Innovations

Effects of Exchange Rate and Exports on the Economic Growth of India and Ethiopia: A Panel Data Analysis

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Abstract: *This study investigates how exchange rates and exports influence the economic growth of India and Ethiopia, using balanced panel data from 1990 to 2025. Employing models with both random and fixed effects where the test of Hausman determines the preferred approach, the analysis reveals that remittances, inflation, and foreign exchange rates significantly and positively impact real GDP growth in both nations. Conversely, unemployment exerts a significant negative effect. Additionally, foreign direct investment (FDI) demonstrates a statistically outstanding positive connection with the growth of the economy. These findings highlight the critical role of stable exchange rate management, investment promotion, and labor market reforms in achieving sustained economic progress. The study recommends that macroeconomic policies be better targeted, the financial sector be reinforced, and labor market policies be enhanced to maximize growth. Overall, these insights contribute to the broader discussion on exchange rate policies, trade, and development strategies in emerging economies.*

Key words: Exchange Rate, Economic Growth, Panel Data Analysis, India, Ethiopia

JEL Code: F31, F43, C33, E24, O16

1.0. Introduction

Exchange rate dynamics in Ethiopia and India present distinct challenges shaped by their economic structures and policy environments. In Ethiopia, nominal exchange rate depreciation is linked to government spending, broad money supply, and interest rates, reflecting the effects of fiscal and monetary expansion (Simeneh, 2020). Trade imbalances and low foreign exchange reserves further accelerate the depreciation of the Ethiopian birr (ADB, 2022). In contrast, India experiences

significant navigation of exchange rates to import pricing, with this effect being complete in the short-run and even stronger over the long-run, contributing to sustained inflation (Yanamandra, 2015; Dua et al., 2021). India's managed float system and open capital account make its exchange rate more responsive to global market changes. Conversely, Ethiopia's closed financial system and state-controlled banking sector limit exchange rate flexibility (Jacob et al., 2021; Sreenu et al., 2022).
Sharma (2020) employs monthly panel data from 2012 to 2017 to examine exchange rate risk and export performance. Sharma (2020) uses monthly panel data from 2012 to 2017 to analyze exchange rate risk and commodity-level export performance in India. The study finds that both real and nominal exchange rate volatility significantly hinders long-term export performance, with nominal volatility having a greater impact. In the short term, nominal exchange rate changes also negatively affect exports, but to a lesser degree. This implies that short-term exchange rate risks can be partially hedged. Sharma emphasizes the importance of stable exchange rates and reduced uncertainty for sustained export growth. 4% to 26.7% due to credit expansion and supply chain disruptions. The fiscal deficit improved slightly, the banking sector remained stable but was closed to international competition, and public debt was 57.8% of GDP (ADB, 2022). Studies on India's exchange rates and inflation show that exchange rate pass-through has long-lasting effects on inflation (Dua et al., 2021; Yanamandra, 2015; Jacob et al., 2021; Sreenu et al., 2022). In Ethiopia, however, studies show that government spending, the broad money supply, and interest rates are the main drivers of the birr's depreciation (Simeneh, 2020).
Using disaggregated sectoral data and ARDL methods, Jyoti and Bhatt (2022/2024) look at how changes in the exchange rate affect India's manufacturing exports. They discover varied impacts: sectors such as chemicals, engineering goods, and textiles gain from moderate volatility, whereas electronics and other manufactured goods suffer adverse effects in the near and distant future. The results show that some industries can adapt and become more competitive when volatility is controlled, suggesting India could pursue sector-specific policies such as targeted support for vulnerable manufacturing industries and incentives to encourage hedging against exchange rate fluctuations.
Between 2003 and 2017, Ethiopia's economy grew at a rate of more than 10% per year. But in the last four years, a number of problems have come up that make it hard to keep the growth rate up and move the country from a low-income to middle-income country and beyond (Andualem, 2021). The economy of Ethiopia in 2023 is complicated. Growth is slow and uneven, there are problems with the budget, and people are vulnerable socially. The government says the economy is growing at a strong 7.2 percent, but independent estimates say it's only growing at a modest 4.5 percent. The services sector is doing well, even though the manufacturing base is

weak. The country is having a hard time getting foreign currency, with reserves below USD 1 billion. This has caused the Birr to be very overvalued, with rates in official and parallel markets being very different.

India is still the world's fastest-growing major economy in 2024, with GDP growth estimates for the fiscal year 2024–25 ranging from 6.5% to 6.9%. The International Monetary Fund (IMF) says that India's RGDP will increasse by 6.5% in both 2024/25 and 2025/26. This growth will be fueled by strong private consumption and a stable economy (IMF, 2024). The World Bank agrees with this positive outlook, predicting a growth rate of 6.6% for FY2024/25 and 6.7% for FY2025/26. They say that India's strength comes from strong public and private investment (World Bank, 2024). The Asian Development Bank (ADB) also predicts that India's economy will grow by 6.5% in both FY2025/26 and FY2026/27 (ADB, 2024).

This study tests two main ideas, based on differing views on how exchange rates influence economic growth. First, it looks for a possible negative link (H0) versus a positive link (H1) between exchange rates and economic growth. Second, it tests whether fixed or random effects better explain the relationship between Ethiopia and Indian growth and exchange rates; H0 suggests a fixed effect, while H1 suggests a random effect.

2.0. Review of Literature

It is considered crucial to analyze both theoretical and empirical studies regarding the influence of exchange rates on international trade flows, particularly in the context of current events and from an interdisciplinary viewpoint. The empirical study examines the correlation between recent exchange rate declines and the economic development of Ethiopia and India.

