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EDITED BY
Larisa Ivascu,
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Kashif Raza,
University of Education Lahore, Pakistan

*CORRESPONDENCE
Muneeb Ahmad,
muneeb112@gmail.com
Lin Xiao,
jessicaxl@126.com

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# Financial development and real exchange rate misalignments effects on environmental pollution

Lin Xiao[1]*, Muneeb Ahmad[2]*, Liaqat Ali Waseem[3], Muhammad Munir Ahmad[4] and Ashfak Ahmad Khan[5]

[1]School of Economics, Tianjin University of Commerce, Tianjin, China, [2]School of Finance, Jiangxi University of Finance and Economics, Nanchang, China, [3]Department of Geography, Government College University, Faisalabad, Pakistan, [4]Department of Commerce, Allama Iqbal Open University, Islamabad, Pakistan, [5]Department of Geography, Faculty of Letters, Karabuk University, Karabuk, Turkey

The research examined the influence of the fundamental exchange rate misalignment and Least Developed Countries (LDCs) in Asia and Africa's financial development on $CO_2$ emissions in Asian countries using panel data from 1970 to 2021. The methodology consists of ARDL bound testing and PMG/ARDL estimators with dynamic OLS estimators. The results reveal that the long-run real exchange rates for least developed countries (LDCs) are expected to rise in $CO_2$ emissions in Asian and African countries with improved trade and net foreign asset positions. The relative productivity and trade openness also increase the exchange rate, which also plays a vital role in the growth of $CO_2$ emissions. Except for Egypt, all least developed countries (LDCs) currencies are overpriced throughout the research period at the same time; it would be harmed by increased openness, foreign direct investment inflows, and currency misalignment. Overvaluation harms Bahrain's economic growth. In comparison, undervaluation helps Egypt that currency misalignment does not affect financial growth in any LDCs over the long run. In the short-run, more real investment, net foreign assets, and official assistance inflows would enhance financial growth in Qatar, Bahrain, Singapore, and South Korea. In contrast, trade openness would slow it down in Egypt and Kuwait. The study suggested that the poor economic performance is due to RER misalignment, which occurs when exchange rate policies are improper and causes a rise in $CO_2$ emissions in many developing countries.

KEYWORDS

**real exchange rate, economic misalignment, financial growth, LDCs technique, asian countries**

**Abbreviations:** PMG, Pooled Mean Group; LDCs, Least Developed Countries; FEER, Fundamental Equilibrium Exchange Rate; DEER, Desired Equilibrium Exchange Rate; BEER, Behavioral Equilibrium Exchange Rate; PEER, Permanent Equilibrium Exchange Rate; MATRIX, Natural Real Exchange Rate; ARDL, Autoregressive Distributed Lag; RER, Respiratory Exchange Ratio; MIS, Misalignment; DOLS, Dynamic ordinary least square model; NFA, Net Foreign Asset; PD, Productivity difference; OP, Trade openness; BM, Broad money supply; TOT, Total Cost of Ownership; NPV, Present Net Value.

## 1 Introduction

The real exchange rate is considered one of the most significant relative prices in an economy and one of the key factors influencing economic growth. Therefore, maintaining a suitably valued currency is necessary for raising economic performance in emerging countries. The research investigates the impacts of RER misalignment, trade openness, technology innovation, energy consumption, and economic growth on $CO_2$ emissions in LDCs of Asia and Africa. The study has focused on finding the answers to the questions: what is the estimation of equilibrium RER? What are the relationships between trade openness, technology innovation and $CO_2$ emissions? One of the main obstacles to economic growth in LDCs is faulty exchange rate policy. The most significant pathways *via* which globalization and technological innovation are spread are the realignment of RER and trade openness. Energy use, GDP growth, and $CO_2$ emissions are all intricately connected. According to the literature on environmental economics, it is still debatable whether or not increased trade openness may significantly contribute to $CO_2$ emissions (Dou et al., 2021). REER has a dramatic effect on developing countries ability to $CO_2$ emissions. However, in both the short and long run, the actual exchange rate reflected the impact of changes in trade openness. claims that the spectacular East Asian growth is due to superior accumulation of physical and net foreign assets, but also prudent government intervention in allocating those resources to highly productive investment. Most of the investigations, both on developed and developing economies, showed the constructive outcome of foreign investment towards economic growth, which is subject to some variables, for example, net foreign assets, foundation, innovation, environmental issues, and exchange transparency. The Asian countries region remains the most vulnerable in the world, with high inflation pressure, a weak external position, chronic foreign currency shortages, rising external debt, incessant public deficits, and a high saving gap despite notable financial performance in some countries over the past decade (AfDB, 2020). Thanks to the currency's depreciation, increased economic development comes at the expense of increased energy consumption and carbon dioxide emissions (Shah et al., 2022). When it comes to international trade, foreign direct investment (FDI) flow has taken precedence over international trade in recent years (Chen and Moore, 2010). Strict enforcement of environmental rules, industry-specific policies, and promotion of renewable energy resources are just some of the immediate measures that should implement to prevent environmental pollution (Shahid et al., 2022). For industrialized countries, FDI has a greater impact on lowering emissions than developing countries (Demena and Afesorgbor, 2020). Regarding foreign direct investment (FDI), China is experiencing a boom, but it is also a major polluter and has the dirtiest cities in the world (Cole et al., 2011). In addition to a positive and statistically significant connection between population and life expectancy in the short run, the population does not affect life expectancy in the long run, provided environmental quality and spending on the environment are high (Shah et al., 2021). In contrast, foreign direct investment (FDI) and the use of renewable energy improve the environmental quality of East Asian economies (Khan et al., 2022). Understanding these factors' role in derunining a sector's total factor productivity (TFP) can aid in searching for novel strategies to increase TFP in these industries (Jafri et al., 2018). It raises the price of imported goods and discourages domestic and international investment because devaluation distorts pricing signals. Therefore, implementing a pro-growth RER strategy is difficult (Aguirre and Calderon, 2006). A country's exports considerably decrease these greenhouse gas emissions, and the agreement can counteract the relationship by decreasing the promotion impact of trade openness on $CO_2$ emissions. Although remittances and energy consumption both raise $CO_2$ emissions, the system GMM predicts that globalization will eventually decrease these emissions (Yang et al., 2020). Asian countries have adopted fixed exchange rate regimes as part of their anti-inflation measures, which are more susceptible to overvaluation than flexible rates (IMF, 2021). According to Hao et al. (2020), FDI can reduce $CO_2$ emissions using province-level panel data. Environment deterioration is aided greatly by authoritarianism, globalization of politics, growth of the economy, improvement in the financial sector, increased use of energy, and growth of gross fixed capital creation (Jahanger et al., 2021). Because it minimizes pollution, free trade positively affects the environment (Erdogan, 2014). Globalization, financial growth, and energy use considerably worsen the GCC countries' environmental quality (Yang et al., 2021). There was a unidirectional causal relationship between the real exchange rate, the balance of trade, and GDP, and between the balance of trade, the real exchange rate, and $CO_2$ emissions (Ahmad et al., 2022). According to Le et al. (2016), high-income countries are less polluted than medium- and low-income countries. It may sum up the impact of RER misalignment on growth in two ways. According to Coudert and Couharde (2008), RER misalignment is a macro-financial disequilibrium primarily in relative pricing that stifles financial growth and erodes the efficiency of resources. Reduced economic growth, exports, and export diversification, as well as an increased risk of currency crises and political instability, are all possible outcomes of an RER misalignment (Ambaw et al., 2022).With an increase in carbon productivity and a shift toward a low-carbon emission, sustainable economic growth pattern, China is well on its way to achieving its goal of sustainability (Jahangir et al., 2022a). Financial growth and RER misalignment may have a linear or nonlinear connection (Rapetti et al., 2012). The findings indicate that the RER misalignment for Asian and African countries has been criticized for overvaluing the currencies of those regions. As a result, the RER misalignment might have serious negative consequences on economic growth in the LDCs of Asia and Africa in both the

short and long run. Often, LDC currencies need to create a good exchange rate regime consistent with macroeconomic policy to resolve the persistent misalignment and reduce its harmful impact on economic growth. The paper also includes preliminary estimates of the RER misalignment for previously criticized Asian countries. Since sample countries have seen a devaluation of over 50% on average over the past decade, the RER disparity may present policy challenges.

