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Real Exchange Rate Misalignment and Economic Growth: An Empirical Analysis for Ethiopia

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ABSTRACT

In both developing and developed economies, academic and policy discussions have consistently emphasized that achieving stable economic growth and maintaining internal and external balance require an exchange rate aligned with its long-term equilibrium value. This paper examines the impact of real exchange rate misalignment on Ethiopia's economic growth from 1980 to 2022. The study begins by estimating the equilibrium real exchange rate using the Behavioral Equilibrium Exchange Rate (BEER) approach to calculate the misalignments. It then analyzes the effects of these misalignments on economic growth using Vector Autoregressive (VAR) and Hansen's (2000) threshold regression model. The VAR and Impulse Response Function (IRF) analyses reveal that real exchange rate misalignments have an immediate positive impact on economic growth, which diminishes between the eighth and sixteenth years and stabilizes as a permanent long-term effect. The threshold regression results indicate that undervaluation of the Ethiopian Birr enhances economic growth up to a 13.95% deviation from the equilibrium real exchange rate, while overvaluation supports growth up to a 7.15% threshold. Beyond these limits, misalignments hinder growth. The study underscores the importance of avoiding excessive deviations from the equilibrium exchange rate to sustain economic growth. Furthermore, it highlights the need for consistent macroeconomic policies to minimize the gap between the actual and equilibrium real exchange rates. These findings emphasize the critical role of exchange rate policy in promoting sustainable economic development in Ethiopia.

Keywords: Real exchange rate misalignments, Economic growth, Threshold Regression, VAR, Ethiopia

INTRODUCTION

In recent decades, real exchange rate misalignment—defined as the difference between the actual and equilibrium real exchange rates—has gained significant attention in policy discussions among economists and policymakers for developing countries' economies. This is due to the recognition that addressing real exchange rate misalignment is crucial for enhancing economic performance and achieving macroeconomic stability. Real exchange rate misalignment occurs when a country's actual real exchange rate diverges from its long-term, sustainable, equilibrium-level real exchange rate, resulting in either undervaluation or overvaluation of the domestic currency. Correcting this misalignment usually requires a combination of demand management measures and adjustments to the real exchange rate (Domaç & Shabsigh, 2001; Edwards, 1989; Khalid et al., 2024).

The literature, including works by Rodrik (2008), Domaç & Shabsigh (2001), Khalid et al. (2024), and Salvatore (2005), widely acknowledges that exchange rate misalignments have three detrimental effects on economic growth. First, they can weaken external competitiveness by making exports too expensive, leading to a decline in the external balance and a reduction in foreign exchange reserves. This situation may eventually result in a severe devaluation during an external balance of payments crisis, which negatively impacts domestic prices and production. Second, exchange rate misalignments can lead to resource misallocation by distorting the relative prices of domestic goods compared to each other and to international prices, hindering domestic investment and reducing production efficiency. Lastly, such misalignments can destabilize domestic financial markets by increasing uncertainty and fostering speculation against the domestic currency.

Therefore, exchange rate misalignment can greatly impact export flows and economic growth in developing countries like Ethiopia, especially in the context of export-driven growth strategies and trade liberalization. The Ethiopian economy has been grappling with significant macroeconomic challenges, including persistent current account deficit, high inflation, a weakening exchange rate, rising unemployment, and slow economic growth. Additionally, the economy suffers from low foreign exchange reserves, a consequence of underdeveloped financial markets and reduced investment from both foreign and domestic investors, driven by ongoing political and economic uncertainties (see EEA, 2024; Nuru, 2022; UN, 2020; UNDP, 2024).

In developing countries, exchange rate policies frequently diverge from theoretically ideal levels because of trade dynamics, global socioeconomic factors, and political influences. Both undervaluation and overvaluation can harm economic growth (see Conrad & Jagessar, 2018; Giordano, 2023; Khalid et al., 2024; Rodrik, 2008). Continuous overvaluation may cause external imbalances by increasing imports, as foreign goods become cheaper than domestically produced ones (Atasoy & Saxena, 2006), while undervaluation can create inflationary pressures and restrict domestic investment resources, hindering supply-side growth (Khalid et al., 2024). In a more organized way, Ulaşan (2018) argued that a prolonged real appreciation could slow long-term growth through two main channels: first, by shifting resource allocation towards the non-traded goods sector, it may hinder future growth potential; and second, by encouraging private debt in foreign currencies, it increases the economy's susceptibility to external shocks. Khalid et al. (2024) highlighted that such misalignments could result in trade conflicts and the adoption of protectionist policies, posing a risk to global economic stability.

In contrast, as noted by Mbaye (2013), undervalued exchange rates can impact economic growth through two primary channels: the "capital accumulation channel" and the "total factor productivity (TFP) growth channel." The capital accumulation channel suggests that an undervalued exchange rate promotes growth by increasing the capital stock in the economy, driving up overall savings and investment (see Rodrik, 2008). The TFP growth channel posits that undervaluing the real exchange rate raises the price of tradable goods, enhancing the profitability of the tradable sector. As production shifts from non-tradable to tradable goods due to the price incentive, which has higher productivity, the overall productivity improves, ultimately fostering economic growth.

These findings revealed the significant impact of exchange rate misalignments on trade and economic growth, underscoring the importance of this study for Ethiopia. Thus, understanding the behavior of real exchange rates is essential for effective macroeconomic policy development in the context of financial globalization (Edwards, 1989). Krugman & Taylor (1978) also emphasized the significance of policymakers recognizing the contractionary impacts caused by an undervaluation of the real exchange rate. Consequently, researchers must evaluate the extent of real exchange rate misalignment to assess their economies' competitiveness. Additionally, they should evaluate because the cyclical fluctuations of currencies in countries with high exchange rate volatility have led to misalignments that could hinder sustainable economic growth.

On July 29, 2024, the National Bank of Ethiopia took a bold step by floating the Birr and ending its fixed exchange rate policy. This policy reform, part of an IMF-backed macroeconomic stabilization program, aims to tackle persistent foreign currency shortages, enhance investor confidence, and ultimately stabilize the economy. Since 1992, when the Ethiopian government adopted the Structural Adjustment Program (SAP), there has been ongoing debate about the impact of the exchange rate policy reforms on economic growth and the most suitable exchange rate system for Ethiopia. However, this debate has been supported by only a limited number of empirical studies. To the best of the author’s knowledge,

only one study (Ayele, 2022) has examined the effect of real exchange rate misalignment on growth in East African Least Developed Countries, including Ethiopia. This study, however, has been criticized for not fully capturing the impact of the misalignment based on its magnitude and direction, lacking detailed justifications for its regression results, and failing to explain the mechanisms through which real exchange rate misalignment affects growth in Ethiopia, as it focused on collective economic growth in East Africa. Thus, this paper seeks to address these gaps by analyzing the impact of real exchange rate misalignment on Ethiopia's economic growth from 1980 to 2022, using the Vector Autoregressive (VAR) and Threshold Regression Methods.

This study makes three important contributions to the existing literature on international economics. First, it addresses the Ethiopian government's ongoing devaluation of the national currency (Birr), which has contributed to unsustainable macroeconomic instability, emphasizing the need to assess the effects of real exchange rate misalignment on Ethiopia's economic growth. Second, it estimates the equilibrium real exchange rate by focusing on macroeconomic fundamentals and evaluating both external and internal balances. This method helps measure the impact of real exchange rate misalignment on economic growth. Finally, the study examines how both overvaluation and undervaluation affect Ethiopia's economic growth.

The remainder of the paper is structured as follows: the second section reviews the empirical literature, followed by the methodology and data presentation in the third section. The fourth section presents the empirical results and discussion, while the fifth section concludes the study.

EMPIRICAL LITERATURE

Over time, the issue of real exchange rate misalignment has gained increasing attention, with many studies suggesting it can slow economic growth, constrain exports, and lead to civil unrest and political instability. As a result, several empirical studies have explored the impact of real exchange rate misalignment on economic growth, employing different measures of misalignment and various growth models. However, these studies have yielded inconclusive results, regardless of the methodologies applied or the economic development levels of the countries examined. Generally, it is believed that many developing economies face significant exchange rate misalignments that impede their economic growth.

There has been a wealth of recent empirical literature confirming a negative relationship between real exchange rate misalignment and economic growth. Domaç & Shabsigh (2001) found that real exchange rate misalignment negatively affected economic growth in four Arab countries—Egypt, Jordan, Morocco, and Tunisia—from 1970–1990, using three different measures of misalignment. Similarly, Abida (2011) demonstrated a negative coefficient for real exchange rate misalignment, indicating that currency overvaluation hampers economic growth in the long run in Tunisia, Algeria, and Morocco. This negative impact of overvaluation on economic growth was also supported by studies from Ambaw et al. (2022) in Asia and the Pacific, Ali et al. (2015) in Nigeria, and MacDonald & Vieira (2010) across sampled ninety countries. Furthermore, Sallenave (2010) assessed the growth effects of real effective exchange rate misalignments in G20 countries from 1980 to 2006, finding that these misalignments adversely impacted economic growth.

Empirical evidence from both developed and developing countries, as shown by Razin & Collins (1997) significant real exchange rate misalignment can distort price signals, misallocate resources across sectors, and negatively affect economic growth. Similarly, Habib et al. (2016) and Ulaşan (2018) found a

negative long-run correlation between real exchange rate misalignments and economic growth in developing nations, suggesting that inappropriate exchange rate policies contribute to the poor economic performance often seen in these countries. In Sub-Saharan Africa, Elbadawi et al. (2012) discovered that overvaluation hampers growth, with the impact lessened by financial development but intensified by foreign aid. Ayele (2022) and Bannaga & Badawi (2014) also found that real exchange rate misalignment impedes economic growth in Ethiopia and Sudan, respectively. Additionally, Rodrik (2008) posits that undervalued real exchange rates, coupled with institutional weaknesses and market failures, lead to underinvestment in the traded goods sector in developing countries.

Additionally, earlier empirical studies, including those by Khalid et al. (2024) in Turkey, and Conrad & Jagessar (2018) in Trinidad& Tobago, have shown that both real exchange rate undervaluation hinder economic growth. Giordano (2023) further emphasized that real effective exchange rate misalignment—whether overvaluation or undervaluation—leads to increased labor misallocation across sectors (though not of capital), which, through this channel, significantly restricts real growth across 54 countries and 12 sectors from 1980 to 2015.

In summary, Aguirre & Calderón (2005), Domaç & Shabsigh (2001), Salvatore (2005), and Atasoy & Saxena (2006) suggest that overvaluation can lead to foreign currency shortages, rent-seeking and corruption, unsustainable current account deficits, the balance of payment crises, and erratic macroeconomic cycles—all of which are detrimental to economic growth. In contrast, Khalid et al. (2024), Rodrik (2008) and Williamson (1990) note that undervaluation of the real exchange rate can create unnecessary inflationary pressures and reduce resources available for domestic investment, thereby limiting supply-side growth potential. Aguirre & Calderón (2005) add that larger misalignments correlate with a greater decline in economic growth. Krugman & Taylor (1978) point out that while real devaluation can be useful as a policy tool, it may raise the cost of imported inputs, potentially harming production. Rodrik (2008) further contends that, given the negative impact of exchange rate misalignment on economic growth in developing countries, undervaluing the real exchange rate can "*act as the second-best mechanism to partly alleviate the relevant distortion, foster desirable structural change, and spur growth*".