2.1. Concepts and Theories on Exchange Rate

Theories regarding the determination of exchange rates have evolved significantly over time, reflecting the varying valuations of currencies by different schools of thought. Krugman and Obstfeld, Lipsey and Chrystal, and Samuelson all say that the rate of exchange is arelative price between currencies that supply and demand have an impact on both goods and financial markets. Keynes elaborates on this viewpoint by highlighting the impact of liquidity preference, speculation, and expectations, suggesting that investor sentiment can induce exchange rate fluctuations that surpass fundamental factors. Bjørnland and colleagues have conducted empirical tests and extensions that corroborate these dynamics. They demonstrate that exchange rates frequently respond rapidly to monetary shocks before gradually establishing long-term equilibria. Ito and Kawai (2017) recently talked about how monetary integration and regional spillovers affect exchange rates. Obstfeld (2020)

reexamined open-economy macro models to incorporate financial globalization and enduring disparities from purchasing power parity.

Recent empirical research continues to enhance and broaden the theoretical frameworks established on these foundations. Chen and Rogoff (2019) illustrate that exchange rate misalignments persist in both advanced and emerging economies due to prolonged adjustment processes. Habib et al., (2020) highlight the worsening of overshooting and susceptibility in developing economies as a result of global financial cycles, while Aizenman et al., (2021) provide evidence that capital mobility and policy credibility substantially influence volatility. Recent studies, such as those by Ilzetzki et al., (2021), demonstrate the evolution of exchange rate regimes and their impact on stability, while Bahmani-Oskooee and Saha (2023) confirm nonlinear adjustment processes between exchange rates and trade balances. These theoretical and empirical contributions collectively underscore that exchange rates are shaped by a complex interplay of relative prices, monetary fundamentals, expectations, and institutional dynamics, with contemporary evidence affirming the enduring relevance of both classical and modern models.

2.1.1. Structure of the World Exchange Rate

The world rate of exchange system has changed a lot over time because of changes in the economy and new technologies. The Gold Standard was the most important thing in the 19th and early 20th centuries. It meant that currencies were tied to a certain amount of gold, which made exchange rates stable but limited flexibility (Eichengreen, 1996). This system had fixed exchange rates based on the amount of gold in each currency. This kept prices stable, but it made it harder for countries to deal with economic shocks.

The Bretton Woods system was put in place in 1944 after the Gold Standard fell apart. It lasted until 1971. During this time, currencies had fixed but adjustable exchange rates, and national currencies were linked to the U.S. dollar, which could be changed into gold at a set rate. This setup helped keep exchange rates stable, but it also allowed for periodic changes in response to macroeconomic pressures. The U.S. dollar became the most important reserve currency and central anchor in the international monetary system (Obstfeld, 2024).

The world moved to floating exchange rates after Bretton Woods fell apart. This means that the value of a currency is set by how much of it is available and how much people want it. This system lets you respond to changes in the economy more easily, but it also makes things more unpredictable. At the same time, currency blocks like the Eurozone created a single currency to keep exchange rates stable within the block. However, differences in the economies of member states continue to be a problem (De Grauwe, 2018).

The rise of crypto currencies based on decentralized block chain technology has recently added a new layer to the global exchange rate system. Digital currencies like Bitcoin get a lot of their value from market sentiment, adoption trends, and speculation, not from traditional macroeconomic fundamentals. These assets offer novel prospects for payment innovation, financial inclusion, and cross-border transactions; however, they also introduce difficulties regarding exchange rate volatility, regulatory oversight, and monetary stability (Chen, 2025).

2.2. Effects of Exchange Rate

Exchange rates, which show how much one currency is worth compared to another, have a big impact on the economy. They are very important for international trade because they affect how competitive exports are. When a country's currency loses value, exports become cheaper and more appealing to foreign buyers, which could lead to more trade (Krugman et al., 2018). Changes in the exchange rate can also affect inflation. When a currency loses value, it makes imports more expensive, which can lead to inflationary pressures. On the other hand, when a currency gains value, it can help lower inflation by making imports less expensive (Mishkin, 2015). Also, exchange rates can affect decisions about foreign direct investment (FDI) because a weaker currency can make it cheaper to buy foreign assets, which can bring in more FDI (Blonigen, 2005). Governments frequently intervene in currency markets to strategically influence exchange rates, with the objectives of preserving export competitiveness or regulating inflation, highlighting the significance of exchange rate management in policy (Frieden, 2015).

2.3. Empirical Literature Review

Numerous empirical studies have been undertaken to elucidate the relationship between exchange rates and trade broadly, as well as the correlation between exchange rate volatility and trade specifically. The exchange rate of a country is very important for its economic growth and stability because changes in the rate can create uncertainty that makes it harder to trade, invest, and plan for the future (Bilgili et al., 2021; Zhu, 2022). For Ethiopia, changes in the exchange rate are closely linked to inflation, borrowing from outside the country, and how competitive its exports are. The economy of the country is still based on agriculture, with coffee, oilseeds, pulses, and livestock making up most of its exports. However, diversification into gold, minerals, and manufactured goods, partly due to Chinese investment and the Belt and Road Initiative, is starting to change the way it trades (Bharti, 2023). To understand how volatility affects both Ethiopia's traditional agricultural exports and its new industrial base, it is important to look into how its exchange rate changes.

The economy of Ethiopia grew by only 5.6% in 2021 because of civil war and COVID-19. Inflation rose sharply from 20.4% to 26.7% because of credit expansion

and supply chain problems. The fiscal deficit improved slightly, the banking sector remained stable but was closed to international competition, and public debt was 57.8% of GDP (AfDB, 2022). Studies on India's exchange rates and inflation show that exchange rate pass-through has long-lasting effects on inflation (Dua et al., 2021; Yanamandra, 2015; Jacob et al., 2021; Sreenu et al., 2022). In Ethiopia, however, studies show that government spending, the broad money supply, and interest rates are the main reasons why the birr is losing value (Simeneh, 2020).