The remainder of the article is set out as follows: The literature review is discussed in Section 2, and the research framework, data analysis procedure and research methods are presented in Section 3. The results and discussion are presented in Section 4, and finally, the conclusions with future suggestions are shown in Section 5.

## 2 Literature review

In countries with high levels of corruption, trade openness raises carbon emissions; in those with low levels of corruption, it lowers them, says Chang (2015). There was no substantial influence on carbon emissions in high-income and upper-middle-income countries due to trade openness, and even worse, trade openness increased carbon emissions in low-income countries (Wang and Zhang, 2021). Globalization, economic growth, and non-renewable energy contribute to rising environmental degradation, financial development and renewable energy usage significantly compress the deterioration (Usman et al., 2022a). For many economies, RER misalignment and its influence on financial development have been extensively studied using various metrics of misalignment and growth models in the extant empirical literature. According to Rodrik (2008), financial growth is negatively impacted by RER misalignment, notably overvaluation. Agricultural growth in Africa is slowed by currency misalignments that persist for an extended period (Cottani et al., 1990). Globalization and renewable energy help countries lower their ecological footprint, whereas financial development, natural resources, and non-renewable energy all have beneficial effects on the footprint (Usman et al., 2022b). Trade openness has a favorable long-run impact on emissions of $CO_2$ in Pakistan (Nasir and Ur Rehman, 2011). Although globalization has been linked to increased pollution levels, environmental benefits have resulted from increased trade, urbanization, and workforce (Kamal et al., 2021). A country's openness to trade positively influences financial growth (Ulaşan, 2015). There is a positive correlation between financial growth and factors such as foreign direct investment (FDI), capital creation, money supply, and openness to trade. Still, inflation negatively correlates (Yang and Shafiq, 2020). It reduced the ecological footprints due to financial growth; this was especially true for Asian countries but not those in Africa, Latin America, and the Caribbean (Jahanger et al., 2022b). The rise in $CO_2$ emissions and financial development has harmed the environment even more (Ayeche et al., 2016). In China's power and heating industry, the influence of energy intensity, input, and energy composition plays a crucial role in reducing $CO_2e$. This emission reduction effect is a rising trend (Jiang et al., 2022). An inverse relationship between carbon emissions and financial development is supported by evidence of financial development's beneficial impact on $CO_2$ emissions (Shahbaz et al., 2013). Financial growth and development are bad for the environment, while transportation infrastructure and foreign investment are good (Nguyen et al., 2021). There's an enduring link between $CO_2$ emissions, financial progress, financial growth, and energy consumption, as shown by the ARDL-bound test results (Mardani et al., 2019). Long-run environmental quality is severely harmed by economic growth, high energy use, and wide-open trade (Usman and Jahanger, 2021). Increased $CO_2$ emissions result from the interplay between ICTs (information and communication technologies) and economic growth, with the moderating influence and international trade playing a similar role (Ke et al., 2022). There are four key sources of carbon dioxide emissions in growing economies: transportation, food security, industry, and finance (Heidari et al., 2019). Environmental levies in China have significantly benefited the economic performance and technical innovation input of substantially polluting businesses (Wang Z. et al., 2022). Although the central financial districts of each province tend to remain relatively unchanged, the southeast coastline area's rate of green technology innovation is notably higher than that of the interior region (Han et al., 2022). Short-run increases in carbon dioxide emissions will result from a rise in GDP per capita during the current (Yuan and Huang, 2022). Per capita income, foreign direct investment, and oil prices have long-run impacts on Pakistan's carbon emissions (Malik et al., 2020). Globalization and green investment greatly mitigate long-term environmental damage (Li et al., 2022). $CO_2$ emissions from SSA countries are positively impacted by energy usage. Industrialization, urbanization, and fossil fuel use, although only somewhat over the long run (Appiah et al., 2021). The financial growth and foreign investment have boosted carbon emissions over time, and per capita, $CO_2$ emissions rise in China as the country becomes more open to trade (Ajaz et al., 2020). Corruption control and regulatory quality reduce environmental efficiency, whereas government effectiveness rises, even after allowing for industrialization, energy use, and population (Bahizire et al., 2022). Liu et al. (2021) used the advanced panel approach based on slope uniformity and the cross-section correlation test to investigate the long-run impact of FDI on China's environment. GDP and FDI influence carbon emissions positively, but international trade appears to have the opposite impact (Alshubiri and Elheddad, 2019). Growth in the economy and the financial sector both boost industrial production, with the former playing a vital role. At the same time, the latter is seen negatively due to the impact of foreign direct investment (Appiah

et al., 2022a). Reports indicate a favorable effect of the renewable energy-growth nexus on institutional membership and a negative moderating effect on the general population (Appiah et al., 2022b). Salahuddin et al. (2018) showed no statistical association between financial development and clean energy usage, as investments are not clean and technology is not applied in applications with advantages for cutting prices. The shift from agricultural to industrial economies in the SSA coincides with infrastructural development (Appiah et al., 2022c). To maximize the impact of RER policies, traditional industrial strategies that raise the responsiveness of the aggregate supply to the RER are necessary. To ensure a stable and competitive RER, foreign currency market intervention and capital flow restriction are among the necessary tools (Guzman et al., 2018). Carbon and energy efficiency are becoming the most important variables in GHG emissions in economies such as the BRICS (Fabbri and Ninni 2014). The middle-income countries positively correlate openness to trade and carbon emissions (Shahbaz et al., 2017). Individual variability may be accommodated by the panel DOLS since it considers varied short-run dynamics, as well as individual-specific temporal trends and fixed effects. Rapid low-carbon technology transfer from high-income to low-income countries is only conceivable because trade is global (Ahmed et al., 2015). If the $CO_2$ emissions and actual trade prices are incorrect, the TFP productivity assessment in China's thermal power industry may be substantially affected (Chen and Jin, 2020). Zhang et al. (2011) investigated at the provincial level shows that the increase of green TFP is reduced when pollutants are included as unwanted outcomes. According to this theory, changing exchange rate definitions and time horizons can lead to varied exchange rate behaviors, with several short, medium, and long-run horizons possible (Driver and Westaway, 2003). The long-run RER and short-run RER error correction estimates generate equilibrium RER and RER misalignment indexes for the countries he picked (Elbadawi and Soto, 1997). For the United States dollar, the Japanese yen, and the German mark, evaluated the sensitivity of FEER estimates for each of these currencies to various formulations and hypotheses. Calculations based on the FEER model are fraught with error because of these two primary influences. Monitoring real exchange rate equilibrium and misalignment is an important tool for governments/central banks to guarantee that the economy remains stable (Baffes et al., 1999). Balance in the FEER method of analyzing current exchange rates is described as macro-financial balance, and the BEER approach identifies the RER misalignment in three stages (Clark and MacDonald, 1998). There appears to be a correlation between economic expansion, elevated energy consumption, and $CO_2$ emissions (Karim et al., 2022). When endogeneity, serial correlation, and non-stationarity are detected, the group mean DOLS based on the between-dimension provides efficient and consistent long-run. The ECOWAS region's economic growth is not significantly aided by financial development (Appiah et al., 2020). They can improve the long-run model's accuracy by using the ARDL method. Carbon emission in Nigeria may largely be attributed to economic growth, financial development, and stock market performance, as shown by the ARDL long-run findings (Yu et al., 2022). According to Behera and Dash (2017), who used the FMOLS and DOLS estimators, there is a positive correlation between FDI and $CO_2$ emissions.