Whilst, most of the recent literature, including studies by Ayele (2022), Deguenonvo (2017), Gala & Lucinda (2006), Habib et al. (2016), Mbaye (2013), Pereira & Missio (2022), Rodrik (2008), and Ulaşan (2018), suggests that an undervalued real exchange rate—not overvaluation—promotes increased private investment in the traded goods sector and fosters economic growth. The majority of empirical evidence fundamentally shows that the primary way undervaluation impacts economic growth is by enhancing export competitiveness. Mbaye (2013) noted that an undervalued real exchange rate positively influences economic growth by boosting the capital stock and enhancing productivity in the tradable sector. Additionally, Pereira & Missio (2022) examined the link between real exchange rate misalignment and growth across 151 countries from 1995 to 2018, finding that a competitive real exchange rate is linked to accelerated economic growth.

Rodrik (2008) examines the relationship between real exchange rate misalignment and economic growth across a sample of 188 countries, concluding that undervaluation compared to purchasing power parity (PPP) is positively and significantly associated with economic growth, especially in developing nations. The studies by Gala & Lucinda (2006) reach similar results using PPP deviation measures and confirm the findings of Rodrik (2008), that is undervaluing the national currency fostered economic growth in 58 developing countries from 1960 to 1999.

The finding of Ulaşan (2018) found that real exchange rate misalignment is positively associated with economic growth in low and middle-income countries, while there is no significant relationship in wealthier nations. Similarly, Habib et al. (2016) demonstrated that weakening real exchange rates significantly boosted annual economic growth in developing countries during the post-Bretton Woods era. Specifically, Ayele (2022) indicated that, in the short-run, real exchange rate misalignment could enhance economic growth in Kenya. In Senegal, Deguenonvo (2017) found that misalignment positively affects long-term economic growth, particularly in cases of devaluation during overvaluation.

METHODOLOGY AND DATA

Estimation of Equilibrium Real Exchange Rate and Measurement of Real Exchange Rate Misalignment

In this study, we utilized the Behavioral Equilibrium Exchange Rate (BEER) approach introduced by Clark & MacDonald (1998) to estimate Ethiopia's equilibrium real exchange rates. The BEER approach determines the equilibrium real exchange rate by estimating a long-term relationship between the real exchange rate ($\boldsymbol{rexr}$) and its fundamental factors, which include, in this study, trade openness ($\boldsymbol{opn}$), government fiscal policy ($\boldsymbol{govfs}$), interest rate differentials ($\boldsymbol{rdf}$), and real net foreign assets ($\boldsymbol{rnfa}$). This method is fairly straightforward, easy to implement, and requires minimal data (Couharde & Sallenave, 2013). This is particularly important due to the scarcity of reliable data in many developing economies, such as Ethiopia.

This approach involves three steps to estimate the equilibrium real exchange rate in Ethiopia: first, estimating the long-run relationship between the real exchange rate and its fundamentals using a Vector Error Correction (VEC) Model, which yields the Behavioral equilibrium exchange rate (BEER). The empirical model of the long-run relationship between the real exchange rate and its fundamentals delivered by theory, which predicts the equilibrium real exchange rate, can be depicted as:

$$\boldsymbol{lnrexr_t = \beta_0 + \beta_1 lnopn_t + \beta_2\, lngovfs_t + \beta_3\, lnrdf_t + \beta_4\, \ln rnfa_t + \varepsilon_t} \qquad (1)$$

where $\boldsymbol{rexr}$ is the real exchange rate, $\boldsymbol{opn}$ is trade openness, $\boldsymbol{govfs}$ is government fiscal policy stance (the ratio of government spending and nominal GDP), $\boldsymbol{rdf}$ is interest rate differentials (the difference between domestic interest rate and foreign interest rate, i.e. US), $\boldsymbol{rnfa}$ is real net foreign assets, $\boldsymbol{ln}$ is natural logarithms; and $\boldsymbol{\varepsilon}$ is an error term.

Second, to calculate the long-run equilibrium real exchange rate, we must isolate the permanent values of the fundamental variables from their short-run fluctuations. This can be done by applying the Hodrick-Prescott (H-P) filter, which extracts the 'long-run', 'steady state', or 'permanent' values of the economic fundamentals at period t by decomposing the time series into a trend μ_t and stationary component, $x_t - \mu_t$ by minimizing (see Hodrick & Prescott, 1997). The reasoning behind this is that fundamental variables may exhibit considerable short-term "noise."

$$\sum_{t=1}^{T}(x_t - \mu_t)^2 + \lambda \sum_{t=2}^{T-1}[(x_{t+1} - \mu_t) - (x_t - \mu_{t-1})]^2 \qquad (2)$$

where λ is an arbitrary constant that represents the penalty for introducing fluctuations into the trend. If λ = 0, the sum of squares is minimized when $x_t - \mu_t$ and the trend is x_t itself. As λ → ∞, the trend approaches linearity. Hodrick and Prescott recommended using a λ value of 14 for annual data.

Finally, compute the equilibrium real exchange rate, referred to as the Permanent Equilibrium Real Exchange Rate (PEER) (a smoothed version of the BEER), by multiplying the permanent values of the fundamental variables by the vector of estimated parameters from the VEC long-run model of equation (1).

$$\boldsymbol{lnrexr = \beta_0 + \beta F^P} \qquad (\mathbf{3})$$

where $\boldsymbol{rexr}$ is the equilibrium real exchange rate, $\boldsymbol{F^P}$ is the vector of permanent values for the fundamentals, and $\boldsymbol{\beta}$ is the vector of estimated parameters.

At this point, we can compute the real exchange rate misalignment ($\boldsymbol{REXRDF_t}$). In this paper, the calculation of real exchange rate misalignment is based on the concept of the Behavioral equilibrium exchange rate (BEER). The common thread in the literature calculating real exchange rate misalignments is the difference between the actual real exchange rate ($\boldsymbol{REXR_t}$) and its predicted equilibrium value (see Elbadawi et al., 2012; Rodrik, 2008), that is, we compute:

$$\boldsymbol{REXRDF_t = REXR_t - ERER_t} \qquad (\mathbf{4})$$

where $\boldsymbol{ERER_t}$ is the predicted equilibrium real exchange rate from equation (3). If the difference is positive (negative), we observed under (over) valuation of the local currency against the USD.

Symmetric Economic Growth Model

After computing the real exchange rate misalignment, its symmetric effect on Ethiopia's economic growth is estimated using the Vector Autoregressive (VAR) method, following the approaches used by Ambaw et al. (2022), El-Ramly & Abdel-Haleim (2008), and Khondker et al. (2012). The VAR model structure assumes that each variable is a linear function of its own past lags and the past lags of other variables. The fundamental economic growth equation estimated by the VAR model is represented as follows:

$$\boldsymbol{lnrgdp_t = \alpha_0 + \alpha_1 lnrge_t + \alpha_2 lnrpcr_t + \alpha_3 lntt_t + \alpha_4 lnrexrdf_t}$$
$$\boldsymbol{+\alpha_5 lninf_t + \alpha_6 lnrdf_t + \alpha_7 lnrnfa_t + \varepsilon_t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{5})$$

Where $\boldsymbol{rgdp}$ is real gross domestic product, $\boldsymbol{rge}$ is real government expenditure, $\boldsymbol{rpcr}$ is a real credit to the private sector, $\boldsymbol{tt}$ is terms of trade, $\boldsymbol{rexrdf}$ is real exchange rate misalignment, $\boldsymbol{inf}$ is the inflation rate, $\boldsymbol{rdf}$ is interest rate differential, $\boldsymbol{rnfa}$ is real net foreign assets, $\boldsymbol{ln}$ is natural logarithms; and $\boldsymbol{\varepsilon}$ is an error term.

Threshold Regression Model

Recent evidence indicates that the effect of real exchange rate misalignments on economic growth varies by direction (undervaluation or overvaluation) and threshold level, highlighting a likely non-linear relationship (Amor et al., 2020; Couharde & Sallenave, 2013; Tipoy et al., 2018). Misalignment effects can shift from positive to negative—or vice versa—once specific thresholds are crossed (see Amor et

al., 2020). Identifying these thresholds is essential for policymakers to implement corrective measures before misalignments significantly hinder economic growth.

The threshold effect of real exchange rate (RER) misalignment on economic growth can be analyzed in two steps. First, the RER misalignment series is decomposed into overvaluation and undervaluation indices using the partial sum approach, enabling an assessment of their asymmetric effects on economic growth. Second, the threshold levels for undervaluation and overvaluation are identified, and their respective impacts on growth are analyzed using Hansen's (2000) threshold regression model. This model specifies distinct regime thresholds and their associated coefficients. The threshold regression model is formulated as follows:

$$\boldsymbol{Y_t = \beta_{0,1} + \beta_{1,1} Q_t + \beta_{2,1} X_t + \varepsilon_t \ \ if\ Q_t \leq \tau} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\boldsymbol{Y_t = \beta_{0,2} + \beta_{1,2} Q_t + \beta_{2,2} X_t + \varepsilon_t \ \ if\ Q_t > \tau} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Here, Y_t denotes the endogenous variable, Q_t is the threshold variable, X_t represents the control variables, and ε_t is the regression error term. The threshold variable divides the overall misalignment series into two regimes: Regime-1 and Regime-2. The model parameters differ based on the regimes defined by the threshold value.

The term τ is unknown and must be estimated empirically. In Equation (8), the ordinary least squares (OLS) estimate of τ is determined as the value that minimizes the sum of squared errors.

$$\boldsymbol{\hat{\tau} = argmin\left(\hat{\tau}^2(\tau)\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where $\hat{\tau}^2(\tau) = \frac{1}{T}\sum_{t=1}^{T}(\widehat{\varepsilon_t})^2$.

Equations (6) and (7) integrate measures of undervaluation and overvaluation into the explanatory variables typically used in economic growth models. The control variables include trade openness (OPN) and the inflation rate (INF), both expressed as percentages.

Data sources

Data spanning from 1980 to 2022 were gathered from various standard sources for the study. The consumer price index, used to calculate the inflation rate, was obtained from the Ethiopian Statistical Service (ESS). Information on credit to the private sector, net foreign assets, and domestic interest rates came from the National Bank of Ethiopia (NBE). The U.S. interest rate was sourced from the Federal Reserve Bank of St. Louis. All other data were collected from the International Monetary Fund (IMF), the World Bank's World Development Indicators (WDI), and the World Economic Outlook (WEO).

EMPIRICAL RESULTS AND DISCUSSION

Time series Properties of Variables

Before estimating the effect of exchange rates on economic growth in Ethiopia, it is essential first to assess the time series characteristics of the relevant variables used to estimate the equilibrium real exchange rate and the effect of the real exchange rate on economic growth. To prevent issues of spurious

correlations and ensure reliable and consistent results in the regression analysis, the time series behavior of each variable is examined using the Augmented Dickey-Fuller (ADF) test under two alternative hypotheses, having no trend and with trend assumptions in the regressions.

