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**Article**

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## FINANCIAL ECONOMICS | RESEARCH ARTICLE

# Asymmetric impact of real exchange rate on inflation in Ethiopia: a non-linear ARDL approach

Samuel Elias Kayamo<sup>1\*</sup>

**Abstract:** A surge in inflation for the last decade has been a top agenda of political and economic debate in Ethiopia. The monetary authority of the country has regularly devalued Ethiopian birr to stabilize the inflation and stimulate exports. Whether this has indeed stabilized inflation and increased export earnings is an issue of debate. This study investigates the asymmetric impact of real exchange rate on inflation for period 1982–2019. The non-linear ARDL bounds test is used to test the presence of long-run co-integrations. Long- and short-run estimations were done based on the non-linear ARDL error correction methodology. The result of the study indicated that the real exchange rate has asymmetric effects on inflation in short- and long-run. The imbalance in real exchange rate (depreciation and appreciation) causes a surge in inflation in the long-run. The policy implication of this study is that flexibility in exchange rate market should be planned to ensure price stability rather than following restrictive exchange rate policy.

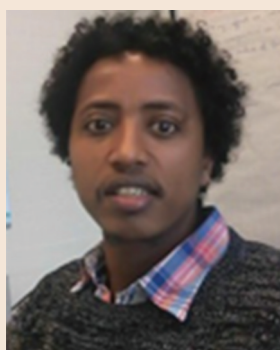
**Subjects:** Macroeconomics; Economic Forecasting; International Economics; Public Finance

**Keywords:** inflation; real exchange rate; non-linear ARDL; Ethiopia

## 1. Introduction

Nominal exchange rate is the price of a country's currency in terms of another country, whereas the real exchange rate is the nominal exchange rate adjusted for relative national price differences (Sarno & Taylor, 2002). Globalization and increased trade openness have made the exchange rate an important economic variable that determines the country's economic performance. Fluctuation of exchange rate directly affects output, consumer price, export performance and imports. In a well-functioning economy, the exchange rate is assumed to fluctuate less and the policy followed is clear.

## ABOUT THE AUTHOR



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Samuel Elias Kayamo is a lecturer at Hawassa University, Ethiopia. He teaches Macroeconomics and Operational Research in Agricultural Economics. His research interests are Agricultural Economics and Environmental Economics such as analyzing the relationship between the real exchange rate and agricultural exports and inflation, waste management, climate change and valuation of environmental resources.

## PUBLIC INTEREST STATEMENT

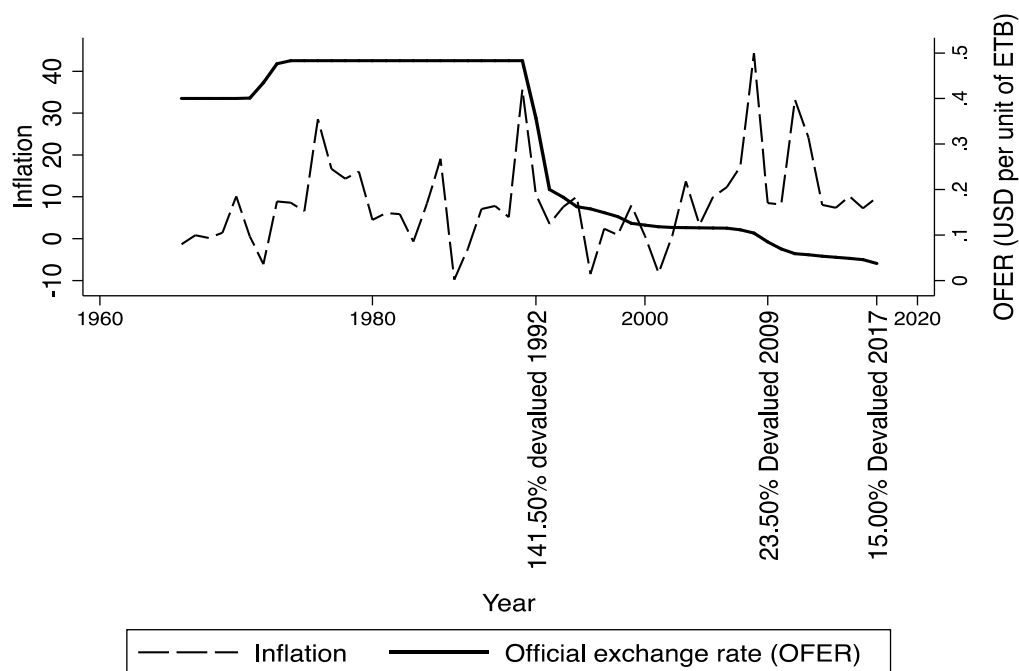
The aim of this study was to empirically test the asymmetric effects of the real exchange rate on inflation in Ethiopia. The results of the study revealed the asymmetric impact of the real exchange rate on short- and long-term inflation. In addition, the result of study clearly indicated that real exchange rate instability (depreciation and appreciation) has long-run inflationary effects. In the short-run, the money supply has a significant and positive effect on inflation. Non-linear ARDL approaches were used to analyze the data. The study suggests that flexibility in the exchange rate market should be planned to ensure price stability rather than following a restrictive exchange rate policy.