# 3 Research methodology

## 3.1 Data collection

The study uses data from six Asian and African countries (Qatar, Bahrain, Singapore, South Korea, Egypt, and Kuwait) to assess the influence of RER misalignment on financial growth from 1970 to 2021. An average of actual bilateral exchange rates against each trading partner is used to calculate the CPI-based REER data, which is acquired from Bruegel databases (https://www.bruegel.org.com). Lane and Milesi-(2021) Ferretti's database (https://www.ferrettigroup.com) provides the net foreign asset position statistics. The PCTOT (product runs of trade) and WEO (world economic outlook) databases of the IMF (https://www.imf.org.com) are used to collect the data on the runs of trade and gross capital creation. World bank database (https://data.worldbank.org) is used to get information on a country's trade openness, productivity gap, official development aid, GDP real and GDP real per person, total population, and extensive currency. The data relating to $CO_2$ emissions (metric tons per capita) has been collected from the World Bank database (https://data.worldbank.org).

## 3.2 Conceptual framework

A problem in international macroeconomics remains the assessment of RER misalignment because of the ambiguity in the run "RER."The purchasing power parity (PPP) model and model-based methodologies are commonly used to measure RER misalignment. Model-based techniques include the Fundamental Equilibrium Exchange Rate (FEER), the Desired Equilibrium Exchange Rate (DEER), the Behavioral Equilibrium Exchange Rate (BEER), the Permanent Equilibrium Exchange Rate (PEER), and the Natural Real Exchange Rate (NREER). The FEER is the equilibrium RER that maintains internal and external balance (Williamson, 1994). RER equilibrium, sustainability of the basics, and a clear definition of the model and methods involved. The research indicated that actual exchange rates for tradable and non-tradable currencies are closely linked. Financial factors are the basis for the BEER model, which aims to explain the exchange rate's real behavior. If driving fundamentals have major transitory parts, Clark and MacDonald (2000) recommend

augmenting the BEER method with a PEER decomposition. Both Williamson's (1994) Fundamental Equilibrium Exchange Rate (FEER) idea and Desired Equilibrium Exchange Rate (DEER) concept are included in the first group. Real exchange rates consistent with macro-financial goals are called DEERs (Bayoumi et al., 1994).

## 3.3 Econometric models

Methodologically, DEER's computation is a compact version of the FEER, requiring the solution of three estimations of current account elasticities (Siregar, 2011). Reducing-form Eq. 1 below estimates the long-run REER-financial variables connection, which includes both fundamental and short-run factors.

$$\log REER_{it} = \alpha_i + \beta_1 lnTOT_{it} + \beta_2 NFA_{it} + \beta_3 lnPD_{it} + \beta_4 lnOP_{it} + \beta_5 lnBM_{it} + \epsilon_{i,t} \quad (1)$$

$RiR_i$ is the real effective exchange rate for the nation. NFA is the net foreign asset, and PD is the productivity difference. OP is trade openness; BM is broad money supply, ln is natural logarithms, and the error run. Weighted geometric averages of bilateral real exchange rates versus crucial trading partners are used to calculate the REER. The value of a foreign currency per unit of home currency is known as the exchange rate, and an increase in it indicates an appreciation. An important variable, in the long run, is known as the total cost of ownership (TOT), while in the short run, it is known as the net present value (NPV). Whether the income effect or the substitution effect dominates, the TOT is detrained by the ratio of the export price index to the import price index. In turn, this boosts demand for tradable commodities, which in turn raises RER. Real currency depreciation can be counterbalanced by this income effect on the demand and supply. PD represents the difference in total labor productivity between the United States and the rest of the world. It will reduce REER's value due to increased trade openness. Social security spending lags far behind GDP growth in its impact on environmentally sustainable development (Wang B. et al., 2022). The helpful and significant complementary link between trade openness and capital creation in encouraging financial growth and trade openness benefits the economy in the short and long run (Keho, 2017). With the use of difference-in-differences (DID), regional economic cooperation like BRI has, on average, a detrimental impact on environmental quality in Belt and Road countries (Zhou et al., 2022). The short-run monetary variable, BM, is broad money as a proportion of GDP. Because of the lack of interest rate data in LDCs, the discrepancy in interest rates is one of the most significant variables in estimating equilibrium RER. REER is expected to rise if TOT, NFA, and PD rise while OP and BM fall.

However, there may be differences in the short-run coefficients and error variances between groups, as the pooled mean group (PMG) estimator shows in this article. Still, the long-run coefficients must be comparable (Pesaran et al., 1999). While allowing for some variation in intercepts and error variance, the PMG method confines the long-run coefficients to be the same across cross-sectional samples. The cointegration form modifies the ARDL model for panel data analysis. Given Y = [lnTOT, NFA, lnPD, lnOP, lnBM], the equilibrium RER is estimated using the PMG/ARDL model from Eq. 1, which states as:

$$\Delta lnREER_{it} = \alpha_i + \varphi_1 lnREER_{i,t-1} + \beta_2 lnY_{i,t} + \sum_{j=1}^{q-1} \delta_{i,j} \Delta lnREER_{i,t-j} + \sum_{j=0}^{p-1} \lambda_{i,j} \Delta lnY_{i,t-j} + \epsilon_{i,t} \quad (2)$$

Where Δ is the first difference of variables, $\alpha_i$ is country-specific intercepts, $\varphi_i$ is the adjustment coefficient, and $\theta = -(\beta_i / \varphi_i)$ is a long-run coefficient. According to, ARDL Bound testing time-series data is utilized to estimate the equilibrium RER for each LDC, considering each LDC's economy. The time series ARDL approach has three benefits over the alternatives. It is feasible to address this uncertainty by utilizing the ARDL to test for long-run associations. A bound test can be used to examine long-run correlations between variables of interest regardless of whether they are stable or integrated order one, I (1), but not I (0) (2). The strategy is effective when it works with small samples. It may employ alternative lag orders for both the dependent and explanatory factors. Cointegration between RER and the unconstrained ARDL model may be tested using the following formula:

$$\Delta lnREER_{i,t} = \eta_i + \sum_{i=1}^{q} \lambda_i lnREER_{i,t-i} + \sum_{i=0}^{p} \rho_i Y_{i,t-i} + \vartheta_{1j} lnREER_{i,t-1} + \vartheta_{2j} lnTOT_{i,t-1} + \vartheta_{3j} NFA_{i,t-1} + \vartheta_{4j} lnPD_{it} + \vartheta_5 \beta_4 lnOP_{it} + \vartheta_6 \beta_5 lnBM_{it} + \epsilon_{i,t} \quad (3)$$

Where, Y = [lnTOT, NFA, lnPD, lnOP, lnBM]; q = 1, . . .., k, and $p = 0,1, \ldots\ldots$ K lags; $\eta_i$ is the unrestricted intercept for country i, and εit is the white noise disturbance run for country i. The dynamic short-run impacts of all fundamental and short-run factors on the RER are explored using the limited ARDL with error correction after the long-run relationship has been tested. ($ECT_{t-1}$), which can be stated as:

$$\Delta lnREER_{i,t} = \eta_i + \sum_{i=1}^{q} \lambda_i lnREER_{i,t-i} + \sum_{i=0}^{p} \gamma_i Y_{i,t-i} + \theta ECT_{i,t-1} + \mu_{i,t} \quad (4)$$