Table 1: ADF Unit Root Test Results

	ADF Test statistics under different assumptions			ADF Test statistics under different assumptions	
Variables	Without trend	With trend	Variables	Without trend	With trend
lnrgdp	-0.908	-1.374	D(lnrgdp)	-5.715***	-5.685***
lnrge	-0.834	-2.448	D(lnrge)	-5.652***	-5.578***
lnrpcr	0.378	-1.886	D(lnrpcr)	-4.137***	-4.177***
lntt	-2.537	-2.842	D(lntt)	-7.197***	-7.126***
lnrexrdf	-1.873	-1.907	D(lnrexrdf)	-5.050***	-4.986***
lninf	-5.015***	-5.597***	D(lninf)	-9.274***	-9.169***
lnrdf	-2.553	-3.233	D(lnrdf)	-9.386***	-10.131***
lnrnfa	-5.080***	-5.012***	D(lnrnfa)	-10.614***	-10.500***
lnrexr	2.421	-0.990	D(lnrexr)	-4.389***	-4.898***
lnopn	-1.180	-3.465	D(lnopn)	-7.020***	-6.922***
lngovfs	0.189	-1.981	D(lngovfs)	-10.391***	-10.873***

Note: ***, **, and * implies significance at 1%, 5% and 10%, respectively

As illustrated in Table 1, a unit root test was conducted to assess the stationarity of the data. The ADF test results indicate that only inflation and real net foreign assets are stationary at their levels, while the remaining variables are non-stationary. However, ADF tests on the differenced variables show that all variables are integrated of order one (I(1)), allowing us to reject the null hypothesis of having a unit root problem. Consequently, it can be concluded that all variables are stationary at their first difference under both scenarios. confirming that they can be jointly estimated using a VAR or VEC model, and their suitability for estimation using a VAR or VEC model. Likewise, Appendix Figure A1 displays a graphical plot of the variables, further supporting the stationarity of the variables at first difference indicated by the ADF test.

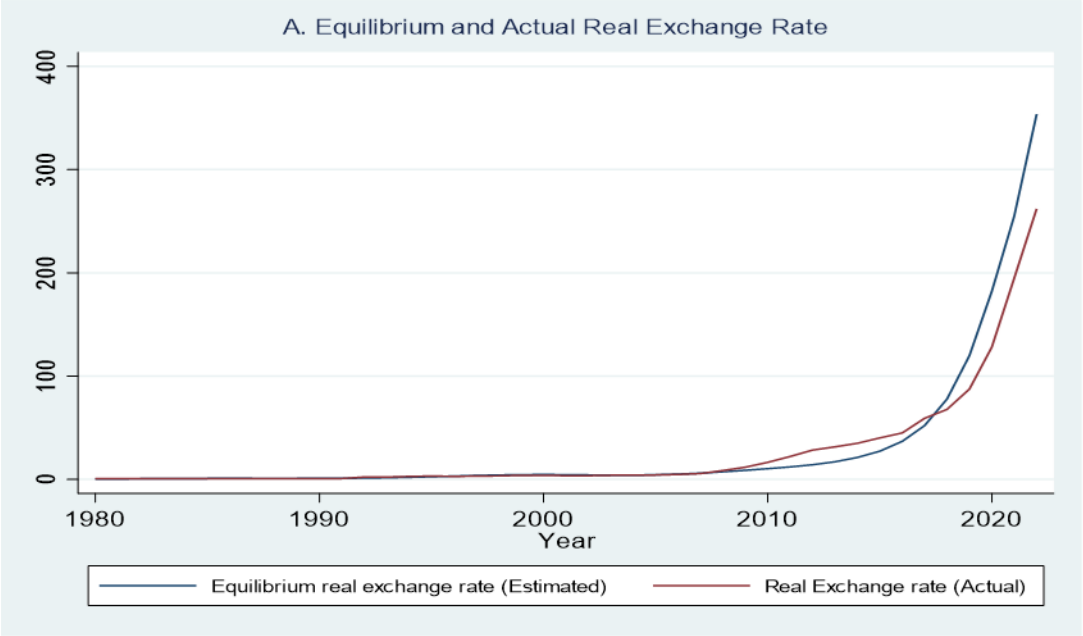
Equilibrium Real Exchange Rate & Real Exchange Rate Misalignment

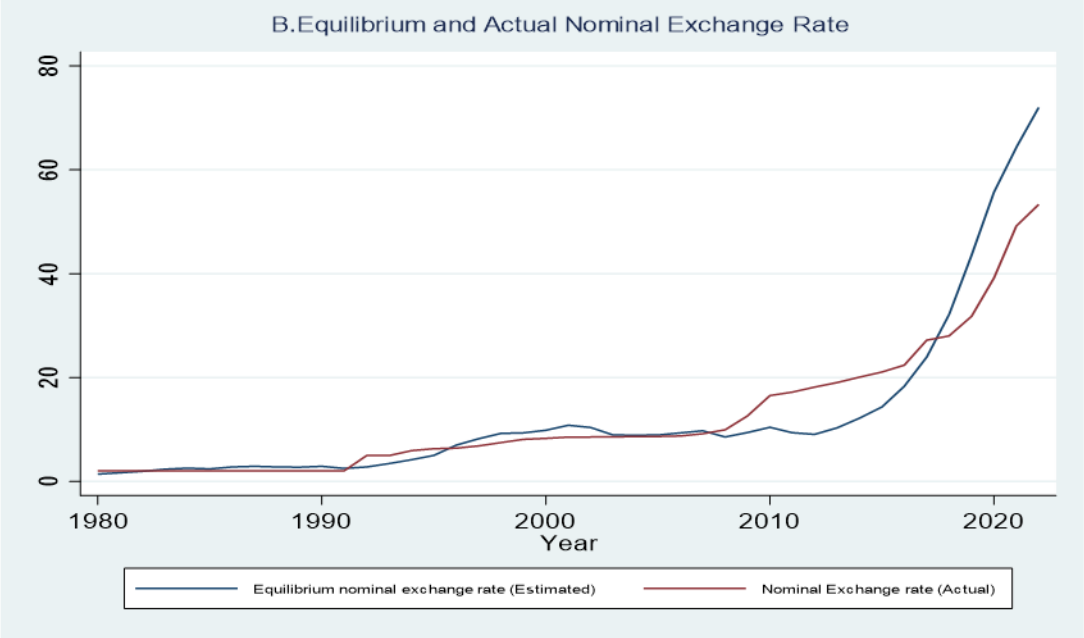
This study used the Behavioral Equilibrium Exchange Rate (BEER) approach (see Clark & MacDonald, 1998) to estimate Ethiopia's equilibrium real exchange rate and assess real exchange rate misalignment. Figure 1, Table 2, and Appendix Table A5 present the estimated equilibrium real exchange rate, the actual real exchange rate, and the real exchange rate misalignment from 1980-2022.[1] The analysis identified three distinct episodes of both undervaluation and overvaluation of the real exchange rate in Ethiopia (see Table 2). The summary provided in Table 2, showed that the average misalignment lies between -91.733 and 9.088 (in Birr, real value). The highest level of misalignment occurred between 2018 and 2022, with an overvaluation of 91.33 Birr, while the lowest misalignment, an undervaluation of

[1] The real exchange rate misalignment is calculated as the difference between the actual real exchange rate and the estimated equilibrium real exchange rate.

0.032 Birr, was recorded between 1980 and 1982. However, overvaluation is relatively more severe than undervaluation during the study period in Ethiopia (See Figure 2).

Figure 1: Equilibrium and Actual Real/Nominal Exchange Rate



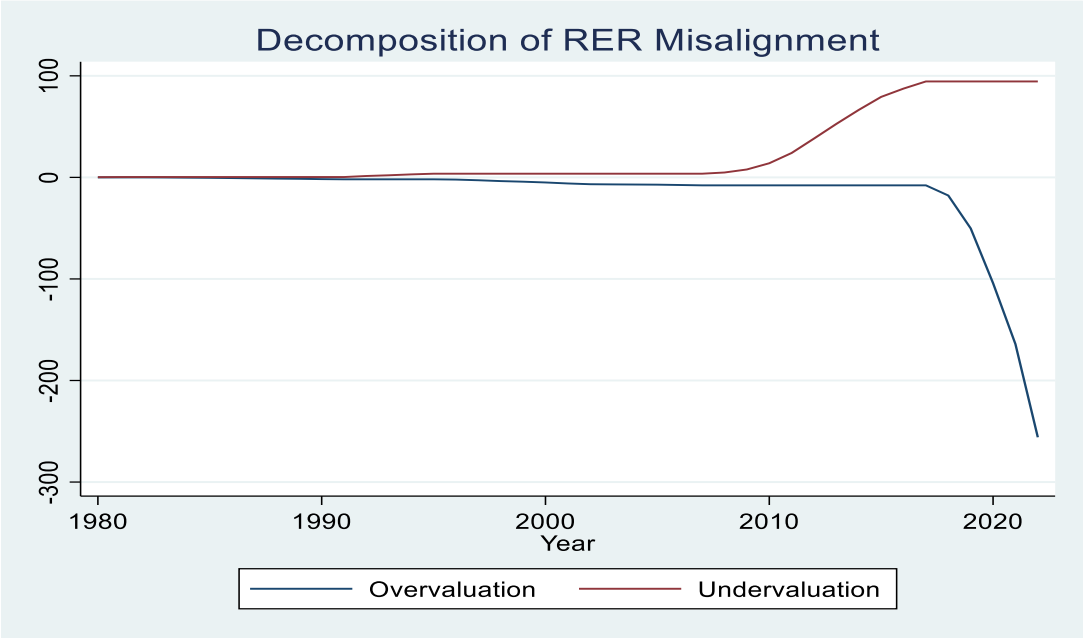


In Ethiopia, economic growth decelerated from 10.2% between 2008 and 2017 to 6.4% from 2018 to 2022. This slowdown could be partly attributed to the overvaluation of the domestic currency during this period. his aligns with the findings of Elbadawi et al. (2012), Razin & Collins (1997), and Rodrik (2008), who highlight the negative impact of currency overvaluation on growth.

The second notable aspect of the result is that the real exchange rate was undervalued between 1992 and 1995, contrary to the belief of the World Bank and IMF that it was overvalued. This was also the

period when the Ethiopian government implemented the Structural Adjustment Program (SAP) in 1992, under the guidance of the IMF and World Bank (see ADBG, 2000). However, the program was discontinued after 1995 due to the macroeconomic instability caused by the structural adjustment policies. For instance, before 1992, Ethiopia's currency, the Birr, was considered overvalued by international financial organizations. The World Bank along with other international organizations identified this misalignment as a major distortion in Ethiopia's economy and recommended implementing a liberalized foreign exchange system. Consequently, in October 1992, the National Bank of Ethiopia devalued the Birr by 59 percent, adjusting the fixed rate from 2.07 to 5.0 Birr per dollar, as part of the Structural Adjustment Program's policy measures. This move aimed to enhance Ethiopia's export competitiveness but also resulted in inflationary pressures on imported goods. Furthermore, as indicated in Table 2, this decision caused the Birr to become less competitive, with an average undervaluation of 0.82 Birr between 1992 and 1995. To address the inflation, the National Bank of Ethiopia raised interest rates from 6.8% in 1992 to an average of 14.5% between 1993 and 1995. This substantial increase in interest rates discouraged domestic investment and borrowing, triggered capital outflows, reduced economic activity, and ultimately slowed down growth.

Figure 2: Relative severity of overvaluation versus undervaluation



Another interesting aspect of the misalignment result is that the real exchange rate was overvalued between 2018 and 2022, during this time the IMF and World Bank labeled the Ethiopian Birr as the most overvalued currency in Sub-Saharan Africa and advocated for its floating to enhance competitiveness and address macroeconomic imbalances (IMF, 2020). In response, the National Bank of Ethiopia took a decisive step by floating the Birr and ending its fixed exchange rate policy on July 29, 2024. This action aimed to secure a $10.7 billion loan from the IMF and World Bank, with the government believing that this reform is the appropriate exchange rate policy for achieving sustainable economic growth.

Table 2: Episodes of Real Exchange Rate Misalignment in Ethiopia

Range	Outcome	Minimum Misalignment	Maximum Misalignment	Average

1980 - 1982	Undervaluation	0.032	0.217	0.123
1983 - 1991	Overvaluation	-0.142	-0.283	-0.223
1992 - 1995	Undervaluation	0.674	1.019	0.815
1996 – 2007	Overvaluation	-0.131	-0.963	-0.496
2008 - 2017	Undervaluation	1.195	14.459	9.088
2018 - 2022	Overvaluation	-9.998	-91.733	-49.615

Note: The negative sign indicates the overvaluation of the real exchange rate while the positive sign denotes the undervaluation of the real exchange rate.