Exchange rate stability is important for controlling inflation as a stable exchange rate is expected to ease domestic inflationary pressures (R. Mundell, 1961; R.A. Mundell, 1963). In Ethiopia, the National Bank of Ethiopia (NBE) follows a very restrictive crawling peg exchange rate system aiming to ensure stability in exchange rate market (Hope, 2004). The NBE sets a range for exchange rate market and the commercial banks buy and sell the currency within that range. For example, if NBE sets a range to exchange one USD to Ethiopian birr (ETB) between ETB 27–28, then the banks are only allowed to buy and sell within that range. Due to this exchange market restriction, the exchange rate of ETB to USD can't adjust automatically. As a result, the gap between the official exchange rate and the parallel black exchange rate market is widening. Devaluation of ETB often has been used by NBE as a means of adjusting the gap between the official exchange rate and the parallel black exchange rate market, improve trade balance and stabilize inflation. However, the black-market exchange rate is still much higher than the official exchange rate. On the other hand, NBE's devaluation policy has been heavily criticized as it is considered the source of inflation.

The trend of devaluation indicated that the higher inflation is frequently followed by a devaluation of ETB (see Figure 1). For example, ETB was devalued by 141.5% as a result of higher inflation in 1991 and as a part of the structural adjustment of the Ethiopian economy. But inflation had not stabilized and the country has often faced staggering inflation in the subsequent years. In 2008, inflation rose 44% , the highest in the country's history, and as a result, later in 2009 ETB was devalued by 23.7%, with the aim of stabilizing inflation and improving export earnings. However, inflation has not stabilized, but it is trending upwards in double digits. This clearly shows that inflation has become the main macroeconomic problem of the Ethiopian economy.

Instability in exchange rate market is not the only factors driving inflation in Ethiopia, but also there are other important economic variables that determine inflation as well. Loening et al. (2009), found that money supply has a significant effect on food inflation in the short term, while (Bane, 2018; Biresaw, 2013) found a bidirectional relationship between money supply and general inflation. In

**Figure 1. The trend between inflation and official exchange rate USD against ETB.**



addition, the higher government spending; interest rate and other structural shocks, such as shocks in agricultural production (Bane, 2018), have been reported as the sources of inflation.

Moreover, the International Monetary Fund (IMF) and World Bank and the Ethiopia governments have diverged views on the sources of inflation. The IMF and the World Bank argue that higher government spending financed by an increase in the money supply (demand side) are typical causes of the increase in food inflation (Loening et al., 2009). The Ethiopian government considers structural problems as sources of inflation, claiming that what has been produced does not reach the market due to structural problems (Denbel et al., 2016; Haji & Gelaw, 2012; Priewe, 2016). These signals that divergent views on the sources of inflation remain unresolved. There are a few related studies (Mainardi, 1991; Taye, 1999; Tensay, 2006) that have assessed the sources of inflation and the impact of devaluation on Ethiopia's domestic price. Therefore the main purpose of this study is to assess the asymmetric impact of real exchange rate on inflation in Ethiopia.

## **2. The trend of the exchange rate and inflation**

Following the collapse of Bretton Woods system in 1971 the Government of Ethiopia were adopted a fixed exchange rate regime pegging the ETB value to devalue or revalue with the US dollar (Taye, 1999). During a Derg regime (The socialist government) in between 1974 and 1991, the exchange rate line was flat as indicated in Figure 1, and the inflation rate was lower and fluctuation was minimal.

After the downfall of the Dergi regime in 1992, the exchange rate regime has been changed into the floating exchange rate in principle but in practice, the National Bank of Ethiopia has been following a crawling peg exchange rate system. The exchange rate of ETB against USD is allowed to depreciate steadily. And the inflation was started to fluctuate particularly in period 1992–2004. The main reason for fluctuation in the inflation and steady depreciation of ETB was related to the government's economic liberalization efforts, armed conflict and the introduction of a floating exchange rate policy (Hope, 2004).

After 2004, there has been an unprecedented rise in inflation, in particular in 2005 when the country had the consequential election. In 2008, the country recorded the highest inflation level (44.35%) that harmed Ethiopian export competitiveness and led to huge trade balance deficit. The higher and unprecedented inflation episodes in which the country has experienced for the last decade resulted in a sharp depreciation of ETB. Huge depreciation of ETB value has followed repeatedly with inflationary year.

The trend of inflation and depreciation ETB seems like a cause and effect. For example, the ETB value has been devalued in 2009 by 23.50%, as the result inflation rate went down in 2010 but it rose again in 2011, resulting in further depreciation of ETB value. In 2017, the NBE devalued ETB value by 15% after a repeated suggestion from World Bank (2014). It was witnessed that before 2017, the inflationary pressure severely harmed the country Export competitiveness and resulted in a huge trade deficit.