Where, μi is unrestricted intercept, $ECT_{i,t-1} = l_{arger,t-1} - \alpha - \beta_1 lnTOT_{i,t-1} - \beta_2 NFA_{,t-1} - \beta_3 lnPD_{i,t-1} - \beta_4 lnOP_{i,t-1} - \beta_5 lnBM_{i,t-1}$ , $\theta$ is the speed of adjustment coefficient towards equilibrium, γi is dynamic short-run effects, and $\mu_{i,t}$ is white noise disturbance run An endogenous explanatory variable may skew ARDL estimation since all explanatory variables are supposed to be exogenous in ARDL estimation. One way to express the panel DOLS is this:

TABLE 1 Shows the results of Unit Root Tests with Levin, ADF and IPS.

| Country | *Unit* | Variables | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *root* | *lnC02* | *lnREER* | *lnTOT* | *NFA* | *lnPD* | *lnOP* | *lnBM* | *lnY* | *lnINV* | *lnHC* | *lnODA* |
| Panel | | | | | | | | | | | | |
| LLC | I (0) | -0.575 | -0.398 | -0.754 | -2.846** | 0.668 | -2.407 | -2.462** | 4.198 | -2.386*** | -2.846*** | -0.192 |
| | I (1) | -20.776*** | -4.407*** | -20.776*** | -19.574*** | -8.194*** | -8.754*** | -24.397*** | -8.475*** | -28.639*** | -24.468*** | -19.475*** |
| IPS | I (0) | -0.392 | -0.075 | -0.606 | -2.739** | 2.762 | -2.08 | -2.239 | 6.208 | 0.006 | 2.019 | -0.639 |
| | I (1) | -7.198*** | -8.475*** | -7.198*** | -7.775*** | -6.766*** | -7.248*** | -24.804*** | -8.686*** | -26.376*** | -24.880*** | -19.266*** |
| ADF- | I (0) | 20.707 | 19.388 | 19.457 | 20.194 | 4.876 | 24.68 | 26.008 | 2.084 | 7.074 | 19.392 | 24.196 |
| Fisher $x^2$ | I (1) | 78.754*** | 75.204*** | 78.754*** | 207.707*** | 84.808*** | 202.284*** | 260.756*** | 88.202*** | 268.802*** | 192.066*** | 238.838*** |
| Time Series—ADF test | | | | | | | | | | | | |
| Qatar | I (0) | -2.026 | -2.192 | -2.384 | -2.766 | -0.207 | -2.840* | -0.766 | -2.219 | -2.462 | -0.219 | -2.06 |
| | I (1) | -4.475*** | -4.839*** | -4.486*** | -4.475*** | -6.046*** | -7.246*** | -8.207*** | -6.246*** | -6.686*** | -8.476*** | -6.880*** |
| Bahrain | I (0) | -2.707 | -2.246 | -2.396 | -2.754 | 0.066 | -2.075 | -2.074 | 2.247 | -2.468 | -2.468 | -2.604 |
| | I (1) | -8.474*** | -4.077*** | -4.768*** | -8.474*** | -4.439*** | -4.746*** | -6.775*** | -4.076*** | -20.026*** | -6.846*** | -6.574*** |
| Egypt | I (0) | -2.038 | 0.192 | -2.757 | -2.407 | -2.078 | -2.196 | -2.074 | 0.659 | -2.075 | -4.646*** | -2.68 |
| | I (1) | -8.684*** | -6.776*** | -8.046*** | -8.684*** | -4.407*** | -6.202*** | -8.407*** | -4.396** | -19.386*** | -4.750*** | -6.666*** |
| Kuwait | I (0) | -2.775 | -2.204 | -2.668* | -2.2 | -2.386 | -2.807 | -2.676 | -0.075 | -0.668 | -0.676 | -2.194 |
| | I (1) | -4.257*** | -6.602*** | -4.464*** | -4.257*** | -6.857*** | -7.020*** | -6.602*** | -6.768*** | -6.780*** | -8.470*** | -6.194*** |
| Singapore | I (0) | -2.208 | -2.686* | -2.486 | -2.39 | 2.288 | -2.198 | -2.578 | 4.284 | -2.884 | -2.659 | -0.575 |
| | I (1) | -6.866*** | -4.804*** | -6.866*** | -4.384*** | -4.000*** | -4.702*** | -4.838*** | -4.408*** | -6.884*** | -8.668*** | -8.046*** |
| South Korea | I (0) | -2.198 | -2.762* | -2.574 | -2.196 | -0.704 | -2.192 | -2.657 | 0.006 | -2.704 | -2.192 | -0.602 |
| | I (1) | -4.257*** | -7.776*** | -4.257*** | -6.608*** | -4.846*** | -20.757*** | -6.074*** | -4.462*** | -6.866*** | -8.004*** | -2.466** |

Notes: ***, **, * are 1%, 5%, and 10%-unit root rejection levels, respectively. SIC, is used for Max-lag selection.

TABLE 2 RER Model Cointegration test results from the Johansen Fisher panel.

| Hypothesized No. of CE (s) | Trace test | | Max-eigen test | |
|---|---|---|---|---|
| | Fisher statistics | Probability | Fisher statistics | Probability |
| None | 90.02 | 0.0001 | 39.07 | 0.01023 |
| At most 1 | 51.07 | 0.0003 | 30.02 | 0.02478 |
| At most 2 | 31.04 | 0.0001 | 15.08 | 0.30525 |

Note: Trend assumption (linear heuristic trend), lags interval (in first difference, 1:1).

$$lnREER_{i,t} = \alpha_i + \beta_i Y_{i,t} + \sum_{j=-k_i}^{k_i} \gamma_{it} \Delta Y_{i,t-k} + \epsilon_{it} \quad (5)$$

Y = {*lnTOT*, *NFA*, *lnPD*, *lnOP*, *lnBM*}, and $\gamma_{it}$ lead and lag differences account for serial correlation and endogeneity issues. Equilibrium RER is calculated by substituting long-run values of fundamentals into the estimated relationship. At the same time, short-run variables are set to zero in step two under the BEER approach Christiano-Fitzerald Full-Length Asymmetric (CF Asymmetric) filtering is used to isolate long-run fundamentals values from cyclical components. As a final step, the RER misalignment is calculated by subtracting the current REER from the predicted equilibrium RER. As a result, we can calculate the index of RER misalignment as follows:

$$MIS_{it} = \ln\left(\frac{REER}{ERER}\right) = lnREER_{it} - lnERER_{it} \quad (6)$$

A real equilibrium return for nation '*i*' at a time '*t*' is denoted by the run "ERER." Eq. 5 shows that the run of trade, relative productivity differences (RPDs), investment openness (TOE), and net foreign assets (NA) influence Turkey's equilibrium REER and that currency misalignment is at a significant level once RER misalignment is assessed.

$$lnY_{it} = \alpha_1 + \alpha_2\, lnINV_{it} + \alpha_3\, lnHC_{it} + \alpha_4\, lnOP_{it} + \alpha_5\, lnODA_{it} + \alpha_6 MIS_{it} + \tau_t \quad (7)$$

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TABLE 3 The PMG/ARDL estimation results for real exchange rate model.

