



Bank of Tanzania

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***Exchange Rate Volatility  
and its Implications on  
Macroeconomic Variables  
in East African Countries***

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# **Exchange Rate Volatility and Its Implications on Macroeconomic Variables in East African Countries<sup>1</sup>**

Nicas Yabu and Deogratius Kimolo

**Bank of Tanzania**

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<sup>1</sup>Tanzania, Kenya and Uganda are the only three EAC countries covered under this study due to long-term historical relationship and data availability.

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## **Abstract**

The study examines the extent of exchange rate volatility and its impact on key macroeconomic variables such as exports, FDI inflows, interest rate and inflation in Tanzania, Kenya and Uganda. The GARCH model is used to compute the extent of exchange rate volatility while the Panel Autoregressive Distributed Lag (ARDL) technique or pooled mean group (PMG) estimator was used to estimate the effects of exchange rate volatility on selected macroeconomic variables. The results indicate that volatility in the exchange rate is a real issue in all the sampled countries and is fundamentally driven by exports and FDI dynamics for the period under consideration. The results also indicate a positive impact of the exchange rate volatility to export performance and lending rates in the long run. However, in the short run, exchange rate volatility appears to be detrimental to both export performance and leads to a reduction in lending rates. Also, the response of FDI to exchange rate volatility seems to be negative in the long run while in the short run the response from the volatility of real exchange rate seems to be insignificant. With respect to inflation, though not significant, the volatility of the exchange rate appears to have a positive impact on inflation. The study recommends that policymakers need institute mitigation measures which could smooth out excessive exchange rate volatility to minimize its likely impact on the economy. This will involve maintaining adequate reserves as well as fast-tracking industrialization agenda. The study also indicated a need for the EAC countries to consider adopting inflation targeting monetary policy framework in order to contain inflation at the appropriate level

## 1.0 Background

During the early 1990s, <sup>2</sup>all EAC countries adopted a range of reforms supported by the IMF/World Bank under the Structural Adjustment Programme. These reforms among others were geared towards more outward-looking trade and market-determined exchange rate policies. Since the adoption of market-determined exchange rate regimes, exchange rates of the EAC member states have been subjected to periodic variations. In some EAC member states, these exchange rate variations have sometimes been too high resulting into volatilities due to domestic and foreign shocks. Such volatility may translate into reduced trade flows, Foreign Direct Investment (FDI), and instability in both interest rates and inflation rates.

Instability in macroeconomic variables imposes a real cost to households' decision making, firms' profitability, financial stability and a country economic performance with regards to export performance, interest rates, foreign direct investment as well as the inflation. For instance, researchers have argued that excessive exchange volatility has reduced economic growth through its impact on trade and investment. A study by Horvath (2005) argued that excessive exchange rate volatility triggers uncertainties, which, in turn, sends bad signal to investors. These uncertainties are known to negatively impact the real economic growth by creating uncertainty about the profits, level of unemployment, as well as poverty. The study by Schnabl (2009) also found that excess exchange rate volatility exerts a negative impact on growth for a sample of emerging European and East Asian countries.

There are growing and firm evidences that exchange rate volatility which is defined as "instability, fickleness or uncertainty" and is also as a measure of risk associated with exchange rate movements imposes significant effects on the volume of trade (Farrell et al. 1983; IMF, 1984; Côté, 1994; McKenzie, 1999; UK Treasury, 2003; Clark et al. 2004; and Ozturk, 2006). Hagen and Zhou (2005) pointed out that exchange rate volatility is perceived negatively, especially in the case of developing countries, in terms of its negative effect on capital inflows and investments. It is known that excess volatility in exchange rate usually restricts the international flow of capital by reducing both direct investment in foreign operating facilities, and financial portfolio investment. International trade and investment decisions also become more difficult due to volatile exchange rate because volatility increases exchange rate risk. As a result of exchange rate volatility, exporters may prefer to switch to domestic activities where profits are relatively less uncertain rather than continuing to trade in foreign markets.

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<sup>2</sup> It should however be noted that in the 1990's Kenya was long ahead with the IMF/World Bank and as such structural reforms in Kenya were home grown without support from the Bretton Wood Institutions. Further, Kenya has always been a market driven economy (unlike Tanzania and Uganda) – to the extent that exchange rates were market driven (could be with some interventions).

Also, McKinnon and Ohno, (1997) noted that excess exchange rate volatility can lead to higher prices of internationally tradable goods by causing traders to incorporate a risk premium to shelter against unanticipated exchange rate volatilities. This will ultimately add to inflationary pressures through the tradable goods.

During the second quarter of 2015, all EAC currencies recorded a substantial depreciation against other major currencies largely due to global appreciation of the US Dollar. Another round of substantial depreciation of EAC currencies has been recorded since the end of January 2017, which raises concerns about the effect of the fast rate of depreciation of the currencies on other macroeconomic variables and the economy at large.

There is a gap in information as to whether or not the recorded exchange rate movements have resulted to volatility and that to what extent such volatility has impacted to macroeconomic variables such as growth, interest rate, inflation and trade flows. It is against this backdrop that this study examined the extent of exchange rate volatility in EAC countries and identifying its subsequent impact on macro-economic variables.

The signed protocol for the establishment of a monetary union in the EAC member states is expected to bring monetary integration, stronger trade, high investment and growth. To ensure that economies going for the monetary union are highly integrated with stable macroeconomic variables, the EAC member states must fulfil certain agreed-upon requirements - the macroeconomic convergence criteria. However, the recorded fluctuations in exchange rates in those countries pose a concern about their effects on the instability of other macroeconomic variables. In addition, the uncertainty generated from exchange rate volatility creates risks to economic agents, which may distort the allocation of resources. Therefore, understanding exchange rate volatility is an issue of great importance for businesses and policymakers alike.

Businesses use volatility models as tools in their risk management and as an input in pricing derivatives, whereas knowledge about what and how economic factors are influenced by exchange rate volatility is important for informed policymaking. In addition, the interactions and interdependence of macroeconomic variables make a concern of analysing volatility in the exchange rate and its implications to macroeconomic variables in the economy. The short-and long-term independence of exchange rates with other macroeconomic economic fundamentals can lead to misalignment in social-economic variables, which in turn affect growth and poverty. In view of this, it is imperative to study the extent of exchange volatility and its likely impact on macroeconomic variables in the EAC countries.

Thus, the overall objective of the study is to examine the dynamics of exchange rate volatility and its subsequent impact on macro-economic variables in the three founder EAC Countries. More specifically, the study intends to estimate the extent of exchange rate volatility in Tanzania, Kenya and Uganda; and assess the impact of exchange rate volatility on trade flows, FDI, inflation and interest rate in Tanzania, Kenya and Uganda.

The rest of the paper is structured as follows. Section 2 presents some stylized facts with respect to the trends of the key variables of interest in the three founder EAC Countries. In section 3 a literature review is presented while section 4 presents the methodology of the study. Chapter 5 discusses the findings of the study, while the conclusion and policy implication is provided in section 6.

## **2.0 Stylized Facts of Macroeconomic Variables**

In this section, the trend and relationship between the exchange rate and other macroeconomic variables in the economies of Tanzania, Kenya and Uganda are described using historical patterns.

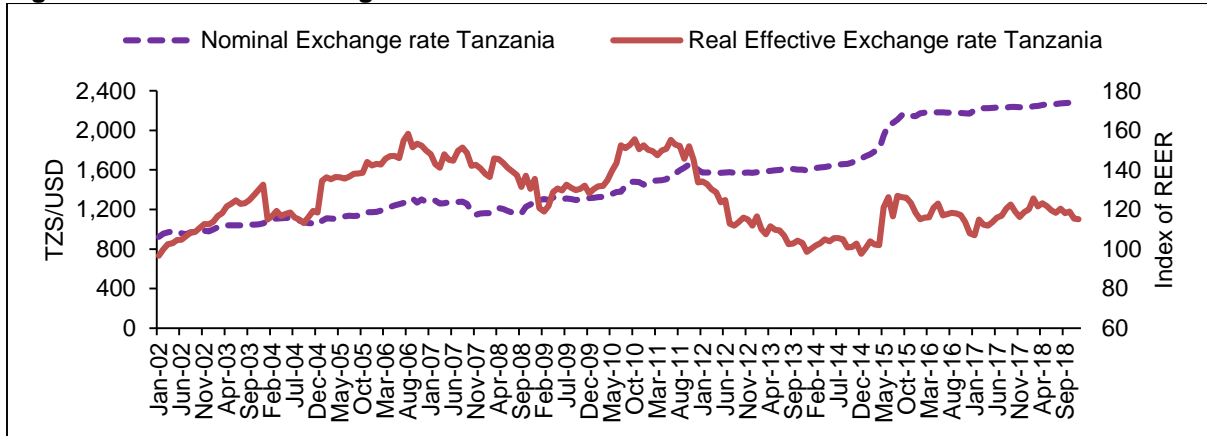
### **2.1 Dynamics of Macroeconomic Variables in Tanzania**

#### **2.1.1 Exchange Rates**

**Figure 2.1** shows the trend in the nominal exchange rate of the Tanzanian shilling against the US dollar as well as the real effective exchange rate of the shilling against a basket of currencies. During the period under review, the shilling exchange rates maintained a generally upward (depreciating) trend with two episodes of sharp depreciation that can be clearly earmarked. The first episode was during the first half of 2011/12. The volatility and rapid depreciation of the shilling during the period was caused by, among others, increase in global demand for dollars, rapid expansion in the oil imports and delays in disbursement of foreign program assistance (BOT, 2014). The second period of sharp depreciation is observed in 2015 mainly attributed to the global strengthening of the US dollar against other currencies due to improved economic activities in the US. The nominal exchange rate has been the major driver of the dynamics of the real effective exchange rate despite that the real effective exchange rate has been fairly stable over the period.



**Figure 2.1: Trend of Exchange Rates in Tanzania**

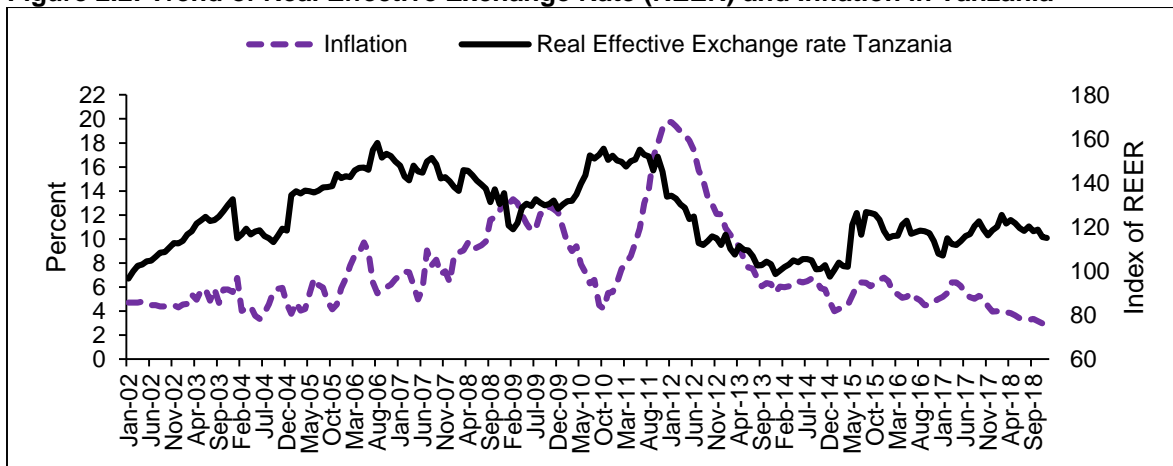


Source: Bank of Tanzania, Various issues

**2.1.2 Exchange Rate and Inflation**

**Figure 2.2**, two episodes of high inflation can be traced. The first episode was during 2008/09. Prior to the first episode, inflation maintained a steadily increasing trend, which was also accompanied by a depreciation of the exchange rate in real terms. Thereafter, from January 2011 inflation maintained a steady upward trend reaching a peak of 19.8 percent in December 2011. This upward trend was preceded by a trend depreciation of the shilling that started early 2010. In this period, inflation was also a result of higher world food and oil prices and aggravated further by unfavourable weather conditions in Tanzania that lead to a shortage of food supply in the market. The situation was made worse by food shortages in neighbouring countries, especially Kenya and Uganda. In the second episode of 2015 however, significant exchange rate depreciation shock didn't translate into higher inflation.