"Inflation" is when the prices of many goods and services go up. Inflation is a big problem for everyone, even the government. The most basic definition of "inflation" is that the average price of goods and services goes up steadily. Inflation doesn't take into account price changes for certain goods or time periods. Inflation must be encouraged for the overall cost of goods and services to increase. Inflation has a big effect on how well a country's economy works. Central banks trying to gain credibility usually do better when they set and explain their monetary policy in terms of underlying inflation instead of headline inflation (Alper et al., 2016).

Recent empirical studies offer detailed insights into the impact of exchange rates on diverse economic variables. Exchange rates have a big effect on trade between countries. When a currency loses value, it usually makes exports more competitive by lowering prices for foreign buyers. However, a 2025 study by Demirtaş on the Istanbul Ataturk Airport Free Zone showed that changes in the exchange rate didn't have a big effect on imports and exports in that free zone. This suggests that some areas or industries may not be as affected by changes in the value of the currency. Duong (2022) discovered that inflation targeting policies in emerging markets are effective in regulating inflation during economic crises, highlighting the necessity of managing exchange rates to alleviate inflationary pressures resulting from currency depreciation.

India faces similar problems, such as high inflation and a falling rupee, which make imports more expensive and increase the current account deficit. However, these problems can also make exports more competitive (Singh et al., 2016). Exchange rate pressures are closely tied to fiscal and monetary policies. Research shows that macroeconomic instability, too much spending, and relying on borrowing from other countries make economies more vulnerable to shocks from outside (Shaik & Rao, 2020). Recent predictions say that the rupee's exchange rate will continue to be affected by global uncertainties in 2023 and beyond. These include the effects of COVID-19, rising prices, trade tensions, and the global shift toward renewable energy. This will have big effects on growth and stability (Zachariah, 2023).

Sime and Ketema's (2022) study, The Impacts of Effective Real Rate of Exchange on Ethiopia's Economic Growth (1974–2020), examines the long-term consequences of the real effective exchange rate (REER) on Ethiopia's economic growth. The authors utilize yearly time series data from 1974 to 2020 and apply the Autoregressive

Distributed Lag (ARDL) bounds testing methodology to investigate the relationship between the Real Effective Exchange Rate (REER) and economic growth. Their results show that REER has a big effect on economic growth in the long run. This means that exchange rate policies are very crucial for figuring out the course of the economy. The study highlights the significance of regulating the REER to promote sustainable economic development in Ethiopia.

3.0. Materials and Method

3.1. Data Type

This panel data study examines Ethiopia and India from 1990 to 2025. The analysis provides policymakers with insights into the challenges of the Foreign Exchange Rate, Inflation, Remittances, Unemployment Rate, and Foreign Direct Investment on Real Gross Domestic Product (RGDP). Policy recommendations may therefore focus on managing these variables to promote RGDP growth. All exogenous and endogenous variables were obtained from the World Bank database.

RGDP = f (Fx, I, Rem, FDI, Ur)…… (1)

3.2. Econometric Methodology

3.2.1. Model of Panel Data

Cross-sectional and time-series data are combined in panel data, monitoring the same group of entities, such as individuals, firms, or countries, as national-level units over multiple time periods. Let T be the number of time intervals t = 1, 2, 3, ..., and N be the number of entities i = 1, 2, 3, ... n.. Panel data consists of NT total observations. A balanced panel possesses an equivalent quantity of observations for each unit, while an unbalanced panel has varying numbers of observations across entities.

There are two known ways to study data of panel: the dynamic panel data models and static panel data models are two important approaches in econometrics. For static models, you can analyze everyone the same way (Common Effects), let everyone keep their own features (Fixed Effects), or treat any differences as random (Random Effects or Error Components) (Sihombing & Arsani, 2021).

3.2.2. Static Panel Model Estimation Techniques

3.2.2.1. Fixed Effects (FE) Model

A regression model with a fixed effect demonstrates that each unit possesses a distinct intercept. Because of the different intercepts, the units will not be the same. The unit intercepts in the fixed effect model remain constant over time, although they may differ among units that are cross-sectional. The model with fixed effect

posits that the variables of independent coefficients remain constant across units of cross sectional and temporal dimensions (Qu, 2020).
The dummy variable technique can be used to implement these fixed effects models. So, you can write the fixed effects model like this:

$Y_{it} = \alpha_i + \beta_1 X_{1it} + \cdots + \beta_p X_{pit} + V_{it}$ ..... (2)

$Y_{it} = \alpha_i + \beta_1 \ln Fx_{it} + \beta_2 I_{it} + \beta_3 \ln Rem_{it} + \beta_4 FDI_{it} + \beta_5 Ur_{it} + V_{it}$ ..... (3)

Where Y_{it} is the panel data for Rall Gross Domestic products of Ethiopia and India, lnFx is the foregn exchange rate, I is inflation, ln Rem is the remittance, FDI is the foreign direct investment and Ur is unemployment rate. Here, α_0 represents the intercept of Real GDP, and β_1, β_2, β_3, β_4 &$\beta_5$are different intercept coefficients.

3.2.2.2. Model of Random Effect

The error correction model (ECM) is another name for random effects model. In this model, the units that cross sections will possess a random intercept rather than fixed intercepts. The model of random effects is based on the idea that, unlike the model of fixed effect, the differences between entities are thought to be random & not related to the predictor or endogenous variables in the model. The essential difference between random &fixed effects lies in whether the effects of unobserved individual contain components that correlate with the observed independent variables in the model, rather than in their stochastic nature. The model of random effect posits that individual-specific effects α_i are stochastic and should be incorporated into the error term. The slope parameters and the error term of composite are the same for each cross-section (Nwakuya & Ijomah, 2021). As a result, the model is now called the Random Effect Model (REM):

$Y_{it} = \alpha_0 + X_{it} * \beta + (\alpha_i + V_{it})$ ..... (4)

Let $\varepsilon_{it} = \alpha_i + V_{it}$, Where ε_{it}, α_i and V_{it} are random variables that are regularly distributed, with a mean of zero and a constant varianceδ_ε^2, δ_α^2 and δ_v^2accordingly.Hence $\text{var}(\varepsilon_{it}) = \delta_\alpha^2 + \delta_v^2$ and Cov $(\varepsilon_{it} + \varepsilon_{it}) = \delta_\alpha^2$; $\rho_\varepsilon = cor(\varepsilon_{it}, \varepsilon_{is}) = \frac{\delta_\alpha{}^2}{\delta_\alpha{}^2 + \delta_\varepsilon{}^2}$ ..... (5)

Rho (ρ) is the relationship between the different types of error or the percentage of the error term's variance that is due to effects that are unique to each person. When individual effects are stronger than the unique error, these variables approach 1.

