1 to 2023Q1. The study employed the ARDL bounds testing approach to cointegration to estimate the determinants of inflation in Kenya. It examined the presence of second-round effects of inflation using the gap model approach. The study establishes that the nominal exchange rate, broad money supply, and output gap are the dominant drivers of inflation in Kenya. In addition, the study finds strong evidence of inflation inertia in the short run. Both structural and monetary factors thus drive inflation in Kenya. Second-round effects exist with headline inflation reverting to core inflation and core inflation to headline inflation. As a result, timely and adequate monetary policy action should focus on core inflation and headline inflation. Implementing policies that enhance production and reduce the output gap is essential to rein in the non-monetary component of inflation pressures.

Keywords: *ARDL, CPI, headline inflation, core inflation, second-round effects*

1. Introduction

Kenya experienced strong economic performance between 2010 and 2022, with an average growth rate of 4.5 percent. However, while inflation remained controlled during this period, it was challenging, particularly in 2011, 2017, and 2022 when it exceeded government targets. For instance, Kenya's inflation in 2022 averaged 7.7 percent, with high volatility peaking at 9.6 percent in October 2022. High and volatile inflation harms growth prospects and adversely affects low-income people (Durevall & Sjö, 2012; Bawa et al., 2016; Ha et al., 2019). In an inflationary environment, rising prices inevitably reduce the purchasing power of consumers, and this erosion of real income is the most significant cost of inflation (Beckerman, 1992; Mankiw, 2010; Öner, 2012).

The elevated inflation pressures in Kenya were not an isolated event. In 2022, there was inflation everywhere in the world (IMF, 2022a) and the situation was much worse in Sub-Saharan Africa (IMF, 2022b; AfDB, 2022). Several factors attributed to the high inflation in 2022 included the aftereffects of the COVID-19 stimulus package (LaBelle & Santacreu, 2022; Kliesen & Wheelock, 2023; Tsiaplias & Wang, 2023), the spillover effects of the Russia-Ukraine war (Ha et al., 2022a; Caldara et al., 2022; Zhang, 2022; Mauraya et al., 2023) and the tightening of global financial markets (Ha et al., 2022b).

Because of the adverse impacts of inflation on economies, central banks worldwide pursue price stability as the primary objective of monetary policy. Consequently, Kenya's overall monetary policy objective is the maintenance of price stability in the economy. The attainment of the objective involves maintaining the inflation rate within a target band of 5±2.5 percent. Over the period 2010-2022, inflation trends have exhibited episodes when inflation breached this target band and periods when inflation was moderate and within the target band. Three significant periods of inflation pressures emerge during the analysis period, namely: 2011-2012, 2017, and 2022. In this paper, we define an inflation episode to start when inflation rates cross the 7.5 percent mark until it returns to the desired level (See figure A1 in annexures).

In 2011, CPI inflation averaged 14.0 percent. The higher prices in 2011 spilled to 2012, when inflation averaged 9.7 percent. The high inflation cycle in the 2011-2012 window started in March 2011 when the inflation rate reached 9.2 percent from 6.5 percent in February 2011. Inflation rates steadily rose, peaking at 19.7 percent in November 2011 (after nine months), implying that at its peak, the inflation rate had surpassed the upper target band by 12.2 percentage points. Inflation rates then eased in the subsequent months to 7.7 percent and 6.1 percent in July and August 2012, respectively. Overall, inflation rates stayed above the upper limit for seventeen (17) months or nearly six (6) quarters. The 2017 inflation episode started in February when the inflation rate stood at 9.0 percent, rising steadily to 11.7 percent in May before trending downwards to 8.0 percent in August 2017 and entering the desired target band at 7.1 percent in September of the same year. In 2017, inflation rates took about four (4) months to reach the inflection point, which was 4.2 percent above the official upper target limit. Overall, the inflationary episode lasted for seven (7) months. In 2022, inflation rates crossed the upper target band in June after reaching 7.9 percent. The 2022 inflation rates took about four (4) months to peak at 9.6 percent in October 2022 and then edged downwards to 9.2 percent in February 2023. However, the inflation pressures of 2022 spilled over to 2023 and are still evolving.

One common observed factor that fuels inflation pressures across the three identified periods is drought. In 2011, 2017, and 2022, drought conditions affected most parts of the country, forcing the government to declare drought a national disaster. Across these different periods, the Meteorological Department reported short-lived cases of delayed

rains. Drought conditions constrained agricultural production, thereby resulting in food supply shortages. As a result, food inflation in 2011 rose from 15.1 percent when overall inflation crossed the official desired target band and peaked at 26.2 percent in November 2011, an average of 20.9 percent during the entire period of the inflation episode. In 2017, food inflation was 15.3 percent at the start of the inflation episode. It increased steadily, peaking at 19.9 percent and registering an average of 15.9 percent during the whole inflation episode. When the 2022 inflation episode began, food inflation was 13.8 percent and peaked at 15.8 percent in October 2022. From June 2022 to February 2023, food inflation averaged 14.6 percent. Figure A1 in annexures shows that whenever food inflation reaches two digits, overall inflation and cost of living increase sharply, while overall inflation seems to remain lower in periods of low food inflation. Thus, containing food inflation is the key to lowering the cost of living.

Fluctuations in the exchange rate are another crucial source of inflation pressures in Kenya. As shown in Figure 1, during inflationary episodes, the shilling was depreciating against the U.S. dollar, and when the shilling strengthened, inflation pressures moderated. Revelli (2020) and Kiptui (2009) have found that exchange rate pass-through to domestic prices in Kenya varies between 0.18 and 0.58, implying that a one percent depreciation of the shilling against the dollar could lead to a 0.58 percent increase in inflation. The linkage between exchange rate and inflation is importing goods and services. Depreciation of the shilling against the dollar potentially leads to inflation as the cost of imported goods and services becomes expensive. Other factors that drive domestic prices include the effects of global economic crisis, such as the European debt crisis of 2011, which affected the output of the global economy and indirectly affected Kenya's exports, tourism sector, and foreign direct investments from European countries (World Bank, 2011; KNBS 2012), the Russia-Ukraine war in 2022, or war among petroleum producing countries.