| Variable | Coefficient | Standard error | t-Statistic | Probability |
|---|---|---|---|---|
| Long run equation | | | | |
| $lnC\ O_2$ | 0.1048 | 0.0485 | 1.0767 | 0.0031 |
| lnTOT | 0.1819 | 0.0548 | 2.8959 | 0.0017 |
| NFA | 0.0081 | 0.0023 | 5.1675 | 0.0000 |
| lnPD | 0.3305 | 0.1075 | 1.5923 | 0.0523 |
| lnOP | -0.3513 | 0.2301 | -2.048 | 0.0137 |
| lnBM | -0.0665 | 0.1059 | -1.0626 | 0.0308 |
| Short run equation | | | | |
| ECT (−1) | -0.1723 | 0.1301 | -1.0107 | 0.0342 |
| $\Delta lnCO_2$ | 0.0316 | 0.0517 | 1.0075 | 0.3061 |
| ΔlnTOT | 0.0137 | 0.0123 | 1.0513 | 0.163 |
| ΔNFA | 0.0003 | 0.0008 | 0.3306 | 0.5648 |
| ΔlnPD | -0.5056 | 0.2342 | -3.1317 | 0.0023 |
| ΔlnOP | -0.1333 | 0.0713 | -1.7316 | 0.005 |
| ΔlnBM | -0.0625 | 0.0506 | -2.0103 | 0.2373 |
| C | 1.0107 | 0.6648 | 1.0171 | 0.033 |
| @Trend | 0.0003 | 0.0008 | 0.3337 | 0.7307 |
| Mean dependent var | -0.0086 | SD dependent var | | 0.1359 |
| SE of regression | 0.0633 | Akaike info criterion | | -1.4251 |
| Sum squared resid | 1.4231 | Schwarz criterion | | -0.6073 |

Note: lnREER, is the dependent variable here. The PMG/ARDL, method is used. A good example is the period from 1970 to 2021. Dependency delays up to 1 (automatic selection). lnTOT, NFA, lnPD, lnOP, and lnBM, are the dynamic regressors (1-lag automatic): The Schwarz Criterion is used to choose models (SIC). ARDL, has been chosen as the model (1, 1, 1, 1, 1, 1).

TABLE 4 Group-mean panel DOLS estimation results for the RER model.

| Variables | DOLS without time trend | | | DOLS with time trend | | |
|---|---|---|---|---|---|---|
| | Coefficient | Std. Error | Prob | Coefficient | Std. Error | Prob |
| $lnCO_2$ | 0.2104 | 0.0646 | 0.0204 | 0.2152 | 0.0821 | 0.0208 |
| lnTOT | 0.1551 | 0.0862 | 0.0192 | 0.15 | 0.0864 | 0.0152 |
| NFA | 0.0015 | 0.002 | 0.0468 | 0.0021 | 0.0015 | 0.1614 |
| lnPD | -0.3284 | 0.1962 | 0.4064 | 0.4072 | 0.5081 | 0.4615 |
| lnOP | -0.5106 | 0.2064 | 0.0002 | -0.1972 | 0.1516 | 0.0326 |
| lnBM | -0.3906 | 0.3202 | 0.0051 | -0.4621 | 0.2162 | 0.0472 |

Note: Grouped estimation; Fixed leads and lags specification (lead = 2, lag = 2); (Prewhitening with lags, 8 = 2, Bartlett kernel, Newey-West fixed bandwidth).

*Y* is real GDP per capita, *INV* is a genuine investment, *HC* is net foreign assets, *OP* is openness to trade, *ODA* is official development aid, *MIS* is misaligned, and $\tau$ is erroneous. Because comprehensive data is not available for the sample LDCs in the study. The dependent variable may be calculated using the 2015 United States dollar value of real GDP per capita. The Washington Consensus predicts that the misalignment coefficient will be negative and the undervaluation coefficient will be positive.

## 4 Results and discussions

The unit root tests are carried out using the Levin-Lin-Chu (LLC), Im, Pesaran and Shin (IPS), and ADF-Fisher Chi-square tests for panel data, and Augmented Dickey-Fuller (ADF) with intercept for time series data in the Table 1 below. Even while the net foreign asset position appears stable at a certain level for the panel, unit root results demonstrated that all data series are integrated order one I (1) and may run an integration test.

TABLE 5 Bound F-test results for Real Exchange Rate Model.

| Country | ARDL | Without deruninistic trend | | | ARDL | With unrestricted trend | | |
|---|---|---|---|---|---|---|---|---|
| | Model | F-test | *t*-test | LM (2) | Model | F-test | *t*-test | LM (2) |
| Qatar | 510,200 | 20.5153 | -4.6218 | 0.2826 | 510,200 | 6.5392 | -4.6846 | 0.516 |
| Bahrain | 200,204 | 8.0532 | -4.4686 | 0.6902 | 200,204 | 20.6516 | -4.8453 | 0.2046 |
| Egypt | 390,021 | 20.0484 | -2.6984 | 0.422 | 390,221 | 6.8621 | -0.2622 | 0.2053 |
| Singapore | 390,221 | 6.4608 | -4.4853 | 0.2608 | 251,020 | 22.5346 | -8.6986 | 0.2182 |
| Kuwait | 200,510 | 6.0822 | -2.5362 | 0.5368 | 307,307 | 6.2842 | -2.0253 | 0.6946 |
| South Korea | 394,200 | 6.5346 | -2.486 | 0.4206 | 309,829 | 4.5321 | -2.8646 | 0.2862 |

Note: For a 1%, 5%, and 10% significant level, Pesaran et al. (2001) found that the critical values for the F-statistic for (k = 5) are [4.42, 4.68], [2.62, 4.86], and [2.26, 4.46].

## 4.1 Estimation of real exchange rate misalignment

The REER and its fundamentals, such as runs of trade, net foreign asset, productivity difference, trade openness, and broad money, should be checked for cointegration to investigate the long- and short-run ruminants of REER. Table 2 shows the results of the Johansen cointegration tests, which reveal that the real exchange rate equation variables have a long-run connection with $CO_2$ emissions. The long-run estimations are therefore possible by using an appropriate panel estimate technique.

The REER panel's long-run and dynamic short-run impacts on the REER are evaluated using the PMG technique (Pesaran et al., 1999). Table 3 shows the PMG and ARDL estimate findings. The adjustment coefficient is negative and statistically significant, indicating that REER and its fundamentals have a long-run cointegrating relationship. According to PMG data, overall fundamentals and short-run variables with their projected long-run signals drive REER. The REER is shown to appreciate in runs of trade and net foreign asset position; Although statistically significant, the net foreign asset position coefficient is negligible. The trade liberalization in LDCs may lower the price of non-tradable items relative to tradable commodities, as confirmed by the negative effect of trade openness and a strong effect to increase $CO_2$ emissions. Sample LDCs' currencies decline in the short run if their relative productivity and trade openness increases the $CO_2$ emissions in Asian countries.

Panel DOLS with and without temporal trends are used to estimate the RER model to verify the robustness of the PMG results. According to Table 4, the DOLS results show similar conclusions to the PMG estimate and the group-mean panel DOLS estimation results for the RER model. The need for foreign currency increases as LDCs purchases more raw materials and capital goods for infrastructure development and increases $CO_2$ emissions.

The effect of relative productivity discrepancy is statistically negligible under the DOLS estimate, which is defined to be negative. All the other variables obtained the anticipated indications and are defined to be statistically significant in LDCs to calculate the REER. Table 5 below shows the results of the bound testing based on the solid F-statistic values provided by (Pesaran et al., 2001). For all of the LDC samples, the REER's long-run link with its fundamentals is confirmed by the F-test results. For Egypt and Kuwait, the t-statistic results of the bound testing are negligible.

