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Exchange Rate Pass-through to Consumer Prices in Ethiopia: A VAR Approach

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Abstract

Ethiopia's currency has experienced a prolonged devaluation in tandem with the high and continuing inflation rate of the nation. In keeping with this, this article aims to investigate how much the exchange rate affects consumer pricing. The study uses monthly time series data spanning from January 2011 to December 2019 and the vector autoregression model. By using impulse responses, the study found that the exchange rate pass-through to consumer prices was lower than the exchange rate pass-through to import prices. The exchange rate pass-through to consumer prices is found to be around 0.17% in the first year and then reduces to 0.14% in the second year. The figures for import prices were 1.19% and 1.725%, respectively. Moreover, the study using the forecasting error variance decomposition analysis showed that there are other factors, such as price expectations, that explain inflation better than the exchange rate. The study, therefore, concludes that the National Bank of Ethiopia need not be concerned about inflation when devaluing the currency. Nonetheless, this does not mean the National Bank of Ethiopia should devalue the currency, as this would still cause problems with the trade balance. The National Bank of Ethiopia can pursue an independent monetary policy and an inflation-targeting regime with relative ease.

***Keywords*: Exchange rate pass-through, consumer price, VAR, Ethiopia, VECM**

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Introduction

The discipline of international finance has gained major attention throughout years due to its need to analyze the global economy. In this discipline, one of the concepts that are the center of attention in better understanding of the global economy is the exchange rate. Exchange rate is defined as the price of one currency in terms of another. Movements in exchange rates not only affect the price of commodities in the world market but also have been thought to affect domestic prices in other countries. The exchange rate pass-through (ERPT) can only analyze such changes in price levels that are brought upon by changes in exchange rates (Gandolfo, 2016).

The ERPT to consumer prices is defined as the degree of responsiveness of consumer price levels to a change in exchange rate levels. Exchange rates affect consumer prices through its major effect on import prices of finished import products or intermediate products. The effect implies that if a domestic country's exchange rate is depreciated, it makes the products imported from a certain foreign country into that domestic country expensive. The same is true if inputs were imported instead of finished products that the foreign inputs would be expensive, which would make the final output also expensive (Savoie-chabot and Khan, 2015).

In Ethiopia, the exchange rate has been marked by persistent high devaluation in the past decade. The devaluation in 2010 was set at around 13 birr per US dollar. Recently, in 2021, this figure has increased to 43 birr per US dollar. The National Bank of Ethiopia devalued the birr with the objective of increasing export earnings by boosting the quantity of exports and decreasing the quantity of imports (Korsa and Rajan, 2018). However, the recent devaluation in Ethiopia has been increasingly associated with the country's recent inflation trend. The country's inflation rate, which was around 7.3% in 2010, has increased to a figure of 21.6% in 2020 (NBE, 2020).

Devaluation in Ethiopia might actually contribute to inflation. This is because firstly when consumers expect devaluation in the near future, they increase their consumption today. This is because they expect the future devaluation to increase prices in the future. In addition, producers who expect the devaluation to be persistent will increase their cost of production (Muhammed, 2012). In line with this, the study tried to evaluate Ethiopia's ERPT level in order to determine whether or not the country's inflation is significantly impacted by the ongoing devaluation.

Examining the degree of ERPT in many countries has shown its major benefits. Analyzing the pass-through is important for optimal policy, shock transmission in open economy models and inflation dynamics. In the case of optimal policy, analyzing pass-through is important because knowing the degree of ERPT helps policy makers make optimal decisions regarding the money supply and the level of trade activity. ERPT is also important for understanding shock transmission in open economy model because these shocks are transmitted though general price levels. The degree of pass-through is also important understanding inflation dynamics especially in countries where there are high inflation rates (Devereux and Yetman, 2007).

In Ethiopia, one of the factors that determine ERPT is whether it is consumer prices or import prices. The pass-through effect in Ethiopia is more persistent in the case of import price than in the case of consumer prices (Berga, 2012). The other factor is based on the direction of exchange rate movements; in the short run, the pass-through effect is stronger for depreciation than appreciation and vice versa in the long run (Teferra, 2020). These studies in general have assessed the factors that determine ERPT through using various models with time series and panel econometric models.

There are two reasons that this project is initiated. Firstly, few studies have determined the degree of ERPT using the time series VAR approach. This study VAR model while based on recent data in Ethiopia. This study also investigated time series trends of exchange rate and price fluctuations in the country. Second, the study is initiated with the aim of providing policy recommendations for the Ethiopian National Bank regarding the level of ERPT.

Review of Related Literature

Theoretical Literature

There are various theoretical frameworks regarding exchange rate pass-through. In this section, before we look at those frameworks, we consider the traditional frameworks that are key to understanding ERPT. One of those is purchasing power parity (PPP), which assumes that the exchange rate equals the ratio of domestic price levels to foreign price. This is mathematically expressed as:

$$E = P/p*$$

Where P^* indicates the foreign price level, P indicates the domestic price level and E implies the exchange rate of domestic currency against foreign currency.

This means that the exchange rate compensates the differences in inflation rates of the two countries. If the foreign price level is low, the exchange rate appreciates. For this reason, an exchange rate target, fixed in relation to the low-price level of the foreign country, helps to stabilize import prices (Muhammed, 2012). The law of one price that is a generalization of PPP also states that for a certain commodity and say two countries, that commodity's price will be similar if expressed in the same currency (Mohammed and Bashir, 2018). This law is expressed in the following functional form:

$$P_t = E_t * {P_t}^f$$

P_t indicates domestic price level in time period t, E_t indicates the exchange rate of the domestic currency against foreign currency in time period t, and ${P_t}^f$ indicates the foreign price level. To give a more accurate measure of ERPT, let us consider markups and foreign marginal costs, which both affect ERPT. Markups affect the degree of pass-through because, for instance, when the exchange rate depreciates, this will force the price of imports to increase. In order not to lose their market shares, foreign firms will mark down the prices denominated in their own currency (Antoniades and Zanbioni, 2016). On the other hand, marginal costs have an impact on pass-through because exporters of certain goods are also importers of certain intermediate inputs at the same time. When an exchange rate depreciates, it makes the foreign exporters' currency strong, and hence they can import the intermediate inputs at a lower cost, meaning low marginal cost. This in turn will lead to an incomplete pass-through as foreign firms will be willing to absorb price changes due to the low cost of production (Koujianou & Hellerstein, 2013).