## **3. Brief literature review and theoretical framework**

### **3.1. Brief literature review**

Average inflation in developing countries is much more than inflation in developed countries since the early 1980s (Bleaney & Fielding, 2002). Many studies have been conducted to identify the determinants of inflation in both developed and developing countries by using different techniques such as the least squares, panel data studies and VAR models. As the results of disparity in the use of different data types and methods of analysis, the mixed results were reported by several

empirical studies on inflation. However, most empirical studies commonly reported the real exchange rate, money supply, aggregate demand and supply factors as the main sources of inflation. In this section, the empirical studies that examined the relationship between the real exchange rate and inflation are extensively reviewed and discussed as follows.

In the USA, Kim (1998) indicated that the USD exchange rate had a negative and significant influence on inflation. The result further confirmed that the exchange rate is grange causes inflation. Similarly, a study by Yongxiang (2001) found con-integration between the nominal effective exchange rate and the domestic price in China. He also implied that the variation in the exchange rate has a significant impact on both the retail selling price and producer prices. Another study by Golinelli and Orsi (1998) concluded that the exchange rate is one of the determining factors for domestic price behavior in Hungary and Poland. In Asia, Achsani et al. (2010) showed that the nominal and real exchange rate have a significant effect on the rate of inflation, and the relationship between the variables are unidirectional.

There are also empirical studies conducted in Sub-Sahara countries on the relationship between the real exchange rate and inflation. In Nigeria, Akinbobola (2012), assessed the association between money supply, real exchange rate and inflation. And the result of study indicated that in the long run real exchange rate and money supply has a significant inverse impact on inflation. Likewise, in Ethiopia, Nigusse et al. (2019), examined the relationship between inflation and real effective exchange rate by using the ARDL approach and found that general inflation and the real effective exchange rate have positive relationships in the long-term, while in the short term the real effective exchange rate, the money supply and the budget deficit are the main drivers of inflation.

Some empirical studies not only assessed the relationships, but also the impact of appreciation or depreciation of the real exchange rate on general inflation. A study by Kamin (2001), assessed the impact of real exchange rate appreciation and depreciation on inflation and found that the appreciation of the real exchange rate causes increase in domestic prices in Mexico. Contrary, Berument and Pasaogullari (2003), reported that the real exchange rate depreciations have an inflationary effect in Turkey. In Ghana, Kyereme (1991) found a significant relationship between the exchange rate and inflation. And he confirmed that a surge in inflation causes a drop in Ghanaian cedi and a depreciation of Ghanaian cedi value against US dollar triggers price inflation. Similarly, a study by Imimole and Enoma (2011), indicated the Naira depreciation has a positive and significant effect on inflation in Nigeria. This implies that depreciation of Naira triggers inflation.

Other empirical studies have associated devaluation of currency with inflation. Among, Prakash and Maiti (2016) indicated that the devaluation of the Fiji dollar triggered strongly domestic inflation and weakly stimulated the aggregate demand. Likewise, in Mexico, a study by Kamin and Rogers (2000) revealed that the devaluation of Mexicana Peso directed to higher inflation and economic contraction in Mexico. Moreover, Ahmad and Ali (1999) found a bidirectional relationship between price level and exchange rate, and he further indicated that the short-run impact of devaluation on inflation is smaller than the impact of inflation on devaluation in Pakistan.

Ethiopia's economy has experienced higher inflation over the past decade and few empirical studies have been conducted on it, and mixed results have been reported. The source of food inflation has been vastly assessed by IMF. For instant, after studying the dynamics of food and non-food prices Loening et al. (2009) found that in the long run, the main determinants of Ethiopian domestic food and non-food prices are the exchange rate and the world prices. Another important source identified as a source of food inflation in Ethiopia is the demand side factors such as the population growth, rise in per capita income and rise in food prices in neighboring countries due to increased demand (IMF, 2008b).

On the other hand, many other empirical studies have also conducted and identified different sources of general inflation in Ethiopia. Supply-side factors are often associated with the sharp rise in inflation, such as the distress sell of farmers, the shift from food to cash aid and the structural problems like the poor market linkage, are considered the source of inflation in Ethiopia (IMF, 2008a). Similarly, Ayalew Birru (2007) indicated that supply shocks as major factors in addition to the inertia and the consumer prices of trading partners are the important determinants of inflation in Ethiopia. Another study by Rashid (2010) linked the sharp rise in domestic inflation to general demand, apart from a few exceptional cases between 2007–08, when cereal production was much lower than official agricultural statistics. Besides the supply and demand factors, other factors such as money supply, high government spending, real interest and shocks in key economic sectors such as agriculture (Bane, 2018), devaluation of Ethiopia's birr (Woldie & Siddig, 2019) were identified as the sources of inflation in Ethiopia. Most importantly, Durevall et al. (2013), concluded that inflation in Ethiopia is strongly related to food inflation.

To conclude, there are no consensus among the empirical studies on relationship between the real exchange rate and inflation rate, it varies depending on the country economic, political and social condition. In some countries appreciation real exchange rate has inflationary impact while in other countries the depreciation of real exchange rate has contractionary effect on inflation. Some empirical studies reported that variability on real exchange rate has no significant inflation on inflation. In Ethiopia, the sources of food inflation were widely investigated by IMF but little has empirically been conducted to assess the effects of real exchange rate on inflation, even if the country has been experienced instability in exchange rate, surge in inflation and shortage in foreign currency reserve.