The Central Bank of Kenya (CBK) typically tightens monetary policy to anchor inflationary expectations and stabilize prices. In 2011, when overall inflation crossed the official upper target band, the CBR was 6.0 percent. It remained unaltered until after two months when CBK increased the rate by twenty-five (25) basis points in May, remaining unchanged until August 2011. Before the overall inflation rate peaked, the CBK raised the CBR by 1,025 basis points when the CBR stood at 16.5 percent. Although in 2017 inflation rate breached the upper limit, CBK did not raise the CBR and was retained at 10 percent, noting that this was also the period when interest rate capping was under implementation. In 2022, however, the CBR was increased in May, two (2) months before the inflation rate crossed the official upper target band. By the time the inflation rate peaked in October 2022, the CBR had increased by 125 basis points. By February 2023, the CBR was increased by 175 basis points to 8.75 percent in March 2023.

From the fiscal front, the government also responded to inflation episodes using fiscal measures such as subsidies on fertilizer to support agricultural production during rainy seasons, food relief and social protection in marginalized areas, and enhanced importation of main food imports commodities such as raw maize. Enhancing the importation of maize was done by removing importation quotas or removing duties on the importation of maize. Table A1 in annexures shows trends in the importation of maize. During food shortages and high cost of living (represented by the inflation episodes in 2011, 2017, and 2022), maize imports rise substantially to enhance local production and stabilize prices. For instance, in 2011, the importation of maize grew by 56.5 percent and 793.9 percent in 2017.

Given the importance of inflation as an economic indicator and its impact on economic well-being, re-examining the factors driving inflation and its dynamics is required. Therefore, this study seeks to empirically examine the drivers of inflation in Kenya and potential second round-effects.

In section two, a brief review of related literature is presented, and section three describes the data, research methodology, and empirical model estimated. The empirical results are discussed in section four, and section five concludes the paper.

2. Literature Review

This section briefly outlines the relevant literature in four areas. The first stream of literature relates to the two leading theories of inflation. The second stream reviews empirical literature concerning determinants of inflation, and the third stream reviews empirical literature relating to the second-round effects of inflation.

2.1. Theories of Inflation

The monetarist and structuralist approaches to inflation have been the primary focus of modern inflation theory and are considered the theoretical cornerstone of inflation research.

The monetarist approach emphasizes that inflation is everywhere a monetary phenomenon. This school of thought argues that demand-side factors underscored by monetary and fiscal policies are at the core of inflation dynamics (Friedman, 1963; Hendry, 2001). The underlying viewpoint of this approach is that increased injection of money in the economy results in excessive demand where too much money is chasing a few goods and services. Consequently, the excess demand over supply drives prices up. According to this theory, inflation dynamics are contingent on the velocity of money and demand for money. The theory is built on the quantity theory of money, and as such, to curb inflation, governments must combine monetary and fiscal policy tools adequately and in a timely manner.

The second school of thought is the structuralist approach, which considers inflation solely driven by supply-side factors that drive production costs upwards, e.g., soaring input prices and labor costs (Bernanke, 2005). This theory argues that specific institutional and geographical constraints influence price developments. Rigidities related to the supply side of the market are essential in driving inflation. According to this school of thought, no single economic model can explain inflation dynamics in all developing countries due to their differences in socio-economic make-up and geographical structures, which affect the domestic distribution of goods and services and international trade.

2.2. Determinants of Inflation

In economic theory, inflation is an essential indicator of economic development and individual welfare (Rochon & Rossi, 2006; Koch & Bosch, 2009; Muritala, 2011; Barro, 2013; Osei-Asare, 2013; Hossain & Mujeri, 2020; Obinna, 2020). Consequently, analysis of the determinants of inflation has long been a topic of interest to economists. Researchers have repeatedly taken several factors to explain inflation with the postulates of theoretical literature. These factors are exchange rate, money supply, interest rate, government expenditure, real GDP, and factors accounting for external shocks such as international oil prices, food prices, and export prices.

Melaku W. (2020) conducted a systematic review of drivers of inflation in 13 African countries and found that output (GDP), exchange rate fluctuations, expansion of money supply and import prices are significant determinants of inflation. Similar assertions are made by Alehegn (2021), who systematically reviews determinants of inflation in 9 Sub-Saharan African (SSA) countries and finds that interest rate is an essential driver of inflation in SSA in addition to money supply, exchange rate and GDP growth rate. Nahoussé (2019) examined the drivers of inflation in West Africa, focusing on six countries within the West African Economic and Monetary Union (WAEMU). The study used the generalized method of moments in the dynamic panel and found that devaluation of the currency, imported inflation, and employment-population ratio positively and significantly affected inflation in the zone. Money growth, however, was found to reduce inflation pressures arguing that in WAEMU, inflation is not systematically a monetary phenomenon since an increased money supply leads to an increase in production and thus, the supply of goods and services lowers inflation pressures.

Country-specific studies have also modeled short-run and long-run determinants of inflation. Nonetheless, the findings of such studies on variables that explain inflation dynamics have been mixed and inconclusive. Many of these studies have underscored the importance of monetary, structural factors, or a combination of both as the source of inflation. For instance, GDP, national income, or output are essential drivers of inflation. Odongo et al. (2022), Melaku M. (2022), Ochieng et al. (2016), and Ndanshau (2010) find that an increase in output or GDP contributes to a reduction in inflation. An increase in GDP reflects increased production, which helps lower demand-pull inflation. In contrast, Neupane (2022), Esperance (2020), and Bane (2018) show that an increase in GDP or output results in increased inflation as incomes improve and demand rises, pushing up commodity prices. Other studies, like Boshra (2022), find a statistically insignificant relationship between GDP growth and inflation rates.

Studies such as Tolasa et al. (2022), Ridwan (2022), Ogenyi and Umeh (2019), Bane (2018), Lim and Sek (2015), Kiganda (2014), and Nguyen et al. (2012) find that expansion of money supply in the economy fuels inflation pressure. In contrast, Neupane (2022) and Ndanshau (2010) report a negative relationship between inflation and money supply citing the role of money supply in accelerating the production of goods and services. Hence, the increased supply mutes demand pressures. Ochieng et al. (2016) find that growth in money is insignificant in explaining inflation dynamics in Kenya.