As it has been stated earlier, there is a clear existing relationship between price levels and exchange rate levels. However, it has started to become widely evident that a change in exchange rate levels does not lead to changes in price levels in the same proportion. The change in exchange rates is not incorporated fully into domestic prices through the quantity of imports. One of the reasons for this is the price to marketing approach (PTM) employed by foreign firms. These foreign firms mark down their price of exports denominated in their own currency with the objective of stabilizing the price in the importing country market (Melesse, 2014).

Empirical Studies

Studies in developing economies have also made their own implications of the degree of pass-through and the factors that affect it. A study made by Aerath (2018) revealed the ERPT to import prices in India to be incomplete. This study used a monthly data on India's imports from 20 source countries. In addition, the study verified that there exists an ERPT heterogeneity across sectors. Younus and Yucel (2020) conducted a VAR time series analysis on the ERPT, composing of data ranging from 2008-2019 and found ERPT in the Pakistani economy to be very high. They reported ERPT to reach a high value of 175% (1.75).

Aleem and Lahiani (2014) used a threshold VAR model to conduct a study on ERPT in the Mexican economy. They implemented this study using a time series data from January 1994 to November 1999 and found ERPT to be statistically significant on the threshold level of the monthly inflation rate of 0.783 and insignificant below this level.

Various empirical studies have been done on assessing the degree of pass-through in Ethiopia. According to Razafimahefa (2012), the ERPT was found on average to be 0.4 percent for a selected group of Sub Saharan African countries (SSA) including Ethiopia. The study has also found that ERPT tends to be low when political and macroeconomic improvements have been made. The study concluded countries with flexible exchange rate regimes have less ERPT compared to countries with fixed exchange rates.

A study made by Berga (2012) attempted to analyze ERPT using a structural VAR model (SVAR). The findings of the study were based on quarterly data using impulse response functions (IRF) to interpret the SVAR model on hand. These findings implied that exchange rate pass-through is stronger for import prices than consumer prices. The ERPT to import prices was found to be -0.489% at the first quarter of the data set, indicating that an additional increase in exchange rates (appreciation in this example) cuts inflation rates by 0.489%. The ERPT coefficient for import prices then decreased as the time horizon expanded.

A study conducted by Teferra (2020) used a panel nonlinear auto regressive distributive lag model (NARDL) on selected SSA including Ethiopia. The study was based on time series data ranging from 1992Q1 to 2018Q4. The study found that nominal effective exchange rate appreciation, world oil price and output gap were the most important factors in determining consumer price index (CPI) inflation in the long run. In addition, the money supply and nominal effective exchange rate depreciation were important in determining ERPT in the short run. In the short run, depreciation was more important than appreciation in determining ERPT, and vice versa in the long run. This demonstrated ERPT's asymmetric nature.

Method of the Study

The study uses monthly data gathered from January 2011 to December 2019 on variables of interest such as the consumer price index (CPI), a nominal effective exchange rate (NEER), import price index (IPI), export price index (EPI), world oil price (WOP), and money supply (MS). The data is gathered from various sources, such as the National Bank of Ethiopia (NBE), the international monetary fund (IMF), the Bruegel database, and the federal reserve economic data (FRED). Monthly data on CPI is gathered form the World Bank, Nominal Effective Exchange rate is gathered from the Bruegel, data on IPI and EPI is collected from the IMF. Data for WOP index and MS is collected from FRED and NBE.

Model Specification

The model specification of this paper is primarily based on both the theoretical and empirical literature, which were discussed in the previous section. The paper uses a six variable VAR model in the following form:

$$Y_t = \propto + \sum_{i=1}^{k} \beta_j Y_{t-k} + \varepsilon_t$$

Where Y_t indicates the vector of endogenous variables (consumer price index, nominal effective exchange rate, export price index, world oil price, openness, and money supply); $\propto$ is a vector of constants and β_j denotes the coefficient matrix or the matrix of autoregressive parameters; and ε_t represents the vector of white noise or reduced error terms. This model specification is mainly based on the model specifications followed by Muhammed (2012), Berga (2012), and Teferra (2020).

The paper uses impulse response functions (IRF) and forecasting error variance decompositions (FEVD) instead of a simple ordinary least square (OLS) method. Both IRF and FEVD are better tools for estimating the VAR model than the OLS method because they trace the effects of shocks within a system on other variables. Impulse response functions are those functions that determine the effects of the shock of one variable on the other variable under a certain time horizon or path. On the other hand, the FEVD reveal how much of the variation of a certain variable is due to the shock of another variable.

In order to analyze ERPT to consumer prices, the paper use IRF to estimate the VAR model in equation (1). Following Peon and Brindis (2014), the ERPT to consumer prices is defined as the cumulative response of the consumer price index to an exchange rate shock divided by the cumulative response of exchange rate to its own shock.

$$ERPT_{CPI} = \frac{CIRF_{NEER}(CPI_t\ )}{CIRF_{NEER}\ (NEER_t\ )}$$

Whereas the numerator term indicates the cumulative response of CPI to a one standard deviation change in the shock of NEER, the denominator term indicates the response of NEER to a one standard deviation change in its own shock.

The model will also compare the ERPT to consumer prices and the ERPT to import prices. The ERPT to imports is also calculated like that of the ERPT to import prices, as follows:

$$ERPT_{IPI} = \frac{CIRF_{NEER}(IPI_t\ )}{CIRF_{NEER}\ (NEER_t\ )}$$

As previously mentioned, the paper also uses FEVD analysis to determine the factors affecting inflation. Details on the FEVD is discussed in the analysis section. Using a VAR model has its own benefits. There are variables whose time trends are often not stationary at levels. But when these variables are changed into their first difference form, these models become stationary. The VAR model is helpful for such models. The other reason is the problem of endogeneity that prevails in a lot of models. Assuming some variables are exogenous is frequently unrealistic, which excludes the possibility that they are endogenous (Gujarati, 2004).