### **3.2. Theoretical framework**

Theoretically, there are many variables that are considered as a source of inflation, such as balance of payments, monetary aspects, tax aspects, demand-pull (aggregated demand) and cost-push, and economic growth. There are also other aspects, such as unexpected shocks from nature, pandemics, hurricanes and earthquakes, that may cause domestic inflation.

The balance of payment aspects states that fluctuation in the exchange rate affects domestic inflation directly or indirectly. Exchange rate fluctuations directly affects the import price, which are the parts of the consumer price index (CIP). For example, depreciation in the exchange rate increases directly the price of all final goods that consumes the imported inputs via an increase or decrease in the import input prices. Indirectly variation in the exchange rate affects the change in the level of prices in both importing and exporting countries which in turn affects the level of import demand and exports products. On the other hand, the fluctuation of exchange rate results in the uncertainties in foreign currency prices, which ultimately leads to the fluctuation of domestic price. In an unstable and fluctuating exchange rate, uncertainty in expectation by itself affects the domestic inflation.

The monetary economists associate inflations with the money supply. Friedman (1959) related the higher inflation for any sustained period with the higher money supply. That means “too much money chasing too few goods”. Whereas, according to the fiscal aspect, the budget deficit is considered as the source of inflation in countries with higher inflation. The fiscal aspect is closely related to the monetary aspect as the government prints money to finance the budget deficit that ultimately leads to inflation.

On the other hand, from the macroeconomic theoretical context, the main source of inflation is the imbalance between the demand-pull (aggregated demand) and cost-push factors (Ball & Doyle, 1969). Aggregate demand is considered to be the sources of inflation according to the demand-pull theory. The demand-pull inflation scenario occurs when the supply of goods and services not able to meet the increase in total expenditure. It is the situation in which many consumers compete to buy



the same good, then the price of that specific good increases. According to the cost-push theory, inflation occurs as a result of an increase in production costs that forces the producer to raise prices to avoid losses. For example, a rise in the exchange rate leads to a rise in the price of imported goods, and subsequently the price of products produced using imported inputs rises.

Another factor believed to determine inflation is the country's economic growth. In the Keynesian school of thought, moderate inflation is important to accelerate economic growth and private investment (Jung & Marshall, 1986). Inflation is expected to initiate economic growth and redistribute income for groups with a lower marginal propensity to save, such as farmers and other lower-paid workers. Whereas, for capitalist entrepreneurs, it promotes investment by raising the nominal return relatively higher than the interest rate (Jung & Marshall, 1986).

In the end, structural factors, such as a shortage of agricultural supplies due to weather conditions, can also affect inflation. For instant, drought damages the important agricultural supply and then the prices of agricultural commodities will skyrocket.

In general, from the above theoretical arguments and according to Gottschalk et al. (2008), inflation can be expressed as a function of the country's exchange rate, economic growth, government budget deficit, money supply and import value. The functional form of the model is shown as follows in Equation (1):

$$CIP = f(RGDP, M2, RER, IM, GFD) \quad (1)$$

where

CPI = inflation rate as indicated by the consumer price index

GFD = gross fiscal deficit of the central government

M2 = money supply M2

RER = Real exchange rate as depicted by the movement in the exchange rate index

IM = Import

RGDP = Real GDP growth

Where, CIP is used as a dependent variable. Money supply, Government budget deficit, and import are measured in millions of USD obtained from the National bank of Ethiopia. CIP is index number and real exchange rate are obtained by multiplying the CIP of United states with the nominal exchange rate and dividing the CIP of Ethiopia. CIP of the United States is obtained from world bank development indicators. The decrease in the real exchange rate means appreciation while the increase in the real exchange rate means depreciation.

## 4. Methodology

### 4.1. Nature and source of data

Data were gathered from NBE, IMF and The World Bank. Annual time series data ranging from 1982–2019 was used. The total observation used for the analysis is 37 years. To study asymmetric impact, real exchanger rate on inflation real exchange rate and other variables which assumed to affect inflation were included. These variables include Consumer Price Index (CPI), Money Supply



(M2), Import (IM), Nominal exchange rate (EXR), Gross Domestic Product (GDP), and Government Budget Deficit (GBD).

#### 4.2. Unit root test (test for stationarity)

The macroeconomic variables most of the time shows a strong trend and hence, are not amenable to conduct econometric analyses related to stationary time series. Thus, in any time series estimation procedures, it is important to test that the variables are stationary (Verbeek, 2008). Stationary series is a series with the constant mean and variance over time. And the covariance value between two periods only depends on the gaps between the periods and not the actual time at which this covariance is considered. If one of the above criteria are not fulfilled, the series is said to be non-stationary. Econometric estimation with non-stationary variables may lead to spurious results. Thus, it is important to check stationarity the variables before undertaking the econometric estimation. In this study, each variable was checked for stationary (i.e., if the mean and variance are constant over time). The augmented Dickey-Fuller (ADF) and Pennon and Parron (PP) test were used. The dataset that is not stationary at level is differenced using the formula  $\Delta Y_t = Y_t - Y_{t-1}$  and checked for stationarity again.