**Figure 2.2: Trend of Real Effective Exchange Rate (REER) and Inflation in Tanzania**

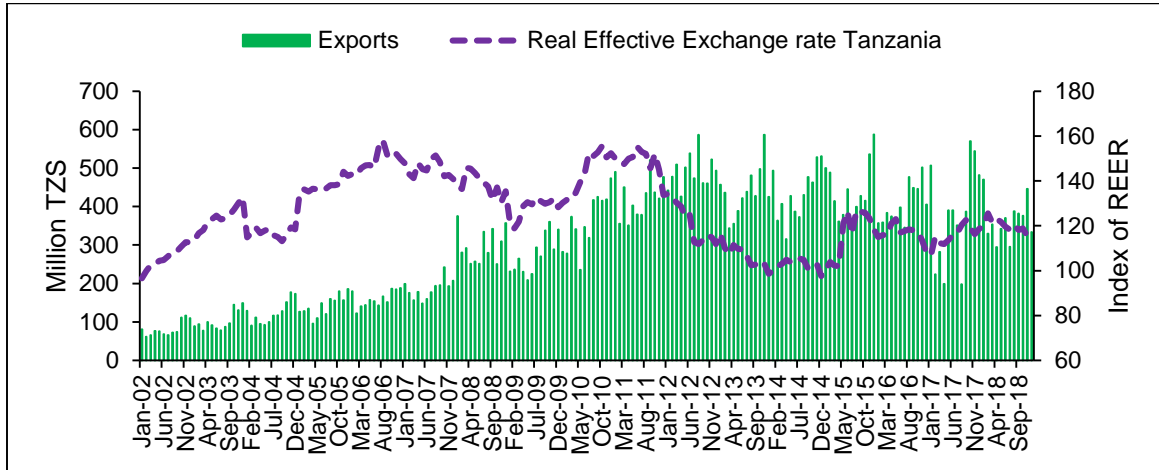


Source: Bank of Tanzania, Various issues

### 2.1.3 Exchange Rate and Export Performance

Over the last 10 years, exports earnings have maintained a general steady growth in Tanzania. The exports have also become more diversified, with particularly rapid growth in exports of gold and manufacturing goods. Despite steady growth, export earnings over the period have been volatile partly (Figure 2.3). The question remains whether the observed variability is partly attributed by volatility in the real effective exchange rate and ultimately on the uncertainties faced by exporters.

**Figure 2.3: Trend of Real Effective Exchange Rate (REER) and Export Performance in Tanzania**

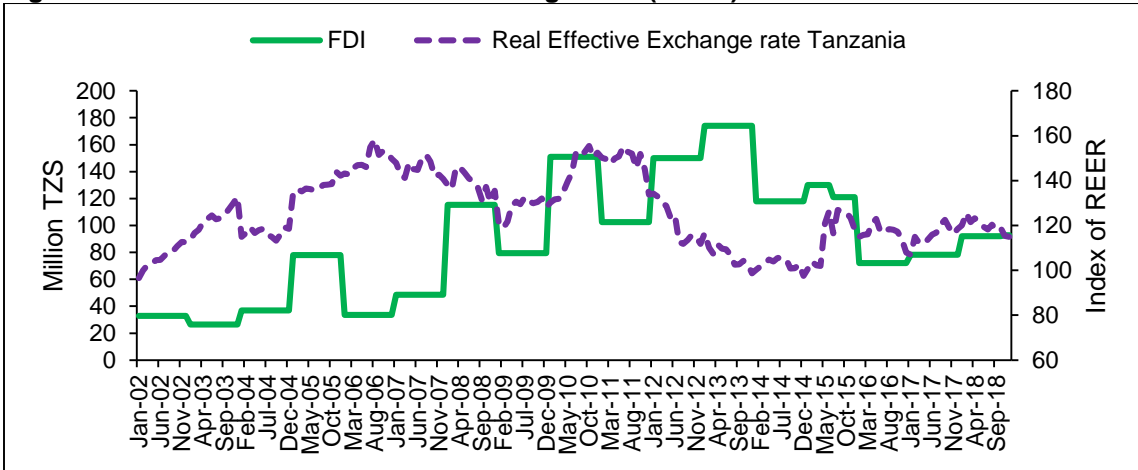


Source: Bank of Tanzania, Various issues

### 2.1.4 Exchange rate and FDI

Since the mid-1980s in recognition of the significant role towards building an enabling environment for private sector growth, Tanzania enacted a number of investment-related laws and policies, put in place attractive investment packages, and undertook a number of other initiatives to promote and develop the private sector. Currently, Tanzania is one of the major destinations for FDI in Sub-Saharan Africa. Foreign Direct Investments (FDI) has remained high following continued investment activities in the country in projects such as natural gas, power generation, cement factory, uranium and coal mines. The strong FDI inflows are also presumed to be partly a result of a stable macroeconomic environment, including a stable exchange rate.

**Figure 2. 4: Trend of Real Effective Exchange Rate (REER) and FDI in Tanzania**

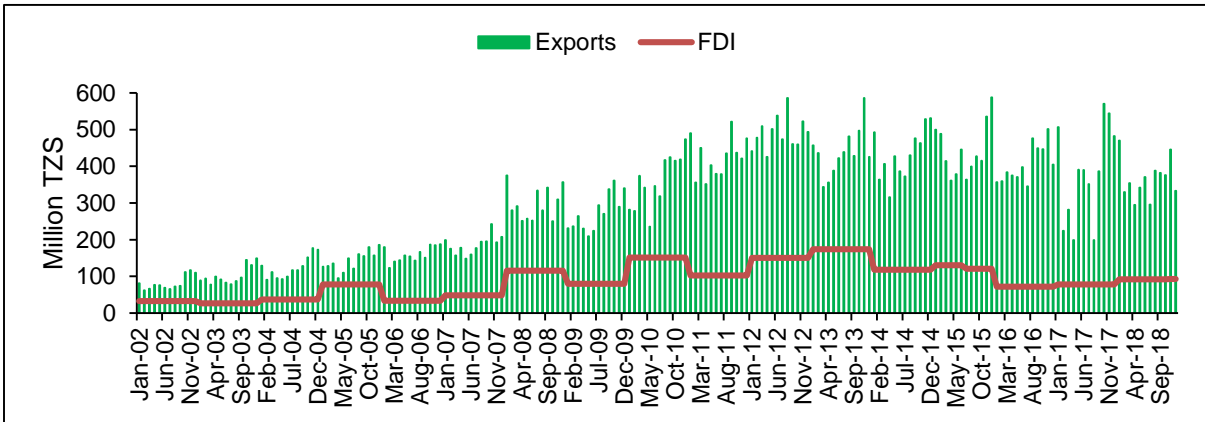


Source: Bank of Tanzania, Various issues

### 2.1.5 Exports and FDI

**Figure 2.5** illustrates the movement of FDI against exports in Tanzania over the last 16 years. It is clear from the chart that the two variables co-move. Thus, the increase in the FDI in Tanzania following several reform initiatives and stable macroeconomic environment have resulted in a significant increase in exports over time. FDI has helped in transferring productivity spill over to the tradable sector and hence helped the country's exports catch up with quality frontier.

**Figure 2.5: Trend of Real Effective Exchange Rate and FDI in Tanzania**



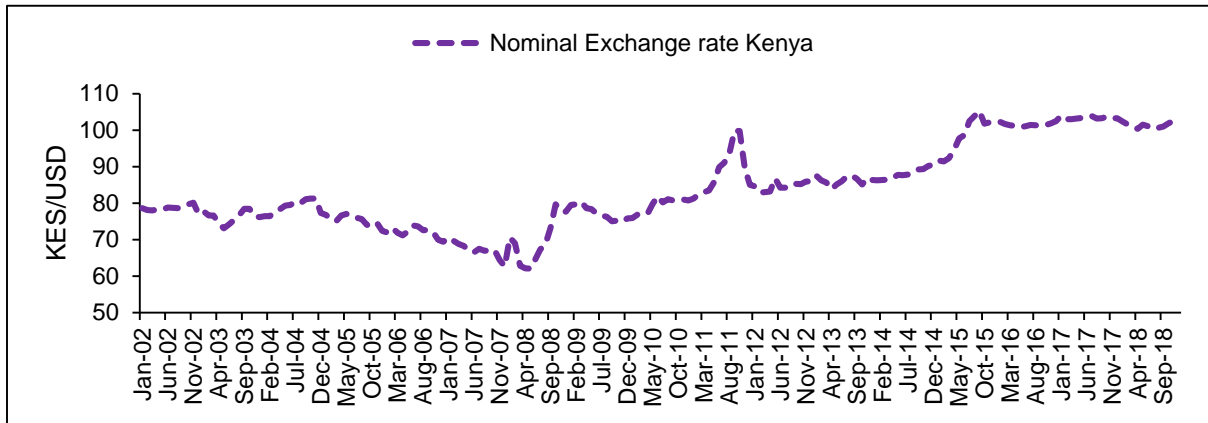
Source: Bank of Tanzania, Various issues

## 2.2 Dynamics of Macroeconomic Variables in Kenya

### 2.2.1 Exchange Rate

The Kenyan shilling in nominal terms maintained a general stable appreciation trend before the Global Financial Crisis of 2008, while in real terms exhibited a steady depreciating trend (Figure 2.6). However, more excessive upward fluctuations have been observed since 2008, indicating a weakening of the shilling in nominal terms as a result of the global financial crisis (The Republic of Kenya, 2012). Thereafter, like other currencies in the world, it depreciated both in real and in nominal terms again in 2015 following global appreciation of the dollar against other currencies.

Figure 2.6: Trend of Nominal Exchange Rates in Kenya

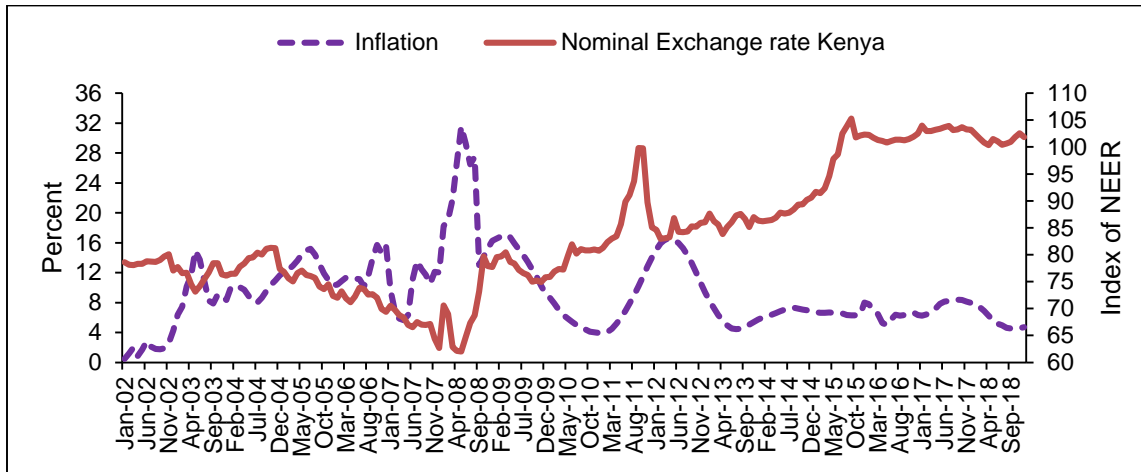


Source: Bank of Kenya

### 2.2.2 Exchange Rate and Inflation Dynamics

Inflation for an open economy such as that of Kenya is driven by both domestic factors (internal pressures) as well as external factors (external pressures). External inflationary pressure mostly emanates from the rise in world prices of commodities mainly food and oil as well as fluctuation in the real exchange rate. Figure 2.7 indicates that the co-movement between inflation and the real effective exchange rate is more pronounced in the period before 2011; thereafter the co-movement is of little evidence afterwards partly suggesting the mild impact of exchange rate volatility on inflation.

