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Climate Risk and Exchange Rate Nexus in Emerging Asian Economies

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We examine the nexus between climate risk and the foreign exchange market in emerging Asian economies. The findings demonstrate that climate risk has a positive and considerable influence on exchange rate dynamics, albeit, the impact is transient. In other words, rising climate risk will strengthen the domestic currencies. To this end, policymakers should prioritize climate risk-mitigating measures to create more opportunities for exchange rate stability.

I. Introduction

Climate risk can affect macroeconomic indicators such as output, inflation, and trade balance through its influence on prices, trade, and government policies (Byrne & Vitenu-Sackey, 2024). This study, therefore, evaluates the effects of climate risk on foreign exchange rate, a key macroeconomic driver of foreign trade. Understanding the nexus is crucial for mitigation, adaptation, and resilience policies. We hypothesize that climate risk exacerbates foreign exchange rate dynamics in Asian emerging countries. Our motivation is based on the unique characteristics of climate risk impacts which are systemic, irreversible, and necessarily require a policy response, hence, may lead to structural shift in the exchange rates dynamics relative to other macro-financial indicators. Second, enhanced climate-related risks can directly impact these economies' production and export capabilities, potentially leading to a deterioration in the current account balance and a subsequent currency depreciation. This is primarily due to reduced export capacity, compounded by an increased demand for imported goods and services (Bonato et al., 2023; Kapfhammer et al., 2020). The motivation is also derived from Modern Portfolio Theory of Harry (1952). It suggests that a country's appeal as an investment destination may be impacted by climate risk, which may affect capital inflows and, consequently exchange rate dynamics through its current account balances. Hence, this study adopted current account balances as a transmitter of the climate risk on the exchange rate. These events significantly affect export capabilities and supply chain disruptions, distorting investors' confidence, creating capital outflows, and widening the current account deficit

and exchange rate pressure. From 1981 to 2022, an analysis of data for emerging Asian economies revealed that climate risk, while temporary in its effect, has a positive and significant influence on the exchange rate. These findings contribute two additions to the existing literature. First, it underscores the significance of non-economic and non-financial elements in the evolution of exchange rates. Secondly, in an era where risk diversification and improved hedging techniques are necessary, it is essential to understand the short-term fluctuations in exchange rates due to climate-related risks.

Numerous empirical studies demonstrate the negative effects of climatic hazards on the exchange rate and overall economic indicators. Hale (2022) shows that disasters connected to climate risk led to a consistent but negligible actual depreciation of the exchange rate. In a separate study, Lee et al. (2022) revealed that high currency depreciation resulting from temperature shocks is observed in nations that are less open to commerce and more reliant on agriculture and tourism. Conversely, further research indicated that exchange rate appreciation was enhanced by energy transition and climate vulnerability (see Cheema-Fox et al., 2022; Deka et al., 2022). Kapfhammer et al. (2020) document that when climate change transition risk is high, major commodity currencies experience a persistent depreciation, and the relationship between commodity price fluctuation and currencies tends to be weak. Also, Bonato et al. (2023) forecasted the impact of climate-related risk using the intraday-data-based realized volatility of exchange rate returns and found a depreciating effect of climate change on the commodity currency exchange rate. This study adds to our understanding of the connection between

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climate risk and exchange rates by highlighting the current account balance as the primary factor in transmitting climate risk to exchange rate dynamics. This factor has been neglected in previous studies. We use the heterogeneous panel method to consider both the short and long-run dynamics of the relationship. Additionally, our analysis includes three sets of samples: the full sample, pre-GFC, and post-GFC, to accommodate differences between turbulent and calm periods. The global financial landscape has undergone significant changes, especially with the onset of the Global Financial Crisis, which may have impacted the relationship between climate risk and exchange rates in the Asian emerging economies. By dividing the data into sub-samples, we aim to capture potential changes in this relationship before and after the crisis due to structural breaks, shifting risk perceptions, and distinct policy challenges. The remainder of the paper is organized as follows. Section II presents the method and data. The results and discussions are presented in Section III, and the paper is concluded in Section IV.

II. Data and Methodology

A. Data description

We utilized annual time series data from 1981 to 2022 for the Asian emerging economies of Bangladesh, China, Indonesia, India, Malaysia, Pakistan, Philippines, Thailand, and Sri Lanka. These countries were selected because they experience a higher frequency of climate-related events compared to other emerging Asian economies. The chosen period also accounts for the impact of the global financial crisis on the dynamics of the relationship. Climate temperature anomalies are used as a proxy for climate risk for a baseline climatology period that spans from 1951 to 1980. The average temperature for each period is computed using observed data and contrasted with the baseline period's average values. As a result, the temperature anomaly that reflects climate risk is the difference between the measured temperature and the baseline temperature. The data was collected through <https://data.giss.nasa.gov/gistemp/>. The official exchange rate (LCU per US\$ period average) and the current account balances, which represent a nation's net flow of foreign exchange, are used to proxy data for the foreign exchange market (Forex Market). Both of these can be found at <https://data.imf.org/ifs>. The choice and basis for the selection of these variables is anchored on Harry Markowitz's Modern Portfolio Theory (1952).