4.0. Data Analysis and Results

4.1. Descriptive Statistic

The table with descriptive statistics presents central tendencies and dispersion measures for the primary economic variables under analysis, separately for each country: unemployment rate (LNUR), real GDP (LNRGDP), inflation (LNI), foreign exchange rate (LNFX), and foreign direct investment (LNFDI). The proximity of means and medians for these variables within individual countries suggests relatively symmetric distributions at the country level. In contrast, the standard deviations indicate that, within countries, LNRGDP and LNFDI exhibit greater volatility than the other variables, reflecting more pronounced fluctuations in real GDP and FDI for specific countries over the observed period. Such variability may be attributed to episodes of economic instability or significant policy interventions experienced by particular states.

Table 1 summarizes the explicative enumeration for the principal determinants by country LNRGDP, LNFX, I, LNREM, FDI, and UReach estimated using 72 observations per country. The mean values represent the central tendency within each country, with LNRGDP averaging 25.83 and FDI averaging 1.24×10^{10}, highlighting substantial variation in FDI relative to other variables across countries. The standard deviation further illustrates data dispersion: FDI shows the highest standard deviation (1.91×10^{10}) among countries, indicating considerable volatility, whereas LNFX shows a lower standard deviation (0.99), indicating greater stability within individual countries.

Statistics for skewness and kurtosis offer more insights into the distributions of data within each country. Most variables exhibit skewness and kurtosis values near or slightly above 1, suggesting distributions that approximate normality at the individual country level. In contrast, the variable I exhibits high kurtosis (6.25), indicating the existence of heavy-tailed data or outliers' distribution in selected countries. The Jarque-Bera test results further assess normality for each country's data, with most variables showing low p-values, indicating significant deviations from normality at the country level. These statistical measures inform understanding of each country's data characteristics and guide subsequent econometric or statistical analyses.

Table 1: Table of decretive analysis

Statistic	LNRGDP	LNFX	I	LNREM	FDI	UR
Mean	25.82865	3.224868	9.818472	21.44519	1.24E+10	4.966236
Median	25.94477	3.516215	7.765	21.85049	2.63E+09	4.083
Maximum	29.06611	4.94364	44.36	25.64816	8.75E+10	17.859
Minimum	22.68347	0.727549	-8.48	15.46751	0	0.0000
Std. Dev.	2.111454	0.990891	9.175912	3.035764	1.91E+10	2.4115
Skewness	-0.07572	-0.63047	1.586347	-0.28866	1.711284	-0.01362
Kurtosis	1.639777	2.592718	6.2474	1.831785	5.455484	1.490744
Jarque-Bera	5.619422	5.267467	61.83581	5.0944	53.20126	6.835786
Probability	0.060222	0.0781	0	0.078315	0	0.032781
Sum	1859.663	232.1905	706.93	1544.054	8.90E+11	357.569
Sum Sq. Dev.	316.553	69.71241	5978.012	653.3825	2.59E+12	412.8884
Observations	72	72	72	72	72	72

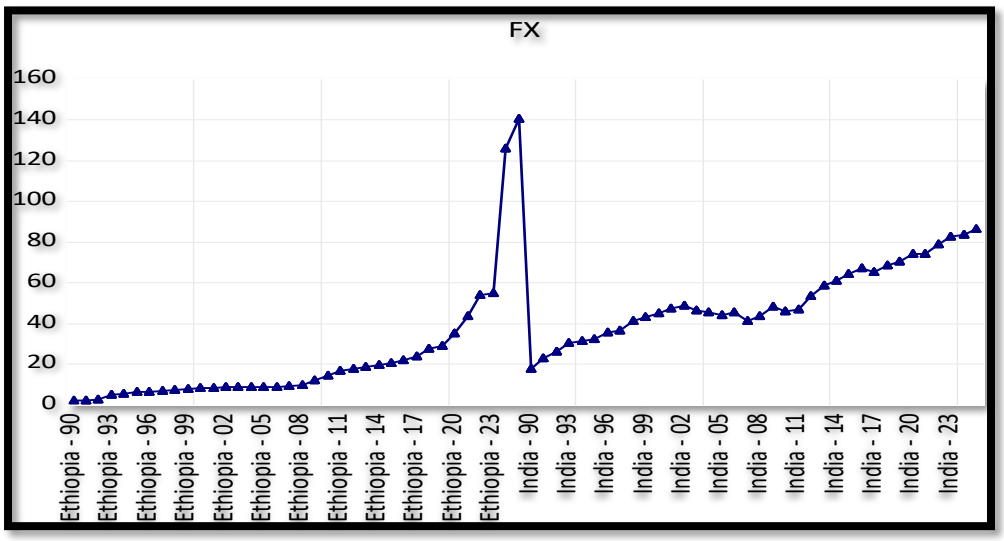
Source: From Authors computation

Figure 1 shows that the results have significant implications for how we study the economy and for how we make policy. The larger swings and unusual patterns in the exchange rate suggest this number is affected by outside events and changes in the economy over time. Researchers and policymakers should be careful when reviewing data that uses these numbers, since unusual patterns can make the results less reliable. Using the right tools to study this data will help give a clearer picture and lead to better policy advice.