Data Presentation and Discussion

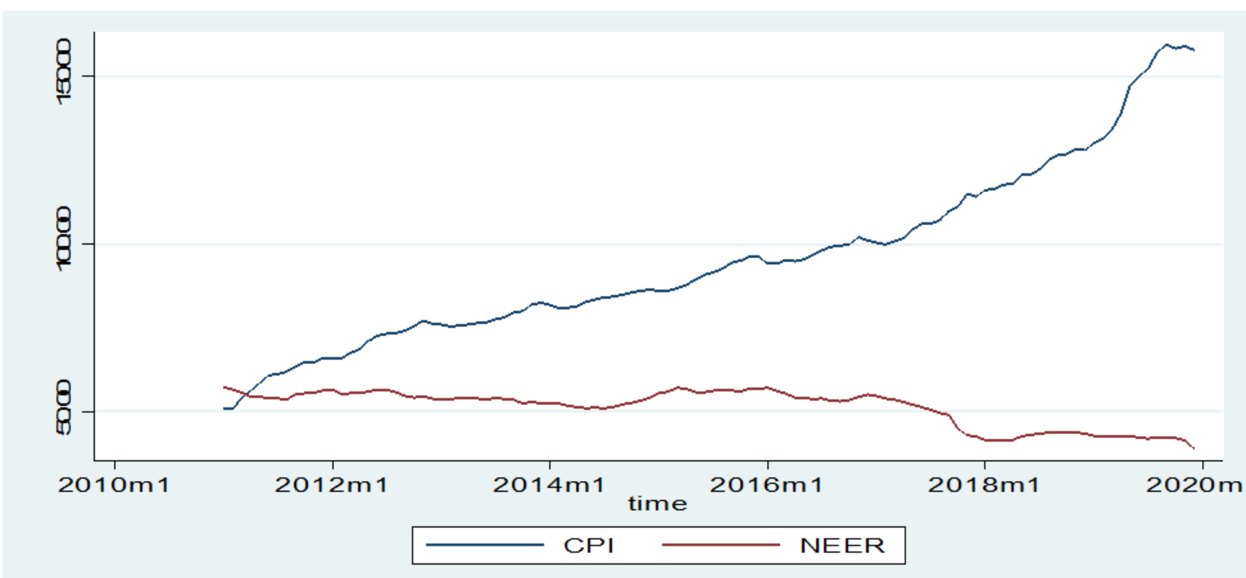
Descriptive Statistics

In this section, we discuss the trend of NEER and CPI. As we can see from the trend of the CPI in figure 4.1 below, the value of CPI, which was initially at 51.08 during the first month of 2011, has increased to a value of 157.90 during the last month of 2019. This reveals the fact that Ethiopia's inflation has been persistent over the years. One of these reasons that Ethiopia's inflation rate is always increasing might be due to the repeated devaluations made by the Ethiopian government.

The figure also shows that between the period 2011 January and 2019 December, the devaluation has also become persistent alongside the inflation. This is because a decrease in the NEER is reported as depreciation. The NEER, which was at 57.36 in January 2011, has now decreased to a value of 38.96 in December 2019. Therefore, the trend implies that Ethiopia's inflation has been accompanied a bit by the depreciation of the exchange rate.

Figure 1

Trend of CPI and NEER



Source: Own computation

Econometric Analysis

Unit Root Test:

In this study, the Augmented Dickey-Fuller test was employed to check for the stationarity of variables. Based on the ADF test, all the variables are integrated of order one, I (1), implying that the null hypothesis of non-stationarity is rejected for each variable at their first difference form at the 1% significance level. But the null hypothesis of non-stationarity is not rejected for the variables in their level form. Therefore, the VAR model is estimated in its first difference form.

Johansen Cointegration Test:

The results from the Johansen test for cointegration imply that the underlying VAR model has at least one cointegrated equation. This means that there is at least one variable that is cointegrated. This is because the trace statistic (114.7069) is greater than the 5% critical value (94.15) at the matrix rank (0). Therefore, the null hypothesis of no cointegration is rejected (Refer to Appendix A.3). This suggested for an estimation of the vector error correction model (VECM). The reason is that a VAR model is not suitable for representing a co-integrated time series (since most of the time variables have to be first differenced, which removes their long run relationship). However, the paper still relied on using the VAR model for the analysis. Appendix F shows the VECM estimation for this paper. The error correction term in the model was found to be 0.0036416 with a p-value of 0.75 (see Appendix F.1). This is not only insignificant but also very slow for the CPI to adjust to its long run equilibrium.

Lag length Selection Criteria:

Based on the lag length selection criteria (see in Appendix A.4), the FPE and AIC suggest six lags while the HBIC and SQIC recommend zero lags. However, when the study uses the lags suggested by this criterion, the VAR model had an autocorrelation problem. Therefore, the study uses eight lags recommended by the LR statistic.

Granger Causality Test:

The granger causality test is used to some extent to identify whether the variables in the VAR model are endogenous in question. The granger causality result shows that the past lags of NEER, IPI, EPI, WOP and MS jointly have an effect on CPI than the lags of CPI itself.

Impulse Response Analysis:

The impulse response of import prices to an exchange rate shock is high for a certain amount of period. A one standard deviation changes in the NEER shock decreases import price in the first month at around 66.4%. At around the sixth month, the effect reaches a peak at around 88.3%. Nevertheless, at the tenth month the effect of a NEER shock on IPI is zero. Even after that, the effect of a NEER shock on IPI tends to become compared to the earlier shocks. The impulse response of an exchange rate shock to its own shock implies that at the first month a positive NEER shock increases NEER by 44.8%. However, after the eighth month the effect of the shock slowly dies out.

To compute the ERPT, the paper employs a technique used by Muhammed (2012) to standardize the effect of the exchange rate on the consumer and import prices. To do this, first the study derives the cumulative impulse responses that are given below, and then based on the table below, the ERPT to consumer prices and import prices is calculated. The ERPT to consumer prices is found by dividing the cumulative impulse response of the CPI to an exchange rate shock by the cumulative impulse response of the exchange rate to an exchange rate shock.

