Inflation, Exchange Rate, and Money Supply Nexus in Tanzania: Application of the ARDL Bounds Testing Approach

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Abstract
The interrelationships among inflation, money supply, and exchange rates are a widely researched area. However, the findings and conclusions are yet contentious hence, our knowledge of the nexus among the variables remain elusive. Using annual time series data (1970-2015) from Tanzania, the study examines the nexus among inflation, money supply, and exchange rate. Using the ARDL bounds testing approach, the study reveals the existence of a long-run equilibrium relation among inflation, money supply, and exchange rates. Furthermore, money supply and exchange rate also have a short-run dynamic causal effect on inflation. The estimated error correction coefficient of 0.73 suggests about 73 percent of the disequilibrium is corrected within a year. This speed of adjustment towards the equilibrium is quite high. Study’s findings support the contention that inflation is a monetary phenomenon in Tanzania. Similarly, the exchange rate pass-through is also a very notable phenomenon. In light of the findings, proper monetary policies such as tightening money supply is required to continue keeping inflation low and stable.

Keywords: Money Supply, Inflation, Exchange rate, ARDL, Bounds testing, Tanzania

1.0 INTRODUCTION

Inflation, money supply, and exchange rate are important variables of economic performance as they determine output growth and demand conditions in an economy. Inflation is understood as a sustained rise in a general level of prices (Blanchard, 2009). High inflation has economic and social costs. It increases production costs, reduces confidence in money as a store of value (Hoai, 2019) creates market inefficiency, discourages long-term investments (Yabu & Kessy, 2015), and ultimately negatively affect economic growth (Kasidi & Mwakanemela, 2013). Furthermore, inflation affects investment planning and international competitiveness of a country. Inflation is amongst the macroeconomic problems that must be kept at a suitable level to enable the economy to grow sustainably. Exchange rate, which is the price of foreign currency in terms of domestic currency (Blanchard, 2009; Ligare et al., 2019) affects the economy as it influences international flows of goods, services, and financial capital. Volatile exchange rate creates uncertainty about future profits from export trade, which could affect firms’ investment decisions in the long run (Khan et al., 2012). Similarly, money supply affects inflation and exchange rate (Blanchard, 2009). Hence, money supply that keeps inflation and exchange rate at stable and reasonable growth rates is a target for monetary policy in most economies.

Several theoretical perspectives have been applied to explain the interrelationships among money supply, inflation, and exchange rate. The quantity theory of money, a monetarist view is certainly the most prominent perspective. The quantity theory of money contends that money supply is directly related to the price of goods and services, such that an increase in the volume of money in the circulation brings about a general rise in the price when the economy is at full employment level. As the economy reaches the full employment, a further increase in money supply will not influence the output; hence, causing excess demand and ultimately putting pressure on prices (Kishor and Kulkani, 1999).
exchange rate pass-through inflation is also found suitable to understand and explain inflation. The perspective suggests that currency depreciation makes imports of intermediate and final goods more expensive, which are then passed over to domestic prices (Goldberg & Knetter, 1997). Whereas currency depreciation can stimulate export demand, supply constraints can put pressures on domestic price as export and domestic demands increase. The effect of exchange rate on inflation can also be explained from the perspective of a firm’s behaviour. As firms become more responsive to the cost increase due to the perceived persistent exchange rate fluctuation, they are more likely to increase the prices of goods and services to make profit (Madesha et al., 2013). The foregoing theoretical insights suggest that the direction of the relationship can go either way; hence, the conclusion remains elusive.

The literature is replete with empirical studies, which have been conducted across the globe to test the validity of the arguments advanced in the theoretical perspectives reviewed in the foregoing paragraphs. For example, Emanuel (2010) and Akinbobola (2012) observed that money supply and exchange rates have a significant long-run effect on inflation in Nigeria. Sean et al., (2019) and Ssebulime and Edward (2019) observed that money supply causes domestic currency depreciation, whose effect is transmitted to inflation. Similarly, Musa et al., (2019) found long-run and causal relationships between money supply and inflation rate whereby money supply increases inflationary pressure in the short and long runs. In Egypt, Helmy, Fayed and Hussien (2018) observed that there was an exchange rate pass-through inflation in Egypt. In addition, Asari, et al., (2011) studied the inter-relationships between inflation, interest rate, and exchange rates in Malaysia and found that, interest rate is positively related to exchange rate, whereas inflation is negatively related to exchange rates in the long run. Madesha et al., (2013) found that exchange rates and inflation had a long-run causal relationship in Zimbabwe, with the direction of causality running in both ways.