Figure 1 shows how exchange rates between the Indian rupee and the US dollar, as well as between the Ethiopian birr and the US dollar, changed from 1990 to 2023, with forecasts for Ethiopia through 2025. In 1990, one US dollar was worth 2.07 birr, showing a strong currency at the time. Over the next few years, the birr lost value slowly, with the decline accelerating in recent years. By 2025, it is expected that one dollar will be worth 142 birr, indicating that the birr has lost significant value over the past 35 years.

From Figure 2, Ethiopia experienced frequent and severe inflation spikes from 1990 to 2025, driven by both structural and external factors. Cost-push inflation resulted from rapid currency depreciation, political instability, and droughts affecting agricultural output. Additionally, fluctuations in global commodity prices, particularly for food and fuel, significantly impacted domestic prices due to Ethiopia's vulnerability to external shocks.

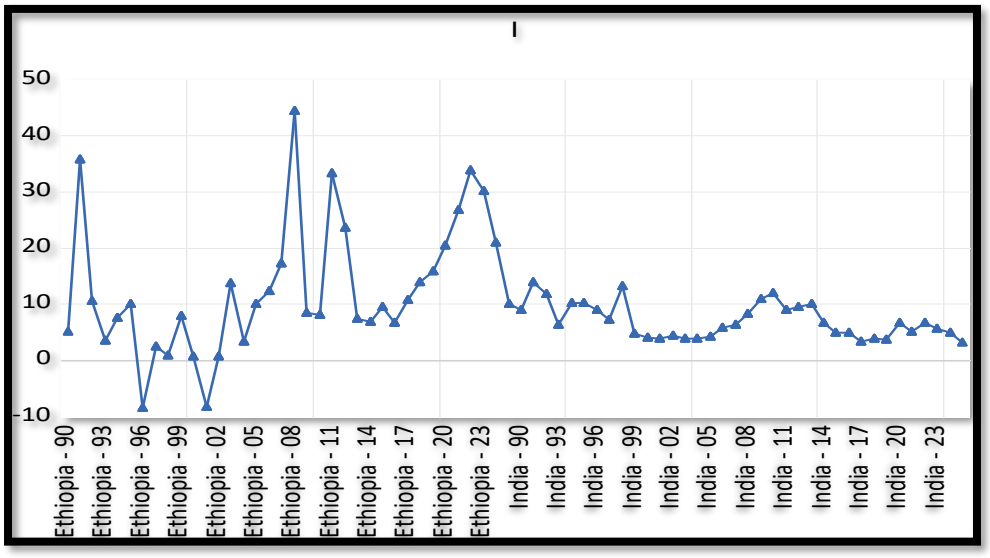
Figure 1: Graph of Foreign Exchange rate of Ethiopia and India from 1990 to 2025



Source: From Authors computation

High and unpredictable inflation undermines consumer and investor confidence, reduces purchasing power, and complicates long-term planning. To stabilize inflation, Ethiopian policymakers should strengthen macroeconomic management and diversify the economy. Stable inflation rates in India from 1990 to 2025 show that a number of economic reforms and institutional improvements have worked.

Figure 2: Graph of Inflation of Ethiopia and India from 1990 to 2025



Source: From Authors computation

The Reserve Bank of India's decision to target inflation, better fiscal discipline, and the creation of buffer stocks for important food items have all helped keep prices stable. India's economy is more stable because it has strong service and industrial sectors. This has helped protect the country from changes in global commodity prices. India's strong policy frameworks and effective crisis management have kept the effects of problems such as changing monsoons and sudden shifts in global oil prices to a minimum. India can keep inflation low and stable by staying alert, making supply-side changes, and investing in making farming more productive. This will help the economy grow in the long term and improve people's lives.

4.2. Stationarity Test

The ADF Fisher Chi-square unit root test findings are shown in Table 2, which also shows the integration order for each variable in the dataset. The variables ln RGDP, lnFx, ln Rem, FDI, and Ur have statistically significant p-values, all well below the 5% threshold. This shows unit roots at the level and stationarity after first differencing, so these variables have an order one integration (I(1)). Inflation (I) has a p-value of 2.73%, which is less than 5%, indicating it is stationary at the level and integrated of order zero (I(0)). In macroeconomic time-series data across all countries included in this dataset, this integration pattern is common because most variables become stationary only after first differencing. I(0) and I(1) variable combination affects future econometric modeling, especially for cointegration analysis and correct model specification, such as distinguishing between partnerships, both short- and long-term.

Table 2: Results of Stationarity from ADF Test

Variables	ADF – Fisher Chi-square		Order of Integration
	Statistic	Probability	
lnRGDP	16.9	0.2%	I(1)
lnFx	14.52	0.58%	I(1)
I	10.94	2.73%	I(0)
lnRem	20.68	0.04%	I(1)
FDI	27.54	0%	I(1)
Ur	26.55	0%	I(1)

Source: From Authors computation

4.3. Results of Fixed and Random Effects

4.3.1. Results of Fixed Effects

The fixed-effects panel regression results in Table 3 show strong, statistically significant relationships between the independent variables and economic growth, as measured by LNRGDP. In particular, LNFX, Inflation (I), and remittances (LNREM)

all have positive, significant coefficients, indicating that when these variables increase, the economy grows faster. Alternative, the unemployment rate (UR) has a anti, significant relationship with LNRGDP, consistent with economic theory. Foreign direct investment (FDI) doesn't exhibit a statistically substantial impact in this specification, indicating that its influence on economic growth may depend on other factors or institutional contexts.