**Figure 2.7: Trend of Nominal Exchange Rates (NEER) and Inflation in Kenya**

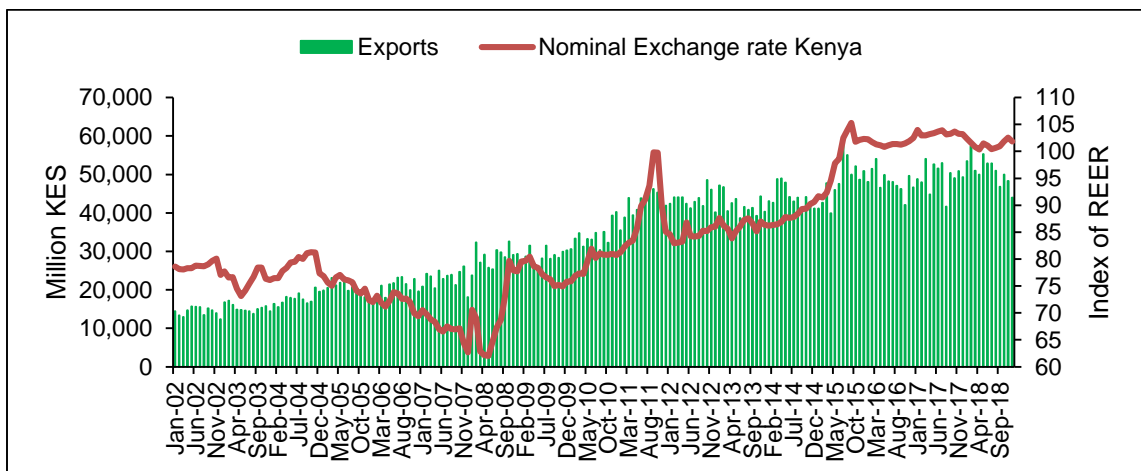


Source: Bank of Kenya

### 2.2.3 Exchange rate and Export Performance

Key export commodities of Kenya have been tea and coffee, followed by horticultural products that have undergone rapid growth over the last few decades and thus Kenya’s involvement in international trade continues to increase drastically. As alluded by Were et al. (2002), the structure of Kenya’s export sector makes it vulnerable to fluctuations in world prices. **Figure 2.8** indicates that exports responded well to exchange rate liberalization, and this is evident from the increase in export volumes over time, during the episodes of exchange rate depreciation, especially from 2006/07 onwards.

**Figure 2.8: Trend of Nominal Exchange Rate and Export Performance in Kenya**

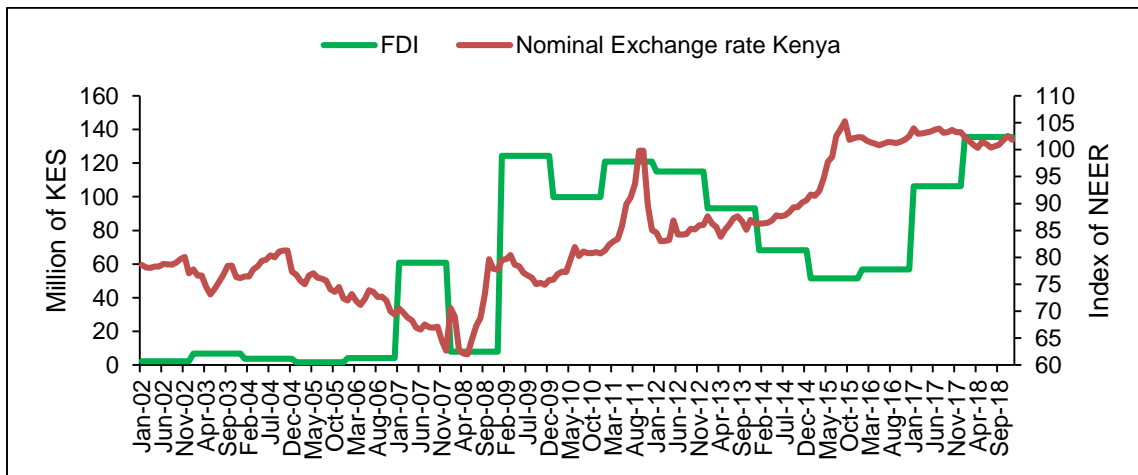


Source: Bank of Kenya

### 2.2.4 Exchange rate and FDI

**Figure 2.9** indicates a weak relationship between the nominal exchange rate and FDI inflows. Before 2008, FDI inflows in Kenya remain relatively weak considering the size of its economy and its level of development. However, since 2012 the FDI flows have significantly increased making Kenya one of the largest recipients of FDI in Africa. This increase was related to investments, mainly by Chinese in the mining and hydrocarbon sectors (CBK, 2016).

**Figure 2.9: Nominal Exchange Rate (NEER) and FDI in Kenya**

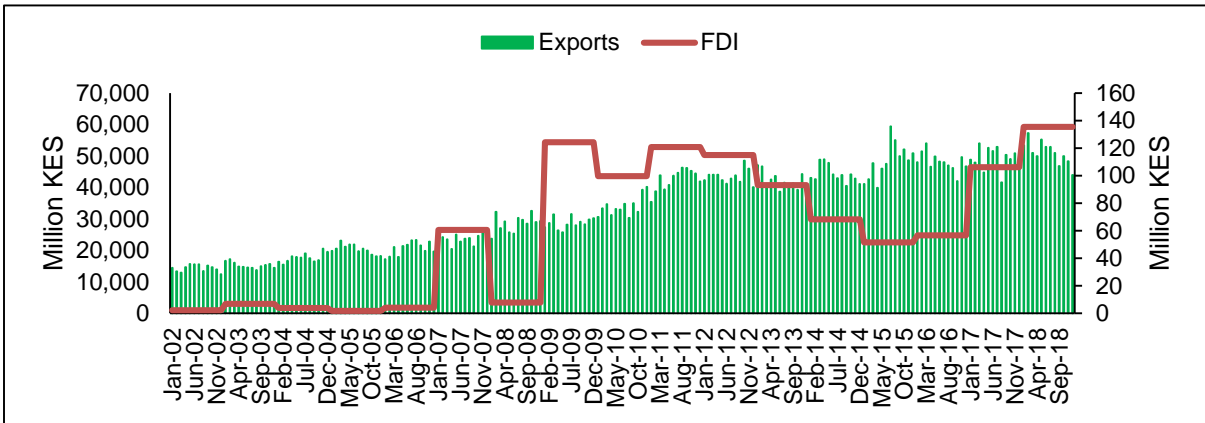


Source: Bank of Kenya

### 2.2.5 Exports and FDI

**Figure 2.10** illustrates the movement of FDI against exports in Kenya over the last 16 years. The figure indicates a weak relationship between the FDI inflows and export performance in Kenya. While exports were on a generally increasing trend, the FDI inflows have been volatile, declining between 2012-2016.

**Figure 2.10: Trend of Exports and FDI in Kenya**



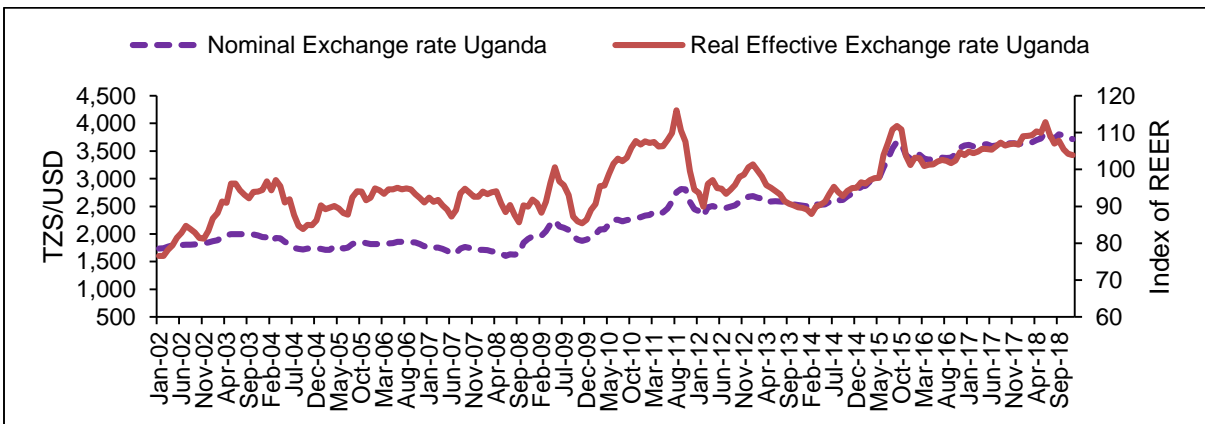
Source: Bank of Kenya

### 2.3 Dynamics of Macroeconomic Variables in Uganda

#### 2.3.1 Exchange Rate

Like other East African countries, the exchange rate between Ugandan shilling and other currencies especially the US Dollar has fluctuated enormously since 2002 with two episodes of sharp depreciation that can be clearly earmarked during the first half of 2011/12 and in 2015 (**Figure 2.11**). It is also worth noting that the movement of the real effective exchange in many cases is reflected by dynamics in the nominal exchange rate.

**Figure 2.11: Trend of Nominal Real Exchange Rates (REER) in Uganda**



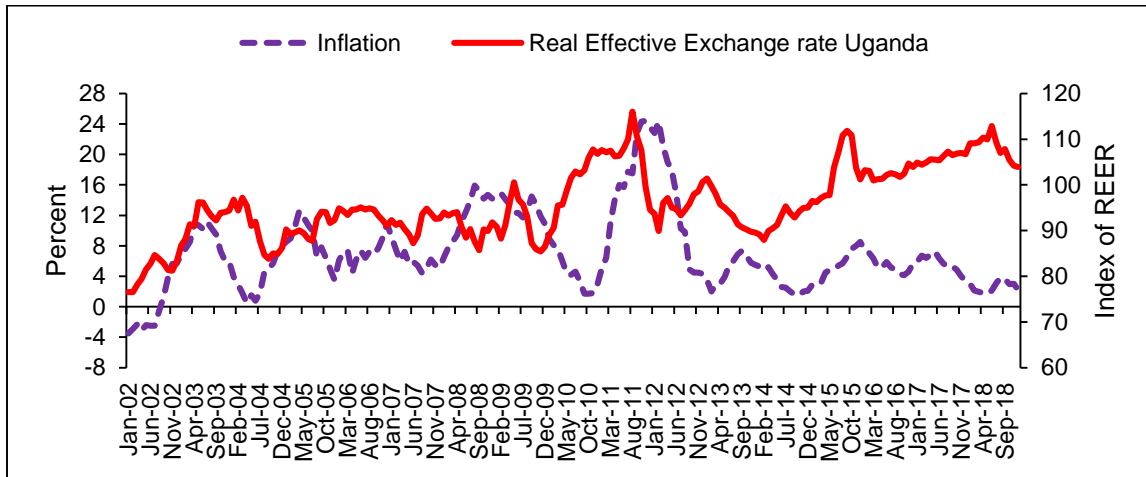
Source: Bank of Uganda

#### 2.3.2 Exchange rate and Inflation Dynamics

In line with a liberalised current and capital account of the balance of payments, the Bank of Uganda pursues a flexible exchange rate policy regime. The Ugandan inflation remained remarkably

variable as shown in **Figure 2.12**. Like other EAC countries in 2011/12, supply-side shocks to the domestic food and international oil prices exerted significant upward pressure on domestic inflation, with headline inflation peaking at 30.5 per cent in October 2011. Co-movement between real effective exchange rate and inflation is discernible, albeit with a lag.