According to Odongo et al. (2022), Tolasa et al. (2022), Dua and Goel (2021), Ogenyi and Umeh (2019), and Alam and Alam (2016), exchange rate has a positive impact on inflation. An increase in the exchange rate makes imported goods and services costly, reflecting imported inflation. However, studies by Esperance (2022), Iya and Aminu (2014), and Ndanshau (2010) find that increase in exchange rate negatively impacts inflation. Additionally, Melaku M. (2022), Ochieng et al. (2016), and Hossain and Islam (2013) do not find a statistically significant relationship between exchange rates and inflation.

Other external indicators, such as international oil prices, drive inflation up (Odongo et al., 2022; Maonga, 2022; Melaku M., 2020; Ochieng et al., 2016). Most economies import refined petroleum products and incur imported inflation through oil importation. Additionally, when global oil prices soar, freight costs increase, leading to increased costs of international trade, thereby transmitting inflation through imports and exports. The positive impact of imported inflation on domestic inflation is also emphasized in the studies of Boshra (2022), Neupane (2022), Tolasa et al. (2022), Lim and Sek (2015), and Nguyen et al. (2012).

It has been established in the literature that increased interest rate propels inflation (Tolasa et al., 2022; Maonga, 2022; Alehegn, 2021; Bane, 2018; Iya & Aminu, 2014; Hossain & Islam, 2013; Nguyen et al., 2012). The transmission of interest rates to inflation comes through two channels, namely: demand for money and the high cost of production, resulting in increased domestic prices.

Meanwhile, myriad studies have shown that lagged inflation is a significant determinant of current inflation, reflecting the effect of inflation inertia. These assertions are evident in the studies of Maonga (2022), Alehegn (2021), Ogenyi and Umeh (2019), Bawa et al. (2016), Ochieng et al. (2016), and Adu and Marbuah (2011). The finding reinforces the idea that inflation expectation is crucial in explaining inflation dynamics.

Indicators of government fiscal operations also shed light on inflation dynamics. Boshra (2022), Melaku M. (2020), Ogenyi and Umeh (2019), and Adu and Marbuah (2011) show that increased government expenditure positively impacts inflation, implying that increasing expenditure equates to an expansionary fiscal policy stance that injects more money into the economy through recurrent and capital spending thereby putting pressure on domestic prices. Conversely, Bane (2018), Lim and Sek (2015), and Iya and Aminu (2014) find that increased government spending lowers inflation. An increase in spending results in an increase in production, which translates to lower prices through an increase in the supply of goods and services in the market. Other studies have also shown that increased public debt increases inflation (Ridwan, 2022; Ogenyi & Umeh, 2019), while Maonga (2022) finds no statistically significant relationship between inflation and public debt.

It is evident from empirics of inflation that drivers of inflation differ from country to country as different analyses provided different results. Consequently, considering the surge in consumer prices in Kenya, especially in the post-COVID

era, a re-examination of inflation drivers in Kenya is crucial, especially by utilizing high-frequency quarterly data. This paper seeks to use quarterly data to re-examine, among other things, the inflation dynamics in Kenya from 2010 to 2022.

2.3. Second-round Effects of Inflation

Several studies have examined the impact of commodity shocks on inflation. Different analytical approaches have been employed to analyze the second-round effects of inflation.

IMF (WEO, 2011) examines the impact of international commodity price shocks on inflation in several countries. The study establishes that food prices often significantly impact consumer prices in developing countries than in developed countries. The study notes that these impacts are more prominent and last long in countries where food commodities occupy a larger portion of the consumer basket.

Choi et al. (2018), Mija et al. (2013) and Jalil and Zea (2011) have employed the vector autoregressive (VAR) approach to study the persistence of inflation and the existence of potential second-round effects. Choi et al. (2018) find that a 10 percent increase in global food prices results in a 0.4 percent increase in domestic inflation in advanced economies. However, the impact subsides quickly. Conversely, for developing countries, the study established that changes in global food prices have larger impacts that tend to be persistent. Mija et al. (2013) analyzed inflation dynamics in the Republic of Moldova. They confirmed the presence of second-round effects on core inflation due to the changes in fuel and food prices.

Other studies employed gap models of inflation, including analysis of the Philips curve. Gelos and Ustyugova (2012) use monthly data from 2001-2010 for advanced, emerging and developing economies to investigate how inflation responds to commodity price shocks. The study reports that in economies where the CPI basket has high food content, commodity price shocks are likely to have prolonged effects on prices. The ability to contain inflationary pressures is high in countries where the central banks are more independent and have more substantial governance scores. This approach is also applied by Shahzad et al. (2022), who find that in Pakistan, food inflation is more persistent compared to noon-food inflation and core inflation. Misati and Munene (2015) use the gap model and Philips curve analysis to examine Kenya's food inflation and second-round effects. The study establishes that food inflation reverts to headline inflation. The estimates for domestic food prices reverting to headline inflation are 0.49 and 0.38, respectively, for non-food and non-fuel inflation.

3. Materials and Methods

3.1. Analytical Framework

The analytical framework of this paper is founded on a mix of monetarist and structuralist viewpoints on sources of inflation. We follow the approach taken by Adu and Marbuah (2011) for a small open economy like Kenya. Inflation refers to a sustained increase in the general level of prices of goods and services, usually measured by the consumer price index, such that the inflation rate is the percentage change in this index for a given period (IMF, 2023). Considering a small open economy, the general price level is the weighted average price of tradable or internationally traded goods (P^T) and the price of non-tradable or domestically traded goods (P^N). Thus:

$logP_t = \alpha(logP^T) + (1-\alpha)(logP^N)$ ..... (1)

0<α<1 is the weight of the price of internationally traded goods. Given that trades can easily be bought and sold in international markets, their prices are determined at the international market such that they are determined by foreign prices (P^f) and exchange rates (E). By invoking the theory of purchasing power parity, then P^T must satisfy the following expression:

$P^T = E \times P^f \therefore logP^T = logE + logP^f$ ..... (2)

Assuming a small economy, local consumers are foreign price takers, and for simplicity, we normalize foreign prices to 1t. Thus, equation (2) is simplified as follows:

$logP^T = logE$ ..... (3)

Substituting equation (3) in equation (1) means that consumer price inflation is typically driven by foreign exchange rate fluctuations.