Symmetric Effects of RER Misalignments on Economic Growth

In this paper, we estimated the real exchange rate misalignment impact on economic growth in Ethiopia. The real exchange rate misalignment is calculated as the difference between the actual real exchange rate and the estimated equilibrium real exchange rate. Incorporating the real exchange rate misalignment in research is crucial for several reasons in both economic theory and policy analysis, as it offers more nuanced information than the actual real exchange rate alone. This approach helps to: (i) analyze the effects of misalignment on trade competitiveness, as misaligned rates may distort trade flows; (ii) inform policymakers on whether currency interventions are needed, guiding adjustments in monetary, fiscal, or exchange rate policies; (iii) since real exchange rate misalignment identifies discrepancies between a country's currency value and its long-term fundamentals, it signals macroeconomic imbalances, such as trade deficits or inflationary pressures, helping to address underlying structural issues that impact growth and stability; and (iv) assist investors in evaluating risk and potential returns, as well as anticipating policy changes. Overall, incorporating real exchange rate differentials allows for a more comprehensive understanding of economic interactions, competitiveness, and policy effects across borders, whereas the real exchange rate alone may overlook currency distortions. Real exchange rate misalignment thus provides deeper insights into how exchange rates affect a country's trade, inflation, growth, and broader macroeconomic stability.

To assess the impact of real exchange rate misalignment within the VAR model, various lag-order selection criteria were applied to determine the optimal lag length for the economic growth model, as Johansen co-integration tests are sensitive to the chosen lag length. As presented in Appendix Table A1, the HQIC and SBIC criteria suggest a lag length of one, while the LR, FPE, and AIC criteria recommend a lag length of two. Consequently, the economic growth model employs two lags of the variables, as the AIC's capacity to penalize model complexity helps to ensure robustness and prevent overfitting.

The stationarity test, in Table 1, revealed that all variables are stationary at their first difference, justifying the application of the Johansen co-integration test. The Johansen co-integration method was employed to determine the number of co-integrated vectors for non-stationary variables of the same order. The co-integration rank test was conducted using trace statistics. As shown in Table 3, the co-integration analysis of the economic growth model, following Johansen's (1991) methodology indicates five co-integrating equations at the 5% significance level. The trace test does not reject the null hypothesis of at most five co-integrating equations. Therefore, the model contains five co-integrated vectors, confirming a long-run relationship among the variables in the economic growth model.

Additionally, to reinforce the Johansen co-integration results and confirm the existence of a long-run relationship among the variables, the Engle-Granger Test for co-integration was conducted specifically

for the economic growth model. For a single equation, this test involves performing an ADF unit root test on the residuals obtained from the co-integrating regression. This approach follows the modified Engle-Granger (EG) and Augmented Engle-Granger (AEG) tests. As presented in Appendix Table A2, the stationarity test of the residuals from the long-run economic growth model of the VAR estimation shows that the ADF test statistic is -5.496, compared to the 99 percent critical value of -2.636. Thus, the null hypothesis of non-stationarity (i.e. no co-integration) is rejected, providing further evidence of a valid long-run relationship among the variables included in the economic growth model.

Table 3: Johansen Cointegration Test of the economic growth model (Trace)

Null hypothesis	Alternative hypothesis	Eigenvalue	Trace statistic	Critical value
$\boldsymbol{CV = 0}$	$CV = 1$	.	283.5853	156.00
$\boldsymbol{CV \leq 1}$	$CV = 2$	0.88685	194.2445	124.24
$\boldsymbol{CV \leq 2}$	$CV = 3$	0.78818	130.6125	94.15
$\boldsymbol{CV \leq 3}$	$CV = 4$	0.70535	80.5121	68.52
$\boldsymbol{CV \leq 4}$	$CV = 5$	0.52278	50.1811	47.21
$\boldsymbol{CV \leq 5}$	$CV = 6$	0.40772	28.7066*	29.68
$\boldsymbol{CV \leq 6}$	$CV = 7$	0.27701	15.4078	15.41
$\boldsymbol{CV \leq 7}$	$CV = 8$	0.18913	6.8120	3.76

Given the evidence of cointegration, the VAR technique was applied to analyze the impact of exchange rate changes on economic growth in Ethiopia. Using a Keynesian analytical framework, the empirical specification was developed by carefully constructing a real exchange rate misalignment series and employing the VAR technique to determine the output response to the misalignment. In empirical analysis, the focus is often on the predicted dynamics from the VAR models rather than the estimated coefficients. For this reason, in empirical applications, the main uses of the VAR estimation are to compute the summary statistics such as Granger causality tests, impulse response functions, and variance decompositions, which are well-accepted and widely used methods for illustrating the co-movement of variables. Thus, this section provides a detailed analysis of these summary statistics derived from the VAR estimation of the economic growth model.[2]

Based on the estimated coefficients from the VAR model in Appendix Table A3, the key parameter of interest, the coefficient on $lnrexrdf$ shows that the first lag of the real exchange rate differential has a very small positive and statistically significant effect on real GDP at the ten percent level of significance, while the coefficient of the second lag is not significantly different from zero. This implies that as the real exchange rate differential index increases (reflecting an excess of the actual real exchange rate

[2] This study conducts VAR stability condition and residual diagnostic tests to ensure the reliability of the estimation results and inferences (see Appendix C).

over the estimated equilibrium real exchange rate – pointing to real undervaluation of the domestic currency), aggregate output rises immediately.[3] Specifically, the estimated coefficient on $lnrexrdf$ suggests that a one percent increase in the real exchange rate misalignment in the first lag leads to a 0.024 percent increase in real GDP.

This result aligns with the conclusions of Deguenonvo (2017), Gala & Lucinda (2006), Habib et al. (2016), Mbaye (2013), Pereira & Missio (2022), Razin & Collins (1997), Rodrik (2008), and Ulaşan (2018), who reached a consensus that undervalued exchange rates—reflected by a rise in real exchange rate misalignment—promote economic growth. An increase in these misalignments (i.e. Undervaluation) enhances growth mainly through export competitiveness, resource reallocation to tradable sectors, increased FDI, raised technology intensity of export, and improved trade balances. However, careful management of exchange rate policies is essential to avoid potential negative side effects like inflation or trade imbalances in the long term that may arise from prolonged undervaluation.

Granger Causality Test after VAR

To assess the true predictive relationship between the real exchange rate misalignment and economic growth in Ethiopia, a Granger causality test was conducted following the VAR estimation. As shown in Table 4, the test results reject the null hypothesis that the coefficients on the two lags of the real exchange rate misalignment (economic growth) in the economic growth equation (real exchange rate misalignment equation) are jointly zero. This allows us to reject the hypothesis that real exchange rate misalignment (denoted as $lnrexrdf$) does not Granger-cause economic growth (denoted as $lnrgdp$) at the 10% significance level. Likewise, we reject the null that economic growth does not Granger-cause real exchange rate misalignment at a 1% significance level.

Thus, the evidence suggests a strong causality from economic growth to real exchange rate misalignment, whereas reverse causality is weaker. This is consistent with the VAR findings that demonstrate a small but immediate positive impact of the real exchange rate misalignment on economic growth. The following insights are notable from the Granger causality test. First, economic growth has significantly influenced the real exchange rate differential in Ethiopia, aligning with the findings of Ito et al. (1999). Moreover, as presented in Table 4, the result shows that the real exchange rate differential serves as a good predictor of economic growth, aligning with research by Ulaşan (2018), Razin & Collins (1997), Conrad & Jagessar (2018), Kreko & Oblath (2020), Elbadawi et al. (2012), and Rodrik (2008). The accompanying impulse-response functions and the related Variance Decomposition presented below provide a more thorough understanding and clearer interpretation of these results.

Table 4: Granger Causality Test after VAR

Null Hypothesis	F-Statistic	P-Value	Decision
$lnrexrdf$ **does not Granger cause** $lnrgdp$	4.6153*	0.099	Reject
$lnrgdp$ **does not Granger cause** $lnrexrdf$	14.329***	0.001	Reject

Note: ****, **, and * implies significance at 1%, 5% and 10%, respectively*

Impulse Response Functions

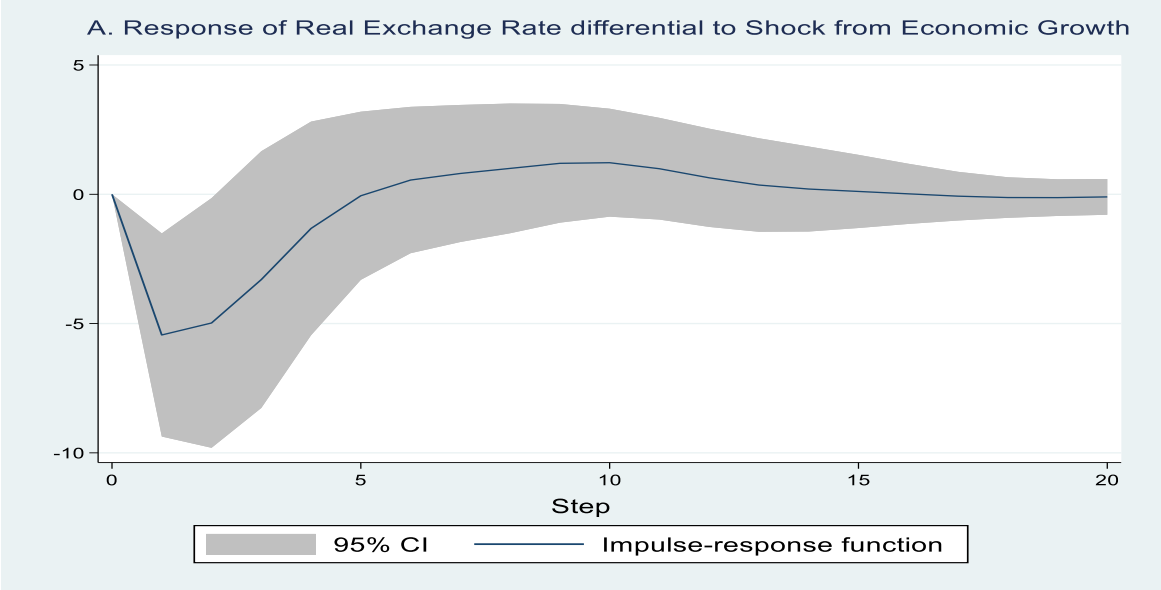
[3] When the ***actual real exchange rate exceeds the equilibrium real exchange rate***, the domestic currency is weaker than its equilibrium or fair value, meaning it is ***undervalued***.