Table 1

Cumulative Impulse Response Results

Month	$CIRF_{NEER}$ (CPI_t)	$CIRF_{NEER}$ $(IPI)_t$	$CIRF_{NEER}$ $(NEER_t))$	$\frac{CIRF_{NEER}(CPI_t)}{CIRF_{NEER}(NEER_t)}$	$\frac{CIRF_{NEER}(IPI_t)}{CIRF_{NEER}(NEER)_t}$
1	-0.183	-0.664	1.448	-0.126381215	-0.458563536
2	-0.249	-1.223	1.806	-0.137873754	-0.677187154
3	-0.396	-1.709	2.014	-0.196623635	-0.848560079
4	-0.428	-1.497	2.183	-0.196060467	-0.68575355
5	-0.463	-1.944	2.346	-0.197357204	-0.828644501
6	-0.431	-2.776	2.542	-0.169551534	-1.092053501
7	-0.564	-3.301	2.428	-0.232289951	-1.359555189
8	-0.386	-3.551	2.432	-0.158717105	-1.460115132
9	-0.399	-3.728	2.353	-0.169570761	-1.584360391
10	-0.374	-3.728	2.245	-0.166592428	-1.660579065
11	-0.346	-3.963	2.216	-0.156137184	-1.788357401
12	-0.241	-4.088	2.159	-0.111625753	-1.893469199
13	-0.296	-4.053	2.025	-0.14617284	-2.001481481
14	-0.264	-3.797	2.016	-0.130952381	-1.88343254
15	-0.327	-3.414	1.907	-0.171473519	-1.79024646
16	-0.291	-3.174	1.858	-0.156620022	-1.708288482
17	-0.249	-3.323	1.862	-0.133727175	-1.784640172
18	-0.228	-3.195	1.866	-0.122186495	-1.71221865
19	-0.261	-3.118	1.859	-0.140398063	-1.677245831
20	-0.250	-3.184	1.928	-0.12966805	-1.651452282
21	-0.279	-3.192	1.942	-0.143666323	-1.643666323
22	-0.245	-3.272	2.012	-0.121769384	-1.626242545
23	-0.263	-3.342	2.061	-0.127607957	-1.62154294
24	-0.302	-3.317	2.070	-0.14589372	-1.602415459

Source: Own Computations

Based on the table above, the ERPT to consumer prices is low throughout the 24-month period. On average, in the first year, a one percent appreciation of the nominal effective exchange rate reduces consumer prices by around 0.17%, and in the second year, the effect reduces to 0.14%. While the low pass-through to consumer prices registered in this paper is consistent with the study of Berga (2012), it is found to be inconsistent with the findings of Muhammed (2012).

There are several reasons why consumer price pass-through is so low. Firstly, the effect of the exchange rate on consumer prices is indirect; the exchange rate affects consumer prices through its effect on import prices. This indirect effect implies a remote effect of the exchange rate on consumer prices. This implies that the exchange rate pass-through to consumer prices is low (Berga, 2012). Secondly, improvements in the fiscal and monetary policy in relation to previous times in Ethiopia could partly explain as to why pass-through to consumer prices is low. For instance, the implementation of the Growth Transformation Plan I & II by the Ethiopian government are good examples for this (Tilahune, 2018). Therefore, the relatively better fiscal and monetary policy credibility can explain low pass-through to consumer prices.

Finally, this might also suggest that most of Ethiopia's inflationary situation is caused by its own shocks. The FEVD analysis in the next section presents whether this is the case or not. The exchange rate pass-through to import prices is high throughout the 24-month period; in fact, it is more than complete after certain periods. On average, in the first year, a one percent appreciation of the NEER shock reduces import prices by around 1.19%; in the second year, a one percent appreciation of the NEER shock reduces import prices by 1.725%.

On behalf of the import prices, it seems that pass-through is high and non-declining. One possible reason for this is the choice of currency for invoicing. It is understandable that much of the payments made by Ethiopian importers are in United States dollars. Devereux et al. (2015) show how ERPT for producer currency pricing is greater than local currency pricing. Producer currency pricing implies that Ethiopian importers make payments denominated in US dollar currency whereas local currency pricing suggests that Ethiopian importers make this payment in their own local currency (birr). Most Ethiopian importers make import payments in dollar terms. As discussed in the previous section, the ERPT to import prices is higher than the ERPT to the CPI. Therefore, this is another reason why pass-through to import prices is high.

Campa and Goldberg (2002) found that countries whose bundle of imports consists of energy and raw materials have pass-through elasticities close to one. Ethiopia is a country whose bundle of imports consists mainly of raw materials for manufacturing products. This implies a higher pass-through to import prices.

Finally, openness is another factor explaining why pass-through to import prices is high. As discussed earlier in the literature, a highly open economy implies that the economy imports many goods. Thus, high openness means that foreign exporters of these imports have a significant market share in this highly open economy. Foreign exporters would then be encouraged to pass through significant changes in the depreciation of the exchange rate to their export prices due to the sizeable market share. Ethiopia is a country with a high degree of openness. The country's openness in 2010 was around 39.35%, and in 2014, it was around 40.80%. The recent figure in 2020 was around 24.02%; from this figure, 16.9% of the trade is in the form of imports, whereas the remaining 7.1% is in the form of exports (WB, 2020). This high level of openness shows the country's heavy dependence on imports. Therefore, the high openness (which is due to high imports as a percentage of GDP) that Ethiopia has experienced over the years explains the high pass-through to import prices.

Forecasting Error Variance Decompositions Analysis (FEVD):

To determine the main factors that affect inflation in Ethiopia, the paper employs the FEVD. As indicated earlier, the FEVD measures the percentage variation of the CPI that is explained by other shocks. The statistics below indicate that much of the variation in CPI is due to its own shock. As per the table below, on average, 70% of the variation in the CPI is explained by its own shock. A NEER shock explains 8.4% of the variation in the CPI on average. This is inconsistent with the findings of Berga (2012), which stated that the world commodity price index had a greater impact. The NEER could have a greater impact given that the birr has been heavily devalued against the dollar within the past decade (Bonsa, 2017).

On the other hand, the import price index, export price index, world oil price, and money supply explain about 7.1%, 5.6%, 4.9%, and 4.07%, respectively. This suggests that inflationary shocks explain Ethiopia 's inflation more than any other factor. The other factors' contributions are very small. One of those inflationary shocks is price expectation. The price expectation implies that much of Ethiopia's high inflation is generated by anticipated high increases in inflation. These expectations are probably due to naturally driven factors such as locust invasions and sudden changes in government policy; these factors probably result mostly in cost-push inflation as they are expected to cause supply shortages.