On the other hand, domestic market forces primarily influence non-tradable goods, and their prices are determined mainly by local supply and demand conditions. Assuming that non-tradable prices are determined by equilibrium in the money market, i.e., $M^s/P = m^d$. Thus:

$P^N = \delta(logM^s - logm^d)$ ..... (4)

Where M^s is money supply, m^d is money demand, and δ is a scaling factor for the link between general demand in the economy and demand for domestic goods and services. Considering that demand for real money balances is also contingent on the level of income, inflation expectation, and the opportunity cost of holding money (interest rate), the money demand equation can be expressed as:

$m^d = f(y, r, \pi^e)$ ..... (5)

Where y = variable capturing income, while interest rate and the expected inflation rate are represented by r and π^e, respectively. Following Adu and Marbuah (2011), we formulate expected inflation as follows:

$\pi_t^e = \gamma\big(L(\pi_t)\big) + (1-\gamma)\Delta logP_{t-1}$ ..... (6)

$(L(\pi_t)$ represents the learning process distribution parameter by agents in the economy. Assuming no learning process, then equation (6) can be simplified as:

$\pi_t^e = \Delta logP_{t-1}$ ..... (7)

Successively and progressively substituting equation (7) to (5) and equation (5) to (4), and then these are substituted to equation (3) and (1) successively. Upon algebraic manipulations and rearrangement, the general price level is expressed as:

$P_t = F(y_t, E_t, M_t, r_t, P_{t-1})$ ..... (8)

Considering the review of inflation episodes in Kenya in the introduction section, it emerged that other than international shocks that influence oil prices, inflation in Kenya is also influenced by weather patterns. With P_t as the consumer price index (CPI) inflation, we, therefore, modify equation (8) to capture domestic supply shocks (proxied by output gap), global supply shocks (proxied by international oil prices), and exchange rate and monetary policy variable (money supply). Thus:

$CPI_t = F(ygap_t, E_t, Oilprice_t, M_t, CPI_{t-1})$ ..... (9)

3.2. Model Specification

Following the empirical framework discussed above, the specific form of our estimable models is thus specified:

$CPI_t = y\_gap_t^{\beta_1} E_t^{\beta_2} Oilprice_t^{\beta_3} M_t^{\beta_4} CPI_{t-1}^{\beta_5}$ ..... (10)

We linearize equation (10) by taking logs on both sides and have the following:

$ln\ CPI_t = \alpha + \beta_1 \ln y\_gap_t + \beta_2 \ln E_t + \beta_3 \ln Oilprice_t + \beta_4 \ln M_t + \beta_5 \ln CPI_{t-1} + \varepsilon_t$ ..... (11)

All variables are defined as before; ε_t is the error term. Assumptions on the error term are that it has zero mean or expected value and constant variance and is not correlated with explanatory variables. $\ln y\_gap_t$ represents the output gap, and $Oilprice_t$ represents the international oil prices.

3.3. Testing for Second-Round Effects

They utilized the gap model approach to check the existence of second-round effects SRE of food and fuel inflation in Kenya following the approach used by Shahzad et al. (2012), Gelos and Ustyugova (2012), and Misati and Munene (2015). Two equations are estimated. Equation (12) checks for the reversion of headline inflation to the core, while equation (13) checks for the reversion of core inflation to headline.

$\pi_t^{headline} - \pi_{t-i}^{headline} = \alpha + \beta\left(\pi_{t-i}^{headline} - \pi_{t-i}^{core}\right) + \varepsilon_t$ ..... (12)

$\pi_t^{core} - \pi_{t-i}^{core} = \gamma + \delta\left(\pi_{t-i}^{core} - \pi_{t-i}^{headline}\right) + \varepsilon_t$ ..... (13)

Headline inflation is represented by $\pi_t^{headline}$, while π_t^{core} represents core inflation.

3.4. Data

This study used quarterly time series data covering the period 2010Q1 to 2023Q1. Variables such as CPI (February 2019 = 100), the exchange rate of Kenya shilling against the U.S. dollar, and real GDP (2016 constant basic prices) were compiled from various Economic Survey Reports by the Kenya National Bureau of Statistics. Core inflation and money supply (M3) were obtained from various CBK's Monthly Economic Indicator bulletins. Global oil prices were derived from the World Bank Commodity Prices Data - Pink Sheet. The output gap was estimated by applying the Hodrick-Prescott (HP) filter on the Real GDP series and decomposing it into trend and cyclical components.

3.5. Estimation Methods

The study conducted a unit root test on all variables to establish their order of integration and ensure that we do not run into the problem of spurious regression. Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests were used. Moreover, Bounds Test for Cointegration was used to determine the presence of a long-run relationship. Having established that some variables were I (0) and others I (1), the study proceeded to estimate the Autoregressive Distributed Lag Model (ARDL) employing cointegration and error correction models. Analysis was based on EViews 9.

4. Empirical Results

4.1. Unit Root Tests

Before estimating the inflation model developed in equation (11), a unit root test was conducted using ADF and PP tests to evaluate the order of integration of variables and ascertain if the ARDL bound test approach or simple OLS was the applicable method. The null hypothesis for ADF and PP tests is that the series or variables have unit roots. We conducted ADF and PP tests with and without the trend, and table 1 presents the results. We find that all variables are integrated with order one (that is, I (1)) save for y_gap, which is found to be integrated with order zero (that is, I (0)). Considering that no variable was integrated of a higher order, it was concluded that the ARDL estimation technique was applicable for analysing inflation dynamics in Kenya.