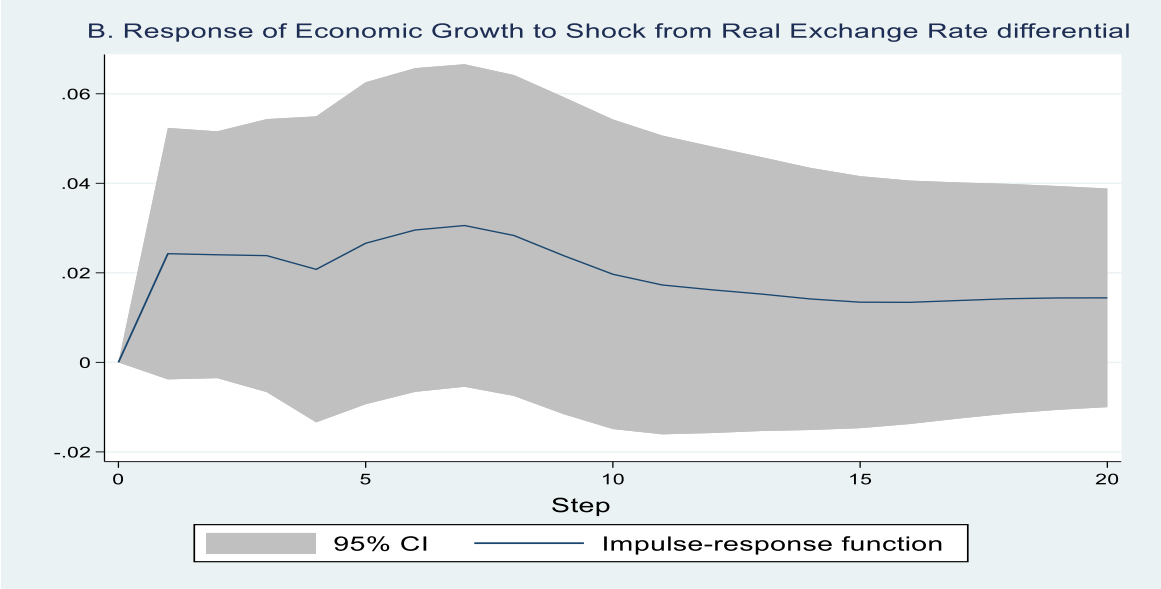
In addition to estimating the VAR model, Impulse Response Function and Variance Decomposition analyses are conducted to explore the short-term interactions between the variables and evaluate their adjustments toward long-term equilibrium. The Impulse Response Function (IRF) helps track the dynamic impact of a one-standard-deviation shock to any of the endogenous variables on both the current and future values of all variables within the system.

As shown in panel A of Figure 3, interestingly, the real exchange rate misalignment was found to respond negatively to a one-standard-deviation shock in economic growth in the first year, which reflects an excess of the estimated equilibrium real exchange rate over the actual real exchange rate – pointing to an appreciation of the domestic currency. This effect is relatively large, the largest negative effect is a decrease in real exchange rate misalignment by nearly 5.44 percentage points in the first year after the shock, before increasing slowly. Generally, based on the existing literature (see Balassa, 1964; Berument & Dincer, 2004; Choudhri & Khan, 2005; Combes et al., 2011; Goldberg & Klein, 1997; Hoffmann & MacDonald, 2009; Ito et al., 1997, 1999; Kallianiotis, 2021; Kim, 1986; Min & Mcdonald, 1993; Rabin & Yeager, 1982; Rodrik, 2008; Samuelson, 1964; Shalishali, 2012; Ulaşan, 2018) four major potential transmission channels are identified through which a one-standard-deviation shock in economic growth in Ethiopia can appreciate the domestic currency. First, in a world with free capital mobility, strong economic growth signals a healthier economy, which attracts foreign investors and encourages ***capital inflows***. Investors from industrialized nations often seek higher returns, even with greater risk, as part of their diversified portfolio. This raises demand for the domestic currency, as it is needed to purchase local assets such as bonds and stocks denominated in the domestic currency. Consequently, these capital inflows put pressure on the exchange rate, causing the domestic currency to appreciate, since investors must acquire it before making investments (Berument & Dincer, 2004; Combes et al., 2011; Goldberg & Klein, 1997; Kallianiotis, 2021; Kim, 1986; Min & Mcdonald, 1993; Rodrik, 2008; Ulaşan, 2018).

Second, economic growth can boost productivity and expand export capacity, leading to an ***improved trade balance***. A stronger trade balance raises demand for the domestic currency, as foreign buyers must exchange their currency to purchase domestic goods and services. Thus, excess demand for cash balances will cause an appreciation of the domestic currency (Balassa, 1964; Rabin & Yeager, 1982; Samuelson, 1964). Third, the ***interest rate*** is another channel through which an economic growth shock can lead to the appreciation of the domestic currency. Strong economic growth often prompts central banks to raise interest rates to avoid overheating or inflation. Higher interest rates make domestic assets more appealing, leading to more foreign capital inflows, and further boosting demand for the domestic currency, which puts additional pressure on the exchange rate to appreciate (Combes et al., 2011; Goldberg & Klein, 1997; Hoffmann & MacDonald, 2009; Shalishali, 2012).

Figure 3: Impulse-Response Functions (IRFs)





Finally, in the theory of ***Balassa-Samuelson's prediction***, another channel for real exchange rate appreciation exists. Numerous studies, including those by Balassa (1964), Choudhri & Khan (2005), Gubler & Sax (2019), Ishaq et al. (2023), Ito et al. (1997, 1999), and Samuelson (1964), have shown that in countries with rapid economic growth, productivity tends to rise more quickly in sectors producing tradable goods (like manufacturing) than in non-tradable sectors (such as services). The Balassa-Samuelson effect predicts that countries with faster productivity growth in tradable sectors will experience real exchange rate appreciation due to rising wages and prices in the non-tradable sector. Japan, along with other Asian countries like Singapore, Hong Kong, Korea, Taiwan, Thailand, and Indonesia, is often cited in the literature as conforming to the Balassa-Samuelson prediction, which highlights the positive link between economic growth and real exchange rate appreciation.

Furthermore, Panel A of Figure 3 from the IRF results indicates that a one-standard-deviation shock to economic growth exerts a positive impact on real exchange rate misalignment starting from the second year, signaling a real devaluation of the domestic currency. This effect begins to dissipate after 10 years. While it is generally expected that economic growth strengthens the domestic currency, numerous studies, including those by Céspedes et al. (2004), Ito et al. (1999), Reinhart & Rogoff (2009), Dornbusch (1976), Mundell (1963), demonstrate that growth shocks can lead to currency depreciation when driven by high debt accumulation, inflation, loose monetary policy, capital flight, or other unsustainable factors. One key factor is when economic growth triggers inflation, reducing purchasing power and undermining investor confidence, which can lead to currency devaluation. Moreover, if growth is accompanied by large deficits or significant debt—particularly foreign-denominated debt—it increases the risk of depreciation, especially when growth is financed through external borrowing. High foreign debt levels raise concerns about repayment capacity, prompting investors to withdraw, which puts pressure on the exchange rate to depreciate.

As illustrated in Panel B of Figure 3, a one standard deviation shock to the real exchange rate misalignment (i.e. undervaluation) has a modest positive effect on economic growth (measured as Real GDP) up until the seventh year. This finding aligns with the VAR estimation, which indicates a modest positive impact from the first lag of the real exchange rate misalignment on economic growth. Although the effect is quite minimal as shown in the IRF result, the largest increase in economic growth is about 0.031 percentage points in the seventh year. After this peak, the effect gradually declines from the eighth to the sixteenth year. Finally, starting from the eighteenth year, the effect becomes permanent and stabilizes. From the IRF results, we observed both the positive and negative effects of real exchange rate misalignment on economic growth in Ethiopia. This highlights the need for a threshold analysis to explore the tipping point at which misalignment influences growth.

In essence, the possible mechanisms through which real exchange rate undervaluation promotes economic growth in Ethiopia include boosting export competitiveness, decreasing reliance on imports, and improving the trade balance. These effects lead to increased investment, consumer confidence, and overall economic activity, creating a reinforcing cycle that supports sustained economic growth. This finding and channels are aligned with the empirical studies by Ayele (2022), Deguenonvo (2017), Elbadawi et al. (2012), Gala & Lucinda (2006), Habib et al. (2016), Mbaye (2013), Pereira & Missio (2022), Razin & Collins (1997), Rodrik (2008), and Ulaşan (2018), which demonstrates that a one standard deviation shock in real exchange rate misalignment (i.e., real undervaluation of the domestic currency) positively influences economic growth.

To elaborate on the above-mentioned possible channels, and as noted by Mbaye (2013), we identify two main channels through which the real exchange rate undervaluation enhances economic growth in Ethiopia. The first pathway, termed the "*capital accumulation channel*," suggests that real exchange rate undervaluation promotes economic growth by boosting the economy's capital stock, a key driver of growth. This concept integrates two forms of capital accumulation. In the first, capital accumulation is concentrated in the tradable goods sector, which sees its share of GDP rise (Razin & Collins, 1997; Rodrik, 2008). In the second, capital stock grows through a general increase in savings and investment (Bhalla, 2008; Razin & Collins, 1997). The second channel is the "*total factor productivity (TFP) growth channel*." This mechanism focuses on the structure of domestic production. A lower real exchange rate - undervaluation, which raises the price of tradable goods relative to non-tradable ones, boosts the profitability of the tradable sector. As production shifts from the non-tradable sector to the more productive tradable sector in response to this price change, overall economic productivity rises, leading to enhanced economic growth.

Conversely, the IRF result also reveals the adverse effect of real exchange rate misalignment (i.e., the real undervaluation of the domestic currency) on economic growth in Ethiopia. Key channels through which undervaluation can harm the Ethiopian economy include increased inflation, distorted price signals, capital flight, deterioration of investor confidence, reduced investment, and negative effects on public debt and sectoral performance. This interpretation aligns with the findings of studies by Ali et al. (2015), Ayele (2022), Bannaga & Badawi (2014), Bird & S. Rajan (2004), Conrad & Jagessar (2018), Couharde & Sallenave (2013), Giordano (2023), Habib et al. (2016), Kebret (1999), Khalid et al. (2024), Krugman & Taylor (1978), Rodrik (2008), Ulaşan (2018), and Williamson (1990). Real exchange rate misalignment can negatively impact economic growth by weakening external competitiveness and causing inefficient allocation of domestic resources (see Ali et al., 2015). Likewise, research by Couharde & Sallenave (2013), Ulaşan (2018), and Kebret (1999) indicates a consistent mechanism whereby devaluation distorts price signals and harms aggregate demand by increasing the cost of imports (causing higher inflation) and discouraging both domestic and foreign direct investments. Moreover, Bird & S. Rajan (2004) noted that devaluation can trigger capital outflows due to declining investor confidence. This result indicates that policymakers must carefully consider these potential negative outcomes when contemplating undervaluation as a strategy for economic management in Ethiopia.

Overall, these conflicting results from IRF analysis regarding the effects of real exchange rate misalignment on economic growth emphasize the critical role of exchange rate policy in promoting sustainable economic development in Ethiopia and highlight the need for a threshold analysis.

Variance Decomposition

Analysis of Variance Decomposition tells us the proportion of the movements due to its own shocks to the other variable. As a result, analyses of variance decomposition, derived from a Vector Autoregression (VAR) estimation, show the extent to which the forecast error variance of a variable is attributed to its own shocks and to shocks from other variables in the system over time.

The variance decomposition analysis results for economic growth, shown in Table 5, column (1), reveal that in the first year, 100% of the variation in economic growth is attributed to its own shocks, with no impact from other variables. However, after 20 years, only 31.1% of the variation is explained by economic growth's own shocks, while 7.5% is attributed to shocks from real exchange rate misalignment. This suggests that economic growth's self-explanatory power diminishes over time, while the exchange rate misalignment's influence increases. Thus, the analysis suggests that real exchange rate misalignment has significant predictive power over economic growth in Ethiopia. On the other hand, the variance decomposition analysis of real exchange rate misalignment, presented in Table 5, column (2), shows that in the first year, 62.6% of the variation is due to its own shocks, with 1.5% explained by economic growth shocks and the rest by other variables. After 10 years, 33.6% of the variation is still attributed to its own shocks, while 2.0% is explained by economic growth shocks. Even after 20 years, the influence of economic growth on the exchange rate remains steady at around 1.9%, indicating a stable relationship between the two variables. However, the self-explanatory power of real exchange rate misalignment decreases over time.