Table 2:

Variance Decomposition Results

Month	Shock of dlog CPI	Shock of dlog NEER	Shock of dlog WOP	Shock of dlog MS	Shock of dlog IPI	Shock of dlog EPI
1	0.946	0.008	0.001	0.022	0.003	0.020
2	0.885	0.039	0.003	0.029	0.017	0.026
3	0.878	0.042	0.004	0.031	0.017	0.029
4	0.840	0.062	0.017	0.030	0.016	0.035
5	0.815	0.061	0.017	0.030	0.039	0.038
6	0.760	0.057	0.024	0.049	0.043	0.067
7	0.734	0.055	0.038	0.055	0.055	0.063
8	0.708	0.069	0.037	0.056	0.068	0.063
9	0.675	0.093	0.038	0.054	0.081	0.060
10	0.671	0.092	0.038	0.054	0.084	0.061
11	0.666	0.092	0.043	0.053	0.084	0.061
12	0.654	0.092	0.046	0.052	0.093	0.063
13	0.647	0.102	0.047	0.051	0.091	0.062
14	0.643	0.103	0.048	0.051	0.092	0.063
15	0.636	0.103	0.055	0.051	0.092	0.064
16	0.632	0.105	0.055	0.052	0.092	0.064
17	0.630	0.105	0.055	0.054	0.092	0.065
18	0.624	0.106	0.055	0.059	0.093	0.064
19	0.622	0.106	0.057	0.058	0.092	0.065
20	0.621	0.106	0.057	0.058	0.093	0.065
21	0.619	0.106	0.060	0.058	0.093	0.064
22	0.617	0.107	0.060	0.058	0.093	0.065
23	0.616	0.107	0.061	0.058	0.093	0.065
24	0.614	0.107	0.061	0.060	0.093	0.065

Source: Own Computations

Diagnostic Tests

The post-estimation tests used for the VAR model include the LM residual test for autocorrelation, the Wald lag exclusion test, the Jarque_bera normality test, and the VAR stability test. The LM residual test for autocorrelation shows that the VAR model is free from autocorrelation (Appendix B.1). Since the P-values of each and every lag are greater than 0.05, the null hypothesis of no autocorrelation is not rejected. The VAR stability test confirms that the VAR model is stable since all the eigenvalues are inside the unit root circle (Appendix B.2). However, the VAR model is non-normal according to the Jarque_bera normality test (Appendix B.3). Since the joint p-value of the variables is less than 0.05, the null hypothesis of normality is rejected. The Wald lag exclusion test implies that the eight lags recommended by the lag length selection criteria are good and sufficient (Appendix B.4).

Conclusion and Recommendations

The paper examined the exchange rate pass-through to consumer prices in Ethiopia over the period from January 2011 to December 2019. The paper also tried to compare the exchange rate pass-through to consumer prices to that of import prices.

Based on the VAR model, using the impulse response function, the degree of ERPT for consumer prices is found to be relatively low. However, in the case of import prices, the exchange rate is high and has been monotonically increasing for the entire 24-month period in the IRF function. This suggests that ERPT decreases along the pricing chain. The low pass-through to consumer prices is a great indicator of how indirect the effect of the exchange rate is on consumer prices. Based on the Granger causality tests, all factors except the export price index have a significant effect on Ethiopia's inflation. Nevertheless, the FEVD analysis shows that much of the variation in inflation in the Ethiopian economy is due to its own shock. This means that shocks like price expectations play a part in explaining Ethiopia's inflation. The degree of EPRT in any country has important implications for that country's trade and monetary policy. The following policy implications are presented.

The high pass-through to import prices does not imply that devaluation measures taken by the Ethiopian government might induce expenditure-switching effects on the part of the Ethiopian importers. This is because the high pass-through to import prices suggests that foreign exporters do not need to fear losing market share. Ethiopia is highly dependent on foreign exporters' products. The high level of openness that the country has faced over the years is a great example of this. This means the devaluation measures would worsen the balance of payments problem. Because there would be no expenditure-switching effects.

The study found low pass-through to consumer prices in Ethiopia. Nevertheless, this does not mean in any way that the country's inflation is low. This only suggests that there are other factors that explain Ethiopia's inflation. One of those factors is price expectation. The fact that the study found low pass-through to consumer prices implies that the Ethiopian government not only needs to focus on dealing with the factors that cause agricultural shortages but also needs to focus on changing the attitudes of its citizens. Therefore, as a result, the NBE should focus on developing a carefully constructed monetary policy and enhancing its institutional capacity.

The low ERPT to consumer prices also implies that the NBE cannot apply appreciation measures to reduce consumer prices. However, the low pass-through implies that the NBE does not need to worry about the impact of exchange rate changes on inflation as this is low. Nevertheless, as mentioned earlier, devaluation should still not be encouraged as this could cause trade deficit problems. Nevertheless, the NBE can pursue an independent monetary policy and an inflation-targeting regime with relative ease. In addition, the NBE should also employ a fully flexible exchange rate regime.

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Appendices

A: Summary Statistics and Pre-estimation tests

A.1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Log CPI	108	4.522	0.269	3.929	5.072
Log NEER	108	3.931	0.111	3.663	4.049
Log EPI	108	4.588	0.138	4.335	4.914
Log IPI	108	4.458	0.263	3.865	4.878
Log MS	108	26.495	0.6064	25.39	27.511
Log WOP	108	4.218	0.334	3.412	4.696

A.2: ADF Test Results

variables	ADF statistic of variables at level form	ADF statistic of variables at first difference from
Log CPI	-1.01	-5.547
Log NEER	0.976	-7.683
Log MS	-0.98	-9.892
Log WOP	-1.355	-7.678
Log EPI	-1.637	-8.354
Log IPI	-1.281	-7.683

A.3: Johansen Cointegration Results

Maximum rank	Parms	LL	Eigen value	Trace statistic	5% critical value
0	**258**	**1547.89**	**.**	**114.7069***	**94.15**
1	269	1573.18	0.39696	64.1296	68.52
2	278	1589.19	0.27395	32.1162	47.21
3	285	1598.01	0.16167	14.4819	29.68
4	290	1602.79	0.09116	4.9227	15.41
5	293	1605.14	0.046	0.2134	3.76
6	294	1605.25	0.00213	0.00213	