According to the ECT (1) run, the rate at which the REER returns to its equilibrium value is particularly slow in Egypt, South Korea, and Qatar. The Bound testing approach provides virtually identical outcomes when performed with or without a trend. ARDL estimates are therefore performed without considering a terministic trend since the trend is considered minor. Because of the cointegration, the ARDL technique may estimate the long-run and short-run coefficients for the REER ruminants. Table 6 shows the results of the unconstrained ARDL estimate, which are comparable to PMG findings. For Qatar and Egypt, the REER depreciates due to an improvement in relative productivity and an increase in a net foreign asset position. In the long run, the REER is appreciated in runs of trade and net foreign assets while depreciating in trade openness and comprehensive money supply for Qatar and Kuwait.

Additionally, the REER appreciates in Bahrain while depreciating in the long run because of improved output. With an increasing money supply in the near run, the real exchange rate of South Korea, Egypt, and Bahrain currencies depreciates. Qatar and Kuwait's currencies will rise in value if their trade and foreign asset improve. Due to greater trade openness, Egypt, Singapore, and South Korea REER depreciate. Popular belief one of the sample LDCs, an increase in the relative productivity gap leads to a decrease in the REER. Empirical data show a strong correlation between Asian countries' $CO_2$ emissions, LDCs' real exchange rates, their runs of trade, net foreign assets, productivity, openness to trade, broad money supply, and trade openness across time.

TABLE 6 Coefficients of ARDL estimation for the RER model.

| Country | Qatar | Bahrain | Egypt | Singapore | South Korea | Kuwait |
|---|---|---|---|---|---|---|
| Long-run estimates | | | | | | |
| $lnCO_{2t-1}$ | 0.098** | -0.009 | -0.16 | 0.517*** | -0.358 | 0.282** |
| | *-0.093* | *-0.103* | *-0.379* | *-0.091* | *-0.518* | *-0.096* |
| $lnTOT_{t-1}$ | 0.098** | -0.009 | -0.16 | 0.517*** | -0.358 | 0.282** |
| | *-0.093* | *-0.103* | *-0.379* | *-0.091* | *-0.518* | *-0.096* |
| $NFA_{t-1}$ | 0.007*** | 0.003* | -0.031** | 0.003* | 0.001 | 0.006*** |
| | *-0.001* | *-0.003* | *-0.015* | *-0.001* | *-0.001* | *-0.001* |
| $lnPD_{t-1}$ | -0.386** | 0.701*** | 0.371 | -0.058 | -0.511 | 1.383* |
| | *-0.162* | *-0.161* | *-1.67* | *-0.097* | *-0.771* | *-0.765* |
| $lnOP_{t-1}$ | -0.177 | -0.167 | 1.762 | -0.098 | -0.627*** | -0.571** |
| | *-0.095* | *-0.163* | *-1.702* | *-0.098* | *-0.095* | *-0.151* |
| $lnBM_{t-1}$ | -0.581*** | -0.505* | 3.351 | 0.309 | 0.301 | -0.579** |
| | *-0.308* | *-0.308* | *-1.796* | *-0.158* | *-0.771* | *-0.158* |
| Short-run estimates | | | | | | |
| $ECT_{t-1}$ | -0.351*** | -0.507*** | -0.097*** | -0.282*** | -0.509*** | -0.625*** |
| $\Delta lnCO_{2t-1}$ | -0.095*** | – | -0.509*** | 0.301*** | 0.303*** | -0.105* |
| $\Delta lnREER_{t-1}$ | -0.095*** | – | -0.509*** | 0.301*** | 0.303*** | -0.105* |
| $\Delta lnREER_{t-2}$ | 0.090** | – | -0.282*** | -0.386*** | – | -0.511*** |
| $\Delta lnREER_{t-3}$ | – | – | | 0.381*** | – | – |
| $\Delta lnTOT$ | 0.097*** | – | | – | – | – |
| $\Delta lnTOT_{t-1}$ | -0.028 | – | | – | – | – |
| $\Delta lnTOT_{t-2}$ | -0.151*** | – | | – | – | – |
| $\Delta NFA$ | – | – | | – | – | 0.005*** |
| $\Delta NFA_{t-1}$ | – | – | | – | – | 0.005** |
| $\Delta lnPD$ | -1.051*** | -0.767*** | | -0.571*** | -0.651 | 0.316 |
| $\Delta lnPD_{t-1}$ | -1.386*** | – | | – | -1.171*** | -1.777*** |
| $\Delta lnPD_{t-2}$ | – | – | | – | -1.790** | – |
| $\Delta lnOP$ | – | – | -0.515*** | -0.510*** | -0.571*** | – |
| $\Delta lnOP_{t-1}$ | – | – | | – | 0.151** | – |
| $\Delta lnOP_{t-2}$ | – | – | | – | -0.107** | – |
| $\Delta lnBM$ | – | -0.509** | -0.077*** | 0.067 | – | – |
| $\Delta lnBM_{t-1}$ | – | 0.163 | -0.771*** | -0.503*** | – | – |
| $\Delta lnBM_{t-2}$ | – | 0.623*** | -0.517*** | 0.096 | – | – |
| $\Delta lnBM_{t-3}$ | – | – | | -0.379*** | – | – |
| C | 1.656*** | 5.150*** | | 0.716*** | 1.709*** | 7.370*** |
| Residual diagnostics and model stability | | | | | | |
| Adju. $R^2$ | 0.771 | 0.507 | 0.7626 | 0.771 | 0.715 | 0.706 |
| F-Statistics (Probability) | 0 | 0 | 0 | 0 | 0 | 0 |
| LM test (pro) | 0.171 | 0.7 | 0.309 | 0.151 | 0.385 | 0.309 |
| Normality | 0.796 | 0.309 | 0.758 | 0.716 | 0.777 | 0.376 |
| BGP (Probability) | 0.738 | 0.308 | 0.1037 | 0.315 | 0.093 | 0.076 |

Note: The figures in parenthesis are standard errors, and ***, **, and * are significant at 1%, 5%, and 10% significance levels, respectively.

## 4.2 The effect of exchange rate misalignment on financial growth

The Johansen panel cointegration test is done again for the financial growth model. The results in Table 7 demonstrate a long-run link between the real GDP per capita and its regressors. Thus, the panel PMG/ARDL and DOLS models are estimated again to assess the influence of RER misalignment on the growth of LDCs. Indeed, the error correction run under the PMG estimation is negative and

TABLE 7 |Johansen fisher panel cointegration test results for growth model.

| Hypothesized No. of CE (s) | Trace test | | Max-eigen test | |
|---|---|---|---|---|
| | Fisher statistics | Probability | Fisher statistics | Probability |
| None | 91.05 | 0.0001 | 72.08 | 0.0003 |
| At most 1 | 40.89 | 0.0051 | 35.09 | 0.0343 |
| At most 2 | 13.87 | 0.4646 | 9.04 | 0.8791 |

Note: Trend assumption (linear terministic trend), lags interval (in first difference, 1:1).