Variable	At Level		At First Difference	
	With Constant	With Constant & Trend	With Constant	With Constant & Trend
ADF Test				
Log of CPI	-1.7736	-3.7402***	-6.2221***	-6.4438***
Log of exchange rate	-0.5758	-2.2620	-5.7333***	-5.6814***
Log of money supply	-3.5856***	-1.3110	-8.1185***	-9.5226***
Log of global oil price	-1.6213	-1.6214	-6.3518***	-6.2979***
Output gap	-3.7315***	-3.6790***	-3.7299***	-3.6890**
PP Test				
Log of CPI	-1.3198	-2.2548	-4.8342***	-5.0561***
Log of exchange rate	-0.5772	-2.5646	-5.5858***	-5.5231***
Log of money supply	-13.1846***	-2.2159	-8.1071***	-10.6063***
Log of global oil price	-1.8105	-1.8554	-6.3518***	-6.2956***
Output gap	-9.2993***	-9.6254***	-14.8734***	-14.5809***

Table 1: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests
Source: Author's Compilation Using Eviews 9 Computations
*Note: The Values Represent the T-Statistic of the ADF (Upper Panel) and PP (Lower Panel) Unit Root Tests. The Asterisks *** and ** Denote the Statistical Significance of the Test at 1, 5, and 10 Percent Levels of Significance, Respectively*

4.2. Bond Test for Cointegration

Having justified the use of the ARDL model, the next precondition was to test for the presence of a cointegrating or long-run relationship between CPI inflation and the regressors. ARDL Bounds Test developed by Pesaran et al. (2001) was utilized. In the Bounds Test approach, the null hypothesis is that there is no cointegration among the variables under the study, while the alternative hypothesis is that there is cointegration among the variables under study. Pesaran et al. (2001) present the critical values for the bounds assuming that variables in the model are either I (0) or I (1) or mixed. Table *2* summarizes the test results for the Bounds cointegration test.

Test Statistic	Value	Level of Significance	I (0) Bound	I (1) Bound
F-statistic	6.7546	10per cent	2.45	3.52
k	4	5per cent	2.86	4.01
		2.50per cent	3.25	4.49
		1per cent	3.74	5.06

Table 2: ARDL Bound Test for Long-Run Relationship
Source: Author's Computation Using Eviews 9
Note: F-Bounds Test, Null Hypothesis: No Long-Run Relationships Exist

The results indicate that F-statistic is 6.75, which is higher than the critical values for the upper bound at a 1 percent significance level, which is 5.06. Therefore, the null hypothesis is rejected, and the conclusion is made that there exists a long-run relationship among the study variables. In running the ARDL model, an optimal lag length of 4 was chosen since the data for the study is quarterly. However, using the in-built EViews Facility following the Schwarz Bayesian Information Criterion (SIC), the selected ARDL model is ARDL (2, 4, 4, 2, 4).

4.3. Regression Results

4.3.1. ARDL Inflation Model

Table 3 highlights findings from the ARDL inflation model. It merges that money supply, exchange rate, global fuel prices, and the output gap positively fuel inflation in Kenya. Specifically, a percentage increase in money supply results in a 0.13 percent increase in the CPI inflation rate. These findings are consistent with Bane Ridwan (2022), Boshra (2022), Melaku M. (2020), Bane (2018) and Bawa et al. (2016). On the contrary, Ndanshau finds a negative and statistically significant effect of money supply on inflation in Tanzania.

Depreciation of the shillings has inflationary costs. According to this study, a percentage increase in the exchange rate (shilling depreciation against the U.S. dollar) pushes the domestic CPI inflation rate upwards by 0.19 percent. Kenya, as a small open economy, relies on importing goods and services to bridge domestic production gaps and bring in products not produced locally. Thus, the deterioration of the shilling against the dollar, a primary trading currency, leads to imported inflation. These results are consistent with findings by Neupane (2022), Tolasa et al. (2022) and Alam & Alam (2016). Other studies, however, found a negative relationship between exchange rate and inflation (Iya & Aminu, 2014; Ndanshau, 2010), while Esperance and Fuling (2022) and Hossain and Islam (2013) find no statistically significant association.

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Log of CPI (-1)	0.0685	0.1793	0.3822	0.7053
Log of CPI (-2)	-0.3519*	0.1726	-2.0393	0.0513
Log of exchange rate	0.1868***	0.0635	2.9403	0.0066
Log of the exchange rate (-1)	0.1486***	0.0673	2.2082	0.0359
Log of the exchange rate (-2)	0.2041***	0.0756	2.7005	0.0118
Log of the exchange rate (-3)	0.0313	0.0811	0.3853	0.7030
Log of exchange rate (-4)	0.1110	0.0711	1.5604	0.1303
Log of money supply	0.1292***	0.0529	2.4423	0.0186
Log of money supply (-1)	0.0309	0.1031	0.3000	0.7665
Log of money supply (-2)	0.0966	0.0982	0.9837	0.3340
Log of money supply (-3)	0.1384*	0.0798	1.7343	0.0943
Log of money supply (-4)	0.1379	0.0909	1.5175	0.1408
Log of global oil price	0.0238***	0.0101	2.3558	0.0260
Log of global oil price (-1)	0.0305***	0.0106	2.8854	0.0076
Log of global oil price (-2)	0.0245***	0.0106	2.2995	0.0294
Output gap	0.0206	0.0807	0.2550	0.8007
Output gap (-1)	0.1415***	0.0652	2.1683	0.0391
Output gap (-2)	-0.0371	0.0725	-0.5118	0.6129
Output gap (-3)	0.1597**	0.0778	2.0526	0.0499
Output gap (-4)	0.1497*	0.0815	1.8376	0.0772
Constant term	0.0025	0.0046	0.5402	0.5935
R-squared	0.7524	Mean dependent var		0.0173
Adjusted R-squared	0.5690	S.D. dependent var		0.0139
S.E. of regression	0.0091	Akaike info criterion		-6.2609
Sum squared residuals	0.0022	Schwarz criterion		-5.4423
Log-likelihood	171.2619	Hannan-Quinn criterion		-5.9515
F-statistic	4.1021	Durbin-Watson stat		1.8984
Prob(F-statistic)	0.0004			

Table 3: Regression Results for ARDL Model (Log of CPI=Dependent Variable)
Source: Author's Computation Based on Eviews 9
Note: The Sample Period Used for Estimation Is 2011Q2–2023Q1.
*The Asterisks ***, **, and * Mark the Statistical Significance of Coefficients at 1, 5, and 10 Percent Significance Levels, Respectively*

Equally, an increase in global oil prices exerts pressure on domestic prices. A review of quarterly Balance of Payment reports by KNBS indicates that Kenya's top 5 exports cannot finance its importation of petroleum products, a major production and energy source factor. The results show that a percent increase in global oil prices pushes CPI inflation upwards by some o.o3 percentage points. Similar findings are documented in Dua and Goel (2021), Melaku M. (2020) and Alam & Alam (2016).