Table 5: Variance Decomposition of Economic Growth & Real Exchange Rate Misalignment

Horizon (Periods)	Variance Decomposition of Economic Growth		Variance Decomposition of Real Exchange Rate Differ-	
	Economic Growth	Real Exchange Rate Differen-	Economic Growth	Real Exchange Rate Differen-
1	1	0	0.015325	0.626424
2	0.909842	0.025366	0.024938	0.495559
3	0.759053	0.032366	0.02178	0.425329
4	0.644381	0.041443	0.018301	0.376028
5	0.558413	0.045319	0.017291	0.350558
6	0.504203	0.055644	0.018491	0.341669
7	0.464344	0.067046	0.019996	0.338575
8	0.434747	0.077052	0.020532	0.336637
9	0.411821	0.083385	0.020333	0.33601
10	0.393254	0.085748	0.019997	0.335871
11	0.378888	0.085746	0.019706	0.335069
12	0.367933	0.084793	0.019462	0.333727
13	0.358788	0.083504	0.01931	0.332553
14	0.350131	0.081979	0.019272	0.331886
15	0.341738	0.080311	0.019291	0.33159
16	0.334046	0.078728	0.01931	0.33146
17	0.327295	0.077419	0.01932	0.331421
18	0.321341	0.07643	0.019323	0.331432
19	0.315936	0.0757	0.019322	0.331446
20	0.310952	0.075151	0.019317	0.331443

In summary, the key insight from the variance decomposition analysis of the two variables is that, in the short term, most of the variance in both economic growth and the real exchange rate misalignment is explained by their own shocks. However, over time, these variables increasingly account for each other's variance, indicating a growing interdependence between economic growth and the real exchange rate misalignment in Ethiopia. Another important takeaway is that one variable progressively explains more of the variance in another variable, highlighting that shocks to one variable have predictive power and are important for understanding the future behavior of the other variable.

Threshold Effects of RER Misalignments on Economic Growth

Recent evidence shows that the impact of real exchange rate misalignments on economic growth depends on both the direction (undervaluation or overvaluation) and the threshold level of the misalignment (Amor et al., 2020; Couharde & Sallenave, 2013; Tipoy et al., 2018). Studies (e.g., Aguirre & Calderón, 2005; Razin & Collins, 1997; Rodrik, 2008; Ulaşan, 2018) find that large over- or undervaluation harms economic growth, while moderate undervaluation can boost it (e.g., Aguirre & Calderón, 2005; Couharde & Sallenave, 2013; Gala & Lucinda, 2006; Mbaye, 2013; Rodrik, 2008). These findings

indicate that misalignment effects may switch from positive to negative—or vice versa—beyond specific thresholds (see Amor et al., 2020). Identifying these thresholds is crucial for policymakers, as it enables the design of targeted measures to correct misalignments before they severely constrain economic growth.

Before estimating the threshold growth models, multicollinearity was assessed using the variance inflation factor (VIF). As shown in Appendix D, all the mean VIF values were below 10, indicating the absence of multicollinearity in the model. Subsequently, the empirical results from Hansen's (2000) threshold regression models are presented in Tables 6 and 7.

Table - 6: Threshold Regression for Growth Model: Threshold Variable - Undervaluation

	Model -1	Model - 2	Model -3
Threshold Test	Test for threshold effects		
F_1	4.11	2.87	2.07
Bootstrap P-value	0.012	0.043	0.432
Threshold Estimate	**7.84**	**13.95**	**24.03**
Lower Regime ($\leq \tau$)			
MIS_t^+ **Coeff**	1.305** (0.046)	1.037** (0.019)	0.730 (0.233)
INF		-0.147 (0.232)	-0.160 (0.204)
OPN			25.663 (0.477)
Upper Regime (>τ)			
MIS_t^+ **Coeff**	-0.057** (0.004)	-0.065*** (0.000)	-0.067*** (0.000)
INF		-0.161*** (0.000)	-0.170*** (0.000)
OPN			7.402 (0.496)

The null hypothesis of the threshold test is the absence of a threshold effect.
The number inside parentheses are P-values: ***, **, and * imply significance at 1%, 5%, and 10%, respectively.

The results in Table 6 reveal a threshold effect in the relationship between undervaluation and economic growth across three threshold regression models: model-1, model-2, and model-3. The identified threshold for undervaluation ranges from 7.84% to 24.03%, with approximately 71% of observations falling within the lower undervaluation regime (undervaluation $\leq \tau$).

Undervaluations within the range of 0%–13.95% have a significant positive effect on economic growth, with a coefficient of 1.037 at a 5% significance level. However, undervaluations exceeding the 13.95% threshold exhibit a statistically significant negative effect (−0.065) at the 1% significance level. In Ethiopia, moderate undervaluation could foster economic growth through various mechanisms, including the export competitiveness channel, import substitution channel, savings and investment channel, employment channel, and productivity growth channel.

By reducing the cost of domestic goods and services in foreign markets, mild undervaluation enhances the competitiveness of export-oriented industries. These industries drive economic growth by improving the trade balance and expanding export activities (see Béreau et al., 2009; Deguenonvo, 2017; Dooley et al., 2003; Rodrik, 2008). Within the savings and investment channel, undervaluation boosts profitability in tradable sectors by raising their price in domestic currency. This results in higher savings for both corporations and households, which in turn fosters increased private and public investment. The subsequent expansion of the economy's capital stock drives growth (see Bhalla, 2008; Mbaye, 2013; Razin & Collins, 1997; Rodrik, 2008).

Additionally, undervaluation supports the expansion of labor-intensive tradable industries, crucial for reducing unemployment and poverty, particularly in developing economies like Ethiopia (see Zou & Wang, 2017). A moderate undervaluation also stimulates "learning by doing" in export-oriented sectors by offering price incentives. This process facilitates access to advanced technology and innovation through trade, boosting economic growth via the total factor productivity channel (see Mbaye, 2013).

In contrast, as shown in Table 6, undervaluations exceeding thresholds of 13.95% have a statistically significant negative effect on economic growth in Ethiopia. This adverse impact can be understood through several key channels. First, excessive undervaluation increases import costs, driving inflation, which erodes consumer purchasing power and raises production costs (see Auboin & Ruta, 2011; Edwards, 1989; Khalid et al., 2024; Rodrik, 2008). Second, large devaluation distorts price signals, undermining investor confidence and aggregate demand by elevating the cost of imported goods and discouraging both domestic and foreign direct investment (see Couharde & Sallenave, 2013; Kebret, 1999; Ulaşan, 2018). Prolonged inflation may also trigger capital outflows as investors seek more stable environments, reducing the capital available for domestic development (see Bird & S. Rajan, 2004).

Although undervaluation may initially enhance export competitiveness, persistent inflation eventually diminishes this advantage, weakening the trade balance and contributing to long-term trade deficits (see Ali et al., 2015). Furthermore, a weaker currency increases the cost of servicing foreign debt, imposing financial strain on both the government and private sector (see Grekou, 2018). Excessive undervaluation can also distort economic incentives, diverting resources toward less productive activities instead of fostering long-term growth sectors like innovation (see Ali et al., 2015). Ultimately, the combined effects of reduced investment, high inflation, and capital flight result in weaker economic growth, creating a cyclical negative impact that hinders sustainable development.

In Model – 3 of Table 6, undervaluations within the range of 13.95% to 24.03% produce an insignificant positive effect (0.730) on economic growth, while undervaluations exceeding 24.03% have a statistically significant negative impact (−0.067) at the 1% level. As previously noted, undervaluations below 13.95% have a positive and significant effect, likely because they fall within a "sweet spot" where the advantages of undervaluation remain largely intact. However, the range between 13.95% and 24.03% may represent a critical threshold where the positive impacts of undervaluation begin to wane. This can be attributed to several factors. First, Ethiopia’s export structure limits the benefits of further currency undervaluation beyond a certain point. The country’s exports are heavily reliant on low-value agricultural commodities, such as coffee, khat, and sesame, which face inelastic demand and limited scalability. Once these sectors reach their maximum export potential, additional undervaluation contributes minimally to revenue or production, constraining its impact on economic growth.

Second, undervaluation increases the cost of imported goods, including essential inputs like fuel, machinery, and intermediate products. Ethiopia's dependence on imports for capital goods and consumer

products amplifies inflationary pressures, which erode the initial price advantage provided by undervaluation. Rising inflation drives up production costs, diminishing the real economic benefits of undervaluation over time. Thus, persistent inflation further undermines the effectiveness of undervaluation in stimulating growth. Finally, excessive undervaluation can cause economic imbalances by redirecting resources from non-tradable sectors to tradable ones. Non-tradable sectors, which are significant contributors to Ethiopia's economic growth and less affected by undervaluation, may suffer from this resource shift, reducing the overall positive impact of undervaluation on growth.

Table 7 provides evidence of a threshold effect in the relationship between overvaluation and economic growth for models 1, 2, and 3, significant at the 1% level. The threshold for overvaluation lies between -6.88% and -7.15%, with approximately 57% of observations falling within the lower overvaluation regime (Overvaluation $\leq \boldsymbol{\tau}$). An overvaluation rate below the -7.15% threshold has a significant positive effect on growth (0.446), whereas overvaluations beyond this threshold yield a statistically insignificant positive impact (0.010). Conversely, overvaluations exceeding the -7.01% threshold show a statistically insignificant negative effect (-0.351). These findings suggest that the relationship between exchange rate overvaluation and economic growth in Ethiopia varies depending on the degree of overvaluation, with distinct behaviors observed in the lower and upper regimes. The subsequent discussion elaborates on these results and explores the potential channels through which these effects manifest.

Table - 7: Threshold Regression for Growth Model: Threshold Variable - Overvaluation

	Model -1	Model - 2	Model - 3
Threshold Test	Test for threshold effects		
F_1	5.91	5.40	3.69
Bootstrap P-value	0.003	0.001	0.006
Threshold Estimate	**-6.88**	**-7.01**	**-7.15**
Lower Regime ($\leq \tau$)			
MIS_t^- **Coeff**	0.413*** (0.009)	0.371*** (0.003)	0.446*** (0.001)
INF		-0.063** (0.032)	-0.073** (0.015)
OPN			24.800 (0.148)
Upper Regime (>τ)			
MIS_t^- **Coeff**	-0.222 (0.789)	-0.351 (0.613)	0.010 (0.993)
INF		-0.426** (0.028)	-0.419** (0.036)
OPN			27.451 (0.673)

The null hypothesis of the threshold test is the absence of a threshold effect.
The number inside parentheses are P-values: ***, **, and * imply significance at 1%, 5%, and 10%, respectively.

When the exchange rate is overvalued by less than 7.15% in absolute value, the local currency remains relatively strong without being excessively so. As shown in Table 7, this moderate overvaluation has a significant and positive impact on economic growth in Ethiopia, supported by both theoretical and empirical evidence through several mechanisms. First, a mildly overvalued currency (below the 7.15% threshold) reduces the cost of imported inputs for domestic producers, lowering production expenses and enhancing productivity in key sectors like manufacturing and agriculture. This cost reduction improves the competitiveness of Ethiopian exports, particularly price-sensitive agricultural goods such as coffee and textiles, in international markets. The resulting increase in export revenues generates critical foreign exchange, which helps finance essential imports, stimulate investment, and drive domestic consumption, directly boosting economic growth.