Few studies on inflation, interest rate, and exchange rates have been conducted in Tanzania. For example, Rutasitara (2004), Mwase (2006), and Ayubu (2013) found a significant relationship between exchange rates and inflation, whereas Mbongo et al., (2014) found money supply causing inflationary spiral and exchange rate variations in the short and long runs. Recently, Myovella and Kisava (2018) applied the bounds testing approach and found a long-run relationship between budget deficit and inflation. Despite the useful insights highlighted above, earlier studies remain largely elusive; hence, no firm conclusion can be made on the nexus among inflation, money supply, and exchange rate. This could be ascribed to some factors including a span of data series used, econometric methodologies applied, and geographical contexts that vary in the levels of institutional and socioeconomic development (Khan et al., 2012). In this respect, the findings from earlier studies lack external validity. Moreover, few studies applied the bound testing approach to examine inflation in a sub-Saharan African setting such as Tanzania (Odhiambo, 2012).

The current study therefore investigates causal relationships between inflation, money supply, and exchange rates to determine whether the observed relationship can be interpreted as causal. The study aims at providing insights into the interrelationships among the discussed variables, which are important in assessing the performance of the implementation of monetary policy. Tanzania is an interesting case to study given that since embarking on economic and institutional reforms in the 1980s and embracing market-based policies, the country has adopted various exchange rate and monetary policy regimes with varying effects on inflation (Nyorekwa & Odhiambo, 2014). As the country heightens her commitment to economic reforms, understanding inflation, money supply, and exchange nexus is imperative for assessing the achievement.

The remainder of the paper is structured as follows. Section 2 presents a review of theoretical and empirical perspectives as well as development of the conceptual model and the main hypothesis for empirical testing. The methodology of the study is described in section 3, followed by the analysis and discussions of the findings in section 4. The study concludes and highlights the main policy and research implications of the findings in section 5.
2.0 Theoretical Framework and Hypotheses Development

Economic literature is replete with theories explaining interrelationships between money supply, exchange rate, and inflation. Traditionally, the Quantity Theory of Money (QTM), the classical monetarist view, which was originally developed by Fisher in 1911 in his seminal work the *Purchasing Power of Money*, suggests that, inflation is due to excessive supply of money in an economy. Money supply raises the level of aggregate demand. If aggregate supply (output) remains constant or increases less rapidly than the aggregate demand, prices will increase more money chase fewer goods. The quantity theory of money assumes that the velocity of circulation of money and real national output are held constant. Moreover, the theory assumes that, an economy is in equilibrium and at full employment, thereby an increase in money supply does not affect output. However, inflation in developing countries is not purely a monetary phenomenon. Developing economies have structural weaknesses that cause supply bottlenecks in certain goods and inputs such as food and foreign exchange (Dwivedi, 2010; Maweje & Lwanga, 2015). In this respect, the relationship between money supply and inflation may still be expected, but not necessarily as proportional as predicted by the theory.

The Purchasing Power Parity (PPP) theory, which is an application of the Law of One Price across countries (Ramirez & Khan, 1999; Mankiw, 2003), is a framework used to explain long-run movements of exchange rates. The theory integrates the goods and money market through relative prices of goods in the domestic and foreign markets. The theory suggests that identical goods are sold at the same price in different markets when the exchange rate is taken into account, all else being equal. As such, a change in one country’s price affects the exchange rate, such that a domestic currency depreciates/appreciates proportionally to a change in domestic price level relative to the foreign market price. The validity of the PPP theory is questionable as it works favourably well for tradable and perfectly substitute goods, while most goods are non-tradable and differentiated (Al-Zyoud, 2015). Nonetheless, the underlying logic of PPP behind exchange rate movements makes the PPP theory pervasive.

