A Panel Data Analysis of Effects of Economic Vulnerability Index Indicators on Real Effective Exchange Rate in Developing Countries

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ABSTRACT

The volatility of exchange rates is considered to be an important measure of a country's economic vulnerability and has a direct or indirect causal relationship with a large number of macroeconomic variables. The aim of this study is to analyze the macroeconomic variables in the economic vulnerability index that affect the exchange rate for developing countries and the extent to which they affect the exchange rate, and to make policy recommendations. We conducted a panel data analysis using data from 11 developing countries between 2000 and 2022 for this purpose. We performed the analyses using the Augmented Mean Group (AMG) estimator. As a result of the analyses, it is found that there is a negative and statistically significant relationship between the real effective exchange rate and inflation, private sector credit debt/GDP and gross public debt/GDP ratio. In addition, the relationship between Real effective exchange rate and current account deficit/GDP ratio, External debt/GDP ratio and growth rate is positive and statistically insignificant. As a policy recommendation, it can be said that for stable and sustainable economic management in developing countries, the exchange rate level should be less volatile and should be compatible with reliable fiscal and monetary policies.

Keywords: *Augmented Mean Group (AMG) Estimator, Real Effective* Exchange Rate, *Developing Countries, Panel Data Analysis, Macroeconomic Indicators*

JEL Codes: C33, O24, F63

1.INTRODUCTION

The fluctuation in exchange rates has a direct or indirect impact on the majority of macroeconomic returns utilized to exploit economic vulnerability, establishing a bidirectional causal link with some of these returns. The heightened economic vulnerability experienced by developing nations necessitates a more cautious and sustainable economic strategy to mitigate the risk of crises. These nations, characterized by high economic vulnerability, often aim to manage exchange rates and adjust various macroeconomic equilibriums to avert potential crises. The determinants of exchange rate fluctuations and the approach to maintaining exchange rate stability are crucial indicators of the global economy. Exchange rate volatility is perceived as a significant economic and financial challenge in both developing and developed nations, with a high probability of crises attributed to the economic instability of nations

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grappling with this issue. In the Monetary Policy Report published by the US Federal Reserve in February 2014, the economic vulnerability index tool started to be used as a measurement tool for high-risk countries. It refers to an index that includes six basic indicators, which considers the relative degree of vulnerability among Developing Countries (EMs) and the change of currencies of EMs against the dollar as a measure of financial market stress. These indicators included in the index are: current account deficit/GDP, gross public debts/GDP, private sector domestic credit debts/GDP, growth, inflation rate and external debt/export variables.

The research conducted an analysis using panel data to examine the impact of the indicators included in the FED's economic vulnerability index on the real effective exchange rate in developing countries. In the study, panel data analysis was used to investigate the effect of variables such as current account deficit/GDP, gross public debt/GDP, private sector domestic credit debt/GDP, growth, inflation rate and external debt/export on the real effective exchange rate in the period 2000-2022. IMF and World Bank databases were used in data compilation. The study covers developing countries highlighted in the 2023 World Bank Economic Expectations Report and whose data are available. The report identified 18 countries in 6 geographical regions and 11 countries were included in the analysis. These countries are Angola, Argentina, Indonesia, South Africa, India, Nigeria, Egypt, Mexico, Pakistan, Thailand and Turkey. The selection of these countries was based on their potential to have a major impact on the world economy.

To reduce high exchange rate levels and prevent or reduce their fluctuations, developing countries need to look carefully at these variables and evaluate their effects during policy formulation and implementation. Considering that exchange rate fluctuations directly affect price stability, financial stability, and trade balance, the results of this study provide important information for policymakers. Decision-makers who manage exchange rate risk gain credibility for the economy with exchange rate stability through stable macroeconomic variables. As a policy recommendation, it can be said that for stable and sustainable economic management in developing countries, the exchange rate level should be low and less volatile and should be in harmony with credible fiscal and monetary policies. This study is organized as a literature review, data and methodology, empirical results, and the conclusion part.

2. LITERATURE REVIEW

The pioneering study done in 2004 by Pastore et al. provided important new understandings of the relationship between exchange rates, inflation targets, and the current account deficit. One of the most recent studies examining the effect of current account balance/GDP and current account deficit ratio on the exchange rate belongs to Kuncoro and Fafurida (2023). In this study, the authors examined the effect of the current account deficit on real exchange rate volatility for Indonesia with monthly data from 2005(7) to 2021(12) by applying regression models and found that the current account deficit plays an important role in controlling exchange rate instability and that the asymmetric behavior of the current account balance affects the real exchange rate. They concluded that it has the potential to weaken monetary policy within the framework of the inflation targeting regime by triggering volatility.

İşler (2021) investigated how and to what extent the exchange rate is affected by macroeconomic variables, and in this context, he used monthly data from Turkey, Brazil, Mexico and South Africa for the period 2003-2018. Three different models were used in the study: Granger Causality, Multiple Linear Regression and Artificial Neural Network Analysis.