TABLE 8 The PMG/ARDL estimation results for the growth model.

| Variable | Coefficient | Standard error | t-Statistic | Probability* |
|---|---|---|---|---|
| Long run equation | | | | |
| $lnCO_2$ | 2.0017 | 0.4086 | 4.0692 | 0.0002 |
| lnINV | 2.0248 | 0.3109 | 4.8018 | 0.0002 |
| lnHC | 2.0117 | 0.3724 | 2.6317 | 0.0014 |
| lnOP | 0.2086 | 0.2692 | 0.8637 | 0.372 |
| lnODA | -0.4712 | 0.3062 | -2.1706 | 0.0372 |
| MIS | -0.6868 | 0.3186 | -2.2862 | 0.0102 |
| Short run equation | | | | |
| $ECT_{t-1}$ | -0.0378 | 0.0064 | -4.2831 | 0 |
| $\Delta lnCO_2$ | 0.0321 | 0.0201 | 1.0972 | 0.1891 |
| ΔlnINV | 0.0248 | 0.0174 | 2.0612 | 0.284 |
| ΔlnINV | 0.0248 | 0.0174 | 2.0612 | 0.284 |
| ΔlnHC | 0.176 | 0.0608 | 2.4696 | 0.3066 |
| ΔlnOP | -0.0174 | 0.0101 | -0.4068 | 0.6864 |
| ΔlnODA | -0.0124 | 0.0172 | -2.371 | 0.2462 |
| ΔMIS | -0.0378 | 0.0178 | -2.8284 | 0.0612 |
| C | 0.3137 | 0.0614 | 4.6028 | 0 |
| Mean dependent var | 0.0312 | SD dependent var | | 0.0624 |
| SE of regression | 0.0101 | Akaike info criterion | | -4.0108 |
| Sum squared resid | 0.2694 | Schwarz criterion | | -4.3712 |
| Log-likelihood | 642.86 | Hannan-Quinn criter | | -4.8612 |

Note: Dependent variable:ΔlnY. Method: PMG/ARDL., Sample: 3,180–2031. Maximum dependent lags: 4 (automatic selection). Dynamic regressors: (4 lags): lnINV, lnHC, lnOP, lnODA, MIS. Model selection method: Schwarz Criterion (SIC). Selected Model: ARDL (2, 2, 2, 2, 2, 2).

statistically significant, showing a long-run link among variables under the growth model.

PMG and panel DOLS estimation results are shown in Tables 8, 9, and both estimations provided equivalent results. Findings reveal that financial growth in LDCs improves when real investment (gross fixed capital creation) increases and net foreign assets development increases. However, growth declines when ODA and RER misalignment increases $CO_2$ emissions.

RER misalignment, which is fundamentally overvaluation, has both long-run (5%) and short-run (10%) negative financial consequences, similar to Rodrik (2008). RER misalignment is a severe problem for Asian countries' LDCs' financial progress. Because of uncertain macroeconomic policies and inadequate institutional structures and legal frameworks in LDCs, official development assistance may have a detrimental impact.

Table 10 displays the results of the Bound tests conducted on each of the sample LDCs. Except for Burundi, all countries' real GDP per capita and regressors show a long-run correlation based on the critical values of Pesaran et al. (2001) F-test statistic. Using the constrained ARDL model, the Bound test findings are confirmed by negative and statistically significant error correction coefficients for all countries, including Qatar, presented in Table 11. Therefore, a general estimation of the ARDL model is possible for all sample LDCs to assess the long and short-run consequences of RER misalignment on financial growth.

TABLE 9 Group-mean panel DOLS estimation results for the growth model.

| | DOLS without time trend | | | DOLS with time trend | | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **Standard error** | **Probability** | **Coefficient** | **Standard error** | **Probability** |
| $lnCO_2$ | 0.406 | 0.0728 | 0,0002 | 0.4038 | 0.0728 | 0.0002 |
| lnINV | 0.482 | 0.0873 | 0.0002 | 0.3698 | 0.0808 | 0.0004 |
| lnHC | 0.6238 | 0.0692 | 0 | 0.269 | 0.4469 | 0.4269 |
| lnOP | 0.0482 | 0.0728 | 0.4772 | 0.2477 | 0.0873 | 0.0406 |
| lnODA | -0.2406 | 0.0622 | 0.0228 | -0.2692 | 0.0482 | 0.0002 |
| MIS | -0.0426 | 0.2062 | 0.7282 | -0.0728 | 0.0828 | 0.2477 |
| SE of Regr | 2.8266 | | | 4.6602 | | |
| Long-run var | 0.0069 | | | 0.0038 | | |

Note: Grouped estimation; Fixed leads and lags specification (lead = 2, lag = 2); (Prewriting with lags = 2, Bartlett kernel, Newey-West fixed bandwidth).

TABLE 10 Bound testing results for the growth model.

| **Country** | **ARDL** | **Without deruninistic trend** | | | **ARDL** | **With unrestricted trend** | | |
|---|---|---|---|---|---|---|---|---|
| | **Model** | ***F-test*** | ***t-test*** | ***LM (2)*** | **Model** | ***F-test*** | ***t-test*** | ***LM (2)*** |
| Qatar | 201,760 | 2.5786 | -0.6044 | 0.6457 | 200,202 | 2.6263 | 0.4062 | 0.8204 |
| Bahrain | 200,002 | 8.6804 | -0.5716 | 0.8646 | 200,002 | 6.4026 | -0.2057 | 0.1857 |
| Egypt | 200,182 | 4.0604 | -4.6463 | 0.6026 | 201,818 | 6.8464 | -6.648 | 0.1626 |
| Singapore | 180,180 | 6.6046 | -2.8163 | 0.6857 | 180,180 | 2.1662 | -2.4486 | 0.6484 |
| South Korea | 180,182 | 8.6304 | -0.6864 | 0.2636 | 180,200 | 2.6257 | -2.0462 | 0.1624 |
| Kuwait | 176,018 | 4.0616 | -4.257 | 0.1636 | 176,018 | 4.6864 | -2.4634 | 0.1618 |

Note: SIC, is used for Lag selection. Bound testing critical values are used (see Table 6 for reference). LM, is the Lagrange Multiplier test for serial correlation.

The ARDL-bounds testing results often support the PMG results. Table 11 shows the outcomes of the estimations that the long-run growth of Egypt and Kuwait is positively impacted by net foreign assets development and $CO_2$ emissions. Egypt's comparatively stable internal macroeconomic state may be the reason for its good impact on the growth of South Korea and Kuwait, despite the negative and significant impact of government development aid on $CO_2$ emissions control. While trade openness hurts Egypt's economy, the effect is negligible compared to other countries and affects $CO_2$ emissions. Overall, the impact of misalignment is statistically negligible on $CO_2$ emissions. LDCs' repeated devaluations in response to their inflationary economies may blame them for their unstable exchange rate policies and $CO_2$ emissions.

To put it another way, the undervaluation of the RER benefits Egypt's economy in the near run. At the same time, overvaluation harms the economies of Bahrain and Kuwait and impacts the $CO_2$ emissions, and at the very least, this lends credence to Rodrik's (2008) argument. Investing in real estate and developing net foreign assets favor and significantly impact $CO_2$ emissions in Singapore and Qatar, respectively. Official aid has a significant and positive impact on $CO_2$ emissions in Egypt and Kuwait growth, but a significant and negative impact on $CO_2$ emissions in Singapore growth. Egypt and Kuwait's growth has been negatively impacted by opening their economies to international trade and increased $CO_2$ emissions.