Second, a stable and moderately overvalued exchange rate signals economic stability, attracting both domestic and foreign investment. This environment encourages capital inflows and investment in infrastructure and industry, with foreign direct investment (FDI) becoming more appealing. A slightly overvalued currency also reduces the cost of imported capital goods, facilitating industrialization and infrastructure development. Ethiopia's economy, which relies heavily on imported machinery and technology, benefits significantly from these reduced costs.

Third, moderate overvaluation can contribute to economic growth by serving as a tool for price stability and inflation control. A mildly overvalued currency makes imports cheaper, mitigating inflationary pressures and creating a favorable environment for economic activity. Additionally, it helps curb imported inflation by reducing the cost of imported consumer goods and intermediate inputs, stabilizing domestic market prices. Finally, lower prices of imported goods due to slight overvaluation enhance household purchasing power, encouraging consumption and boosting aggregate demand. This has a positive social welfare effect, as cheaper imports improve access to essential goods like food, medicine, and fuel. This is particularly beneficial for low-income households, enhancing living standards across the country.

Generally, Ethiopia's reliance on imported inputs for infrastructure and industrialization, coupled with its focus on increasing export revenues, makes these mechanisms particularly relevant. Evidence from other developing economies suggests that a carefully managed, mildly overvalued exchange rate supports economic growth by balancing competitiveness with the affordability of imports.

The negative but insignificant effect of the upper regime (overvaluation above 7.01%) on economic growth suggests that overvaluation beyond this threshold may impede growth. However, the lack of statistical significance indicates insufficient evidence to establish a strong or conclusive relationship. This could be attributed to factors such as high variability in the data or the influence of mitigating elements (stabilizing factors) like policy interventions, external shocks, or structural characteristics of the economy that weaken the observed effect.

Finally, as seen in Table 7, the differing signs in the upper regimes (overvaluation above 7.01% and above 7.15%) in the threshold analysis may reflect the complex, non-linear relationship between overvaluation and growth, where the threshold effect is influenced by both the degree of overvaluation and the specific context in which it occurs. The variation in signs between the two upper regimes could be attributed to the following two factors. First, the relationship between overvaluation and economic growth may not follow a strict linear pattern. Between 7.01% and 7.15%, certain factors, such as adjustments in monetary policy (for example, devaluation by NBE) or external influences (e.g., international trade conditions, investments, or capital flows), could temporarily reduce the negative effects of overvaluation. This might explain why overvaluation above 7.01% shows a negative but insignificant effect, while overvaluation above 7.15% exhibits a positive but insignificant effect.

Second, there could be a threshold interaction where overvaluation beyond a certain level (7.15%) is still seen as manageable, or the economy may be adjusting in ways that mitigate its adverse impact on growth. For example, exporters might adapt to exchange rate changes, or the government might introduce compensatory policies, leading to a positive but insignificant relationship in the higher overvaluation regime.

CONCLUSION AND POLICY IMPLICATIONS

In the open economy setting, the exchange rate remains a key policy tool, as ineffective currency management can lead to significant economic challenges and welfare losses. For many least-developed countries in Africa, ongoing foreign currency shortages combined with persistent current account and fiscal deficits, increasing external debt service obligations, and high inflation continue to be major policy issues. Consequently, this paper primarily aims to assess the effects of real exchange rate misalignments on Ethiopia's economic growth. To achieve this, we calculated fundamental real exchange rate misalignments by measuring deviations of the actual real exchange rate from its long-term equilibrium level. The Behavioral Equilibrium Exchange Rate (BEER) approach is employed to estimate the long-term equilibrium real exchange rate in Ethiopia. After computing the fundamental real exchange rate misalignments, we analyzed their impact on Ethiopia's economic growth using the VAR and Threshold Regression models.

Analyzing the time series data spanning from 1980 to 2022, we found the following key results: First, Ethiopia’s real exchange rates exhibit a high degree of misalignment, with three distinct episodes of both undervaluation and overvaluation throughout the period. At no point during the sample period did the actual real exchange rate align closely with its equilibrium value. This persistent misalignment may partly result from unsuitable macroeconomic, trade, and exchange rate policies in Ethiopia (see Habib et al., 2016; Ulaşan, 2018). Second, results from the VAR estimation and Impulse Response Function (IRF) analysis indicate that real exchange rate differentials have an immediate and significantly positive effect on economic growth, which diminishes gradually from the eighth to the sixteenth year, and then the effect becomes permanent and stabilizes in the long run. Similarly, the IRF results reveal that economic growth shocks positively impact real exchange rate misalignment beginning in the second year, leading to a real devaluation of the domestic currency. This effect starts to wane after 10 years.

Finally, findings from Hansen's (2000) threshold growth model indicates that the impact of currency misalignments depends on their direction (undervaluation or overvaluation) and magnitude, underscoring the critical role of exchange rate levels in explaining variations in growth rates. Specifically, overvaluation with an absolute value below the 7.15% threshold significantly boosts growth, whereas overvaluation beyond 7.01% has a negative but statistically insignificant effect. Conversely, undervaluation below 13.95% positively influences growth, while undervaluation exceeding 13.95% has a statistically significant negative effect.

This study’s empirical findings supported the Ethiopian Government's move to adopt a market-based exchange rate policy on July 29, 2024. The study by Dakoure et al. (2023) on Sub-Saharan African countries and Khalid et al. (2024) on Turkey indicates that real exchange rate misalignment tends to be more pronounced and persistent in countries with fixed exchange rate systems compared to those with floating regimes. Therefore, we believe that the recent Ethiopian government exchange rate policy reform will help to mitigate the extent of real exchange rate misalignment and reduce its persistence.

As discussed, the IRF results revealed both positive and negative effects of real exchange rate misalignment on Ethiopia's economic growth between 1980 and 2022. This finding suggests that undervaluing the domestic currency does not necessarily lead to positive economic growth. Thus, this study underscores that policymakers must carefully consider the potential negative impacts of misalignment on growth when contemplating devaluation as a strategy for economic management in Ethiopia. Moreover, the paper has highlighted the mixed findings on the effects of real exchange rate misalignment on economic growth, underscoring the essential role of exchange rate policy in fostering sustainable economic development in Ethiopia. It also stresses the need for the adoption of an effective exchange rate regime alongside consistent macroeconomic policies to close the gap between the actual real exchange rate and its equilibrium value.

Finally, the policy implications for Ethiopia, based on the threshold regression results, emphasize the importance of avoiding prolonged overvaluation, particularly when it exceeds the 7.01% threshold. Instead, maintaining a competitive exchange rate with an undervaluation of up to 13.95% can foster growth. However, undervaluation alone is not enough to sustain long-term economic growth. This requires complementary macroeconomic policies, including sound monetary and fiscal measures, along with structural reforms that enhance capital accumulation, foster research and development, and encourage trade openness.

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APPENDIX

Appendix Table A1: Optimal Lag Order Selection Criteria for the economic growth model

Lag-order selection criteria

Sample: 1982 thru 2022 Number of obs = 41

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-56.9664				3.3e-09	3.16909	3.29085	3.50345
1	211.27	536.47	64	0.000	1.6e-13	-6.79368	-5.6979*	-3.78448*
2	285.075	147.61*	64	0.000	1.5e-13*	-7.27196*	-5.20215	-1.58792

* optimal lag
Endogenous: lnrgdp lnrge lnrpcr lntt lnrexrdf lninf lnrdf lnrnfa
Exogenous: _cons

Appendix Table A2: Engle-Granger Test for Cointegration for the Economic Growth Model

Dickey-Fuller test for unit root — Number of obs = 40
Variable: error — Number of lags = 0

H0: Random walk without drift, a = 0, d = 0

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	-5.496	-2.636	-1.950	-1.606

Appendix Table A3: Vector Autoregression (VAR) Estimation of the Economic Growth Mode

Vector autoregression

Sample: 1982 thru 2022 — Number of obs = 41
Log likelihood = 285.0752 — AIC = -7.271961
FPE = 1.47e-13 — HQIC = -5.202146
Det(Sigma_ml) = 1.26e-16 — SBIC = -1.587918

Equation	Parms	RMSE	R-sq	chi2	P>chi2
lnrgdp	17	.014844	0.9991	43919.5	0.0000
lnrge	17	.133637	0.9739	1532.142	0.0000
lnrpcr	17	.101997	0.9953	8770.016	0.0000
lntt	17	.100429	0.6190	66.62313	0.0000
lnrexrdf	17	.169328	0.8247	192.872	0.0000
lninf	17	.72151	0.5069	42.14757	0.0004
lnrdf	17	.138051	0.9302	546.1551	0.0000
lnrnfa	17	1.02021	0.3593	22.98913	0.1140

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
lnrgdp						
lnrgdp						
L1.	.7560284	.1756756	4.30	0.000	.4117107	1.100346
L2.	.1409132	.1722553	0.82	0.413	-.196701	.4785273
lnrge						
L1.	.0026431	.0147844	0.18	0.858	-.0263337	.0316199
L2.	-.011655	.0156695	-0.74	0.457	-.0423666	.0190566
lnrpcr						
L1.	.0224925	.0215856	1.04	0.297	-.0198145	.0647994
L2.	.0003892	.0157248	0.02	0.980	-.0304309	.0312092
lntt						
L1.	-.0291705	.026924	-1.08	0.279	-.0819405	.0235996
L2.	-.0080981	.0268151	-0.30	0.763	-.0606548	.0444586
lnrexrdf						
L1.	.0242827	.014328	1.69	0.090	-.0037996	.0523651
L2.	-.0050869	.0139614	-0.36	0.716	-.0324508	.0222769
lninf						
L1.	-.0008108	.0032978	-0.25	0.806	-.0072744	.0056528
L2.	-.0047472	.0028414	-1.67	0.095	-.0103162	.0008218
lnrdf						
L1.	.0208424	.0075067	2.78	0.005	.0061296	.0355552
L2.	.0230902	.0094251	2.45	0.014	.0046173	.0415631
lnrnfa						
L1.	-.0044428	.0026402	-1.68	0.092	-.0096175	.0007319
L2.	-.0039735	.0024794	-1.60	0.109	-.008833	.000886
_cons	1.458074	.5838246	2.50	0.013	.3137989	2.602349

Note: The VAR estimation results for the model with the other seven variables are not reported, as they are not the focus of this study.