As a result of the study, it was stated that the current account deficit variable had a significant effect on the exchange rate. In his study, Aka (2020) used quarterly data of the Turkish economy covering the period 1988-2019 and applied the Granger causality test for exchange rates and the current account deficit, one of the selected macroeconomic indicators, and shared the result that there is a one-way causality relationship from the exchange rate to the current account balance. Sadıç (2019) first estimated the effect of the current account deficit/GDP, one of the economic vulnerability index indicators, on the exchange rate with the random effects model, which is a panel regression model, and stated that the current account balance/GDP ratio negatively affects the exchange rate. This situation can be explained by the fact that the increase in the mentioned variables will cause the country risk premium to increase. The increase in the country risk premium causes an outflow of foreign capital as it increases the risk perception of investors. In this case, the country's currency loses value and the real exchange rate decreases.

Both the actual exchange rate and the domestic currency are depreciating in this scenario. Şit and Karadağ (2019) utilized the ARDL bounds test to examine extensive monthly data from 2003 to 2018. The findings revealed a favorable correlation, in both the near and distant future, between the currency exchange rate and the current account deficit, subject to the total level of wealth. Adusei and Gyapong (2017) conducted a study using data from 1975 to 2014 to examine how Ghana's macroeconomic variables influenced the exchange rate. It was found that the recorded difference in the exchange rate was reduced by 19.2% and showed a negative relationship with the exchange rate. Kaplan and Yapraklı (2014) conducted a study to analyze the influence of the ratio between the current account system and GDP on the exchange rate in developing nations. The study included the period from 2000 to 2012. The researchers identified a negative correlation between the two variables and highlighted the necessity of altering the existing account regime to prevent it from being adversely affected by the currency fluctuations of developing nations.

According to the Panel VAR model results of the study of Sadıç (2019), which examined the effect of the gross public debt/GDP ratio on the exchange rate, he shared the conclusion that the real effective exchange rate reacted negatively to a one standard deviation shock in the gross public debt/GDP ratio. Kaplan and Yapraklı (2014), Chei-Wei and Su (2012) and Pastore et al. (2004) concluded in their study that there was a negative relationship between the two variables.

Research commonly employs the inflation rate as a fundamental macroeconomic indicator to examine its relationship with the currency rate. However, experts present varied views about the relationship between these two traits. Based on the research conducted by Kaboro and Mose (2021), Sadıç (2019), and Abdoh et al. (2016), it has been shown that the inflation rate does not have a significant influence on the real effective exchange rate. Both Khan et al. (2019) and Kaplan and Yapraklı (2014) concur that there exists a consistent negative link between the inflation rate and the exchange rate. Eşsiz (2022), Gür (2022), and Makhdom (2020) conducted a causal analysis to examine the relationship between inflation and the exchange rate in Turkey. They together announce the identification of a long-lasting and beneficial link between the two variables. Furthermore, Dengiz (2022) performed an investigation on the relationship between inflation targeting and the real effective exchange rate. The study employed panel data from 17 OECD nations that adopted the inflation targeting strategy from 2006 to 2021. In this specific context, empirical data suggests that inflation plays a crucial role in determining the real effective exchange rate.

Kaboro and Mose (2021) examined the impact of inflation on the level of uncertainty in currency rates within the member countries of the East African Community (EAC) by

examining secondary panel data spanning from 2000 to 2016. The researchers observed a significant negative effect of inflation on the volatility of currency rates. The study conducted by İşler (2021) investigated the relationship between inflation rates and exchange rates in Turkey, Brazil, Mexico, and South Africa. This study extends the previous research undertaken by Hacıevliyagil and Demir (2016) on Turkey and the BRICS (T-BRICS) countries, as well as Su (2015) on Turkey and the United States. The investigation employed significant macroeconomic indices. The findings demonstrated a robust association between inflation rates and exchange rates, specifically in Turkey. Furthermore, they concluded that the effects of shocks on inflation rates persist over six to ten future periods.

Antwi and Issah (2020) and Adusei and Gyapong (2017) have come to different results on the impact of macroeconomic variables on the currency exchange rate in Ghana. Adusei and Gyapong (2017) identified a negative link between inflation and the exchange rate.Their investigation concluded that there is no statistically significant relationship between the inflation rate and the exchange rate. Carissa and Khoirudin (2020) and Abdoh et al. (2016) conducted two studies with contrasting results about the statistically significant relationship between the inflation rate and the exchange rate. Abdoh et al. (2016) conducted a panel data study to examine the influence of inflation on the currency rate in a selection of ASEAN states from 2005 to 2014. Muhammad and Khan (2012) used Johansen Cointegration analysis to investigate which macroeconomic factors and to what extent they affected the Pakistani exchange rate in the period 1982-2008. As a result, it is emphasized that the inflation rate has a long-term bidirectional relationship with the exchange rate. Similarly, Nucu (2011) examined the effect of the inflation rate on the Romanian Leu and concluded that there was a positive relationship. Pastore et al. (2004), although exchange rate shocks affect inflation, they also have negative real effects that slow down investments. As a result of the pass-through between these two variables, it is expected that inflation will exceed the targeted rate in terms of costs under strong devaluation pressure.