The output gap, which measures capacity utilization and structural bottlenecks in domestic production, also affects the CPI inflation rate. Whenever there are shocks in domestic production, especially in the real sector, the supply of goods and services falls below demand levels, pushing prices upwards. Results show that a percent increase in output gap results in a 0.14 percent increase in CPI inflation rates. These findings mirror the findings by Dua and Goel (2021), Bane (2018) and Nguyen et al. (2012). In general, these results have revealed that inflation in Kenya is not just a monetary phenomenon but is also influenced by domestic and external structural factors. As a result, policy on price stabilization should focus on monetary indicators and non-monetary factors.

4.3.2. Post-estimation Diagnostics for the ARDL Model

The study conducted various post-estimation diagnostics to ensure that the model satisfies the classical assumptions of linear regression and that coefficient estimates efficiently inform policymaking reliably. Results of post-estimation diagnostics are presented in table 4, which gives the ARDL inflation model diagnostic tests.

Tests	F-statistic	DF	Prob.	Prob. Chi-Square (2)
Breusch-Godfrey LM serial correlation test	0.0997	F (2,25)	0.9055	0.8271
Breusch-Pagan-Godfrey Heteroskedasticity test	0.7492	F (20,27)	0.7447	0.6445
Heteroscedasticity (ARCH)	2.7019	F (1,45)	0.1072	0.1028
Normality test of the residual-Jarque-Bera test	3.3685		0.1856	
Ramsey RESET (F-statistic)	1.0526	F (1, 26)	0.3144	
Durbin-Watson (D-stat = 1.8984)				

Table 4: Summary of Diagnostic Tests of the ARDL Inflation Model
Source: Author's Compilation Based on Diagnostics Tests after ARDL Model Estimation Using Eviews 9

LM Serial correlation test and heteroskedasticity test were conducted to verify errors for white noise. Breusch-Godfrey LM serial correlation test, revealed no serial correlation, while the Breusch-Pagan-Godfrey Heteroskedasticity test and ARCH test proved that the residuals were homoscedastic. Jarque-Bera test for normality revealed that the residuals of the estimated ARDL model were normally distributed. In contrast, the Ramsey RESET test showed that the model lacked specification problems. Further, we ran CUSUM and the CUSUMSQ tests to check for model stability. A model is stable if its recursive residual is within the two critical bounds. Results for CUSUM and CUSUMSQ tests showed in figure A2 in annexures, and they reveal that the model was stable across all periods.

4.3.3. Long Run Estimation Results

Long-run determinants of inflation in Kenya are presented in table 5. In the long run, inflation in Kenya is positively driven by the exchange rate, money supply, global oil prices, and output gap. These variables are positively associated with CPI inflation and are statistically significant. Increased money supply fuels demand pressures that outstrip supply, pushing prices upwards. Persistent depreciation of the shilling makes the cost of imported goods expensive, leading to imported inflation.

Moreover, shocks in global oil prices also fuel imported inflation, considering that Kenya is a net importer of crude and refined oil. Results also show that structural shocks that curtail domestic production affect prices. About one-fifth of Kenya's domestic production emanates from agriculture, livestock, fisheries, and forestry activities, which is also the primary source of food production. Moreover, food and non-alcoholic beverages account for about 32.9 percent of the CPI basket, comprising 330 items. Agricultural production shortages are thus crucial for GDP and a pivotal pointer to persistent inflation pressures, as shown by the positive coefficient for the output gap.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log of exchange rate	0.5312	0.1020	5.2102	0.0000
Log of money supply	0.4153	0.1236	3.3614	0.0023
Log of global oil price	0.0614	0.0140	4.3779	0.0002
Output gap	0.3384	0.1065	3.1771	0.0037
C	0.0019	0.0036	0.5461	0.5895

Table 5: Regression Results of the Long-Run Model
Source: Author's computation using EViews 9
*Note: The dependent variable is a log of CPI over the sample period 2010Q1–2023Q1. The asterisks ***, **, and * mark the statistical significance of coefficients at 1, 5, and 10 percent significance levels, respectively.*

4.3.4. Results for the Dynamic Short Run Model

Short-run results also show that money supply, exchange rate global oil prices positively and significantly affect inflation in Kenya. Additionally, we find the presence of inflation inertia in the short run, indicating that the inflation rate in the previous period significantly affects the rate of current inflation. The degree of inertia is 0.35 showing that the reduction in inflation is slow. These findings are consistent with Maonga (2022), Ochieng et al. (2016) and Ndanshau (2010). Output gap has appositive association with inflation in the short run, but the coefficient is not statistically significant. Furthermore, the estimate for ECT coefficient or cointegrating equation (-1) is -1.28, having the expected negative sign, and is statistically significant at 1 percent. Exponentiating the ECT coefficient estimate to the original scale yields 27.7 percent. The resulting value represents the speed at which inflation adjusts back to its long-run equilibrium following a deviation from that equilibrium. These findings show that about 27.7 percent of the deviation of CPI inflation from the long-run equilibrium is corrected each quarter. In other words, if inflation experiences a shock that pushes it away from its long-run equilibrium, it will take approximately 4-5 quarters for inflation to return to its long-term equilibrium level.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (Log of CPI (-1))	0.3519*	0.1726	2.0393	0.0513
D (Log of exchange rate)	0.1868***	0.0635	2.9403	0.0066
D (Log of money supply)	0.1292***	0.0529	2.4423	0.0186
D (Log of global oil price)	0.0238***	0.0101	2.3558	0.0260
D (Output gap)	0.0206	0.0807	0.2550	0.8007
Coint. Eq. (-1)	-1.2834	0.2362	-5.4342	0.0000

Table 6: Estimation Results of the Error Correction Model
Source: Author's Computation Using Eviews 9
*Note: The dependent variable is a log of CPI over the sample period 2010Q1–2023Q1. The asterisks ***, **, and * mark the statistical significance of coefficients at 1, 5, and 10 percent significance levels, respectively.*

4.4. Results for Second Round Effects

Table 7 presents results for the reversion of headline inflation to core inflation. The estimated beta (**β**) is negative and statistically significant. According to Misati and Munene (2015), a value of **β** of-1 signals that headline inflation reverts fully to core inflation. In this case, the estimated **β** is -0.87, which confirms the existence of second-round effects in Kenya with a reversion of headline inflation to core inflation. These findings are like Shahzda et al. (2022), who find a beta 0f -

0.66 for Pakistan. On the contrary, Misati and Munene (2015) found a non-negative beta of 0.02 for Kenya using monthly data.