Another perspective linking the exchange rate and inflation is the exchange rate pass-through. The perspective suggests that in an open economy with a flexible exchange rate system, exchange rate depreciation or appreciation will probably influence domestic consumer and producers indices through import prices. Domestic price for imported goods responds to nominal exchange rates such that changes in import prices are to some extent passed on to producer and consumer prices in the domestic markets (Goldberg & Knetter, 1997). Based on this perspective, it is clear that a country such as Tanzania, which relies much on imports for domestic consumption, production or any other purposes, is likely to be highly susceptible to price fluctuations in exporting countries.

The balance of research in this area has been in favour of understanding and determining the degree of pass-through (strong or weak) and its associated factors rather than on the presence or absence of the pass-through. Dornbusch (1987) explains why the pass-through is likely to be incomplete. The author summarizes four factors to that effect: (i) the degree of market integration, (ii) the degree of product differentiation, (iii) the functional form of the demand curve, and (iv) the market structure and the degree of strategic interaction among suppliers.

The relationship between money supply and exchange rate is well captured in the monetary approach. The approach contends that supply and demand for money affect the relative price of foreign and domestic prices (Frankel & Rose, 1994). That is to say, an increase in money supply in the domestic market increases the domestic price leading to the appreciation of the foreign currency.

The empirical literature is also replete with studies examining the interrelationships between money supply, inflation, and exchange with the purpose of testing arguments of the theories highlighted above. The studies have focused either on two or all three variables using different approaches. For example,
Takhtamanova (2008) shows that appreciation of domestic currency leads to a decline in inflation in 14 OECD countries. This suggests that a change in the exchange rate is passed-through to inflation among the studied countries. Similarly, using monthly data on the Bayesian Vector Regressive (B-VAR) approach; Sean et al., (2019) found that money supply growth depreciates domestic currency and increases inflation in Cambodia. In Egypt, Helmy et al., (2018) applied a structural VAR approach to determine the effect of exchange rate on inflation and found that the extent of the exchange rate through to inflation is substantial, albeit incomplete.

Some empirical studies have also been conducted in sub-Saharan Africa. These studies show that both money supply and exchange rate influence inflation (Akinbobola, 2012; Emmanuel, 2010; Maweje & Lwanga, 2015), money supply influences exchange rate (Ndung’u, 1999), exchange rate influences inflation (Oriavyote and Eshenake, 2012), and exchange rate and inflation influence each other (Madesha et al., 2013).

For the case of Tanzania, Mbogo (2008) investigated the exchange rate dynamics in Tanzania from 1986 to 2006 using the OLS technique. The study shows that changes in money supply and trade balance trigger movements in the exchange rate implying that the past money supply and trade balance help to predict better the exchange rate. Mwase (2006) analysed the exchange rate pass-through to inflation in Tanzania using data covering the period from 1990 to 2005. The findings show a small but persistent effect of exchange rate shocks on the short run. In the long run, there is a negative relationship between exchange rate depreciation and inflation. Rutasitara (2004) examined major determinants of inflation focusing on the role of exchange rate policy change in Tanzania. The study results reveal that official devaluation significantly influences the rate of inflation. Finally, using OLS, VAR and ECM techniques, Mbongo et al., (2014) found that money supply and exchange rate have a significant impact on inflation in the short and long run.

Despite that, a few studies have been undertaken in this geographical context, the results are still inconsistent and lack common argument. Largely, the variation in empirical results reflects the differences in the variables including, the geographical context used, and econometric techniques applied that vary in the sample size requirements. This implies that further investigation is imperative. For example, most studies on inflation and exchange rates put money supply in the background, without directly testing its effect. Besides, earlier studies were conducted in different contexts; hence, their external validity is questionable. This is because countries differ in the level of socioeconomic and institutional development, this could lead to variation in the effectiveness of monetary policy.