The growth rate is a frequently utilized variable in research examining its correlation with the exchange rate. It bears resemblance to the inflation rate. Jamil et al. (2023), Dengiz (2022), Khan et al. (2019), Mariano et al. (2015) have independently conducted research and all concluded that there is a statistically significant positive relationship between the growth rate and the real effective exchange rate. In their study, Jamil et al. (2023) examined data spanning from 1970 to 2020 from Australia, Hong Kong, Japan, New Zealand, and Singapore. The objective was to investigate the impact of GDP growth and other variables on exchange rate regimes. We discovered a notably positive effect of GDP growth on advanced markets. In their study, Khan et al. (2019) found a direct correlation between the rise in China's gross domestic product and the exchange rate of USD/CNY, indicating a positive association. Kaboro, Mose (2021), and Nucu (2011) found a statistically significant negative impact of the growth rate on exchange rate uncertainty. In contrast, Sadıç (2019) suggested that the growth rate does not have a significant impact on the real effective exchange rate. The study done by Kubar and Çoban (2021) produced results that were in line with the findings of Sadıç (2019). Kubar and Çoban (2021) conducted a study from 1995 to 2016, utilizing annual data and employing panel data analysis, to investigate the relationship between the growth rate and the exchange rate. Nevertheless, their research uncovered no statistically significant correlation between these two characteristics.

Research indicates that a rise in the ratio of domestic credit to the private sector's GDP has a positive effect on the exchange rate. Specifically, allocating more domestic credit to investment leads to higher individual income. Consequently, there would be a rise in the need for foreign

currency, which could result in a devaluation of the domestic currency (Sadıç, 2019; Yapraklı and Kaplan, 2014).Studies investigating the impact of the external debt/export ratio on the exchange rate suggest that a greater external debt/export ratio increases the country's risk premium (CDS), hence negatively affecting the exchange rate (Sadıç, 2019; Kaplan and Yapraklı, 2014).

While the majority of research in the literature focuses on conducting causality tests on individual nations, there are only a limited number of studies that have classified countries according to different characteristics (such as least developed, developing, etc.) and examined them using panel data analysis. Studies differ in their examination of the macroeconomic variables believed to influence the exchange rate, but they mostly focus on interest rates, inflation, international trade, and growth data.

Author(s)/Year of Study	Country(s)/Period	Method	Results
Kuncoro and Fafurida (2023)	Indonesia / 2005M7 - 2021M12	Regression Analysis	Current Account Deficit, Foreign Exchange Reserves Positive
Jamil et al. (2023)	Australia, Hong Kong, Japan, New Zealand and Singapore / 1970-2020	ML Bianry Logistic Regression	Exports, GDP, Foreign Direct investment, GDP per capita positive
Eşsiz (2022)	Turkiye /2009M1-2020M12	Granger Causality Analysis	Inflation Significant, long-term relationship
Gür (2022)	Turkiye / 2010M1-2022M4	Johansen Cointegration Analysis	Inflation Positive long-term relationship
Dengiz (2022)	OECD 17 Countries /2006-2021	Panel Data Analysis	Central Bank total reserves, M3 money supply, growth, current account balance, real interest rate and Inflation Significant. Foreign Direct Investor is insignificant
İşler (2021)	Türkiye, Brazil, Mexico and South Africa / 2003Q1-2018Q4	Granger Causality Analysis, Multiple Linear Regression Analysis, Artificial Neural Network Analysis	Current account deficit, foreign trade deficit, consumer price index, producer price index and oil price variables were found to be significant and effective on the exchange rate.
Kubar and Çoban (2021)	Brazil, Eurozone, Israel, Japan, UK China, Russia, Iran, Singapore, Turkiye / 1995-2016	Panel Data Analysis	Foreign Trade Rate, Interest, Investment Negative, Growth, GDP Def. Positive
Kobaro and Mose (2021)	Community of East African Countries / 2000-2016	Panel Data Analysis	Growth, Budget Deficit, Savings, positive, relationship inflation negative