Table 3: Result of Effect on Fixed

Variables	Coefficient	Std. Error	t-Statistic	Prob.
LNFX	0.533708	0.119194	4.477627	0.0000
I	0.015917	0.005108	3.129692	0.0026
LNREM	0.096111	0.01429	6.727307	0.0000
FDI	1.96E-11	3.20E-12	6.148076	0.0000
UR	-0.96611	0.162686	-5.94038	0.0000
C	19.39927	1.055009	18.38788	0.0000

Source: From Authors computation

The model in Table 3 has a very high R-squared (0.97) and adjusted R-squared (0.97), indicating that it explains a large portion of the fluctuation in the dependent variable. The model has strength is further confirmed by a very significant F-statistic. The Durbin-Watson statistic, on the other hand, implies that the residuals might have a positive serial correlation. This means that more diagnostic testing or the use of robust standard-error adjustments is needed to ensure the results are accurate.

These results are consistent with several recent empirical investigations. Saadaoui and Bouzgarrou (2022) and Nguyen et al. (2023) demonstrate robust correlations among financial, investment, and labor-market variables and economic growth within panel-data frameworks. Moreover, Samargandi, Fidrmuc, and Ghosh (2020) underscore the importance of financial development and investment, whereas Azman-Saini, Baharumshah, and Law (2010) assert that the impact of FDI is dependent on the financial context. Pradhan et al. (2021) further validate the significant contribution of remittances to GDP growth in developing nations. These findings collectively strengthen the existing literature that emphasizes the pivotal roles of financial, inflation, and labor-market factors in driving economic growth.

LNRGDP = 0.533708345764*LNFX + 0.0159707949115*I + 0.221103793504*LNREM + 1.96284710363e-11*FDI - 0.0871441296554*UR + 19.3992728253 + [CX=F]

The fixed-effects regression model shows that finance, inflation, and labor-market variables play a key role in explaining economic growth across the sampled countries. The positive and statistically significant coefficient for LNFX (0.5337) suggests a strong link between real GDP growth and increases in foreign exchange reserves or activity. This finding supports Nguyen et al. (2023) and Samargandi et al. (2020), who found that a strong financial sector is important for economic growth. Inflation (I) also has a positive coefficient (0.0160), which supports the traditional view that capital accumulation drives growth, as seen in both classical and modern growth models.

Remittances (LNREM) have a strong positive effect (0.2211), consistent with Pradhan et al. (2021), who argue that remittances sent home by workers abroad increase family income and spur economic activity. The unemployment rate (UR) negatively affects real GDP growth (-0.0871), supporting Okun's law, which holds that high unemployment, is bad for the economy (also see Saadaoui & Bouzgarrou, 2022). The impact of overseas direct investment (FDI) is very close to zero and not important in this case, so FDI does not have a direct effect on economic growth. This aligns with Azman-Saini et al. (2010), who argue that the impact of FDI depends on the quality of a country's financial rules and systems.

The strong R-squared value of 0.97 for the model indicates that these factors collectively explain almost all of the differences in economic growth across the panel. Adding cross-section fixed effects ([CX=F]) helps account for unobserved heterogeneity, making coefficient estimates more reliable. These findings not only corroborate existing growth theories but also provide empirical validation for policy measures designed to strengthen financial systems, increase investment, facilitate remittance flows, and mitigate unemployment, thereby promoting sustainable economic development.

4.3.2. **Results of Random Effects**

The random-effects panel regression for the countries panel dataset reveals a strong, statistically significant relationship between LNFX and LNRGDP from 1990 to 2025. The estimated coefficient for LNFX is 1.085152 probability value below 0.01, meaning that a one percent rise in LNFX corresponds to a 1.09% increase in LNRGDP, controlling for other variables. An R-squared value of 0.93 shows that the model accounts for the majority of the change in the explanatory variable.

Table 4: Result of Random Effect

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFX	0.533708	0.119194	4.477627	0.0000
I	0.015917	0.005108	3.129692	0.0026
LNREM	0.096111	0.01429	6.727307	0.0000
FDI	1.96E-11	3.20E-12	6.148076	0.0000
UR	-0.96611	0.162686	-5.94038	0.0000
C	19.39927	1.055009	18.38788	0.0000

Source: Estimated by Author

The F-statistic reported in Table 4 further confirms the model's overall significance for the countries included in the panel dataset. However, the low serial correlation may be present in the residuals, according to the Durbin-Watson statistic., warranting additional diagnostic testing and potential model adjustments. These findings are consistent with recent empirical studies, such as Saadaoui & Bouzgarrou (2022), which demonstrated that financial variables significantly influence economic growth in panel data analyses, and Nguyen et al. (2023), which identified similarly robust correlations between exchange rate proxies and GDP in emerging economies. Overall, the results indicate that LNFX is a key explanatory variable for differences in economic growth among the countries in the panel sample, as measured by LNRGDP within the panel data framework.

4.3.3. Result of Hausman Test

The Hausman test helps select in panel data between fixed effects and random effects models econometrics. The statistic known as chi-square of 166.14 and p-value of 0.0000 show strong proof that the random effects estimator is reliable and effective, refuting the null hypothesis.

Table 5: Result of Hausman test

Hausman Test Correlation; Examination for Random Effect model				
Test Type	**Chi-Sq. Statistic**	**Chi-Sq. d.f.**		**Prob.**
Cross-section random	166.1438	1		0.0000
Comparative Analysis of Cross-Sectional Random Effects Tests				
Variable	Fixed	Random	Var(Diff.)	Prob.
LNFX	1.085152	1.858134	0.003596	0.0000