Figure 1 shows the conceptual framework of the study. The study posits that an increase in money supply implies that people have more money for spending on goods and services. In the short run, this creates an imbalance between the supply side and demand side due to excessive demand for goods and services. In the long run, to meet strong demand for goods and services, producers will hire more workers creating strong demand for labour, leading to an increase rise wages to attract more workers. Consequently, the general price level would eventually increase to compensate for the higher cost of production associated with higher wages. Equilibrium in the money market requires a balance between money supply and demand. A high price level increases the demand for imports as domestic commodities become relatively expensive. As a result, the domestic currency depreciates.
Given the foregoing discussions, the following hypotheses are developed for empirical testing:

**Hypothesis 1:** All else being equal, there exists a long-run relationship (cointegration) among inflation, money supply, and exchange rate.

**Hypothesis 2:** All else being equal, increase in money supply and exchange rate depreciation cause inflation in the short run and long run.

### 3.0 DATA AND METHODOLOGY

The study used annual time series data for 1970 to 2015 to analyze causality among money supply, inflation, and exchange rates in Tanzania. The data set was compiled from BOT (2016). To ensure validity and consistency, the collected data were compared with data from other sources including various published reports from the National Bureau of Statistics (NBS) (www.nbs.go.tz), the World Bank (World Development Indicators) (https://databank.worldbank.org) and Penn World Tables (https://www.rug.nl/ggdc). Generally, data were found to be consistent across the various sources.

### 3.1 Econometric Model and Estimation Methods

The study applied the Autoregressive Distributive Lag Model (ARDL) bound test approach developed by Pesaran et al. (2001) to analyze the causal relationship among inflation, exchange rate and money supply. Originally, Engle and Granger (1987) demonstrated that once variables (say X and Y) are cointegrated, there always exists a corresponding error correction representation. Impliedly, changes in the dependent variables are the function of disequilibrium in the co-integrating relationship captured by the error correction term and changes in explanatory variables (Erjavec & Cota, 2003). Similarly, the long run and short-run relationships among variables have been analyzed using the standard Johanson Cointegration and VECM frameworks. However, the ARDL method yields more consistent and robust results. The ARDL bounds testing approach is more efficient with small samples and permits the analysis of the long-run and short-run relationships irrespective of whether the underlying variables are I(0), I(1), or a mixture of the two (Fosu & Magnus, 2006). Though ARDL model does not require a pre-testing for the unit roots, a critical condition is that the explanatory must not be I(2). As such, the test
for unit roots might still be necessary to ensure that variables are not I (2). The general ARDL model can be presented as shown in equation 1:

\[ \Delta \ln \text{INF}_t = \alpha + \sum_{i=1}^{k+d} \beta_i \Delta \ln \text{INF}_{t-1} + \varphi \Delta \text{lnER}_{t-1} + \sum_{i=1}^{k+d} \theta_i \Delta \text{lnMS}_{t-1} + \lambda_1 \ln \text{INF}_{t-1} + \lambda_2 \ln \text{MS}_{t-1} + \lambda_3 \ln \text{ER}_{t-1} + \omega_t \]  

(1)

Where:

\( k \) is the optimal lag order, and \( d \) is the maximum order of integration of the variables; \( \omega_t \) is the stochastic error term, and \( \Delta \) denotes the first difference operator, whereas \( \text{ER} \), \( \text{MS} \) and \( \text{INF} \) are exchange rate, money supply and inflation, respectively, all in natural logarithm.

The part of the equation with coefficients \( \beta, \varphi, \) and \( \theta \) represents the short-run dynamics of the model whereas the second part with coefficients \( \lambda_1, \lambda_2 \) and \( \lambda_3 \) represents the long-run dynamic relationship. Based on equation 1, the hypotheses for empirical testing of the long-run relationship can be formulated as follows:

\( H_0: \lambda_1 = \lambda_2 = \lambda_3 = 0 \)

\( H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq 0 \)

From hypotheses 1 and 2, the bounds testing is conducted whereby the F-test is performed to determine whether there exists cointegration among the variables under study. The results are then compared; the computed values of F-statistics with the critical values (Pesaran, 1997; Pesaran et al., 2001). If the null hypothesis \( (H_0) \) is rejected, it implies that the long-run relationship exists. In the bound testing approach, if the computed F-statistics lies below the lower bound critical value, the null hypothesis \( (H_0) \) cannot be rejected. If the computed F-statistics lies above the upper bound critical value, the null hypothesis \( (H_0) \) can be rejected, meaning that there exists a long-run relationship among the variables. There is also a possibility of no decision, which occurs when the computed F-statistics fall within the lower and upper bounds.