Carissa and Khoirudin (2020)	Indonesia/2016M08-2019M06	Multiple Linear Regression Analysis	Money supply, interest rates and imports are positive, inflation is neutral.
Makhdom (2020)	Turkiye/2005M01-2019M10	ARDL Boundary Test	Interest and inflation are positive, unemployment, money supply (M1) and foreign trade balance are negative.
Antwi and Issah (2020)	Ghana / 2000-2019	VAR	Inflation, Lending, Money Supply are Neutral
Aka (2020)	Türkiye / 1988Q1-2019Q2	Granger Causality	Current Account Deficit is one-way towards the terms of trade and External Debt; There is a bidirectional causality between oil prices.
Şit and Karadağ (2019)	Türkiye / 2003M1 - 2018M6	ARDL Boundary Test	Current Account Deficit, foreign trade deficit, Central Bank reserve, Inflation Positive, Interest Rate negative
Khan et al. (2019)	China /1980 -2017	ARDL Boundary Test	Interest Rate and inflation are negative, GDP and Trade Openness are positive
Adusei and Gyapong(2017)	Ghana /1975 -2014	Partial Least Squares	Policy Rate, Inflation, Current Account Deficit, Negative, Money Supply/GDP, External Debt, GDP positive
Abdoh et al. (2016)	ASEAN Countries / 2005-2014	Panel Data Analysis	Export positive, Interest Rate and Inflation are neutral.
Hacıevliyagil and Demir (2016)	BRICS-T /2002 -2013	Johansen Cointegration Test	Inflation positive, Imports to Turkiye and India -
Su (2015)	Turkiye / 1980 - 2010	PANEL VAR	Nominal Money Supply, Inflation Significant impact, Interest Rate and GDP some level of impact.

Kaplan and Yapraklı (2014)	12 developing countries/ 2000-2012	Panel Data Analysis	Current Account Deficit, Domestic Private Sector Loans, Public Debt, Inf negative, Foreign Exchange Reserve and External Debt positive
Mariano (2015)	Philippines / 1973 - 2014	Johansen Cointegration Test	GDP, money volume, net foreign assets, budget deficit, import positive relationship
Chi-Wei Su (2012)	China / 1994-2010	Nonlinear Cointegration Test	The degree of openness of the economy, the ratio of public expenditures to GDP, the difference in relative productive activity and the real money supply are negative and significant.
Kamer Ainur and Condrea (2012)	Romania / 2007-2011	Regression Analysis	Significant positive relationship with monetary size and gross international reserves
Muhammad and Khan (2012)	Pakistan / 1982-2008	Johansen Cointegration Test, Granger Causality Test	Money supply, trade balance, foreign exchange reserves, inflation and interest rate are long-term bidirectional relationships.
Nucu (2011)	Romania /2000 -2010	SPSS	GDP and Money Supply are negative , Inflation and Interest Rate are positive,

Table 2.1 Literature Table on the Relationship between Economic Fragility Index Indicators and Exchange Rate: 2011-2023

3. DATA AND METHODOLOGY

3.1. Data and Variables

This study has incorporated a total of seven variables, as indicated by the current literature. The real effective exchange rate is the dependent variable, whereas the independent variables consist of the current account balance/GDP, gross government debt/GDP, private sector domestic credit/GDP, growth rate, inflation rate, and foreign debt/export ratio. According to the existing literature and economic theories, the exchange rate is an indicator of the economy's vulnerability. It takes into account several macroeconomic factors, such as total consumption, total expenditure, and total investment (FED, 2014). Hence, considering the real effective exchange rate as a measure of a nation's or area's economic performance can enable a comprehensive analysis of the economy.

All six remaining variables, which are macroeconomic indicators, have been regarded as explanatory variables. The reason for this is that changes in the exchange rate can impact a nation's economic performance through many means, such as causing delays in investments and increasing the expenses of capital accumulation for industrialists. Hence, it is imperative to examine these variables in order to comprehend the economic performance of developing nations. The variables were derived from the databases of the International Monetary Fund (IMF) and the World Bank (World Bank Data). The data for all the factors stated spans from 2000 to 2022. Table 3.1 contains descriptions of the variables and the sources of their data.

Data Code	Data Description	Sources
Y1	**Real Effective Exchange Rate (2007=100) 65 COUNTRIES** The Real Effective Exchange Rate is a measure of how the value of a country's currency changes in relation to a basket of currencies from its trading partners.	https://www.bruegel.org/publications/datasets/real-effective-exchange-rates-for-178-countries-a-new-database
X1	**Current Deficit /GDP Ratio** This indicator is measured in millions of US dollars and as a percentage of GDP.	https://databank.worldbank.org/source/world-development-indicators/preview/on#
X2	**External Debt / Total Export Ratio** It measures the ratio of export revenues to total foreign debt.	https://data.worldbank.org/indicator/DT.TDS.DECT.EX.ZS?end=2021&locations=BR-CN-IN-RU-ZA-TR&start=1998
X3	**Inflation** The annual growth rate and the 2015 base year index were measured with a breakdown into food, energy, and total excluding food and energy.	https://databank.worldbank.org/source/world-development-indicators/preview/on#
X4	**Private Sector Credit Debt / GDP** It refers to the share of domestic credit given to the private sector in GDP.	https://data.worldbank.org/indicator/FS.AST.PRVT.GD.ZS?end=2022&locations=RU&start=1998&view=chart
X5	**Gross Public Debt / GDP** It gives the ratio of Government Debt to GDP.	https://www.imf.org/external/datamapper/GGXWDG_NGDP@WEO/OEMDC/ADVEC/WEOWORLD/AGO
X6	**Growth** The annual percentage growth rate of Gross Domestic Product (GDP) is calculated based on the constant value of the local currency. The sizes are determined using fixed 2015 pricing and are denominated in US dollars.	https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2022&locations=RU-BR-IN-TR-ZA-CN&start=2008