Dependent Variable	$\pi_t^{headline} - \pi_{t-i}^{headline}$			
Explanatory Variable	$\boldsymbol{\beta}$	**Std. Error**	**t-Statistic**	**Prob.**
$\left(\pi_{t-i}^{headline} - \pi_{t-i}^{core}\right)$	-0.8797***	0.2990	-2.9424	0.0050
Constant term	2.5889	1.0311	2.5108	0.0155

Table 7: Reversion of Headline Inflation to Core Inflation
Source: Author's Computation Using Eviews 9
*Note: *** showed that coefficients are significant at 1 percent*

Gelos and Ustyugova (2012) note that it is crucial to examine whether core inflation reverts to headline inflation. Confirmation of such a reversion implies that shocks to headline inflation, such as hikes in commodity prices, contribute to inflation expectations and price-setting behavior, thereby fuelling core inflation (Gelos & Ustyugova, 2012). Table 8 presents the results of the reversion of core inflation to headline inflation. Usually, a value of **δ** of 0 indicates that core inflation does not revert to headline inflation, while a coefficient of -1 implies complete reversion. Our results show a coefficient of -0.49 which is statistically significant and different from zero. This finding confirms the existence of second-round effects in Kenya, with core inflation reverting to headline inflation. These results are consistent with Misati and Munene (2015), who finds a coefficient of -0.5 for Kenya, Shahzda et al. (2022), who finds a coefficient of -0.11 for Pakistan and Gelos and Ustyugova (2012), who finds the presence of second-round effects for many emerging and developing economies.

Dependent Variable	$\boldsymbol{\pi_t^{core} - \pi_{t-i}^{core}}$			
Explanatory Variable	$\boldsymbol{\delta}$	**Std. Error**	**t-Statistic**	**Prob.**
$\left(\pi_{t-i}^{core} - \pi_{t-i}^{headline}\right)$	-0.4935***	0.1106	-4.4610	0.0000
Constant term	-0.2773	0.0914	-3.0358	0.0038

Table 8: Reversion of Core Inflation to Headline Inflation
Source: Author's Computation Using Eviews 9
*Note: *** showed that coefficients are significant at 1 percent*

5. Conclusions

This study sought to investigate the inflation dynamics by re-examining the determinants of inflation and estimating the second-round effects of inflation in Kenya. The study utilized quarterly data covering the period 2010Q1 to 2023Q1. ARDL inflation model that incorporates monetarist and structuralist sources of inflation was estimated, while the gap model was used to determine the second-round effects of inflation. The study concludes that inflation in Kenya is a monetary and structural phenomenon (emanating from prolonged dry weather that interferes with agricultural production and food supply), as evidenced by the positive effect of the output gap on inflation in the long and short run. In addition, domestic money supply intensifies inflationary pressures, meaning that in fighting inflation, demand-pull factors cannot be ignored. Besides monetary and domestic supply shocks, overall inflation is influenced by exchange rate fluctuations and global commodity and oil prices. Short-run disequilibrium in inflation is adjusted to a steady state. However, inflation takes about 4-5 quarters to fully return to the steady state long-run equilibrium after a shock. The extended period to equilibrium has implications for the timing and magnitude of monetary and fiscal policy actions. Second-round effects show that headline inflation reverts to core inflation, and core inflation reverts to headline inflation. The presence of second-round effects, which are also persistent, has implications on the conduct of monetary policy, considering that over 30 percent of headline inflation is food inflation.

Money supply plays a crucial role in explaining inflation in both the long-run and short-run, suggesting that controlling monetary expansion is essential for disinflation and initiatives to lower the cost of living in Kenya. Therefore, targeting monetary growth can be considered a short-term target variable in operationalizing monetary policy. However, considering the positive relationship between inflation and the output gap and the fact that the consumer basket is heavy on food items, policies that enhance food availability need to be pursued vigorously. The presence of second-round effects and the longer adjustment period to steady state inflation rate shows that monetary policy response to inflation pressures must be timely and adequate to ensure price stabilization and avoid a wage-price spiral. Continued vigilance in assessing and monitoring global developments is vital for timely policy action addressing vulnerabilities that may arise from international markets.