A.4: Lag Length Selection Criteria Results

Selection-order-criteria
Sample:2011m10 -2019m12 Number of obs. = 99

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1225.8	-	-	-	8.00E-19	-24.624	-24.5787 *	-24.4851*
1	1266.91	82.23	36	0.000	7.20E-19	-24.746	-24.3	-23.645
2	1278.32	22.822	36	0.957	1.20E-18	-24.249	-23.422	-22.204
3	1297.4	38.152	36	0.372	1.70E-18	-23.907	-22.698	-20.919
4	1308.3	21.804	36	0.97	3.00E-18	-23.4	-21.809	-19.468

5	1333.02	49.44	36	0.067	4.00E-18	-23.172	-21.199	-18.297
6	1503.67	341.31	36	0.000	2.9e-19*	-25.8924*	-23.538	-20.073
7	1534.9	62.461	36	0.004	3.70E-19	-25.796	-23.06	-19.033
8	**1575.27**	**80.727***	**36**	**0.000**	**4.10E-19**	**-25.884**	**-22.766**	**-18.177**

Endogenous: dlCPI, dlNEER, dlEPI, dlWOP, dlIPI, dlMS
Exogenous: cons_

A.5: Granger Causality Results for dlog CPI

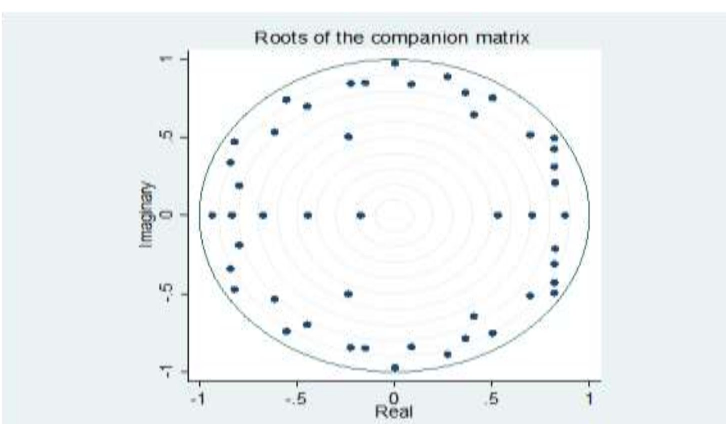
Excluded	Chi-sq	df	Prob>chi-sq
dlog NEER	8.9025	8	0.039
dlog MS	11.379	8	0.005
dlog WOP	20.058	8	0.006
dlog EPI	18.196	8	0.255
dlog IPI	16.367	8	0.015
All	74.136	40	0.001

Appendix B: Post Estimation Test

B.1: Lm Residual Test for Autocorrelation

Lag	Chi2	df	Prob>Chi2
1	37.7241	36	0.39036
2	38.6983	36	0.34879
3	35.4643	36	0.49389
4	26.6615	36	0.87136
5	16.9762	36	0.99704
6	29.1105	36	0.78536
7	30.2905	36	0.73643
8	29.2977	36	0.77788

B.2: VAR Stability Test



B.3: Jarque-Bera Normality Test

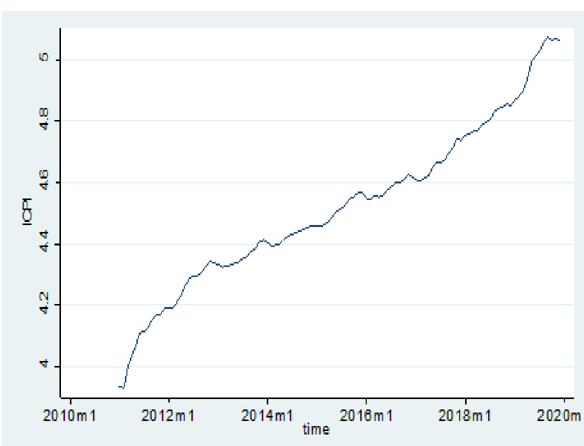
lag	Chi2	df	Prob>Chi2
1	123.21	36	0.000
2	53.751	36	0.029
3	86.154	36	0.000
4	58.35	36	0.011
5	72.838	36	0.000
6	2437.877	36	0.000
7	101.447	36	0.000
8	96.359	36	0.000

B.4: Wald Lag Exclusion Tests

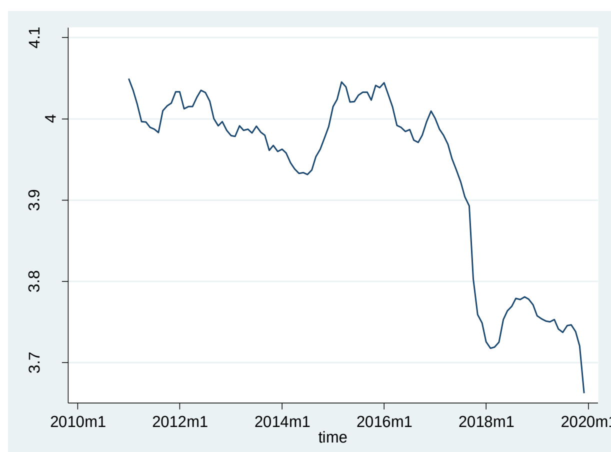
Equation	Chi2	df	Prob>chi2	Equation	Chi3	df	Prob>chi3
dlog CPI	11.129	2	0.00383	dlog CPI	-6.7476	-12.31	-17.873
dlog EPI	0.942	2	0.62451	dlog EPI	0.87135	0.7126	0.55386
dlog IPI	16.533	2	0.00026	dlog IPI	-10.355	-18.621	-26.888
dlog MS	3.162	2	0.20258	dlog MS	-1.1712	-2.6509	-4.1306
dlog WOP	2.222	2	0.32916	dlog WOP	-0.3758	-1.3222	-2.2686
dlog NEER	712.09	2	0.000	dlog NEER	-474.06	-830.11	-1186.2
All	746.078	2	0.000	All	-496.72	-869.76	-1242.8