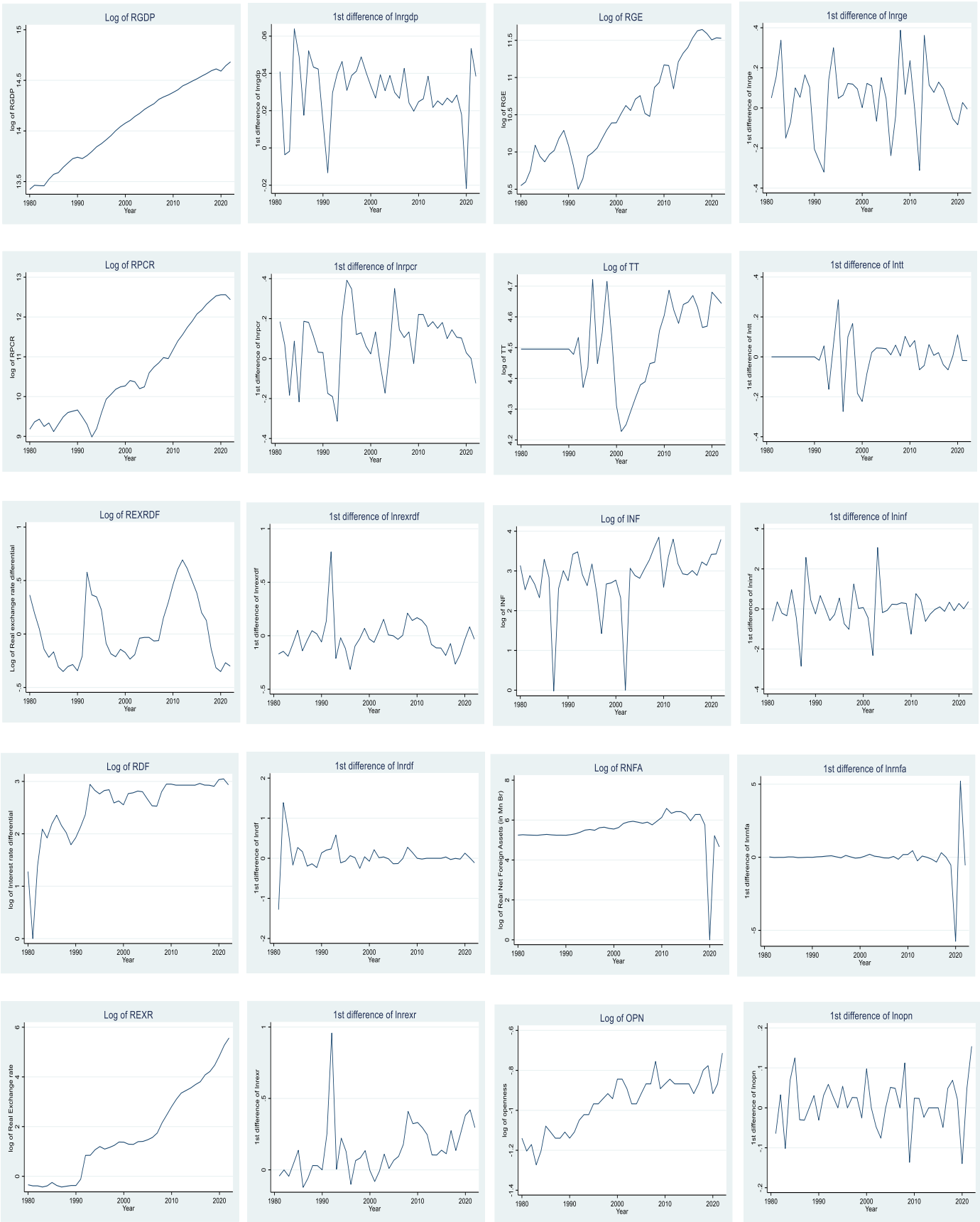
Appendix Table A4: Granger Causality Tests

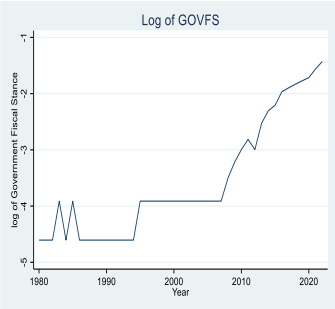
Equation	Excluded	chi2	df	Prob > chi2
lnrgdp	lnrge	.57024	2	0.752
lnrgdp	lnrpcr	1.9579	2	0.376
lnrgdp	lntt	1.5682	2	0.457
lnrgdp	lnrexrdf	4.6153	2	0.099
lnrgdp	lninf	2.8025	2	0.246
lnrgdp	lnrdf	21.666	2	0.000
lnrgdp	lnrnfa	5.6417	2	0.060
lnrgdp	ALL	50.552	14	0.000
lnrge	lnrgdp	18.326	2	0.000
lnrge	lnrpcr	7.1494	2	0.028
lnrge	lntt	1.3122	2	0.519
lnrge	lnrexrdf	3.1263	2	0.209
lnrge	lninf	1.3861	2	0.500
lnrge	lnrdf	9.1465	2	0.010
lnrge	lnrnfa	7.7696	2	0.021
lnrge	ALL	61.292	14	0.000
lnrpcr	lnrgdp	3.6525	2	0.161
lnrpcr	lnrge	11.857	2	0.003
lnrpcr	lntt	3.7239	2	0.155
lnrpcr	lnrexrdf	25.89	2	0.000
lnrpcr	lninf	4.5359	2	0.104
lnrpcr	lnrdf	2.5456	2	0.280
lnrpcr	lnrnfa	1.9275	2	0.381
lnrpcr	ALL	96.83	14	0.000
lntt	lnrgdp	2.0734	2	0.355
lntt	lnrge	1.6618	2	0.436
lntt	lnrpcr	1.6269	2	0.443
lntt	lnrexrdf	2.1118	2	0.348
lntt	lninf	1.1301	2	0.568
lntt	lnrdf	2.0199	2	0.364
lntt	lnrnfa	.19	2	0.909
lntt	ALL	13.879	14	0.459
lnrexrdf	lnrgdp	14.329	2	0.001
lnrexrdf	lnrge	.34283	2	0.842
lnrexrdf	lnrpcr	5.5616	2	0.062
lnrexrdf	lntt	1.8486	2	0.397
lnrexrdf	lninf	2.4996	2	0.287
lnrexrdf	lnrdf	4.5587	2	0.102
lnrexrdf	lnrnfa	2.0385	2	0.361
lnrexrdf	ALL	20.163	14	0.125
lninf	lnrgdp	11.27	2	0.004
lninf	lnrge	2.2463	2	0.325
lninf	lnrpcr	9.3189	2	0.009
lninf	lntt	10.65	2	0.005
lninf	lnrexrdf	.31484	2	0.854
lninf	lnrdf	14.139	2	0.001
lninf	lnrnfa	1.3759	2	0.503
lninf	ALL	38.278	14	0.000
lnrdf	lnrgdp	1.5871	2	0.452
lnrdf	lnrge	17.24	2	0.000
lnrdf	lnrpcr	4.2497	2	0.119
lnrdf	lntt	1.6161	2	0.446
lnrdf	lnrexrdf	5.0639	2	0.080
lnrdf	lninf	2.171	2	0.338
lnrdf	lnrnfa	1.5399	2	0.463
lnrdf	ALL	82.956	14	0.000
lnrnfa	lnrgdp	2.1853	2	0.335
lnrnfa	lnrge	3.1816	2	0.204
lnrnfa	lnrpcr	4.8857	2	0.087
lnrnfa	lntt	1.8306	2	0.400
lnrnfa	lnrexrdf	8.7421	2	0.013
lnrnfa	lninf	3.24	2	0.198
lnrnfa	lnrdf	1.1672	2	0.558
lnrnfa	ALL	18.975	14	0.166

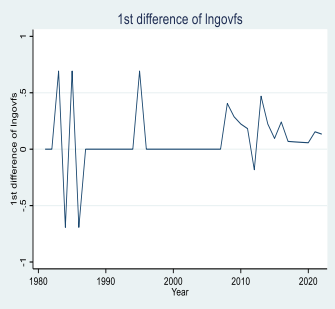
Appendix Table A5: Equilibrium and Actual Real Exchange Rate & Misalignment

Year	Equilibrium Real exchange rate	Actual Real exchange rate	Misalignment	Outcome
1980	0.49286	0.71	0.2171399	**Undervaluation**
1981	0.5595857	0.68	0.1204143	
1982	0.6475456	0.68	0.0324544	
1983	0.7497503	0.65	-0.0997503	**Overvaluation**
1984	0.8455863	0.68	-0.1655863	
1985	0.9217678	0.78	-0.1417679	
1986	0.938943	0.69	-0.248943	
1987	0.9231753	0.65	-0.2731754	
1988	0.9079581	0.67	-0.2379581	
1989	0.918265	0.69	-0.228265	
1990	0.9727262	0.69	-0.2827262	
1991	1.09361	0.89	-0.2036102	
1992	1.301343	2.32	1.018657	**Undervaluation**
1993	1.615437	2.33	0.7145633	
1994	2.056178	2.91	0.8538225	
1995	2.635883	3.31	0.6741168	
1996	3.262341	2.99	-0.2723415	**Overvaluation**
1997	3.838767	3.19	-0.648767	
1998	4.290917	3.47	-0.8209174	
1999	4.581003	3.97	-0.6110027	
2000	4.69598	3.95	-0.7459795	
2001	4.603102	3.64	-0.9631021	
2002	4.37875	3.61	-0.76875	
2003	4.192447	4.03	-0.162447	
2004	4.201321	4.07	-0.131321	
2005	4.490369	4.35	-0.1403694	
2006	5.102291	4.78	-0.3222904	
2007	6.071234	5.71	-0.3612342	
2008	7.404664	8.6	1.195337	**Undervaluation**
2009	8.870376	11.88	3.009624	
2010	10.43996	16.55	6.110036	
2011	12.14562	22.23	10.08438	
2012	14.21814	28.44	14.22186	
2013	17.12068	31.58	14.45932	
2014	21.26946	35.03	13.76054	
2015	27.38478	40.2	12.81522	
2016	36.84494	45	8.15506	
2017	52.15485	59.22	7.065151	
2018	77.80792	67.81	-9.997925	**Overvaluation**
2019	119.8362	87.48	-32.35624	
2020	182.0937	128.14	-53.95366	
2021	254.9325	194.9	-60.0325	
2022	353.7232	261.99	-91.73322	

Appendix Figure A1: Graphical plots of variables







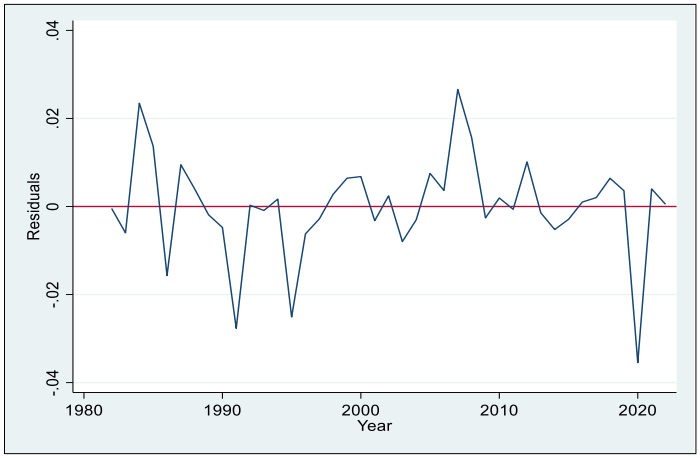
Appendix C: VAR stability condition and residual diagnostic tests

C1: Stability condition

Eigenvalue	Modulus
.9837559	.983756
.7799598 + .2380498i	.815478
.7799598 - .2380498i	.815478
.3146082 + .723289i	.788749
.3146082 - .723289i	.788749
.5990873 + .2839422i	.66297
.5990873 - .2839422i	.66297
-.02415844 + .620934i	.621404
-.02415844 - .620934i	.621404
-.302545 + .2858375i	.416217
-.302545 - .2858375i	.416217
-.321385 + .2038197i	.380566
-.321385 - .2038197i	.380566
.2882787 + .1575953i	.328544
.2882787 - .1575953i	.328544
.02829111	.028291

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

C2: Residual diagnostic test



C3: Autocorrelation test

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	59.5257	64	0.63524
2	63.3615	64	0.49905
3	68.5751	64	0.32500

H0: no autocorrelation at lag order

Appendix D: Threshold growth model VIF test

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
mis_positi~m |      1.91    0.522586
mis_negati~m |      1.73    0.579611
         OPN |      1.59    0.628680
         INF |      1.33    0.753975
-------------+----------------------
    Mean VIF |      1.64
```

Appendix E: Forecasted Equilibrium Nominal Exchange Rate for the 2023-2028 period

Year	2023	2024	2025	2026	2027	2028
Forecasted Equilibrium Nominal Exchange Rate	85.57	101.77	121.15	144.32	172.03	205.17

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