Once cointegration is established, the conditional ARDL long-run model for \( \text{INF} \) can be estimated based on the following equation:

\[ \ln \text{INF}_t = \beta_0 + \gamma_1 \ln \text{MS}_{t-1} + \gamma_2 \ln \text{ER}_{t-1} + \gamma_3 \text{RFM} + \mu_t \]  

(2)

All variables are as defined earlier, while \( \mu \) is the error term. In this model, a dummy variable \( \text{RFM} \) is included in the long-run model, representing economic liberalisation taking into account policy regime switches in Tanzania from the centralized to market based economic policies. The dummy variable is important for determining whether economic reforms carried out by the country have any significant effect on inflation. Hence, \( D = 1 \) for a period after 1985 and \( D = 0 \) for the period before 1985. See section 2 for more descriptions of the evolution of reforms.

The last step is obtaining the short-run dynamic coefficients, which entails estimating an error correction model. The ARDL-ECM model can be expressed as follows:

\[ \Delta \ln \text{INF}_t = \partial_0 + \partial_1 \Delta \ln \text{INF}_t + \partial_2 \Delta \ln \text{ER}_{t-1} + \partial_3 \Delta \ln \text{MS}_{t-1} + \delta \text{ECM}_{t-1} + \epsilon_t \]  

(3)

The coefficients \( \partial_1, \partial_2 \), and \( \partial_3 \) are the short-run dynamic coefficients of the model’s convergence to equilibrium, while ECM is error correction term. Its coefficient, that is, \( \delta \) measures the speed of
adjustment. The coefficient of ECM is expected to be negative, implying that the dependent variable was above the equilibrium in the previous period, it would thus be corrected through a downward movement in the next period, that is period t.

3.2 Unit Root Test and Lag Order Selection

The study used two tests of unit roots namely, the augmented Dickey-Fuller (ADF) test, a test developed by Dickey and Fuller (1981) and Phillips-Perron (PP) test, which was developed by Phillips and Peron (1988). In both tests, the null hypothesis is that a time series variable has no unit root, meaning that it is integrated of order 0. By rejecting the null hypothesis, it suggests that the time series variable is integrated of order 1 or higher. Hence, the time series can be differenced to keep it stationary. The results of the ADF and PP are reported in Table 1.

The lag length to be introduced in the causality test is an important practical question, because the causality test is sensitive to the number of lags. In this respect, choosing the lag length more or less than the true lag length can lead to model misspecification, which produces inefficient and inconsistent parameters (Alam, 2010). In this study, the optimal number of lags is the one selected by the majority of the lag selection criteria. The optimal number of lags was selected based on Final Prediction Error (FPE) criterion; Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), Schwarz’s-Bayesian Information Criterion (SBIC) as they are the most commonly used methods.

4.0 RESULTS OF ANALYSIS

Table 1 presents the results of ADF and Phillips-Perron unit root tests. The test statistics show that money supply, inflation, and exchange rate are but not stationary at a level when tested at the 5 percent level of significance. However, when tested at the first difference, all variables were all stationary. As the variables are integrated of order 1, the ARDL bounds testing are a valid approach for examining long-run relationships (Pesaran et al., 2001).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dickey-Fuller Test</th>
<th>Phillips-Perron Test</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money supply (MS)</td>
<td>-2.124</td>
<td>-2.947</td>
<td>3.294</td>
</tr>
<tr>
<td>Exchange Rate (ER)</td>
<td>-2.109</td>
<td>-2.989</td>
<td>-1.434</td>
</tr>
<tr>
<td>Inflation (INF)</td>
<td>-2.013</td>
<td>-2.947</td>
<td>-3.206</td>
</tr>
<tr>
<td>1st Difference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money supply (MS)</td>
<td>-6.563*</td>
<td>-2.950</td>
<td>-11.325</td>
</tr>
<tr>
<td>Exchange Rate (ER)</td>
<td>-4.560*</td>
<td>-2.997</td>
<td>-4.458</td>
</tr>
<tr>
<td>Inflation (INF)</td>
<td>-5.038*</td>
<td>-2.950</td>
<td>-7.512*</td>
</tr>
</tbody>
</table>
Table 2 shows the results of testing the optimal lag length of the ARDL model. Three lag selection criteria namely, FPE, AIC, and HQIC recommend 2 lags, whereas SBIC proposes 1 lag. In this respect, the study proceeded to estimate the ARDL model with two (2) lags as suggested by the majority of the selection criteria.