**Figure 2.12: Trend of Real Effective Exchange Rate (REER) and Inflation in Uganda**



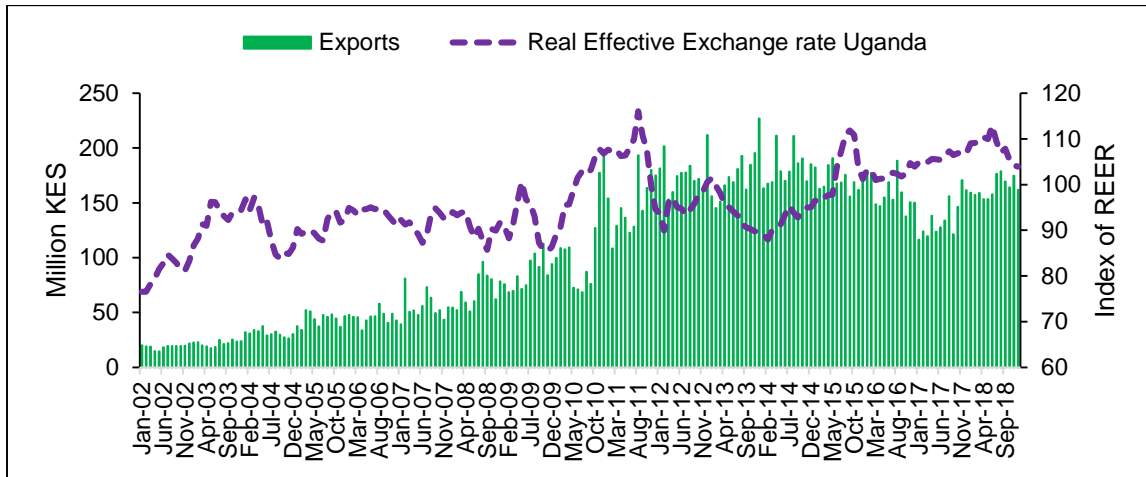
Source: Bank of Uganda

### 2.3.3 Exchange Rate and Export Performance in Uganda

Uganda's exports mainly comprise agricultural products, which include coffee, cotton, tea, flowers, processed fish and fish products and vanilla among others. Trade policy reforms (trade liberalization) in the 1990's decontrolled producer prices and dismantled the monopoly power of former marketing boards both of which reinforced the exchange rate policy reform that led to considerable improvements in price incentives that resulted into positive supply responses both in terms of volume and composition of exports. **Figure 2.13** indicates co-movement between real effective exchange rate and value of exports in Uganda particularly.



**Figure 2.13: Trend of Real Effective Exchange Rate (REER) and Export Performance in Uganda**

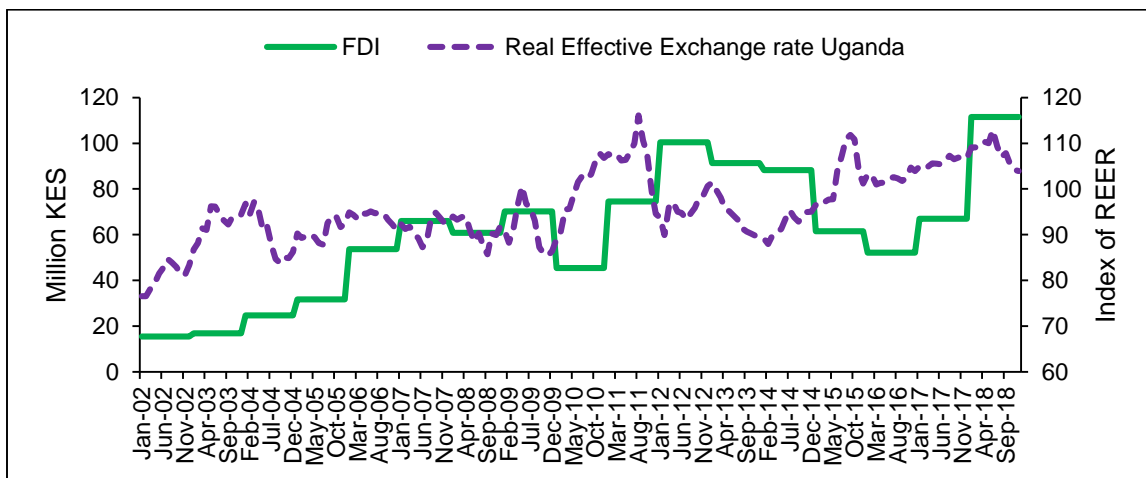


Source: Bank of Uganda

**2.3.4 Exchange rate and FDI in Uganda**

**Figure 2.14** indicates that FDI inflows in Uganda have maintained a steady increasing trend since early 2000. However, the inflows declined in 2014/15 mainly due to lower foreign investment in the oil industry (BOU, 2016). The figure indicates a positive association between real effective exchange rate with FDI.

**Figure 2.14: Trend of Real Effective Exchange Rate (REER) and FDI in Uganda**

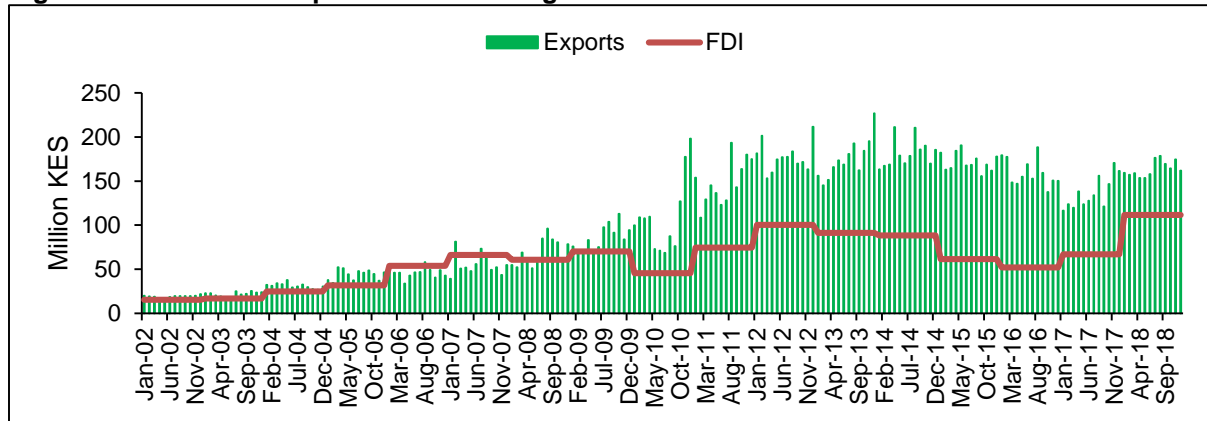


Source: Bank of Uganda

### 2.3.5 Exports and FDI in Uganda

**Figure 2.15** illustrates the movement of FDI against exports in Uganda over the last 16 years. Like the case of Tanzania, there is a strong correlation between FDI inflows and exports in Uganda. The FDI inflows in Uganda have maintained a steady increasing trend since early 2000 consistent with an improvement in the export's performance. However, the inflows declined in 2014/15 mainly due to lower foreign investment in the oil industry (BOU, 2016) and this was consistent with deterioration in the export performance.

**Figure 2.15: Trend of Exports and FDI in Uganda**



Source: Bank of Uganda

## 3. 0 Literature Review

### 3.1 Theoretical Literature Review

It is widely presumed that volatility in the exchange rates of small open market economies is one of the main sources of economic instability around the world (Gerardo and Felipe, 2002). Foreign exchange rate volatility influences the value of a firm since future cash flows of the firm will change with fluctuations in foreign exchange rates. Luehrman (1991) found that depreciation in the currency of a country affects the competitiveness of the firms engaged in international competition, leading to increased demand for its export goods. Adler and Dumas (1984) reported that although firms, whose operations are widely domestic, may be influenced by the fluctuations in foreign exchange rates, their input and output prices may be affected by currency movements.

The literature has provided extensive evidence on the link between exchange rate volatility and trade since the collapse of the Breton Woods system of the fixed exchange rate. Fluctuations in the exchange rate may negatively affect the competitiveness of tradable goods and in turn, reduce the volume of trade and worsen the balance of payments. However, whether or not a high degree

of exchange-rate variability has an impact on foreign trade, continues to be an important question in most Less Developed Countries (LDCs), since it has relevance for decision making concerning choice of an exchange-rate system as well as the conduct of exchange-rate policy (Brada and Mendez, 1988; Caballero and Corbo, 1989; Arize, *et. al.*, 2000).

The theoretical literature offers many models explaining the association between the exchange rate and the volume of trade. For instance, the model of Clark (1973) and Hooper and Kohlhagen (1978) claimed that exchange rate volatility increases the risk-averse traders and then squeezes the volume of trade. Another group of theoretical models indicate that exchange rate volatility has an unclear impact on trade, sometimes positive and other times negative (Franke 1991; Sercu and Vanhulle 1992; and De Grauwe 1988). For example, De Grauwe (1988) point out that, an increase in risk has both substitution and an income effect.

As far as the link between exchange rate volatility and FDI is concerned, theories discuss based on two wings: the production flexibility wing and the risk aversion wing. The production flexibility side, exchange rate volatility fosters FDI since foreign producers are assumed to be able to adjust the use of one of their variable factors following the realization of a stochastic input in profits (Goldberg and Kolstad 1995). For the case of the risk aversion theory, FDI decreases as exchange rate volatility increases in the sense that higher fluctuations in the exchange rate lower the certainty equivalent expected exchange rate, which in turn reduces FDI.

### **3.2 Empirical Literature Review**

On the empirical side, the literature provides mixed findings, depending on the model specifications, sample periods, a proxy of trade used, other macroeconomic indicators included, and methods of measuring the exchange rate volatility and trade. For instance, Choudhury (2005) investigates the effects of the exchange rate volatility on United States exports to Canada and Japan during under the flexible exchange rate period. He used the univariate GARCH model to measure the extent of exchange rate volatility, applied the multivariate cointegration method, and constrained error correction models to study the stated relationship. He found that exchange rate volatility had a negative impact on the volume of bilateral exports.

Also, Arize et al (2000) investigated the exchange rate volatility on trade-proxied by exports of 13 less developed countries with quarterly data series for the period 1973-1996 using the Johansen's Multivariate procedure and Error Correction Model. Their result shows a significant negative effect of volatility on export flows. The study by Broda, (2004) replicated the same by employing panel data of 75 countries for the same period of 1973-1996, using VAR model. The findings show that there were substantial shocks to terms of trade and real GDP in the short-term. The result from

impulse responses indicated the presence of the negative shocks resulted from larger exchange rate changes in countries that adopted a flexible exchange rate.

According to the study by (Arize, Osang, and Slottje, 2004), increases in the volatility of the real effective exchange rate, is usually expected to exert a significant negative impact on competitiveness of exports and ultimately reduce export demand in both the short-run and the long run and these effects may result in significant reallocation of resources by market participants. The issue is particularly important for countries that switched from a fixed to a flexible exchange rate regime due to the higher degree of volatility associated with flexible exchange rates.

Clark (1973) used panel data analysis for emerging countries and established a negative relationship between exchange rate volatility and exports. His findings were consistent with risk-averse theories in the sense that in the absence of hedging facilities while producers are risks averse, any rise in exchange rate volatility would cause them to decrease their risk exposure in order to prevent its consequence on the profitability.

On the impact of exchange rate volatility on interest rates, Study by Karfakis and Kim (1995) employed Australian exchange rate data and discovered that unanticipated current account deficit is linked with nominal exchange rate depreciation and an increase in interest rates.

Empirical evidence on the impact of exchange rate volatility on FDI flow is mixed. For example, Cushman 1988; Stokman and Vlar 1996; and Foad (2005) indicate that exchange rate volatility exerts a positive impact on FDI flow to the host countries. These findings are grounded on the fact that FDI is considered to be a substitute for exports. That is, an increase in exchange rate volatility in the host country induces a multinational firm to serve the host country via a local production facility rather than exports, thereby insulating against currency risk. The other side of empirical literature argues that exchange rate volatility negatively affects the flow of FDI (Dixit and Pindyck 1994; and Darby et al. 1999). Their argument is that a country with a high degree of exchange rate volatility would have a high degree of currency risk, which converts the flow of FDI to countries with more stable exchange rates.

Different literature records mixed results, again depending on methodology, area-specific and other macroeconomic variables used. For instance, Accam (1997) examined this relationship in some selected 20 least developed countries, using OLS estimation, and employing standard deviation as a proxy for instability in exchange rate volatility. Accam's findings indicate that there was a significant negative relationship between exchange rate uncertainty and FDI flows for the period. Alaba (2003) estimated the extent of exchange rate volatility using GARCH and its ultimate impact

on FDI to agriculture and manufacturing using an error correction model in Sub-Saharan African countries. The results show that the official market exchange rate movement significantly reduces FDI inflows to agriculture and insignificant for the manufacturing FDI. Also, Chaduhary et al. (2012) used annual data from 1980 to 2010 for the sample of Asian economies by applying autoregressive distributed lag and GARCH approach to examine the effect of the volatility of exchange rate on FDI. The result shows that there is a positive and significant relationship between FDI and volatility exchange rate.

The effect of exchange rate volatility on inflation is analysed in a multi-direction view in both theory and empirical literature. For instance, Edwards (1993) findings who conducted the cross-country research in developing countries indicate that inflation is much lower and less volatile in a peg exchange rate regime than countries that practice flexible exchange rate system. The implication from Edwards' findings is that exchange rate volatility in a free-floating exchange rate regime affect inflation. Also, Odedokun (1995), using data from 35 countries for the period 1971 to 1990, obtained results suggesting that among other variables domestic currency depreciation has positive effects on inflation.