Source: From Authors computation

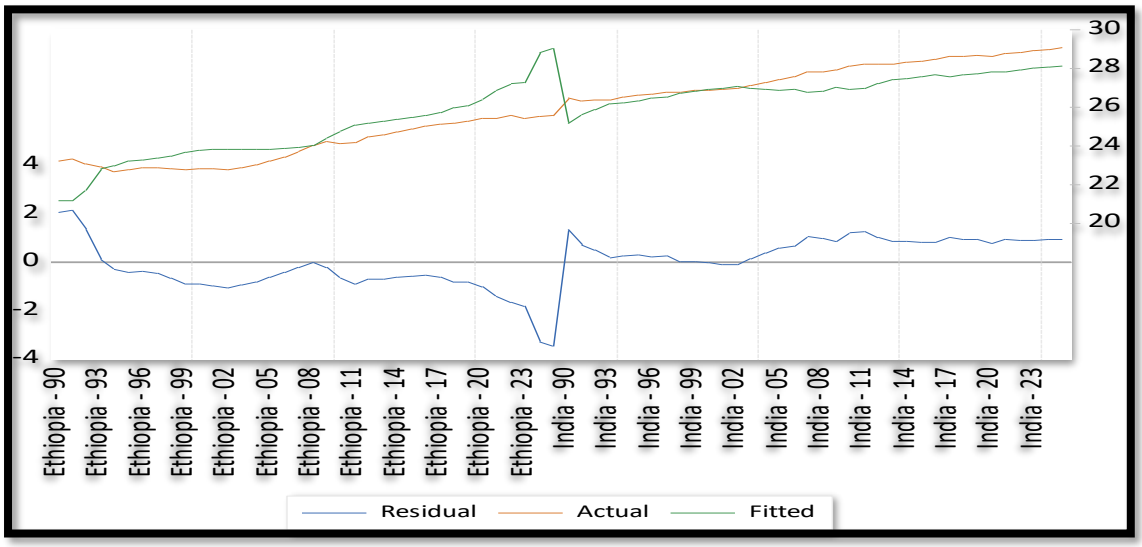
Table 5 shows a strong association between the repressors and the individual effects, making the random-effects model unsuitable here. Analysis of "LNFX" finds a marked difference between the two estimators. These results strongly support the fixed effects model, which is more accurate and unbiased when individual effects are correlated. This highlights the need to account for unobserved heterogeneity in panel data analysis.

4.4. Diagnosis Test

4.4.1. Actual, Fitted, and Residual values

The plot from Figure 3 shows how the actual, fitted, and residual values from a regression model are related. This is probably done with panel data. The fitted and actual lines are very close together, indicating that the model captures the overall trend in the data. But there is a clear difference in the middle of the plot, where the actual and fitted lines separate a lot. This causes a large spike followed by a drop in the residuals. This indicates that the model has difficulty accommodating a sudden change or outlier during this timeframe, potentially attributable to a structural break, an atypical event, or a deficiency in the model specification for those observations. Aside from this one oddity, the model is functioning well because the residuals are largely around zero and don't exhibit any discernible patterns. Still, the presence of large residuals warrants further study to determine whether they are due to real-world events or whether the model needs improvement by adding more variables or using different modeling methods. The model works well overall, except for one problem noted (Wooldridge, 2010).

Figure 3: Actual Fitted Residual Graph

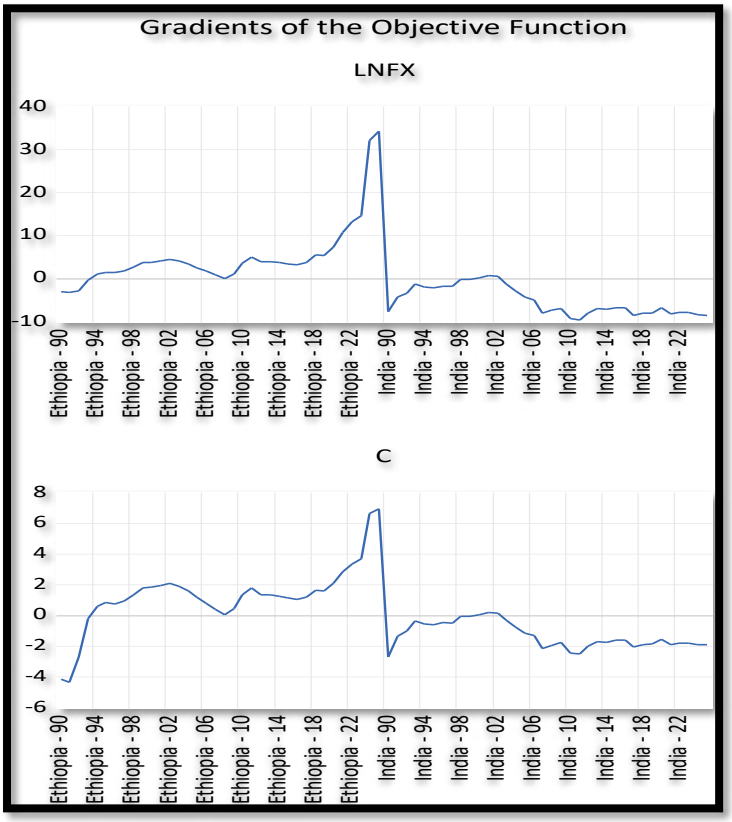


Source: From Authors computation

4.4.2. Gradients of the Objective Function

Several recent studies have examined how gradients behave in optimization, especially when they change quickly, how they converge, and how they help find the best path through complex loss landscapes.

Figure 4: Gradients of the objective function



Source: From Authors computation

For example, Mishkin et al. (2024) introduce the notion of directional smoothness, providing path-dependent convergence guarantees for gradient descent that surpass traditional L-smoothness limits and illustrating the impact of gradient behavior on optimization paths and convergence rates.

At the same time, Boskos et al. (March 2025) proposed a gradient sampling algorithm for non-smooth objective functions, demonstrating that it can still reach stationary points even when traditional gradients are unavailable. The Gradients objective function discusses real-world examples in which high learning rates lead to gradient instabilities that appear as spikes and dips. These instabilities help models escape from sharp minima into flatter regions, thereby improving generalization.