**Table 2: Results of Lag Order Selection Criteria**

<table>
<thead>
<tr>
<th>lag</th>
<th>LL</th>
<th>LR</th>
<th>df</th>
<th>p</th>
<th>FPE</th>
<th>AIC</th>
<th>HQIC</th>
<th>SBIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-145.2</td>
<td></td>
<td></td>
<td>0.233</td>
<td>7.059</td>
<td>7.104</td>
<td>7.183</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-3.17</td>
<td>284.1</td>
<td>9</td>
<td>0.000</td>
<td>0.0004</td>
<td>0.722</td>
<td>0.905</td>
<td>1.219*</td>
</tr>
<tr>
<td>2</td>
<td>-9.17</td>
<td>24.7*</td>
<td>9</td>
<td>0.003</td>
<td>0.0004*</td>
<td>0.563*</td>
<td>0.882*</td>
<td>1.432</td>
</tr>
<tr>
<td>3</td>
<td>-13.15</td>
<td>7.97</td>
<td>9</td>
<td>0.537</td>
<td>0.0005</td>
<td>0.802</td>
<td>1.257</td>
<td>2.043</td>
</tr>
<tr>
<td>4</td>
<td>-20.13</td>
<td>13.95</td>
<td>9</td>
<td>0.124</td>
<td>0.0005</td>
<td>0.899</td>
<td>1.490</td>
<td>2.512</td>
</tr>
</tbody>
</table>

4.1 ARDL Model Results and Discussions

Table 3 shows the results of the ARDL bounds test. The value of F-statistics is 11.243, which is certainly greater than the upper bound critical value (6.36) at the 1percent significance level as computed by Pesaran et al. (2001). Hence, there exists a long-run relationship among inflation, money supply, and exchange rate. As observed by Akinbobola (2012) in Nigeria, money supply and exchange rate tend to be in a long-run equilibrium condition with inflation. Having determined the existence of the long-run equilibrium relationship, the long run and short-run models were estimated to determine causal relationships among the variables of the study.

**Table 3: F-test of Cointegration Relationship**

<table>
<thead>
<tr>
<th>Test Statistics</th>
<th>Value</th>
<th>Significance</th>
<th>Bound Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistics</td>
<td>11.243</td>
<td>I(0)</td>
<td>I(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1%</td>
<td>5.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5%</td>
<td>3.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10%</td>
<td>3.17</td>
</tr>
</tbody>
</table>

Table 4 shows the results of the analysis of the long-run model. Both money supply and exchange rate variables are statistically significantly different from zero at the 1percent (p=0.000) and 10percent (p=0.063) significance levels, respectively. That is to say, depreciation of the Tanzanian shilling causes the domestic price to increase, which is in line with the exchange rate pass-through inflation thesis. This thesis has received strong empirical support in the current study. The results align with the results in a study by Mbongo et al., (2014) who found that money supply causes inflation in Tanzania. As such, our results corroborate findings of earlier studies. For example, Rutasitara (2004) and Mwase (2006) found that exchange rate depreciation has a strong inflationary effect in Tanzania. Similarly, in Uganda, Ssebulme and Edward (2019) also found evidence of exchange rate pass-through inflation thesis, whereby currency depreciation was found to be related to inflation.