In addition, Ezirim, et al., (2012) employed the autoregressive distributed lag analytical framework to investigate the interdependencies between exchange rates and inflation rates behaviour in Nigeria. Findings indicate that exchange rates movements and inflation spiral are cointegrated, associating both in the short run and in the long run. They indicated that that in a regime of inflation targeting, exchange rate volatility might trigger high inflation; thus, a policy aimed at exchange rates manipulation becomes important. Looking at the issue from the opposite side, Bleaney and Francisco (2008) indicate that inflation targeting reduces the volatility of real exchange rate expectations, given the tendency of associating it with floating exchange rate regimes. Again, the implication from this side is that inflation is the function of exchange rates, and exchange volatility is emanated from inflation fluctuations.

Therefore, volatility in the exchange rate has a prolonged effect, which ultimately affects economic growth. For instance, Danmola (2013) analysed the impact of exchange rate volatility on macroeconomic variables in Nigeria using Correlation Matrix, Ordinary Least Square (OLS) and Granger Causality test. The findings show that exchange rate volatility affected FDI, trade openness, inflationary rate and Gross Domestic Product in the country.

The literature review provides a theoretical and empirical examination on exchange rate volatility and its implications on macroeconomic variables. Generally, volatility in the exchange rate has been referenced to have a significant impact on macroeconomic variables. Therefore, theoretical

and empirical evidence discussed are based to establish the research methodology to be used in this study; which is presented in the following section.

## 4.0 Methodology

### 4.1 Modelling Exchange rate Volatility

The most common methods for generating future volatility estimates are moving average, whereby each past volatility within that time period is weighted equally in the resulting volatility estimate, and exponential smoothing model, which gives more weight to the most recent observations of volatility.

However, according to Campbell, et al., (1997), it is both logically inconsistent and statistically inefficient to use volatility measures that are based on the assumption of constant volatility over some period and putting more weight on the recent observations of volatility, when the resulting series moves through time. As a results ARCH/GARCH family models, which assume that volatility changes over time, are perceived to perform better compared to the previous methods in terms of estimating volatility.

Therefore, this study uses GARCH family models to estimate the extent of exchange rate volatility. Formulation of the GARCH model follows the following steps: Let  $\varepsilon_t$  be a random variable that has a mean and a variance conditionally on the information set  $\mathcal{F}_{t-1}$  (the  $\sigma$ -field generated by  $\varepsilon_{t-j}$ ,  $j \geq 1$ ). The ARCH model  $\varepsilon_t$  has the following properties: First,  $E\{\varepsilon_t / \mathcal{F}_{t-1}\} = 0$  and, second, the conditional variance  $h_t = E\{\varepsilon_t^2 / \mathcal{F}_{t-1}\}$  is a nontrivial positive-value parametric function of  $\mathcal{F}_{t-1}$ . The sequence  $\{\varepsilon_t\}$  may be observed directly or it may be an error or innovation sequence of an econometric model. In the latter case,

$$\varepsilon_t = y_t - \mu_t(y_t) \quad (1)$$

where  $y_t$  is an observable random variable and  $\mu_t(y_t) = E\{y_t / \mathcal{F}_{t-1}\}$ , the conditional mean of  $y_t$  given  $\mathcal{F}_{t-1}$ . Engle's (1982) application was of this type. Engle assumed that  $\varepsilon_t$  can be decomposed as:

$$\varepsilon_t = z_t \sigma_t^{1/2} \quad (2)$$

where  $\{z_t\}$  is a sequence of independent, identically distributed (iid) random variables with zero mean and unit variance. It implies  $E\{\varepsilon_t / \mathcal{F}_{t-1}\} \sim D(0, \sigma_t)$  where  $D$  stands for the distribution (typically

assumed to be a normal or a leptokurtic one). The following conditional variance defines an ARCH model of order  $q$ :

$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^q \alpha_j \varepsilon_{t-j}^2 \quad (3)$$

For  $\alpha_0 > 0$ ,  $\alpha_j \geq 0$ ,  $j = 1, \dots, q-1$ , and  $\alpha_q > 0$ .

The parameter restrictions in (3) form a necessary and sufficient condition for strictly positive or non-negativity restriction of the conditional variance.

Formulating the variance equation, with the last period volatility, forms the ARCH term, and the last period variance, which forms the GARCH term, together with constant yield the following equation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i e_{t-1}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (4)$$

The autoregressive root, which governs persistence of volatility shocks, is the sum of  $\alpha$  and  $\beta$ . If the sum of  $\alpha$  and  $\beta$  is greater or very close to unity then, the volatility persists overtime. According to equation (4), the error variance at time “ $t$ ” is assumed to depend on previous squared error terms. Also, the variance at a time, “ $t$ ” is conditional on those in previous periods and hence, the term conditional heteroscedasticity (Engle, 2004).

Whereas there are other ARCH/GARCH family models such as GARCH-M models, Threshold GARCH models, IGARCH models and so forth, which may also be used to measure volatility, the classic GARCH model is widely used because it provides an easy interpretation of its results. It is appropriate for comparison purposes with results from other studies. One of the advantages of the GARCH model is that when estimated, it gives both ARCH and GARCH coefficients from which conclusions can be made. That is, if the sum of their coefficients is close or more than one, the prediction is that volatility persists over time rather than dying out. However, when the estimated results seem to violate non-negativity restriction of the conditional variance, the Exponential Generalised Autoregressive Conditional Heteroscedasticity (EGARCH) is estimated to account for that.

## **4.2 Modelling impact of exchange rate volatility on other macroeconomic variables in the EAC Member States**

### **4.2.1 Functional Form of Variables**

After modelling the extent of exchange rate volatility in EAC member states, in a dynamic heterogeneous panel environment, the next step was to model exchange rate volatility on trade

flows, FDI, inflation and interest rates. The idea is to find out whether or not exchange rate volatility caused volatility in trade flows, FDI, inflation and interest rates. The exchange rate used in this study is the real effective exchange rates (REER), which takes into account any changes in relative prices and trades with trading partners; while the interest rate used refers to overall lending rate.

A general representation of the model is given by:

$$LVEX_t = \lambda_{10} + \lambda_{11} \sum_{i=1}^k VEX_{t-i} + \lambda_{12} \sum_{i=1}^k LEXP_{t-i} + \lambda_{13} \sum_{i=1}^k INT_{t-i} + \lambda_{14} \sum_{i=1}^k LFDI_{t-i} + \lambda_{15} \sum_{i=1}^k INFL_{t-i} + \varepsilon_{1t}$$

(5)

$$LEXP_t = \lambda_{20} + \lambda_{21} \sum_{i=1}^k LVEX_{t-i} + \lambda_{22} \sum_{i=1}^k LEXP_{t-i} + \lambda_{23} \sum_{i=1}^k INT_{t-i} + \lambda_{24} \sum_{i=1}^k LFDI_{t-i} + \lambda_{25} \sum_{i=1}^k INFL_{t-i} + \varepsilon_{2t} \quad (6)$$

$$INT_t = \lambda_{30} + \lambda_{31} \sum_{i=1}^k LVEX_{t-i} + \lambda_{32} \sum_{i=1}^k LEXP_{t-i} + \lambda_{33} \sum_{i=1}^k INT_{t-i} + \lambda_{34} \sum_{i=1}^k LFDI_{t-i} + \lambda_{35} \sum_{i=1}^k INFL_{t-i} + \varepsilon_{3t} \quad (7)$$

$$LFDI_t = \lambda_{40} + \lambda_{41} \sum_{i=1}^k LVEX_{t-i} + \lambda_{42} \sum_{i=1}^k LEXP_{t-i} + \lambda_{43} \sum_{i=1}^k INT_{t-i} + \lambda_{44} \sum_{i=1}^k LFDI_{t-i} + \lambda_{45} \sum_{i=1}^k INFL_{t-i} + \varepsilon_{4t} \quad (8)$$

$$INFL_t = \lambda_{50} + \lambda_{51} \sum_{i=1}^k LVEX_{t-i} + \lambda_{52} \sum_{i=1}^k LEXP_{t-i} + \lambda_{53} \sum_{i=1}^k INT_{t-i} + \lambda_{54} \sum_{i=1}^k LFDI_{t-i} + \lambda_{55} \sum_{i=1}^k INFL_{t-i} + \varepsilon_{5t} \quad (9)$$

Where VEX is volatility series of the real effective exchange rate, EXP is exports-proxy for trade flows, INT is interest rate--overall lending rate, FDI is foreign direct investment, INFL is inflation and  $\varepsilon$  is error term.

#### 4.2.2 Estimation Technique

The Panel Autoregressive Distributed Lag (ARDL) technique or pooled mean group (PMG) estimator was used to estimate the effects of exchange rate volatility on selected macroeconomic variables. The ARDL bound testing technique possesses several advantages when compared to other single equation estimation techniques like Engle-Granger and Fully Modified Ordinary Least Squares (FMOLS): foremost unlike ARDL, there are no formal tests for cointegration in Engle-Granger and FMOLS. Moreover, when compared to Engle-Granger, ARDL reduces the endogeneity issues and all the variables are implicitly assumed to be endogenous.

Also, the long run and short-run variables are estimated simultaneously, removing problems associated with omitted variables and autocorrelation. And lastly, the ARDL bound testing



technique does not usually need information on the order of integration of variables, which is necessary for the Engle-Granger and Fully Modified OLS and also in the JML technique.

In the other techniques, it is necessary for the variables to have the same order of integration.<sup>3</sup> Accordingly, a problem arises when the variables possess dissimilar orders of integration; to address this problem Pesaran *et al.* (1996, 2001) recommended the ARDL technique that does not involve the arrangement of variables into I (0) or I (1).

Pesaran and Shin (1999) contended that the ARDL technique can be reliably employed in small samples to estimate and test hypotheses on the long-run coefficient in both cases where the underlying regressors are I(1) or I(0). Therefore, the current study employs the ARDL technique to examine the effects of exchange rate volatility on selected macroeconomic variables in East Africa.

The ARDL model (p, q, q, q) will take the following form:

$$y_{it} = \sum_{j=1}^p \lambda_{ij} y_{i,t-j} + \sum_{j=0}^q \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (10)$$

where  $y_{it}$  denotes the dependent variables for group and  $x_{ij}$  ( $k \times 1$ ) is the vector explanatory variables for group  $i$ ,  $\delta'_{ij}$  are ( $k \times 1$ ) coefficient vectors, groups are denoted by  $i = 1, 2, \dots, N$ , time periods by  $t = 1, 2, \dots, T$ , whereas  $\mu_i$  represents the fixed effects.

This model can be reparametrized as a VECM system:

$$\Delta y_{it} = \theta_i (y_{i,t-1} - \psi_i x_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (11)$$

In the above equation  $\lambda_{ij}$  represents the long-run parameters and  $\theta_i$  are error correction parameters. In the present analysis, Y represents exchange rate volatility, and X is a set of various explanatory variables including FDI, exports, inflation, and lending rate. The parameters on the left side in parenthesis are the long run and term on the right hand side is short-run dynamics. The short-run parameter can be anticipated that has significant negative value under the pre-assumption that variables direct a convergence to long-term equilibrium.

<sup>3</sup> Pesaran and Pesaran (1997, p. 291) points out that the residual-based cointegration are inefficient and can lead to misleading results, especially when there are more than two I(1) variables under consideration.

The panel ARDL is consistent under the assumption of a long-run slope homogeneity Ndambendia, Njoupouognigni (2010). The key assumptions of the ARDL estimator are in this fashion: foremost, the error terms are assumed to be serially uncorrelated and are distributed independently of the regressors, explicitly, the explanatory variables can be treated as exogenous; moreover, there is a long-run relationship between the dependent and explanatory variables; and lastly, the long-run parameters are the same across countries.

### **4.3 Data source and Data Analysis**

The study utilized the monthly time series data covering the period 2002 - 2018. This period is selected to capture the period before and after the financial crisis of 2008, from which all EAC countries have been facing financial and economic challenges that emanated from the crisis. Also, in early 2015, all EAC currencies recorded a significant depreciation against other major currencies mainly on account of global appreciation of the US Dollar. Therefore, the exchange rates of these countries have been passing through some policy interventions. The major sources of data are EAC Central Banks and International Financial Statistics (IFS).