Table 3.1 Description of Variables and Data Source

In the World Bank's 2023 Global Economic Outlook Report, a total of 18 countries from 6 geographical regions are included in the Developing country classification. Due to data availability, China, Russia, Poland, Brazil, Saudi Arabia, Iran and Bangladesh were excluded in the analysis even though they are included in the developing country group in the World Bank 2023 Global Economic Outlook Report, and a panel data analysis was conducted with the remaining 11 countries for the years 2000-2022.The 11 Developing Countries included in the econometric analysis are shown in Table 3.2 below.

1.Angola	6.India	11.Pakistan
2.Argentina	7.Nigeria	
3.Turkiye	8.Mexico	
4.Indonesia	9.Egypt	
5.South Africa	10.Thailand	

Table 3.2 Sample Countries

3.2. Methodology

The study utilized panel data analysis to assess the influence of indicators within the economic vulnerability index on the exchange rate. Panel data analysis, by incorporating both cross-sectional and time-series dimensions of the data, improves the explanatory power and reliability of the conclusions compared to other methods, thanks to the larger number of observations available.

$$y_{it} = \alpha + X'_{it}\,\beta + \mu_{it}\;\; i = 1, \ldots..N\,;\; t = 1, \ldots, T \qquad (3.1)$$

Equation (3.1) denotes the panel data model. In the model, the symbol "i" is used to represent the cross-sectional dimension, while the symbol "t" is used to indicate the time dimension. The symbol "α" denotes the intercept term, whereas the symbol "β" represents the slope coefficient. Panel data analysis encompasses two effects: the unit effect and the time effect. The unit effect is a consistent representation of the attributes of individual units that remains unchanged across time yet differs between different units. The time effect represents the temporal aspect of the variable and remains consistent across different units, although it changes over time (Sadıç, 2019).

3.3. Augmented Mean Group (AMG) Estimator

Since there is a cross sectional dependence and slope heterogeneity in data, we use the Augmented Mean Group Estimator (AMG) method, proposed by Eberhardt and Bond (2009) and Eberhardt and Teal (2010), was developed as an alternative to the CCEMG method for determining the long-run cointegration coefficients of series with cointegration relationship. We prefer to use AMG because of following reasons: First of all, the AMG estimator provides efficient results despite the presence of common factor and dynamic effects in the series. It also solves endogeneity problem. Unlike Pooled Mean Group (PMG), AMG provides country specific short and long run results. Because of these reasons, this estimator was selected in this study.

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$$\Delta Y_{it} = b'\Delta X_{it} + \sum_{t=2}^{T} c_t\,\Delta D_t + e_{it} \qquad (3.2)$$

$$y_{it=}\, a_i + b'x_{it} + c_i t + d_i \hat{\mu}_t + e_{it} \qquad (3.3)$$

$$\hat{b}_{AMG} = \frac{1}{N} \sum_i \hat{b}_i \qquad (3.4)$$

In the first stage of the AMG method, in the pooled regression model extended with time dummies (D_t), the coefficients of time dummies are obtained by estimating the variables with First Differences Ordinary Least Squares (FD-OLS). These coefficients, which carry the effects of unobservable common factors among all countries in the panel, are characterized as "Common Dynamic Process". In the second stage, the $\hat{c}t$ parameters calculated for the time dummy coefficients in equation (3.2) are included in equation (3.3) as $\mu\hat{t}$ as an unobserved common factor. In the last stage, AMG panel coefficients are calculated by taking the weighted average of the coefficients calculated separately for each country in the panel (Eberhardt and Teal, 2010). According to Eberhardt (2012), who compares the CCEMG and AMG long-run cointegration coefficient estimators, these estimators perform similarly well. According to Eberdhardt (2012), Pesaran (2006) aims to achieve accurate estimation of model parameters that are associated with observable variables. The coefficients obtained for cross-sectional mean variables and their mean estimates have no major interpretability from an empirical standpoint. Their purpose is solely to adjust for the biased effect caused by the unobservable common factor (Erkan, 2024).

When analyzing financial and macroeconomic data that have a strong reciprocal relationship, it is common to discover the presence of cross-sectional dependence. Hence, it is crucial to assess the existence of cross-sectional dependence before and/or subsequent to performing empirical research. Three tests exist within the existing body of research on panel econometrics to investigate cross-sectional dependence. These tests are the Friedman (1937), Frees (1995), and Pesaran's (2004) cross-sectional dependence (CD) tests. This study examined the issue of cross-sectional independence by employing Pesaran's (2004) CD test for imbalanced panels. The test analyzes correlation coefficients derived from the residuals of individual regressions.