#### 4.3. Non-linear ARDL (henceforth: NARDL) specification of the inflation function

To estimate the long-run and short-run relationship between inflation, real exchange rate, money supply, government budget deficit and import, the following linear equation is postulated as follow:

$$LNIP_t = \alpha + \beta_1 LNGFD_t + \beta_2 LNM2_t + \beta_3 LNRER_t + \beta_4 LNRGDP_t + \beta_5 LNIM_t + \varepsilon_t \quad (2)$$

Where;

LNRGD = Log of real GDP (Gross Domestic Product)

LNRER = Log of Real exchange rate

LNM2 = Log of Money supply

LNGFD = Log of government fiscal deficit

LNIM = Log of import

LN = Natural Logarithm

The above model assumes that a linear combination between dependent and independent variables as indicated in Equation (2). However, the linear specification might be mis specified if the relationship between the dependent and independent variables are non-linear or when independent variable let say x has an asymmetric effect on dependent variable let say y. This study assumes that the real exchange rate has an asymmetric impact on inflation. Depreciation of real exchange rate is assumed to increase inflation by making import expensive whereas appreciation of the real exchange rate is assumed to have the opposite impact on inflation. Thus, in this study, it is expected that the real exchange rate has an asymmetric impact on the inflation in Ethiopia.

To analyse the non-linear relationship between the variables, several models have been developed and used widely in many literatures. Among those, the thresh-old ECM (Balke & Fomby, 1997), Markov-switching ECM (Psaradakis et al., 2004), the smooth transition regression ECM (Kapetanios et al., 2006) and most recently (Shin et al., 2014) has developed a non-linear ARDL model to analyse non-linear time series. Analysing using non-linear time series has advantages

since in case the series component (both negative and positive) are co-integrated and in that case analysing by using linear ARDL model will be wrong. Besides, structural break and asymmetries only can be handled through the non-linear model.

Moreover, the non-linear ARDL (NARDL) model developed by (Shin et al., 2014) is preferred because of the following reasons. First, it helps to test the presence of co-integration between the exchange rate and inflation. Second, it helps to test both the linear and non-linear co-integration. Third, it helps to estimates the short and long-run relationship between the independent and dependent variables.

The Shin et al. (2014) specifies the NARDL by decomposing the independent variable into its positive and negative partial sums as indicated below in Equation (3):

$$x_t = x_0 + x_t^+ + x_t^- \quad (3)$$

Following Shin et al. (2014), the non-linear asymmetric cointegration regression can be expressed in Equation (4):

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \mu \quad (4)$$

where  $\beta^+$  is the long-run coefficient related to the positive change in  $x_t$  and  $\beta^-$  is the long-run coefficient related to the negative change in  $x_t$ . Following the Shin et al. (2014), the non-linear asymmetric conditional ARDL of this study is presented in Equation (5). The positive change of real exchange rate is denoted with a plus sign and the negative effect of real exchange is denoted by a minus sign. After this, two additional variables are developed, the one represents depreciation real exchange rate denoted by a plus sign and other represents appreciation of real exchange rate denoted by minus sign and devaluation as the partial sum of positive and negatives changes.

$$\ln CIP_t = f(\ln RER_t^-, \ln RER_t^+, \ln RGDP_t, \ln M2_t, \ln IM_t, \ln GBD_t) \quad (5)$$

To estimate the long-run and short-run estimates, the (Shin et al., 2014)'S NARDL is specified by decomposing  $x_t$  into its positive and negative partial sums as follow:

$$\Delta y_t = \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\delta_j^+ x_{t-j}^+ + \delta_j^- x_{t-j}^-) + \mu_t \quad (6)$$

Following the Equation (6), the non-linear ARDL model for this specific study developed as follows:

$$\begin{aligned} \Delta \ln CIP_t = & \delta_0 + \delta_1 \ln RGDP_{t-1} + \delta_2 \ln M2_{t-1} + \delta_3 \ln RER_{t-1}^+ + \delta_4 \ln RER_{t-1}^- + \\ & \delta_5 \ln IM_{t-1} + \delta_6 \ln GBD_{t-1} + \sum_{j=1}^{p1} \beta_{1j} \ln CIP_{t-j} + \sum_{j=0}^{q2} \beta_{2j} \ln M2_{t-j} + \sum_{j=0}^{q3} \beta_{3j} \ln GBD_{t-j} + \\ & \sum_{j=0}^{q4} \beta_{4j} \ln IM_{t-j} + \sum_{j=0}^{q5} \beta_{5j} \ln RER_{t-j}^- + \sum_{j=0}^{q6} \beta_{6j} \ln RER_{t-j}^+ + \sum_{j=0}^{q7} \beta_{7j} \ln RGDP_{t-j} + \\ & \mu_t \end{aligned} \quad (7)$$

Where,  $p$  represents the optimal lag lengths selected for dependent variables whereas  $q1$ - $q7$  represents the optimum lag lengths determined by lag selection criterion.