It has often been argued that macroeconomic data are characterized by a stochastic trend and, if unresolved, the statistical behaviour of the estimators will be influenced by such a trend such that results may be spurious. In this case, the unit root test was conducted to find out the stationarity of variables used in the estimation. The study applied the commonly used method to test for the presence of unit roots are the ADF tests (Dickey and Fuller, 1979 and 1981) as well as Phillip Perron (1988).

The following section applies the methodology to present findings on the extent of exchange rate volatility and its likely impact on macroeconomic variables. The data examination exercise is also presented in order to diagnose the behaviour of data used.

#### **Definition of variables**

The data set contains monthly measures on the following variables

1. The volatility of nominal exchange rate (LVEX): Estimated using EGARCH, ARCH and GARCH models introduced in section 5.2
2. Exports (LEXP): Total exports of goods and services (FOB), in millions of US Dollars, converted into logarithm
3. Interest Rate (INT): Overall lending rate, percent
4. Foreign direct investment (LFDI): Inward Foreign Direct Investment, in millions of US Dollars, converted into logarithm

5. Inflation (INFL): Year on year inflation rate expressed in percent

## 5.0 Discussion of Findings

### 5.1 Introduction

This section presents empirical results from the estimated volatility model where the extent of exchange rate volatility is estimated and discussed. The estimation has been extended to assess the impact of exchange rate volatility on trade flows, FDI, inflation and interest rate from which the preliminary data diagnostics are first presented to describe the statistical behaviour of the variables used.

### 5.2 Establishing the presence or absence of volatility of exchange rate (VEX)

All procedures for volatility estimation were conducted before and after estimation to ensure robustness. To ensure that appropriate mean equations were specified, both Q and Q-squared tests were employed. Also, the ARCH test was carried out before and after volatility estimation to ensure that ARCH effect exists and does not exist, respectively (not presented here).

**Table 5.1** presents estimated results for the exchange rate volatility in Tanzania, Kenya and Uganda. Generally, results indicate the presence of exchange rate volatility in Tanzania, Kenya and Uganda as it has been described by either ARCH or/and GARCH coefficients. For the case of Tanzania and Uganda, the exchange rate volatilities were estimated using GARCH (1, 1) specification after minimization of both the Schwarz (SIC) and Akaike (AIC) criteria. More specifically, exchange rate volatility in Tanzania originated from the last variance (GARCH component) and it was statistically significant at 5 percent. Meanwhile, exchange rate volatility in Uganda was originated from both the way exchange rate deviates from its own mean (ARCH component) and last variance and was significant at 5 percent and 1 percent, respectively.

For the case of Kenya, the coefficient of the GARCH terms ( $\beta$ ) was negative (not presented here), which violated the non-negativity condition. To resolve the negativity problem, the exchange rate volatility was estimated using the EGARCH specification as proposed by Nelson (1991). The EGARCH model is specified as:

$$\log(\delta_t^2) = \lambda + \alpha \log(\delta_{t-1}^2) + \beta \left| \frac{\varepsilon_{t-1}}{\delta_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\delta_{t-1}} \quad (12)$$

Where  $\delta_t^2$  is the conditional variance of the exchange rate,  $\varepsilon_{t-1}$  stands for the residuals and is the ARCH term, which measures information about volatility in the previous period,  $\delta_{t-1}^2$  is the GARCH term representing the last period's forecast variance and  $\lambda$ ,  $\alpha$ ,  $\beta$  and  $\gamma$  are parameters to be estimated. Both AIC and SIC were minimized in the specification of the EGARCH (1, 1). Results indicate that the EGARCH coefficients of 0.9658 is positive and properly identified. This coefficient rectifies the aforementioned problem of negative coefficients. Results confirm that the volatility of the exchange rate was contributed by the last period's forecast variance in exchange rates.

Findings indicate that the sum of the ARCH and GARCH coefficients ( $\alpha+\beta$ ) for the case of Kenya and Uganda is very close to 1, indicating that volatility shocks in exchange rates were quite persistent over time, while for Tanzania was not.

**Table 5.1: Estimation Results of Exchange Rate Volatility**

		Coefficient	Std. Error	z-Statistic	Prob.
<b>TANZANIA</b>	C	1.40E-33	1.09E-33	1.2869	0.1981
	RESID (-1) ^ 2	0.5903	0.4022	1.4675	0.1423
	GARCH (-1)	0.0104	0.0042	2.4792**	0.0132
<b>KENYA</b>	C	-2.5239	0.9699	-2.6022	0.0093
	RES /SQR[GARCH] (1)	0.0789	0.0281	2.8152*	0.0049
	RES/SQR[GARCH] (1)	0.0603	0.6664	0.0905	0.9279
	EGARCH (1)	0.9658	0.2471	3.908*	0.0001
<b>UGANDA</b>	C	2.50E-29	1.52E-29	1.6403	0.1009
	RESID (-1) ^2	0.1501	0.0603	2.4892**	0.0128
	GARCH (-1)	0.8912	0.1797	4.9594*	0.0008

Source: Author's estimates.

Note: \* and \*\* indicate significant at 1 and 5 percent level, respectively.

The comparison of the levels of exchange rate volatility in Tanzania, Kenya and Uganda is presented in the next sub-section using the means, variances and standard deviations. These indicate the country with a high or low level of exchange rate volatility in those countries.

### 5.3 Descriptive Statistics

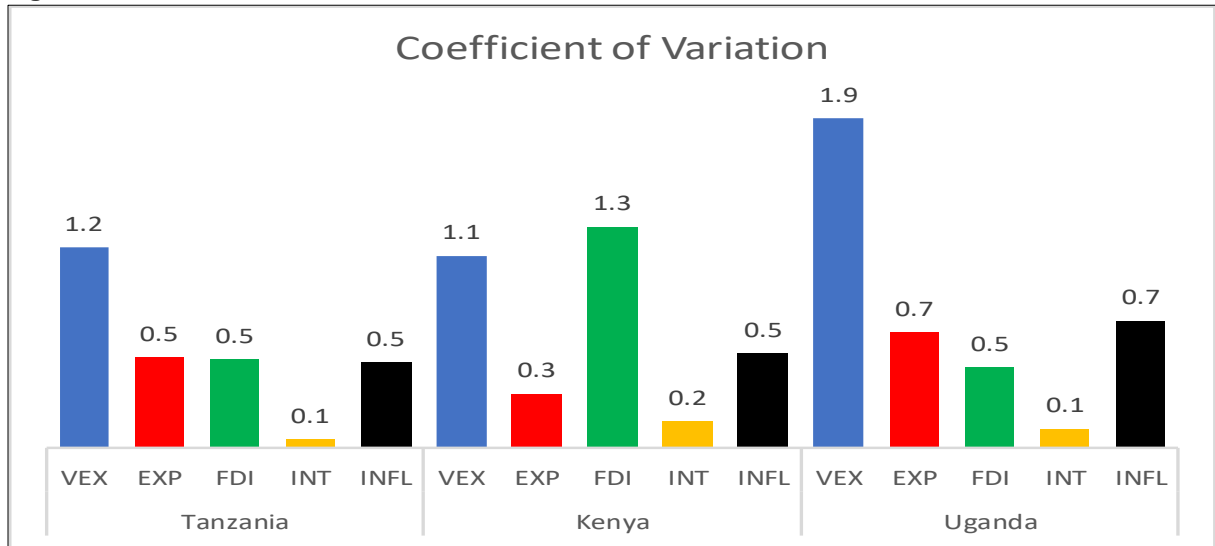
#### 5.3.1 Summary

Preliminary diagnostic tests were conducted to check the behaviour of the data used. The summary statistics of all variables used are presented in Annex 2. Results give important information about the macroeconomic variables in Tanzania, Kenya and Uganda.

**Figure 5.1** illustrates that the coefficient of variation (defined as the ratio of the standard deviation to the mean) in the exchange volatility series was much higher in Uganda, followed by Tanzania during the study period. Therefore, the degree of exchange rate volatility was higher in Uganda and Tanzania and lower in Kenya.

Also, Uganda recorded the highest coefficient of variation in inflation and trade flows-proxied by exports compared to Kenya and Tanzania. Thus, the degree of deviation of the exchange rate volatility, inflation and exports from the mean value in Uganda is far more than in Kenya and Tanzania. On the other hand, Kenya recorded the highest coefficient of variation for FDI, and lending rates compared to Uganda and Tanzania.

**Figure 5.1: Coefficient of variation**



Source: Author's estimates.

## 5.4 Estimation of the Impact of Exchange Rate Volatility on Macroeconomic Variables

### 5.4.1 Panel Unit Root Test

Several panel data unit root tests were conducted for all five variables and results from the Levin–Lin–Chu (2002), Im, Pesaran and Shin (2003) as well as Augmented Dickey-Fuller (1981) tests for variables at both levels as well after the first difference are summarized in Annex 3 and 4. Results suggest only exchange rate volatility series and inflation are stationary at level, all other variables are stationary after taking the first difference. Thus, we have equally observed that our data is suffering from either I (0) and I (1).

### 5.4.3 Results of the ARDL bound estimations

#### Model 1: Determinants of Exchange Rate Volatility

The long-run and short-run estimates of the drivers of volatility in the exchange rate are presented in **Table 5.2**. In the long-run volatility of exchange rate is impacted negatively by FDI flows and positively by exports at a 10 percent significance level. The coefficients of FDI and exports are statistically significant at the 10 percent level in Model 1. The long-run result of the impact of FDI on the exchange rate is consistent with the proposition by Afridi (1995) and Edwards (1988) that the impact of FDI on exchange rate rests on whether proceeds from FDI are used for the purchase of tradable goods or non-tradable goods. For the case when the spending is made on the purchase of non-tradable goods will lead to an appreciation of the exchange rate and thus reduces the volatility which for the case of East African countries is mostly on the depreciating side. The same applies to the case of an increase in foreign exchanges.

In the short-run, however, the volatility of the exchange rate is predominantly impacted (negatively) by exports only. The error correction term (-0.12) in the short-run model is negative and significant implying that there is a long-run causality running from explanatory variables to the dependent variable. It also confirms that the speed of adjustment to long-run equilibrium is 12 percent monthly (since the dataset is monthly).

**Table 5.2: ARDL Bound Results for Model 1**

Dependent Variable: D(LVEX)				
Method: ARDL				
Dynamic regressors (12 lags, automatic): INFL LFDI INT LEXPO				
Fixed regressors: C				
Selected Model: ARDL (2, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
INFL	-0.021513	0.034974	-0.615127	0.5387
LFDI	-1.036256	0.535399	-1.935483	0.0535*
INT	0.148842	0.114235	1.302943	0.1932
LEXPO	0.842311	0.470676	1.789576	0.0741*
Short Run Equation				
COINTEQ01	-0.120057	0.057307	-2.094970	0.0367**
D (LVEX (-1))	0.028769	0.158437	0.181581	0.8560
D(INFL)	0.000730	0.004418	0.165291	0.8688
D(LFDI)	-0.070438	0.085961	-0.819423	0.4129
D(INT)	-0.039282	0.033014	-1.189882	0.2346
D(LEXPO)	-0.099073	0.033947	-2.918469	0.0037***
C	-0.050162	0.034273	-1.463601	0.1439
Mean dependent var	-0.013411	S.D. dependent var		0.544169
S.E. of regression	0.515956	Akaike info criterion		1.547585
Sum squared resid	137.0982	Schwarz criterion		1.746269
Log likelihood	-392.8480	Hannan-Quinn criter.		1.625290

**Model 2: Impact of Exchange rate volatility on exports**

The exchange rate volatility is noticed to positively affect the exports in the long-run, at the 1 percent level of significance (Annex 5). The results indicate that for a 1 percent increase in exchange rate volatility raises exports by 0.13 percent. In the short-run model, though not statistically significant, the volatility of the exchange rate is noticed to negatively affect export consistent with prior expectation. A reasonable clarification may perhaps be that at the occurrence of increasing volatility, risk-averse traders would immediately hold back on their high-risk exporting commitments

in efforts to reduce likely trade losses. The significance of the error correction term in the model suggests that both long-run and short-run models can be estimated.

The short-run findings of the study are consistent with the findings from the study by Choudhury (2005), Arize, Osang, and Slottje (2004) and Clark (1973) that exchange rate volatility has a negative impact on the export demand in the short-run. However, in the long-run, the findings of the current study are contrary to the findings of the aforementioned studies.