The AMG estimator estimates the effect of cross-sectional mean regressors on the variables of interest. This is the unique feature that makes AMG better than previous versions that assumed cross-sectional effects. AMG can be estimated by the following equation:

$$y_{it} = \alpha_i + \sum_{l=0}^{q} \beta_{il}\, y_{it-1} + \sum_{l=0}^{p} \delta_{il}\, x_{it-1} + \sum_{l=0}^{z} \mu_{il}\, z_{it-1} + u_{it} \qquad (3.5)$$

$$z_t = (y_t + x_t),\ y_t = n^{-1} \sum_i^N y_t \ ve\ x_t = n^{-1} \sum_i^N x_t \qquad (3.6)$$

The econometric equation used in the study:

$$Y1_{it} = \alpha_i + \beta_1 X1_{it} + \beta_2 X2_{it} + \beta_3 X3_{it} + \beta_4 X4_{it} + \beta_5 X5_{it} + \beta_6 X6_{it} + \varepsilon_{it} \qquad (3.7)$$

3.4. Empirical Results

Once we specify the model for empirical research, a few requirements guide us in selecting the appropriate econometric methods. Therefore, we conduct a study to determine the most appropriate and effective estimator by examining tests for heterogeneity of slope coefficients.

The descriptive statistics presented in Table 3.3 comprehensively summarize the dataset. The results encompass measures of central tendency and dispersion.

Variable	Obs.	Mean	Std. Dev	Min.	Max.
Y1 (Real Effective Exchange Rate)	253	101,9808	26,27446	48,46	222,15
X1 (Current Deficit /GDP Ratio)	253	-0,0065	4,898715	-16,01295	20,79404
X2 (External Debt / Total Export Ratio)	253	11,2554	8,906792	0,253938	40,2876
X3 (Inflation)	253	14,4459	31,6352	-16,76214	418,019
X4 (Private Sector Credit Debt / GDP)	253	36,2199	28,5738	1,96654	126,9325
X5 (Gross Public Debt / GDP)	253	53,2546	24,08565	7,3	147,2
X6 (Growth)	253	3,6064	3,863297	-10,89448	15,32916

Table 3.3 Descriptive Statistics Results

3.4.1. Cross Sectional Dependence

An essential factor to take into account in panel data analysis is the existence of cross-sectional dependence, as proposed by Goldin (1966). Failure to consider this element can result in uneven estimations and deceptive insights. In this particular situation, HM Pesaran (2004) suggested the utilization of the Pesaran CD and standardized Lagrange Multiplier (LM) tests. Additionally, Breusch and Pagan (1980) introduced the Breusch-Pagan LM test as a means of identifying cross-sectional dependence. In emerging nations, different financial and economic goals are partially or completely interconnected. Nevertheless, the interconnectedness across nations demonstrates both commonalities and variations when seen from various angles. Thus, the Pesaran (2004) cross-sectional dependence (CD) test was utilized in the current investigation to prevent biased estimations. After analyzing the significance values in the table, it was concluded that the panel displays cross-sectional dependence. The Table 3.4 displaying the estimation results for the Pesaran CD test is presented below:

Test Statistics	Value
LM Test	78,59**
CD Test	2,873***
Bias Adjusted LM Test	1.495

Table 3.4 The Results of Cross Section Dependence Tests

Notes: ***, It shows significance at the 1 percent level. ** Indicates % 5 significance level.
The null hypothesis is that there is no cross-sectional dependence. Both LM and the CD test results shows that there is cross section dependency in these data.

The null hypothesis is that there is no cross-sectional dependence. Both LM and the CD test results shows that there is cross section dependency in these data.
After showing cross dependence, below the table 3.5 unit root test results of variables are given.

	Level		First Difference	
	Constant	**Cons.+ Trend**	**Constant**	**Cons.+ Trend**
Y1	-1,780	-2,648	-3,993***	-4,161***

X1	-3,217***	-3,327***	-4,601***	-4,418***
X2	-2,428**	-4,509***	-5,434***	-5,403***
X3	-2,627***	-3,485***	-5,311***	-5,337***
X4	-2,157*	-2,190	-3,439***	-3,528***
X5	-2,604***	-3,365***	-3,712***	-3,947***
X6	-3,105***	-3,679***	-5,596***	-5,683***

Table 3.5 CIPS Unit Root Test Results
Notes: *** Indicates % 1 significance level. ** Indicates % 5 significance level, * Indicates % 10 significance level

The CIPS test establishes a basic hypothesis that includes a unit root. Based on the results, the first difference of whole variables are stationary.