Similarly, money supply has a strong, positive, and significant effect on inflation. The results seem to be consistent within the East African region. For example, Kiganda (2014) and Ndung’u (1999) in Kenya and, Maweje and Lunga and Ssebulime and Edward (2019) in Uganda found a causal effect
of money supply on inflation. Overall, the results suggest that inflation in Tanzania can be regarded as a monetary phenomenon and the monetarist approach can be used to explain and understand it even though in a developing country context, inflation is strongly ascribed to structural and bureaucratic factors (Harvey and Cushing, 2014). The fact that the rural sector dominates the Tanzanian economy, the supply shocks are expected to dominate the demand shocks as the causes of inflation (Adam, et al., 2012; Nyorekwa and Odhiambo, 2014).

Table 4: Estimated long-run coefficients

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.700</td>
<td>0.764</td>
</tr>
<tr>
<td>MS_t</td>
<td>2.096</td>
<td>0.436</td>
</tr>
<tr>
<td>ER_t</td>
<td>0.129</td>
<td>0.068</td>
</tr>
<tr>
<td>RFM</td>
<td>0.196</td>
<td>0.364</td>
</tr>
</tbody>
</table>

* = p<0.10; *** = p<0.01

The results of the estimated short-run dynamic model are shown in Table 5. Given that inflation, money supply, and exchange rate are cointegrated, the Error Correction Model (ECM) was estimated for assessing short-run dynamics and the speed of adjustment towards the equilibrium relationship. The Error Correction Coefficient (ECM) has the expected sign, with a value of -0.725 and statistically significant (p=0.000). This suggests that about 73 percent of the deviation from the equilibrium in the previous year is corrected in the current year. As such, it appears that inflation was above the long-run equilibrium in the previous period, thus, it decreases towards the equilibrium in the current period. The size of the coefficient suggests that the speed of adjustment towards equilibrium is reasonably high (-0.725).

The coefficient of exchange rate is positive and highly significant, suggesting that exchange rate depreciation causes inflation in the short run. This result implies that Tanzanian economy is likely to continue to be vulnerable to exchange rate volatilities as long as it continues relying heavily on import of intermediate and capital goods such as refined petroleum and equipment (URT, 2019). Our results support further the exchange rate-pass through inflation and the PPP theory. The findings in this study echo those in revealed earlier studies including Mwase (2006) and, Oriavyote and Eshenake (2012). The money supply and inflation are also causally related. However, the coefficient of the variable money supply is negative and statistically significant at the 1percentlevel (p<0.004). This is apriori expectation in terms of the sign. A plausible explanation could be an increase in money supply increases output hence, keeping the inflation low. Further examination of the validity of this relationship is imperative. Nonetheless, this result is consistent with the result of earlier studies (e.g. Mbongo et al., 2014), which is a negative short-run of money supply on inflation rate in Tanzania.

Table 5: Error Correction Representation of ARDL Model

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.622</td>
<td>0.743</td>
</tr>
<tr>
<td>ΔINF_{t-1}</td>
<td>0.033</td>
<td>0.134</td>
</tr>
<tr>
<td>ΔMS_t</td>
<td>-1.267</td>
<td>0.415</td>
</tr>
<tr>
<td>ΔMS_{t-1}</td>
<td>-0.694</td>
<td>0.541</td>
</tr>
<tr>
<td>ΔER_t</td>
<td>1.1192</td>
<td>0.399</td>
</tr>
<tr>
<td>ΔER_{t-1}</td>
<td>0.482</td>
<td>0.564</td>
</tr>
<tr>
<td>ECM_{t-1}</td>
<td>-0.725</td>
<td>0.147</td>
</tr>
<tr>
<td>Observations</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Diagnostic tests</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Autocorrelation (Durbin-Watson) (4, 46); p=0.641
Heteroscedasticity (Breusch-Pagan) Chi2=1.75; p=0.185
Normality (Jaque-Bera) Chi2=1.394; p=0.4981

***=p<0.01

The test for parameter stability indicates that both the CUSUM and CUSUMSQ curves are within the 5 percent critical regions (see Figure 2). This suggests that the inflation model is stable.