### **Model 3: Impact of Exchange rate volatility on lending rates**

The exchange rate volatility is noticed to positively affect the lending rates in the long-run, at the 1 percent level of significance (Annex 6). The results indicate that for a 1 percent increase in exchange rate volatility raises exports by 0.97 percent. In the short-run model, lending rates are also positively and significantly affected by exports.

The long-run and the short-run findings of the study is consistent with the findings from the study by Karfakis and Kim (1995) which discovered that unanticipated nominal exchange rate volatility is linked with and an increase in interest rates through its impact on current account deficit.

### **Model 4: Impact of Exchange rate volatility on FDI**

From Annex 7, the significance of the error correction term in the model suggests that both long-run and short-run models can be estimated. The exchange rate volatility is observed to negatively affect the FDI in the long-run, at the 1 percent level of significance. The results indicate that for a 1 percent increase in exchange rate volatility reduces FDI by 0.23 percent in the long run. In the short-run model, all explanatory variables are observed to be statistically insignificant.

These findings are in line with the findings of Accam (1997) and Alaba (2003) which examined the relationship between exchange rate volatility and FDI flows over time. The results of the two studies indicate that the official market exchange rate movement significantly reduces FDI inflows. However, findings of the current study are contrary to findings by Chaduhary et al. (2012) as well as Cushman (1988), Stokman and Vlar (1996), and Foad (2005) which indicate a positive impact of exchange rate volatility on FDI flow to the host countries.

### **Model 5: Impact of Exchange rate volatility on inflation**

As reported in Annex 8, the exchange rate volatility exerts a positive insignificant effect on inflation in the long-run. This finding is consistent with findings of the study by Edwards (1993) who



conducted the cross-country research in developing countries as well as that of Odedokun (1995), using data from 35 countries for the period 1971 to 1990 where the domestic currency volatility was found to exert positive effects on inflation. In the short-run model, the volatility of the exchange rate is noticed to negatively affect inflation contrary to prior expectation.

#### **5.4.4 Granger Causality Tests**

The pairwise Granger causality test, as well as pairwise Dumitrescu-Hurlin Panel causality test for all variables used, are presented in Annex 10 and Annex 11. For the case of pairwise Granger causality test that assumes common coefficients, there is unidirectional causality between volatility in lending rate and inflation; and lending rate and exports at 1 percent significant level.

For the case of Dumitrescu-Hurlin Panel causality test, four bi-directional causalities and one uni-direction causality have been detected. there is unidirectional causality between volatility in lending rate and inflation; and lending rate and exports. There was bi-directional causality between the lending rate and inflation, FDI and inflation, the volatility of exchange rate and inflation as well as the volatility of exchange rate and exports. The uni-direction causality runs from the volatility of the exchange rate to FDI and not otherwise.

## **6.0 Conclusions and Policy Implications**

This study estimated the extent of exchange rate volatility and assessed its subsequent impact on macroeconomic variables, basically, trade flows, FDI, interest rate and inflation in Tanzania, Kenya and Uganda. The exchange rate used in this study is the real effective exchange rates (REER), which takes into account any changes in relative prices and trades with trading partners. Also, the interest rate which was used was the overall lending rate. To estimate exchange rate volatility, the study used the ARCH/GARCH family models, which assume that volatility changes over time. At the same time, the Panel Autoregressive Distributed Lag (ARDL) bound testing technique or pooled mean group (PMG) estimator was used to assess the impact of exchange rate volatility on macroeconomic variables.

The results confirm that volatility in the exchange rate is a practical issue in all the sampled countries and is fundamentally driven by exports dynamics for the period under consideration.

With respect to exports, the results indicate a positive impact of the exchange rate volatility to export performance in the long run. However, in the short run, exchange rate volatility seems to be detrimental to export performance.

For the case of lending rates, results suggest that volatility in the exchange rate raises lending rates in the long run but reduces lending rates in the short-run period. The long-run response, excess exchange rate volatility can lead to higher prices of tradable goods by causing traders to incorporate a risk premium to accommodate unanticipated exchange rate volatilities from which inflationary pressures cause banks to increase lending rates to hedge themselves.

The response of FDI seems to be different. While there was a negative response of FDI in the long run, the short responses from the volatility of the real exchange rate seem to be insignificant. For the case of long-run response, this is due to the fact that excessive volatility in exchange rate creates a high degree of currency risk, which alters the flow of FDI to countries with more unstable exchange rates.

With respect to inflation, though not significant, the volatility of the exchange rate appears to have a positive impact on inflation.

Two major policy implications can be drawn based on the findings of the relationship between exchange rate volatility and macroeconomic variables in EAC countries.

*First*, policymakers need institute mitigation measures, which could reduce exchange rate volatility to minimize its likely impact on the economy. The EAC central banks may think to keep enough reserves, which will be used as intervening tools in stabilizing exchange rate fluctuations. Also, most EAC countries are still depending on traditional exports as a means of foreign exchange earnings, which are subjected to low prices in the world market. There is a need to fast-track industrialization agenda, which will promote manufacturing sector in order to create value addition and not only be able to earn more foreign exchange but also solve problems emanated from the inflationary pressure induced by the exchange rate volatility.

*Second*, for the case of Tanzania and Kenya, where the Pairwise Dumitrescu-Hurlin Panel Causality Tests indicated the bi-directional causality between exchange rate volatility and inflation, there is a need to consider adopting inflation targeting monetary policy framework in order to contain inflation at the appropriate level. Further study is recommended to investigate the impact of exchange rate volatility in EAC economies using alternative methods such as panel vector error correction model.

This study contributes to closing the gap on theoretical and empirical literature by providing new evidence on the extent of exchange rate volatility and its impact on key macroeconomic variables such as flows, FDI, interest rate and inflation in the East African countries. The results of this study provide strong evidence that exchange rate volatility is a real issue in all the sampled countries and

is fundamentally driven by exports and FDI dynamics for the period under consideration. Moreover, the results indicate a positive impact of the exchange rate volatility to export performance, inflation and lending rates in the long run. On the other hand, the response of FDI to exchange rate volatility seems to be negative in the long run. Another contribution of this study is that the findings of the research provide an important guide in designing appropriate macroeconomic policies such as fiscal, monetary, trade, industrial and investment policies to enhance sustainable development.

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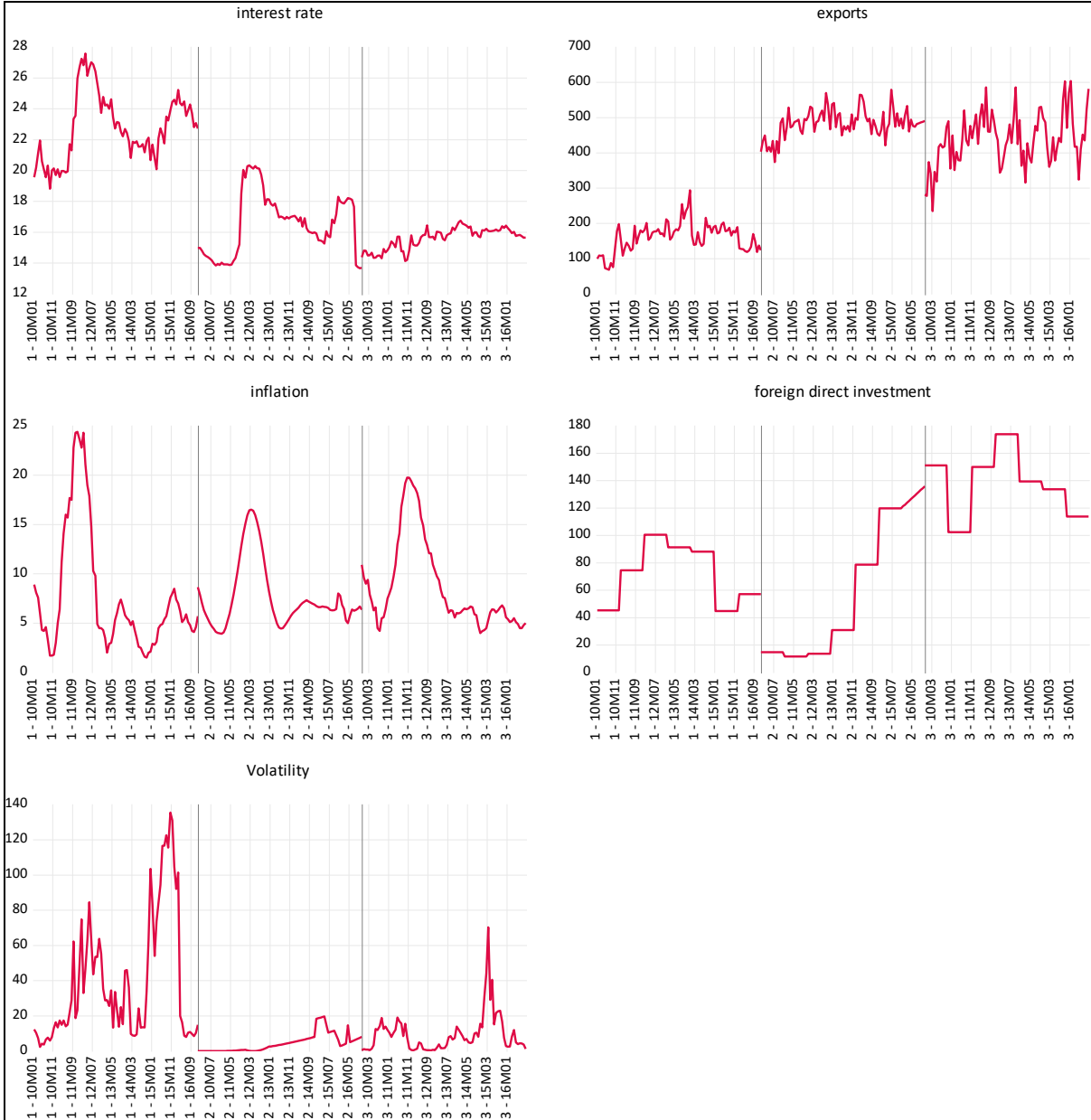
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## Annexes

### Annex 1: Graphical Presentation of Variables



**Annex 2: Descriptive Statistics**

	Observations	Mean	Median	Std. Dev.	Coefficient of Variation	Maximum	Minimum
<b>INFL</b>	540	8.33	6.80	4.97	0.60	31.54	-3.50
<b>INT</b>	540	17.34	16.29	3.32	0.19	27.58	11.97
<b>VEX</b>	540	17.17	8.53	22.38	1.30	135.55	0.00
<b>EXP O</b>	540	257.91	210.96	166.61	0.65	603.75	14.40
<b>FDI</b>	540	61.15	53.69	47.17	0.77	173.94	1.77

Source: Author's estimates

**Annex 3: Unit Root Tests (t-statistic) in levels**

Variable	Levin, Lin & Chu H0: Common unit roots Ha: Stationarity		Im, Pesaran and Shin H0: Individual unit roots Ha: Stationarity		PP - Fisher Chi-square H0: Individual unit roots Ha: Stationarity	
	Level	First Difference	Level	First Difference	Level	First Difference
<b>VEX</b>	-1.75045***	-59.7121***	-3.20193***	-49.4310***	26.5747***	166.602***
<b>INT</b>	-0.87112	-25.3519***	-2.53953***	-23.9564***	17.2461***	278.636***
<b>INFL</b>	0.0494***	0.0479***	0.0129***	0.0007***	0.3987	0.0000***
<b>EXPO</b>	0.10996	-15.3499***	0.47455	-19.2099***	2.72666	224.281***
<b>FDI</b>	0.52743	-28.9322***	0.62006	-23.8096***	4.00117	289.741***

\*\*\* denotes significance at 1%, \*\* denotes significance at 5%



## Annex 4: Unit Root Tests (t-statistic) in logs

Variable	Levin, Lin & Chu H0: Common unit roots Ha: Stationarity		Im, Pesaran and Shin H0: Individual unit roots Ha: Stationarity		PP - Fisher Chi-square H0: Individual unit roots Ha: Stationarity	
	Level	First Difference	Level	First Difference	Level	First Difference
Log (VEX)	-0.64671	-27.9218***	-1.89651**	-25.7812***	13.9610**	268.238***
INT	-0.87112	-25.3519***	-2.53953***	-23.9564***	17.2461***	278.636***
INFL	0.0494***	0.0479***	0.0129***	0.0007***	0.3987	0.0000***
Log (EXPO)	-2.81141***	-20.3712***	-0.89569	-21.6380***	7.17129	258.511***
Log (FDI)	-0.86845	-23.6302***	-0.32887	-19.4491***	5.30790	193.228***