The coefficients  $\beta_{1j} = \beta_{2j} = \beta_{3j} = \beta_{4j} = \beta_{5j} = \beta_{6j} = \beta_{7j}$  captures short-run dynamics, while the coefficients  $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6$  represents the long-run relationships. The presence of long-run relationship can be proven by rejecting the null hypothesis, which states no long-run relationship  $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$ .

The ECM of NRD model can be estimated by using Pesaran et al. (2001)'s bound testing procedure. The advantage of this techniques is flexible and simple in testing the effect and adjustment asymmetry (Bahmani-Oskooee & Fariditavana, 2016). The test of co-integration generates two values, which are the upper and lower bounds critical values. Both the upper and lower bounds critical values compared with the Wald-F-statistics obtained together to check the presence of co-integration (Pesaran et al., 2001). There are three possible results concerning the co-integration relationship between the variables. First, the presence of co-integration can be proven if the calculated Wald F-statistics greater than the upper bound critical bound. Second, the no long-run co-integration null-hypothesis can be accepted if the Wald-F-statistics lays below the lower critical value. Third, the decision can be inconclusive if the Wald F-statistics lays between the upper and lower bound critical values.

After proving the presence of co-integration, the short-run dynamics and the Error Correction Term (ECT) to be developed. The non-linear ARDL ECT has two important parts, the short-run coefficients and the ECT that delivers the speed of adjustment. The non-linear ARDL ECT model is specified as follows:

$$\begin{aligned} LNCIP_t = & \sum_{j=1}^p \beta_5 LINGFD_{t-1} + \sum_{j=1}^p \beta_6 LNM2_{t-1} + \sum_{j=1}^p \beta_7 LNRER_{t-1}^+ \sum_{j=1}^p \beta_7 LNRER_{t-1}^- \\ & + \sum_{j=1}^p \beta_8 LNRGDP_{t-1} \sum_{j=1}^p \beta_8 LNIM_{t-1} + ECT_{t-1} + \varepsilon_t \end{aligned} \quad (8)$$

Where ECT stands for the error correction term. The negative sign is expected between the ECT and the dependent variable.

## 5. Results and discussions

In this chapter, the results of the NARDL approach are discussed. It includes the unit root testing, maximum lag selection, the long-run estimates of NARDL model and estimates of NADRL error correction model.

### 5.1. Unit root testing

The results of the augmented Dickey-Fuller test is presented in Table 1, and the PP test is presented in Table 2. From the result of ADF and PP tests, variables  $\ln CIP$  and  $\ln RGDP$  are stationary at level and variables  $\ln GFD$ ,  $\ln M2$ ,  $\ln IM$  and  $\ln ER$  are stationary at first differences. Therefore, stationarity testing gives us a solid justification to test the presence of con-integration and adopting the non-linear ARDL approach as estimation techniques.

### 5.2. Maximum lag selection

Table 3 presents different lag selection criteria. Two lag selection criteria namely LR and FPE indicated two lags as an optimum lag length and another two selection criteria such as SC and HQ indicated one lag as an optimum lag length. AIC selection criteria indicated that four lags as an optimum lag length. So, in this case it is difficult to follow one selection criterion and ignore another. But, Perron (1989) suggested to use maximum 2 lags for annual data and 4 lags for high frequency data like quarterly data. A study by Mahmood and Alkhateeb (2018) has also used 2 lags

**Table 1. Augmented Dickey-Fuller (ADF) Unit Root Test**

Variable	Level	P-value	First Difference	P-value
lnCIP	-4.618	0.000	-8.661	0.000
lnGFD	-5.100	0.000	-8.128	0.000
lnRER	-8.933	0.000	-7.614	0.000
lnM2	2.522	0.998	-3.519	0.013
lnRGDP	-4.773	0.000	-5.653	0.000
lnIM	-1.066	0.718	-3.004	0.044

**Table 2. Unit root test using Phillips-Perron test**

Variable	Level	P-value	First Difference	P-value
lnCIP	-4.555	0.000	-17.842	0.000
lnGFD	-5.069	0.000	-12.808	0.000
lnRER	-9.104	0.000	-39.318	0.000
lnM2	1.858	0.999	-3.463	0.015
lnRGDP	-4.795	0.000	-15.252	0.000
lnIM	-1.133	0.692	-3.321	0.021

**Table 3. Lag selection criteria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-173.4862	NA	0.001551	10.5580	10.82737	10.64987
1	-28.71239	229.9349	2.67e-06	4.15955	6.045056*	4.802563*
2	13.85499	52.58323*	2.24e-06*	3.77323	7.274887	4.967399
3	47.89560	30.03583	4.68e-06	3.88849	9.006291	5.633810
4	92.42426	23.57400	1.39e-05	3.38680*	10.12075	5.683276

\*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

for annual data. Thus, two lags were used to run co-integration test and to estimate non-linear ARDL error correction model.