Appendix C: Time Series Plots

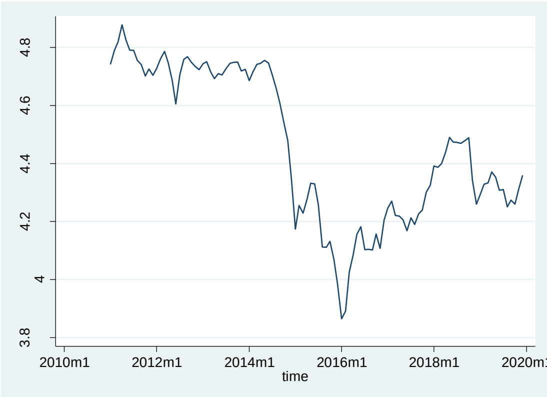
Log CPI

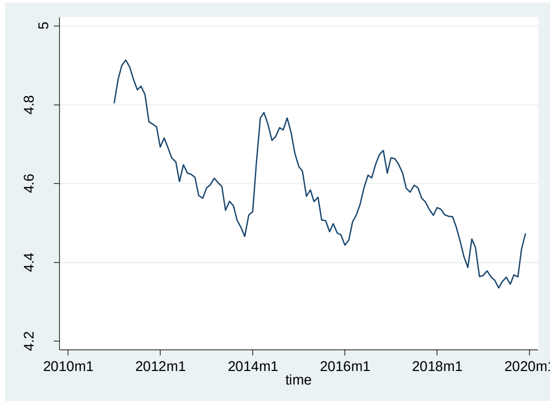


Log NEER

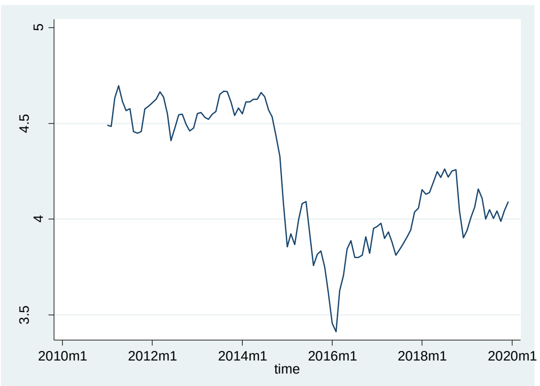


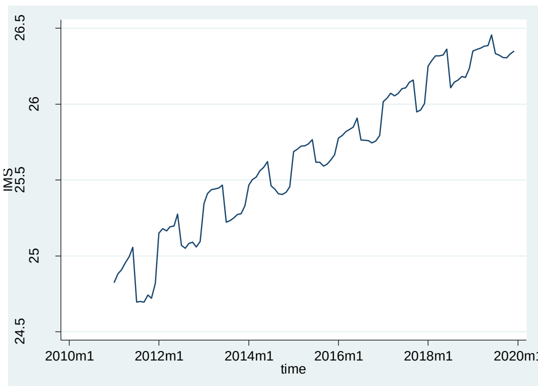
Log IPI **Log EPI**





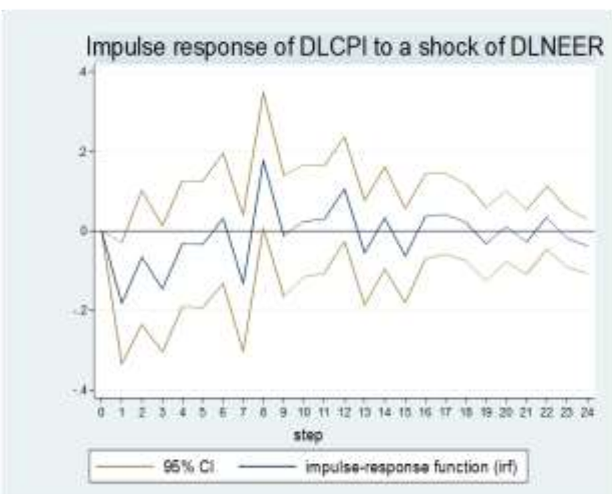
Log WOP **Log MS**

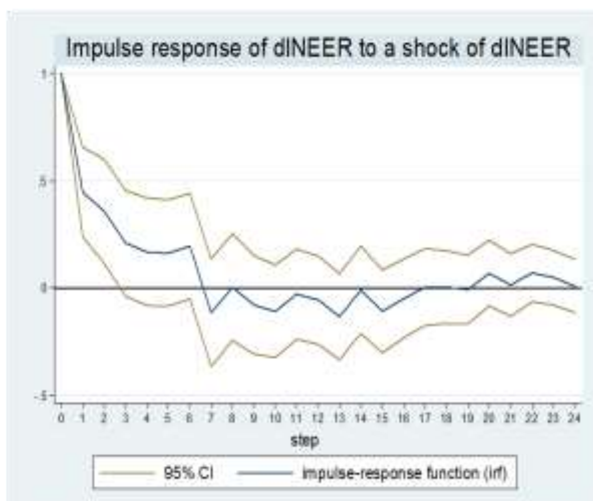


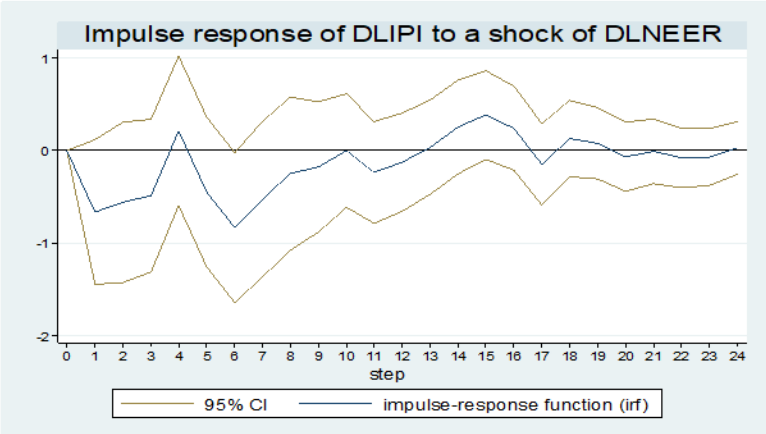


Appendix D: Impulse Responses

D.1: Impulse Responses (graph)