3.4.2. Homogeneity of Coefficients

Following an examination of the cross-sectional dependence in the panel, the variability of slope coefficients within the panel is also assessed. When analyzing panel data in econometrics, it is important to consider that having different slopes and coefficients might lead to conclusions that are not trustworthy and can be deceptive (Breitung, 2001). In this particular situation, the SCH test, which was devised by Pesaran and Yamagata in 2008, operates under the assumption that the slope coefficients are consistent throughout the panel. However, if the data are shown to be statistically significant, rejecting the null hypothesis will result in the conclusion that the slopes are different from each other. The outcomes of the Slope Homogeneity Test are given in table 3.6 as follows:

Test	**T-Statistics**
Δ	8.610***
Δ_{adj}	10.662***

Table 3.6 The Results of Coefficients Homogeneity Test
Notes: *** Indicates % 1 significance level. ** Indicates % 5 significance level, * Indicates % 10 significance level.

The null hypothesis of slope homogeneity is tested using the T statistics presented in Table 3.6. The results indicate rejection of the null hypothesis that the slope coefficients are homogeneous, leading to the conclusion that the slope coefficients exhibit heterogeneity.

3.4.3. Augmented Mean Group (AMG) Estimator Results

In the model, logarithmic values of the dependent variable real effective exchange rate (Y1) and the independent variable inflation rate (X3) are used. AMG test results are reported in Table 3.7. According to these results, for the whole panel, a negative significant relationship was found between the Real Effective Exchange Rate and the inflation rate at the 5% significance level, a negative significant relationship was found between the gross public debt/GDP ratio at the 1% significance level and a positive significant relationship was found with the growth rate

at the 5% significance level, a positive insignificant relationship was found between the current account deficit/GDP ratio and the external debt/exports ratio, and a negative insignificant relationship was found with the private sector loans/GDP ratio. A 1% increase in the inflation rate decreases the Real Effective Exchange Rate by approximately 0.06% and a 1% increase in the Gross Public Debt/GDP ratio decreases the Real Effective Exchange Rate by approximately 0.001%. These results reveal the importance of outsourcing in developing countries with low Real Effective Exchange Rate. Again, by looking at the results, we can say that a 1% increase in the growth rate will cause an increase of 0.005% in the real effective exchange rate.

Country	X1	X2	logX3	dX4	X5	X6
All Panel	0.0023	0.0009	-0.0667	-0.0019	-0.0018	0.0054
	(0.292)	(0.269)	(0.018)**	(0.151)	(0.000)***	(0.016)**
Angola	-0.0035	0.0056	-0.0115	0.0045	-0.0035	0.0009
	(0.057)*	(0.047)**	(0.737)	(0.603)	(0.001)***	(0.832)
Argentina	-0.0058	0.0012	-0.1275	0.0042	-0.0015	0.0054
	(0.581	(0.539)	(0.262)	(0.744)	(0.091)*	(0.021)**
Indonesia	0.0128	0.0024	-0.0757	-0.0054	-0.0006	0.0263
	(0.007)***	(0.308)	(0.013)**	(0.325)	(0.544)	(0.071)*
South Africa	0.0107	-0.0018	-0.3048	-0.0008	-0.0024	0.0004
	(0.148)	(0.641)	(0.044)**	(0.738)	(0.086)*	(0.912)
Egypt	-0.0032	0.00003	-0.0016	-0.0006	-0.0035	0.0085
	(0.688)	(0.992)	(0.984)	(0.924)	(0.088)*	(0.383)
Mexico	0.0002	-0.0020	-0.0487	-0.0062	-0.0014	0.0035
	(0.977)	(0.385)	(0.316)	(0.236)	(0.136)	(0.075)*
Nigeria	-0.0012	0.0020	0.0357	0.0017	-0.0013	0.0019
	(0.636)	(0.527)	(0.258)	(0.631)	(0.212)	(0.404)
Pakistan	0.0028	-0.0006	-0.0245	-0.0098	-0.0010	0.0006
	(0.298)	(0.754)	(0.477)	(0.151)	(0.517)	(0.853)
Thailand	-0.0010	-0.00006	-0.0055	-0.0002	-0.0020	0.0022
	(0.406)	(0.973)	(0.712)	(0.804)	(0.034)**	(0.251)
Turkiye	-0.0019	0.0054	-0.1214	-0.0027	-0.0007	0.0017
	(0.672)	(0.143)	(0.053)**	(0.380)	(0.702)	(0.463)
India (Bharat)	0.0163	-0.0023	-0.0522	-0.0062	-0.0022	0.0075
	(0.001)***	(0.025)**	(0.428)	(0.047)**	(0.042)**	(0.012)**