### 5.3. Bound testing approaches to cointegration

The result of the bound test is presented in Table 4. The value of F-statistics is greater than the upper bound critical value as tabulated by Pesaran et al. (2001), thereby rejecting the null hypothesis of no co-integration and thus it can be concluded that the variables are con-integrated. This indicates that the presence of a long-run relationship between inflation, economic growth, government budget deficit, money supply, import and real exchange rate in Ethiopia for the period 1982–2019.

### 5.4. NARDL long-run estimates

The result of the NARDL model (Pane A) and diagnostic tests (Pane B) to check the consistency of the model are presented in Table 5. The diagnostic tests of heteroscedastic and autocorrelation indicated that the estimated NARDL model does not have any corresponding problems. The

**Table 4. NARDL bounds test**

Level of Significance	Lower Limit	Upper Limit	F-statistic
10%	2.12	3.23	16.127
5%	2.45	3.61	
2.5%	2.75	3.99	
1%	3.15	4.43	

**Table 5. Long-run estimates of NARDL model**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnGDP	0.304	0.238	1.276	0.216
lnIM	-0.734	0.235	-3.121	0.005
lnM2	0.232	0.180	1.287	0.212
lnRER <sup>+</sup>	1.126	0.338	3.325	0.003
lnRER <sup>-</sup>	1.033	0.332	3.105	0.005
lnRGDP	0.203	0.261	0.778	0.445
C	8.319	2.306	3.607	0.001
Panel (B) Diagnostic Checking				
R-squared	0.899			
Adjusted R-squared	0.824	Prob.		
LM test	2.126	0.161		
Breusch-Pagan-Godfrey	0.425	0.951		
ARCH	0.868	0.358		

(\*\*) and (\*) represents 5% and 10% level of the significance level.

coefficient of LM test is insignificant signaling that the model is free from serial correlation problems, and the ARCH test result also indicates that there is no problem with heteroscedasticity. The entire diagnostic test proved that the NARDL model is reliable and consistent.

The long-run coefficients of positive and negative change in the real exchange rate are 1.12 and 1.03 respectively. It indicated that a 1 per cent depreciation is likely to increase inflation by 1.12 per cent. Similarly, appreciation of the real exchange rate is expected to increase inflation by 1.03 per cent. This indicates that depreciation has relatively more inflationary effects than appreciation in the long-run. The same results found by (Laryea & Sumaila, 2001; Loening et al., 2009) indicated that the exchange rate has a positive impact on inflation. Another study by Woldie and Siddig (2019) showed that in the long-run devaluation of the exchange rate has an inflationary impact and contrary, Ambachew et al. (2012) indicated that the depreciation of exchange rate decreases inflation. Similarly, Nigusse et al. (2019) in their study proved devaluation reduces inflation while appreciation of real effective exchange rate triggers inflation in Ethiopia.

The results also indicated that there is a negative and significant relationship between the import and inflation of the country signaling that increase in import reduces the rate inflation whereas cutting the amount of import triggers a surge in the inflation in the long-run. Other variables such as Money supply, budget deficit and economic growth has no significant impact on the inflation level in the long-run.

### 5.5. NARDL error correction model

The NARDL error correction model is estimated to identify the short-term relationships and check the stability of the long-term parameters and the result of the NARDL model is shown in Table 6. The coefficient of the error correction term is  $-0.97$ , which is negative; less than one and is also significant at 1% significance level. The coefficient error correction coefficient is high, indicating that the short-run disequilibrium can be adjusted in a shorter period of time, in this case at a speed of 0.97 (Table 6).

The results of the study confirmed that there is short-run and long-run asymmetric impact of the real exchange rate over inflation rate in Ethiopia (Table 7). In short-run depreciation of real exchange rate reduces the inflation rate while the appreciation of the real exchange rate increases the inflation rate of the country. Depreciation of real exchange rate by 1% reduces inflation by 0.35 per cent while the appreciation of the real exchange rate in 1% causes 1.75% surge in inflation. The same result found by Nigusse et al. (2019), real effective exchange rate, money supply and budget deficit positively influenced inflation in Ethiopia.

On the other hand, money supply has a positive and significant impact on the inflation rate indicating that the increase in money supply causes an increase in the inflation. The coefficient of money supply is 2.99 indicating that a 1% increase in money supply triggers inflation by 2.99%.

Economics growth of the country affects inflation negatively and significantly in the short-run, indicating that the increase in the corresponding variables causes a decrease in inflation which is contrary to Ethiopia government claim that the source of inflation is economic growth. One can also argue that Ethiopia is an agrarian country and a better economic growth means better production in agricultural sector, which ultimately reduces the rate inflation due higher agricultural growth.

**Table 6. Estimates of E.C.M. of NARDL model**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(lnGDF)	-0.065	0.121	-0.537	0.597
D(lnGDF(-1))	-0.308	0.135	-2.279	0.033
D(lnIM)	0.582	0.294	1.974	0.062
D(lnM2)	2.995	1.055	2.838	0.010
D(lnRER_POS)	-0.352	0.163	-2.153	0.043
D(lnRER_NEG)	1.718	0.333	5.153	0.000
D(lnRGDP)	-0.448	0.129	-3.466	0.002
D(lnRGDP(-1))	-0.706	0.116	-6.049	0.000
ECT	-0.971	0.105	-9.243	0.000

**Table 7. Test for short-run and long-run asymmetry**

Type of Asymmetry	Wald/F-Statistic	Prob.	Conclusion
Long-run	28.003	0.000	Asymmetry
Short-run	29.255	0.000	Asymmetry

### 5.6. Stability checking

Finally, to check stability and structural break of the model the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) testes proposed by Borensztein et al. (1998) were used. As indicated in Figures 2 and 3 the estimated lines are within the 5% critical limits indicating that the model reliable and stability.