The study tested whether the estimated model violated any of the assumptions underlying it. This entailed testing for serial correlations, heteroscedasticity, and normality of residuals as well as parameter stability. The results of the tests are shown in Table 5; see the bottom three rows. In testing for autocorrelation, the null hypothesis of no serial correlation of residuals could not be rejected at any acceptable level of significance (p=0.641). Similarly, using the Jarque-Bera test of normality, results...
indicate that, the hypothesis of normally distributed errors cannot be rejected (p=0.498). Likewise, for the test for heteroscedasticity (p=0.185).

5.0 CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Conclusions

This study examined the nexus among inflation, money supply, and exchange rate based on the ARDL bounds testing approach for testing causal relationships. Understanding the long-run relationship among these variables is crucial because it helps to inform scholars and policymakers on the effectiveness of the monetary policy of the country in a bid to maintain a stable economy through moderate and stable inflation and exchange rate. The study revealed evidence of long-run causal relationships among inflation, money supply, and exchange rate. This suggests that learning about past behaviours of the exchange rate and money supply is critical for understanding current and future inflation dynamics in Tanzania.

The analysis has shown that, growth in money supply causes inflation rate in the long run, which confirms earlier observation that inflation in Tanzania is a monetary phenomenon. That is, the volume of money in circulation that does not commensurate with the growth in output tends to affect the economy in terms of price instability. While this is true for a long-run relationship, the short results suggest otherwise. It appears that growth in money supply in the short run is largely associated with lower inflation rate. In theory, particularly the monetary view, money supply does not cause inflation in the short run, but other factors do. Other factors were not tested in the current study hence; no firm conclusion can be made. However, it is assumed that growth in money was associated with growth in output relative to the growth in money supply hence, leading to low inflation in the short run.

The hypothesis that exchange rate granger causes inflation aimed at testing the exchange rate pass-through inflation thesis. The findings of the study support this tenet. In reality, such a strong relationship is expected for a country such as Tanzania where import trade tends to dominate export trade as evidenced by persistent negative trade. Similarly, import of intermediate goods such as oil claims a large proportion of Tanzanian imports (URT, 2019). As such, Tanzania is likely to continue to be vulnerable to external shock especially due to volatility of oil prices.

5.2 Implications for Policy and Research

The findings of the present study have some policy and research implications. Firstly, the existence of a long-run relationship implies that if a policy is used to manage the exchange rate, this will certainly affect inflation in the short run and long run. For example, targeting lower inflation might require some appreciation of the exchange rate with a corresponding loss of export competitiveness in the long run. Monetary and exchange rate policies appear to be the most appropriate in stabilizing domestic price. As Nyoni (2019) indicates, the predicted inflation rate in Tanzania is likely to hover around 5 percent up to the year 2027. Hence, maintaining moderate inflation and a stable exchange rate is vital for economic stability. As such, a tight monetary policy could help in maintaining a reasonably low and stable inflation rates.

Secondly, the existence of a short-run causality between exchange rate and inflation has important implications for policy as well. The direct short-run effect of exchange rate on inflation implies that whereas currency depreciation is an important monetary policy strategy for promoting exports and improving the Balance of Payments, it can as well lead to a persistent increase in inflation and constrain further economic growth. This is a policy dilemma for a country wishing to achieve both price stability and export competitiveness through exchange rate policy. For this reason, an attempt of implementing the exchange rate policy to achieve external balance should be made cautiously.
The findings and conclusions in this study should be viewed in the light of some limitations. Firstly, the study tested the monetary view of inflation focusing on money supply and exchange rate only. Future studies should include other factors and apply other approaches to increase our understanding of inflation dynamics in Tanzania. This could help to resolve the unexpected negative short-run causal relationship between money supply and inflation. Studies that used relatively more variables seem to have obtained positive relationships (see Ayubu, 2013; Ssebulime & Edward, 2019; Maweje & Lwanga, 2016). Secondly, Pesaran et al. (2001) suggest that ARDL bounds testing of cointegration is more appropriate for small samples. However, this approach considers only uni-directional causality. Thus, VECM approach could be used to examine the potential for bivariate causality among variables. Finally, the data set used is country-specific time series data. The external validity of the findings might be limited. Future research may approach the problem through multicountry panel data.
References