Table 3.7 AMG Test Results

When the country-based results are analyzed, a positive significant relationship was found between the Real Effective Exchange Rate and the current account deficit/GDP ratio for Indonesia and India at the 1% significance level, while a negative significant relationship was found for Angola at the 10% significance level. This positive relationship found in Indonesia and India indicates that the international competitiveness levels of countries increase as a result of the increase in the Real Effective Exchange Rate. In Turkey, Brazil, Mexico, Egypt, Thailand, Thailand, Argentina, Pakistan, Nigeria, there is no significant relationship between Real Effective Exchange Rate and current account deficit/GDP ratio. For India, a negative relationship between the Real Effective Exchange Rate and the external debt / total exports ratio is found for India and a positive significant relationship is found for Angola. For India, this implies that total debt is growing faster than the economy's main source of external income and that it may have problems in fulfilling its debt obligations, while for Angola, on the contrary, it is a positive result. A negative significant relationship was found between the Real Effective Exchange Rate and the inflation rate for S. Africa, Indonesia and Turkey. For India, it is concluded that there is a negative significant relationship between Real Effective Exchange Rate and private sector credit debt/GDP ratio at 5% significance level. There is a significant negative relationship between the Real Effective Exchange Rate and the gross public debt/GDP ratio in Angola, Argentina, South Africa, Egypt, India and Thailand. There is a significant positive relationship between Real Effective Exchange Rate and growth rate in India, Argentina, Indonesia and Mexico.

4. CONCLUSION

In developing countries, the private sector and public institutions can raise funds to meet their foreign exchange needs through external borrowing due to low savings rates and low capital accumulation in proportion to low income. Therefore, the level of the exchange rate is crucial for sustainable borrowing and stable growth.

In this study, the effect of selected macroeconomic indicators on the real effective exchange rate is analyzed with panel data methods based on the data of 11 countries among 18 developing countries for the period 2000–2022. In the analysis, the Pesaran (2004) horizontal cross-section dependence (CD) test is used to avoid biased estimates. The results of the horizontal cross-section dependence test reject the null hypothesis of "no horizontal cross-section dependence" for all variables. For 16 developing countries, various fiscal and economic targets are partially or fully dependent on each other. Then, the homogeneity test developed by Pesaran and Yamagata (2008) was conducted to test whether the variables were homogeneous. According to the test results, the null hypothesis that the slope coefficients are homogeneous is rejected, and it is concluded that the slope coefficients are not homogeneous. Therefore, we continued the analysis using non-homogeneous panel data methods that consider country-specific characteristics.

As a result of the tests, a negative significant relationship was found between the real effective exchange rate and inflation and gross public debt/GDP ratio for the whole panel. A 1% increase in the inflation rate decreases the Real Effective Exchange Rate by approximately 0.06% and a 1% increase in the Gross Public Debt/GDP ratio decreases the Real Effective Exchange Rate by approximately 0.002%. It is concluded that the growth rate has a positive significant effect on the real effective exchange rate, while the current account deficit/GDP and external debt/exports ratio have a positive but statistically insignificant effect. The negative effect of domestic credits to the private sector/GDP ratio on the exchange rate can be explained as the

transfer of domestic credits to the private sector to investment will reduce the external debt ratio, which in turn leads to a decrease in foreign exchange demand and exchange rate.
When we look at the results of the significant analysis specific to countries, it is stated in the World Bank 2023 economic outlook report that the economic reforms in Angola in recent years (flexible exchange rate regime, central bank independence, stable monetary policy, and fiscal consolidation) have led to improvements in macroeconomic indicators. As a result of the analysis, it is concluded that there is a positive relationship between the external debt export ratio and the real effective exchange rate in countries that generally have a current account surplus due to oil revenues. Angola is one of those countries. Exports have dominated Argentina's growth performance over the last few years, with agricultural products accounting for about a third of total exports. Another country in a similar situation is India, where agriculture is the main employer. According to the analysis's findings, there is a significant positive relationship between growth and the real effective exchange rate in both countries. In Indonesia, the main source of economic growth is exports, and a wide range of export commodities, especially rice, are produced. Similar to India, the current account deficit to GDP ratio has a positive and highly significant effect on the real effective exchange rate.

These results indicate that in developing countries, especially as a result of the increase in gross public debt/GDP ratios, the country risk premium (CDS) will increase, which increases the risk perception of foreign investors and causes capital outflows. As a result, the value of the national currency decreases and the value of foreign currency increases. Changes in the real effective exchange rate are found to be most affected by changes in inflation, growth and gross public debt/GDP ratio, respectively. When the results of similar studies are analysed, it is seen that the results of the study are consistent with the literature and the insignificant results are due to the period range and country differences.

In order to reduce high exchange rate volatility, developing countries need to look carefully at these variables and evaluate their effects during policy formulation and implementation. Considering that exchange rate fluctuations directly affect price stability, financial stability, and trade balance, the results of the study provide important information for policymakers. Decision-makers who manage exchange rate risk gain credibility for the economy with exchange rate stability through stable macroeconomic variables. As a policy recommendation, it can be said that for stable and sustainable economic management in developing countries, the exchange rate level should be low and less volatile and should be in harmony with credible fiscal and monetary policies.

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