4.4.3. Results from Wald Test

The Wald Test results in Table 6 show a significant joint effect for the model coefficients, with near-zero p-values for both the F- and Chi-square statistics. This strong significance rejects that all coefficients are zero, according to the null hypothesis. Thus, the explanatory variables collectively influence the dependent variable. The normalized restriction summary offers individual coefficient estimates and standard errors; C (1) and C(6) are notably higher than the others. These results highlight the importance of the regression variables and their meaningful relationship with the outcome variable.

Table 6: Results of Wald Test

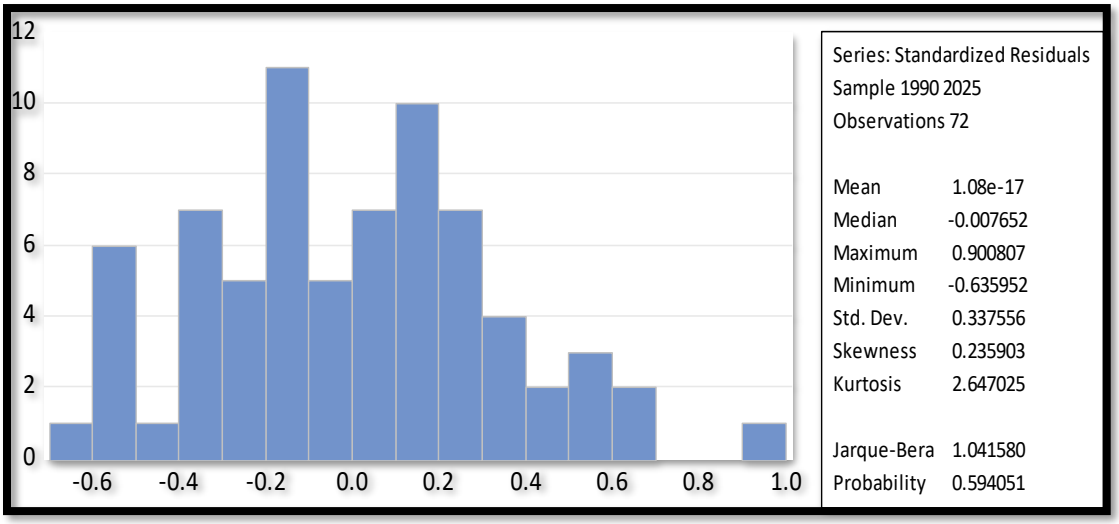
Statistic	Value	df	Probability
F-statistic	64401.07	(6,65)	0.0000
Chi-square	386406.4	6	0.0000

Source: From author's computation

4.4.4. Results from Normality Test

Statistical tests and visual aids, such as histograms, assess the normality of standardized residuals. The histogram in Figure 5 is symmetric, with most values near the mean and tapering tails.

Figure 5: Normality Test Result



Source: From author's computation

This suggests the data is approximately normal. Quantitative metrics support this: skewness (0.236) shows slight right asymmetry, and kurtosis (2.65) is close to the typical result of 3. The statistics of Jarque Bera is 1.042, with a p-value of 0.594, well above 5%. Therefore, the null hypothesis of normality is not rejected. Both graphical and statistical evidence indicate that the standardized residuals are approximately

normally distributed, supporting the use of inferential procedures that assume normally distributed errors.

5.0. Conclusion

This study empirically examined the effects of exchange rates and exports on the economic growth of India and Ethiopia using panel data from 1990 to 2025. Models with fixed effects and models with random effects were both estimated. According to the Hausman test, the fixed effects specification. Foreign exchange rates, inflation, and remittances each have significant and positive influences on economic growth. This finding aligns with previous research on financial development and external inflows in emerging economies. Conversely, the unemployment rate shows a strong inverse relationship with growth. This outcome is in line with established findings on labor market dynamics. The analysis further reveals that foreign direct investment (FDI) has a statistically significant direct impact on real GDP growth. This effect depends on the quality of financial and institutional frameworks, as prior literature has found. The residuals show serial correlation, according to the Durbin-Watson statistic. This finding underscores the need for additional diagnostic testing and robust estimation techniques.

Based on these findings, several policy recommendations follow. First, both India and Ethiopia should prioritize stable exchange rate management. This approach promotes economic stability and enhances export competitiveness. Ethiopia should address the root causes of currency depreciation. India should monitor exchange rates to manage inflation and support exports. Second, governments should facilitate investment and remittance inflows. Improving regulatory frameworks and infrastructure will help. Introducing incentives for capital formation and productive use of remittances is essential, as both have shown strong positive effects on growth. Third, addressing labor market challenges is imperative. Targeted skills development, labor market reforms, and small business support can reduce unemployment and foster growth. Fourth, strengthening the financial sector and institutions is necessary to maximize the benefits of inflation, FDI, and remittances. Promoting financial inclusion and regulatory compliance will boost resilience to external shocks. Lastly, future research and policy analysis should use robust standard errors to account for potential serial correlation. Adopting dynamic panel models is also recommended for econometric validity and reliability. Overall, this research highlights the importance of sound macroeconomic management, institutional development, and evidence-based policy in driving sustainable growth in emerging economies.

Declarations

Data and material availability

- The author's state that the data obtained from the World Bank database can be provided to the publisher upon request.

Conflicting interests

- No conflicts of interest are disclosed by the writers.

Authors' contributions

- The authors contributed substantially to all stages of the research.

Consent for publication:

- It is not applicable.

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Abbreviation

ADB - Asian Development Bank
ADBG – African Development Bank Group
ARDL – Autoregressive Distributive Lag
ECM error component model (ECM)
FDI – Foreign Direct Investment
Fx – Foreign Exchange Rate
GDP – Gross Domestic Product
I -Inflation
IMF – International Monetary Fund
NBE - National Bank of Ethiopia
RBI - Reserve Bank of India
Rem – Remittance inflow
REM Random-Effect Model
Ur – Unemployment rate
US Dollar – United State Dollar