LDC economies might benefit from increased real investment and net foreign assets development, but this could be offset by a drop-in growth if RER misalignment, trade liberalization, and government development aid increase $CO_2$ emissions. Currency misalignment has been shown to hurt financial growth through the ARDL technique (Mamun et al., 2020). With an overvalued RER, LDCs' external competitiveness and financial performance might be improved by effective exchange rate management and consistent macroeconomic policy implementation that impact $CO_2$ emissions. Equilibrium Real Exchange Rate (ERER), which was initially proposed, uses a "model-based approach" (Elbadawi, 1994). LDCs, on the other hand, remained the primary recipients of official development aid, increasing the CO2 emissions in

TABLE 11 Coefficients of ARDL estimation for the growth model.

| Country | Qatar | Bahrain | Egypt | Singapore | South Korea | Kuwait |
|---|---|---|---|---|---|---|
| Long-run estimates | | | | | | |
| $lnCO_{2t-1}$ | 0.408 | 2.0812 | 0.003 | 0.388 | -2.008 | 0.0064 |
| | -0.482 | -4.008 | -0.042 | -0.606 | -2.0812 | -0.208 |
| $lnINV_{t-1}$ | 0.51 | 2.624 | 0.001 | 0.424 | -2.484 | 0.081 |
| | -0.477 | -4.502 | -0.026 | -0.428 | -2.677 | -0.048 |
| $lnHC_{t-1}$ | -0.406 | 0.408 | 0.638*** | 0.642 | 8.248 | 0.678*** |
| | -0.826 | -2.51 | -0.048 | -0.814 | -6.128 | -0.248 |
| $lnOP_{t-1}$ | -2.481 | 2.428 | -0.384*** | -0.048 | -3.042 | 0.222 |
| | -6.424 | -4.481 | -0.084 | -0.382 | -0.626 | -0.202 |
| $lnODA_{t-1}$ | 0.424 | -3.006 | 0.206*** | -0.628** | 2.626 | -0.264** |
| | -0.804 | -2.826 | -0.048 | -0.238 | -2.428 | -0.082 |
| $MIS_{t-1}$ | -2.678 | 2.448 | 0.026 | -0.802 | -2.048 | 0.301 |
| | -4.264 | -4.802 | -0.042 | -0.776 | -3.062 | -0.301 |
| Short-run estimates | | | | | | |
| $ECT_{t-1}$ | -0.081*** | -0.042*** | -0.424*** | -0.238*** | -0.048*** | -0.281*** |
| $\Delta lnCO_{2t-1}$ | 0.428*** | | 0.428*** | | -0.502** | 0.703*** |
| $\Delta lnY_{t-1}$ | | | 0.428*** | | -0.502** | 0.703*** |
| ΔlnINV | | | | 0.301*** | -0.004 | -0.026** |
| $\Delta lnINV_{t-1}$ | | | | | | -0.038* |
| ΔlnHC | 0.638*** | | | | | |
| ΔlnOP | 0.026 | | -0.077** | -0.281*** | -0.042** | |
| $\Delta lnOP_{t-1}$ | 0.081** | | | | 0.064*** | |
| ΔlnODA | | | 0.038*** | -0.277*** | 0.026 | -0.042 |
| $\Delta lnODA_{t-1}$ | | | | | | 0.062*** |
| ΔMIS | | -0.248*** | 0.064*** | | -0.006 | 0.084*** |
| $\Delta MIS_{t-1}$ | | | | | | -0.028** |
| C | 2.081*** | -0.628*** | 4.264*** | | 0.382*** | 2.081*** |
| Residual diagnostics and model stability | | | | | | |
| Adju. $R^2$ | 0.5104 | 0.651 | 0.6678 | 0.6301 | 0.8022 | 0.8028 |
| F-Statistics (Probability) | 0.00001 | 0 | 0 | 0 | 0 | 0 |
| LM test (pro) | 0.6448 | 0.6678 | 0.6026 | 0.8148 | 0.2776 | 0.2281 |
| Normality | 0.4848 | 0.0481 | 0.2226 | 0.2812 | 0.4818 | 0.8124 |
| BGP (Probability) | 0.4822 | 0.8064 | 0.7038 | 0.6774 | 0.4228 | 0.6281 |
| CUSUM | Pass | Pass | Pass | Pass | Pass | Pass |
| CUSUM Sq | Pass | Pass | Pass | Pass | Pass | Pass |

Note: The figures in parenthesis are standard errors, and ***, **, and * are significant at 1%, 5%, and 10% significance levels, respectively.

developed countries, which necessitates a stable macroeconomic policy environment and robust legal frameworks in the receiving states. Aid's influence on growth would be diminished in countries with overvalued or uncompetitive currencies, and trade openness would lead to an increase in imports while export responses in $CO_2$ emissions would be lower, resulting in a balance of payments challenges. FDI, capital inputs, products, and services move to host countries or areas due to international trade openness, increasing $CO_2$ emissions. Academics and scholars have debated and verified the link between trade opening and financial development (Pigka-Balanika, 2013). According to Chen and Gupta (2006), international trade leads to knowledge spillovers, higher productivity, and better net foreign assets impact on $CO_2$ emissions because of the notion that economies may develop indefinitely due to increasing returns to scale. Asian countries' LDCs may be negatively impacted by this shift, as they rely heavily on exports of essential agricultural commodities and behind-the-border impediments such as poor trade logistics performance and weak customs administration. If a country's external industry is well-diversified and exports more high-value-added items, trade liberalization might favor $CO_2$ emissions in countries.

# 5 Conclusions and recommendations

The research looked at the influence of the real exchange rate misalignment on Asian countries' LDCs' financial development. The ARDL bounds testing results often support the panel estimate results. Asian LDCs' continuing foreign currency shortages, persistent current account and fiscal deficits, growing external debt payment load, excessive inflation, and expanding saving gap, remained significant policy issues of $CO_2$ emissions growth. If the relative productivity and trade openness grow, it also increases the exchange rate; except for Egypt, all LDCs currencies are overpriced throughout the research period. According to the panel's estimates, the long-run financial growth of LDCs would be enhanced by a rise in real investment and net foreign assets. At the same time, it would be harmed by increased openness, net foreign assistance inflows, and currency misalignment. The RER is expected to rise if the country's trade and net foreign asset positions improve, while it is expected to fall if the country's trade openness and money supply increase. Overvaluation harms Bahrain's financial growth. While undervaluation helps Egypt, currency misalignment does not affect financial growth in any LDCs over the long run. As a result of the RER misalignment, the financial growth of LDCs might be negatively impacted by $CO_2$ emissions growth both in the short and long run. These evaluations show that if fixed capital creation and human development are increased, but trade openness and official assistance inflows are increased to a greater extent, financial growth may improve but may drop, which can help $CO_2$ emissions growth. The exchange rate policy's long-run viability rests on its capacity to respond to financial shocks promptly and on its ability to maintain a stable financial and political system that helps to reduce $CO_2$ emissions in the future. In the medium run, $CO_2$ emissions growth due to more real investment, net foreign assets, and official assistance inflows would enhance financial growth in Qatar, Bahrain, Singapore, and South Korea. In contrast, trade openness would slow it down in Egypt and Kuwait. As a result, to fix the ongoing misalignment and reduce its negative impact on financial growth, the currencies of LDCs often require the implementation of an appropriate exchange rate regime commensurate with macroeconomic policy.

## 5.1 Future suggestions

The exchange rate is still a vital policy instrument for open economies because of the high financial cost and significant welfare losses from improper management raise $CO_2$ emissions. Increasing the cost of importing raw materials and capital goods for developing businesses and infrastructure projects generates $CO_2$ emissions in Asian countries. So, it is vital to limit imports because it would place a tremendous load on the local economy. As a result, to address the chronic overvaluation of the currency and the associated macroeconomic instability, additional policies and regulatory frameworks are necessary.

# Data availability statement

The original contributions presented in the study are included in the article/supplementary Materials, further inquiries can be directed to the corresponding author.

# Author contributions

LX and MA directed the project. LW, MMA, LX and MA perfomed the experiments. MA and MMA analyzed the spectra and made the simulations; AK developed the theoretical framework. AK, LX and MA wrote the article. MA, LW and MMA performed the measurements. AK and MMA were involved in planning and supervised the work. LX and MA processed the experimental data, performed the analysis, drafted the manuscript, and designed the figures. MA performed the table 5 calculations. AK manufactured the samples and characterized them with environmental data analysis. AK also performed the environmental data characterization. MMA aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.

# Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

# Publisher's note

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