### 6. Conclusions

Ethiopia has registered attractive Economic growth for the last decade. With the continued and attractive economic growth moderate inflation is an inevitable consequence and it is assumed that economic growth is enhanced when moderate inflation mobilizes the resources of a country. But

Figure 2. Cumulative sum (CUSUM).

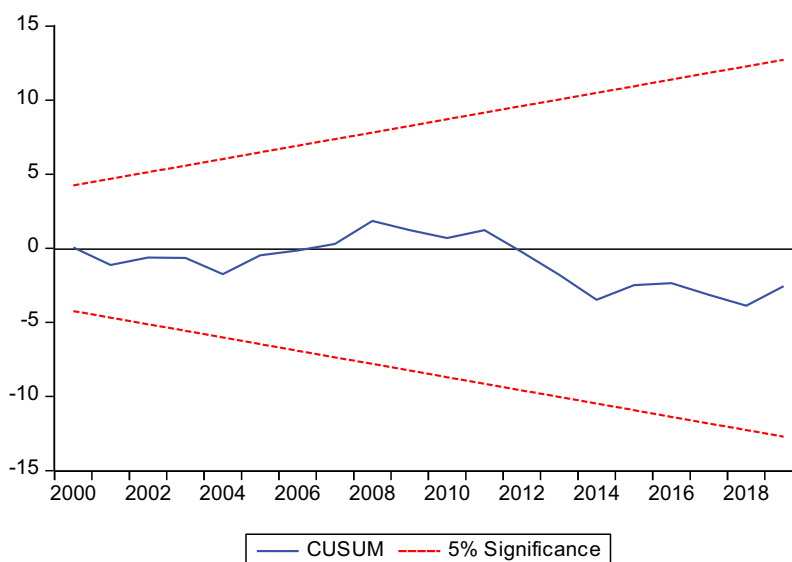
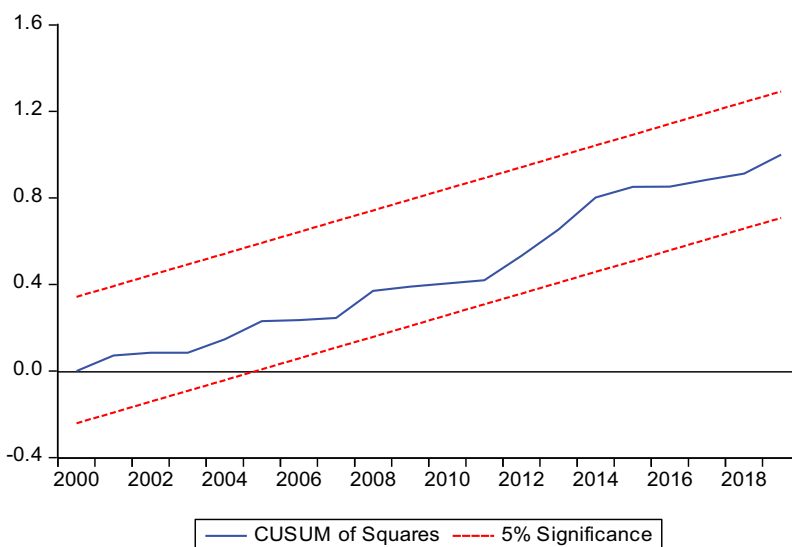


Figure 3. Cumulative sum of squares (CUSUMSQ).





Ethiopia inflation is far higher than moderate and the inflation pressure is harming the life of many people and reducing the confidence of investors to make some productive investments. This paper empirically investigates the asymmetric impact of real exchange rate on inflation by using annual time-series data from 1982 to 2019. The data were analyzed by using NARDL approach. The bounds test of co-integration confirmed the presence of long-run co-integration between inflation and the macroeconomic variables included in the model.

The result from the analysis showed that in the long run the appreciation and depreciation of real exchange rate have inflationary effects in Ethiopia whereas the increases in the import reduce inflation. In the short-run, the real exchange rate has asymmetric effects indicating that depreciation of real exchange rate reduces inflation whereas appreciation of real-exchange rate triggers inflation. Besides, in short-run money supply is a major source for the surge in the inflation in Ethiopia while the robust economic growth reduces inflation.

From the result of the study, it is quite clear that the main triggering factor of inflation in Ethiopia is instability in the exchange rate and money supply. Therefore, it is important to follow the tight monetary policy aimed at tightening the stock of money and avoiding instability in exchange rate market. Moreover, to curb inflation National Bank of Ethiopia needs to ensure stable exchange rate by attracting foreign private investment through the macroeconomic policies which provides incentives for foreign investors.

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