\*\*\* denotes significance at 1%, \*\* denotes significance at 5%

## Annex 5: ARDL Results for Model 2

Dependent Variable: D(LEXPO)				
Method: ARDL				
Included observations: 504				
Maximum dependent lags: 12 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (12 lags, automatic): LVEX INFL LFDI INT				
Fixed regressors: C				
Number of models evaluated: 144				
Selected Model: ARDL(12, 1, 1, 1, 1)				
Note: final equation sample is larger than selection sample				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
<b>Long Run Equation</b>				
LVEX	0.129238	0.045712	2.827228	0.0049***
INFL	0.027111	0.012670	2.139782	0.0329**
LFDI	0.789199	0.087089	9.061997	0.0000***
INT	-0.032411	0.057107	-0.567555	0.5706
<b>Short Run Equation</b>				
COINTEQ01	-0.098296	0.060415	-1.627021	0.1044
D(LEXPO(-1))	-0.457536	0.069664	-6.567792	0.0000***
D(LEXPO(-2))	-0.342208	0.034881	-9.810703	0.0000***
D(LEXPO(-3))	-0.213579	0.033186	-6.435844	0.0000***
D(LEXPO(-4))	-0.237023	0.059979	-3.951778	0.0001***

<b>D(LEXPO(-5))</b>	-0.276905	0.075222	-3.681159	0.0003***
<b>D(LEXPO(-6))</b>	-0.234439	0.053095	-4.415474	0.0000***
<b>D(LEXPO(-7))</b>	-0.343691	0.047275	-7.270022	0.0000***
<b>D(LEXPO(-8))</b>	-0.237094	0.139332	-1.701652	0.0895*
<b>D(LEXPO(-9))</b>	-0.231665	0.105308	-2.199894	0.0283**
<b>D(LEXPO(-10))</b>	-0.240762	0.044014	-5.470184	0.0000***
<b>D(LEXPO(-11))</b>	-0.155698	0.015683	-9.927997	0.0000***
<b>D(LVEX)</b>	-0.020347	0.012634	-1.610512	0.1079
<b>D(INFL)</b>	0.016538	0.009759	1.694642	0.0908*
<b>D(LFDI)</b>	-0.037184	0.037572	-0.989676	0.3228
<b>D(INT)</b>	0.013440	0.006182	2.174125	0.0302**
<b>C</b>	0.226130	0.144372	1.566305	0.1179
Mean dependent var	0.008978	S.D. dependent var	0.155579	
S.E. of regression	0.125549	Akaike info criterion	-1.195389	
Sum squared resid	7.644877	Schwarz criterion	-0.758285	
Log likelihood	377.7550	Hannan-Quinn criter.	-1.024439	

**Annex 6: ARDL Results for Model 3**

Dependent Variable: D(INT)				
Method: ARDL				
Dynamic regressors (12 lags, automatic): LEXPO LVEX INFL LFDI				
Fixed regressors: C				
Selected Model: ARDL (3, 1, 1, 1, 1)				
<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>	<b>Prob.*</b>
<b>Long Run Equation</b>				
<b>LEXPO</b>	1.823200	0.748302	2.436448	0.0152**
<b>LVEX</b>	0.979007	0.301186	3.250506	0.0012***
<b>INFL</b>	0.207854	0.060612	3.429225	0.0007***
<b>LFDI</b>	-0.472167	0.983174	-0.480248	0.6313
<b>Short Run Equation</b>				
<b>COINTEQ01</b>	-0.107388	0.082300	-1.304848	0.1925
<b>D(INT(-1))</b>	-0.093303	0.121454	-0.768213	0.4427
<b>D (INT(-2))</b>	-0.068247	0.063523	-1.074365	0.2832
<b>D(LEXPO)</b>	0.231170	0.052317	4.418619	0.0000***
<b>D(LVEX)</b>	-0.091135	0.040783	-2.234602	0.0259**
<b>D(INFL)</b>	-0.032395	0.036303	-0.892353	0.3726
<b>D(LFDI)</b>	0.539246	0.326419	1.652003	0.0991*
<b>C</b>	1.034951	0.953743	1.085147	0.2784
Mean dependent var	-0.006977	S.D. dependent var	0.734460	
S.E. of regression	0.660211	Akaike info criterion	1.766178	
Sum squared resid	223.1700	Schwarz criterion	1.988704	

Log likelihood	-448.8681	Hannan-Quinn criter.	1.853207
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**Annex 7: ARDL Results for Model 4**

Dependent Variable: D(LFDI)				
Method: ARDL				
Dynamic regressors (12 lags, automatic): INT LEXPO LVEX INFL				
Fixed regressors: C				
Selected Model: ARDL (1, 1, 1, 1, 1)				
<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>	<b>Prob.*</b>
<b>Long Run Equation</b>				
<b>INT</b>	0.066278	0.043829	1.512201	0.1311
<b>LEXPO</b>	0.506001	0.102604	4.931577	0.0000***
<b>LVEX</b>	-0.237579	0.064342	-3.692439	0.0002***
<b>INFL</b>	0.017663	0.011874	1.487570	0.1375
<b>Short Run Equation</b>				
<b>COINTEQ01</b>	-0.070638	0.029011	-2.434892	0.0152**
<b>D(INT)</b>	0.024840	0.016062	1.546539	0.1226
<b>D(LEXPO)</b>	0.039580	0.052741	0.750469	0.4533
<b>D(LVEX)</b>	0.007843	0.005271	1.487940	0.1374
<b>D(INFL)</b>	-0.017530	0.018693	-0.937780	0.3488
<b>C</b>	0.059865	0.027141	2.205715	0.0278**
Mean dependent var	0.012347	S.D. dependent var	0.197572	
S.E. of regression	0.190287	Akaike info criterion	-0.888698	
Sum squared resid	18.75626	Schwarz criterion	-0.713856	
Log likelihood	261.9484	Hannan-Quinn criter.	-0.820318	

## Annex 8: ARDL Results for Model 5

Dependent Variable: D(INFL)				
Method: ARDL				
Dynamic regressors (12 lags, automatic): LFDI INT LEXPO LVEX				
Fixed regressors: C				
Selected Model: ARDL (6, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
<b>Long Run Equation</b>				
LFDI	-0.566533	1.180872	-0.479758	0.6316
INT	-0.584238	0.476580	-1.225895	0.2208
LEXPO	2.223681	1.655555	1.343163	0.1798
LVEX	0.548965	0.499401	1.099248	0.2722
<b>Short Run Equation</b>				
COINTEQ01	-0.071335	0.013581	-5.252639	0.0000***
D(INFL(-1))	0.209546	0.020746	10.10064	0.0000***
D(INFL(-2))	0.168784	0.006419	26.29505	0.0000***
D(INFL(-3))	0.126195	0.021008	6.007111	0.0000***
D(INFL(-4))	-0.036288	0.066940	-0.542097	0.5880
D(INFL(-5))	-0.001996	0.088003	-0.022680	0.9819
D(LFDI)	-0.061789	0.818413	-0.075498	0.9398
D(INT)	0.191902	0.219927	0.872570	0.3833
D(LEXPO)	0.690801	0.213637	3.233536	0.0013***
D(LVEX)	-0.143573	0.080037	-1.793839	0.0734*
C	0.627710	0.218044	2.878828	0.0042***
Mean dependent var	0.023373	S.D. dependent var		1.381138
S.E. of regression	1.185584	Akaike info criterion		3.052135
Sum squared resid	707.0215	Schwarz criterion		3.346187
Log likelihood	-787.0764	Hannan-Quinn criter.		3.167138

**Annex 9: Lag length selection**

VAR Lag Order Selection Criteria  
 Endogenous variables: INFL INT LEXPO LFDI LVEX  
 Exogenous variables: C  
 Date: 04/07/19 Time: 09:23  
 Sample: 2002M01 2016M12  
 Included observations: 516

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5317.914	NA	627.7005	20.63145	20.67259	20.64757
1	-1508.396	7530.443	0.000267	5.962773	6.209640*	6.059513
2	-1445.780	122.5622	0.000231	5.816975	6.269564	5.994331*
3	-1408.938	71.39762	0.000221*	5.771079*	6.429390	6.029051
4	-1388.312	39.57356	0.000225	5.788032	6.652065	6.126619
5	-1376.977	21.52862	0.000237	5.840995	6.910751	6.260199
6	-1357.998	35.67705	0.000243	5.864333	7.139811	6.364153
7	-1339.286	34.81384	0.000249	5.888704	7.369904	6.469140
8	-1314.664	45.32973*	0.000249	5.890172	7.577094	6.551224

\* indicates lag order selected by the criterion  
 LR: sequential modified LR test statistic (each test at 5% level)  
 FPE: Final prediction error  
 AIC: Akaike information criterion  
 SC: Schwarz information criterion  
 HQ: Hannan-Quinn information criterion

**Annex 10: Panel Causality Test-Stacked Test/Common coefficients**

<b>Null Hypothesis:</b>	<b>Obs</b>	<b>F-Statistic</b>	<b>Prob.</b>
INT does not Granger Cause INFL	252	1.03524	0.3567
INFL does not Granger Cause INT		7.37499	0.0008***
LEXPO does not Granger Cause INFL	252	1.00902	0.3661
INFL does not Granger Cause LEXPO		0.00888	0.9912
LFDI does not Granger Cause INFL	252	0.28763	0.7503
INFL does not Granger Cause LFDI		1.46868	0.2322
LVEX does not Granger Cause INFL	252	0.47962	0.6196
INFL does not Granger Cause LVEX		1.81184	0.1655
LEXPO does not Granger Cause INT	252	2.19008	0.1141
INT does not Granger Cause LEXPO		5.67927	0.0039***
LFDI does not Granger Cause INT	252	0.62553	0.5358
INT does not Granger Cause LFDI		1.05817	0.3487
LVEX does not Granger Cause INT	252	0.70908	0.4931
INT does not Granger Cause LVEX		0.92854	0.3965
LFDI does not Granger Cause LEXPO	252	0.08193	0.9214
LEXPO does not Granger Cause LFDI		0.91263	0.4028
LVEX does not Granger Cause LEXPO	252	2.21957	0.1108
LEXPO does not Granger Cause LVEX		0.52291	0.5934
LVEX does not Granger Cause LFDI	252	0.08281	0.9206
LFDI does not Granger Cause LVEX		0.46545	0.6284

## Annex 11: Pairwise Dumitrescu-Hurlin Panel Causality Tests

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
INT does not homogeneously cause INFL	8.95333	9.28517	0.0000***
INFL does not homogeneously cause INT	7.26400	7.30657	3.E-13***
LEXPO does not homogeneously cause INFL	0.16144	-1.01218	0.3114
INFL does not homogeneously cause LEXPO	0.85226	-0.20307	0.8391
LFDI does not homogeneously cause INFL	13.1254	14.1717	0.0000***
INFL does not homogeneously cause LFDI	3.16666	2.50764	0.0122***
LVEX does not homogeneously cause INFL	11.2797	12.0098	0.0000***
INFL does not homogeneously cause LVEX	2.79468	2.07196	0.0383***
LEXPO does not homogeneously cause INT	0.16084	-1.01288	0.3111
INT does not homogeneously cause LEXPO	2.43931	1.65573	0.0978
LFDI does not homogeneously cause INT	0.85090	-0.20466	0.8378
INT does not homogeneously cause LFDI	1.52951	0.59015	0.5551
LVEX does not homogeneously cause INT	1.03737	0.01373	0.9890
INT does not homogeneously cause LVEX	0.07857	-1.10925	0.2673
LFDI does not homogeneously cause LEXPO	1.18865	0.19093	0.8486
LEXPO does not homogeneously cause LFDI	0.53052	-0.57991	0.5620
LVEX does not homogeneously cause LEXPO	4.18785	3.70368	0.0002***
LEXPO does not homogeneously cause LVEX	3.34156	2.71248	0.0067***
LVEX does not homogeneously cause LFDI	3.15052	2.48873	0.0128***
LFDI does not homogeneously cause LVEX	0.66095	-0.42714	0.6693

Annex 12: Normality Test of Residuals