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Annexures

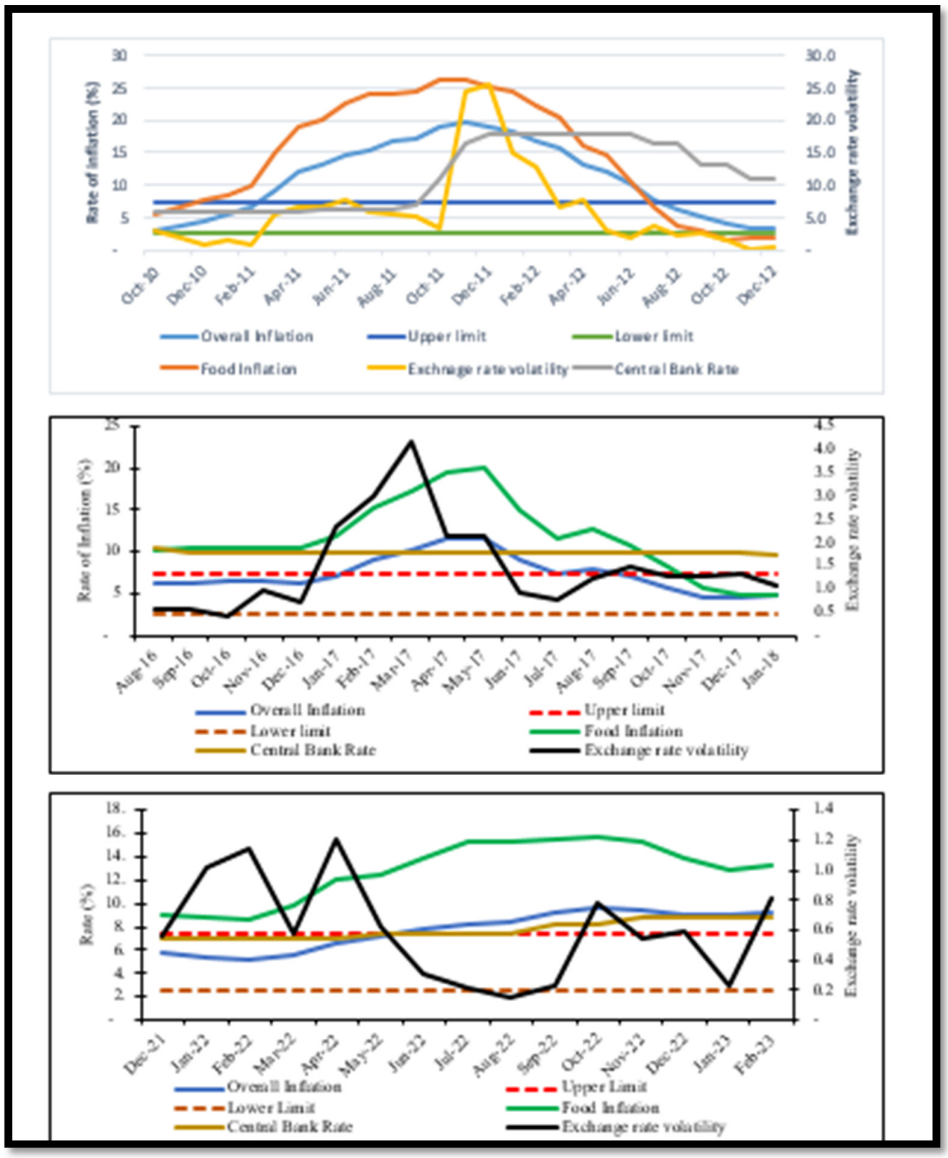

Figure 1
Source: KNBS (Various), CPI Report and CBK (Various), Monthly Economic Indicators

	Maize (tons)	Annual % Growth (Maize)
2010	229,611.0	
2011	359,232.0	56.5
2012	324,622.0	-67.6
2013	93,473.0	-71.2
2014	458,940.0	391.0
2015	490,024.0	6.8
2016	148,558.1	-69.7
2017	1,327,971.7	793.9
2018	529,558.3	-60.1
2019	228,723.5	-56.8
2020	273,472.2	19.6
2021	486,525.0	77.9
2022*	707,718.4	45.5

Table A1: Quantities of Imported Maize from 2010 to 2022
Source: KNBS (Various), Economic Survey and KNBS (Various), Quarterly Balance of Payments Reports
Note – * data available up to September 2022

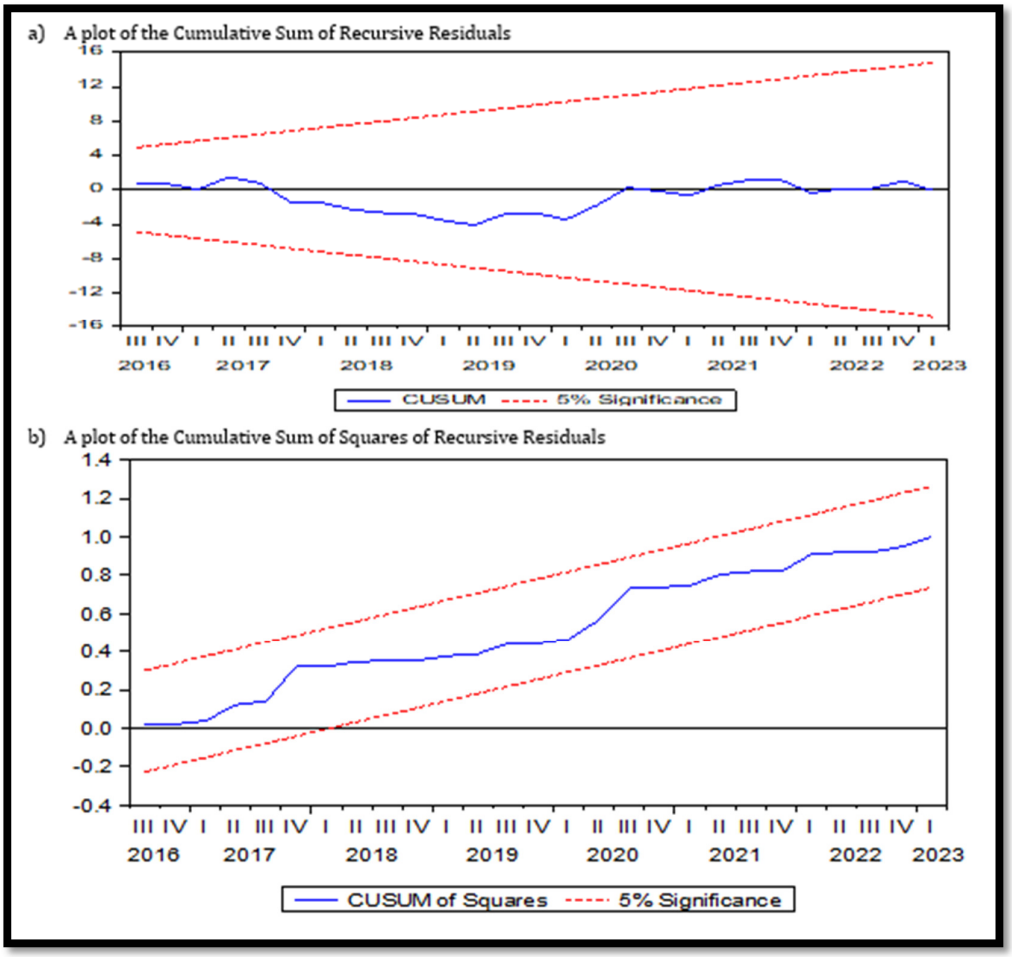

Figure 2: CUSUM and CUSUMQ Tests for Model Stability
Source: Computation Using EViews 9