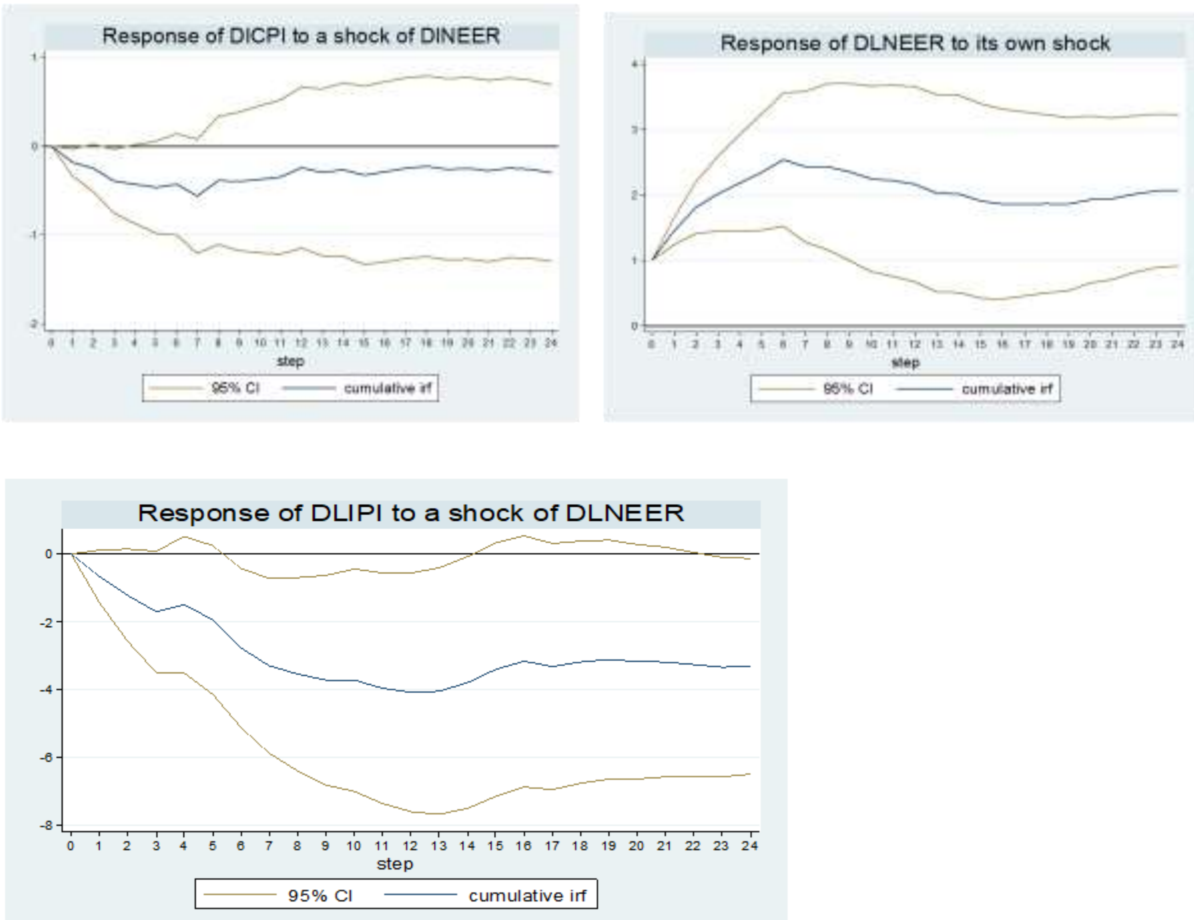




D.2: Impulse Response Estimates (Tables)

Month	$IRF_{NEER}\,(CPI_t\,)$	$IRF_{NEER}\,(IPI_t\,)$	$IRF_{NEER}\,(NEER_t\,)$
1	-0.183	-0.664	0.448
2	-0.066	-0.559	0.359
3	-0.147	-0.486	0.208
4	-0.032	0.212	0.168
5	-0.035	-0.447	0.163
6	0.032	-0.833	0.196
7	-0.133	-0.525	-0.114
8	0.178	-0.249	0.004
9	-0.012	-0.177	-0.079
10	0.024	-0.000	-0.108
11	0.028	-0.235	-0.029
12	0.105	-0.125	-0.057
13	-0.056	0.035	-0.135
14	0.032	0.256	-0.008
15	-0.063	0.383	-0.109
16	0.036	0.240	-0.049
17	0.042	-0.149	0.004
18	0.021	0.129	0.004
19	-0.034	0.077	-0.007
20	0.011	-0.066	0.069
21	-0.028	-0.008	0.014
22	0.034	-0.080	0.070
23	-0.018	-0.071	0.049
24	-0.039	0.025	0.009

Appendix E: Cumulative Impulse Responses (Graph)



Appendix F: Using VECM to estimate Exchange rate pass through (Alternative Model)

Variables	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
Error Correction term	0.0036416 (-0.765)	-	-	-	-
dlCPI	0.2406708	-0.0434303	0.0893757	-0.0105	0.04468
	(-0.042)	(-0.718)	(-0.429)	(-0.914)	(-0.617)
dlNEER	-0.434303	0.1413575	0.0149426	0.06278	-0.0641
	(-0.718)	(-0.092)	(-0.862)	(-0.47)	(-0.432)
dlEPI	-0.0323265	0.0524791	-0.0748366	-0.0492	-0.0209
	(-0.378)	(-0.182)	(-0.054)	(-0.213)	(-0.589)
dlMS	0.49339	0.0548514	0.1894151	-0.0092	-0.0416
	(-0.295)	(-0.226)	(0000)	(-0.858)	(-0.403)
dlWOP	0.036682	-0.0320963	0.074961	-0.0036	0.02335
	(-0.312)	(-0.385)	(-0.034)	(-0.916)	(-0.493)
dlIPI	-0.0281539	0.0433396	-0.0894132	0.00365	-0.0567

	(-0.611)	(-0.443)	(-0.100)	(-0.944)	(0.277)

Where the Constant is 0.001341 with a P- value of 0.556

F.1: Long run response of lCPI

Variable	Coefficient
lNEER	1.667025
	(-0.001)
lEPI	0.9677263
	(0.000)
lMS	0.146309
	(-0.381)
lWOP	-2.240856
	(0.000)
lIPI	3.32236
	(0.000)

Where the constant is -25.32522