B. Model specification

We use the Pesaran & Smith (1995) and Pesaran et al. (1999) Panel Autoregressive Distributed Lag (PARDL) model, which takes into account the estimation of both the short- and long-term responses of variables. The following factors make this model tenable for the investigation. First, considering the nature of the data series being studied, the model permits the use of non-stationary series. Secondly, it enables a degree of variation in the slope coefficient, which is necessary given the features of the cross-sections under

consideration. Thirdly, the model is suitable for large N and large T panels. As part of our objectives, we further investigate the impact of climate risk on forex market performance before (pre-GFC) and after (post-GFC) to evaluate possible differences in the nexus. Hence, the generic representation of the panel ARDL model following Pesaran & Smith (2014) and Pesaran et al. (1999) is expressed below.

$$y_{it} = \sum_{k=1}^p \delta_{ik} y_{i,t-k} + \sum_{j=0}^q \varphi_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (1)$$

Where i , is the number of countries (cross-sections), $i = 1, \dots, N$; t is the number of periods (time dimension), $t = 1, \dots, T$; μ_i are the country-specific effects; ε_{it} is the panel disturbance term; x_{it} is a $k \times 1$ vector of explanatory variables; φ_{ij} are the $1 \times k$ coefficient of vectors; and δ_{ij} are scalars for the cointegrated series of order 1. Hence, the error correction for Equation (1) can be written as:

$$\begin{aligned} \Delta y_{it} = & \rho_i (y_{it-1} - \theta_i x_{it}) \\ & + \sum_{j=0}^{p-1} \delta_{ij} \Delta y_{it-1} \\ & + \sum_{j=0}^{q-1} \varphi_{ij} \Delta x_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \quad (2)$$

Here $\rho_i = -(1 - \sum_j = 1 \theta_{ij})$ is the speed of adjustment, $\theta_i = \sum_j = 1 \rho \delta_{ij} / (-\sum_k \delta_k)$ is the vector of long-run parameters, while $\delta_{it} = -\sum_m = j + 1 \rho \delta_m$ and $\varphi_{it} = \sum_m = j + 1 \varphi_m$ are the short-run parameters. Following Equation (2), we can write the estimable linear PARDL for the study as follows:

$$\begin{aligned} \Delta e_{it} = & \alpha_{0i} + \beta_1 e_{it-1} + \beta_2 clr_{it-1} + \beta_3 cab_{it-1} \\ & + \sum_{j=1}^{N1} \varphi_{1ij} \Delta e_{it-1} \\ & + \sum_{j=0}^{N2} \varphi_{2ij} \Delta clr_{it-1} \\ & + \sum_{j=0}^{N3} \varphi_{3ij} \Delta cab_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \quad (3)$$

Where e_i is the log of the nominal exchange rate for each unit i , $i=1,2,\dots,N$; clr denotes the log of climate risk, which is the temperature anomaly for the period under review; cab is the log of current account balances; u is the country-specific effect; i is the sampled units; and t is the number of periods, $t=1,2,\dots,T$.

The error correction version of the Equation (3) yields the following:

$$\begin{aligned} \Delta e_{it} = & \gamma e_{it-1} + \sum_{j=1}^{N1} \varphi_{1ij} \Delta e_{it-1} \\ & + \sum_{j=0}^{N2} \varphi_{2ij} \Delta clr_{it-1} \\ & + \sum_{j=0}^{N3} \varphi_{3ij} \Delta cab_{it-1} + \mu_i + \varepsilon_{it} \end{aligned}$$

The error correction term e_{it-1} captures the long-run equilibrium in the PARDL specified, while its associated parameters γ_i is the speed of adjustment term that measures how long the system takes to converge to its long-run equilibrium in the presence of shocks.

Table 1. Unit root test results

Test method	<i>e</i>	<i>Clr</i>	<i>Cab</i>
Panel A: Null Hypothesis: Unit Root with common process			
Harris-Tzavalis [rho]	-45.5419***b	-9.6648***a	-7.8023***a
Breitung [t-stat.]	-10.4958***b	-3.2539***a	-4.0820***a
Levin, Lin & Chu [t*]	-6.6461***b	-3.0173***a	-4.5210***a
Panel B: Null Hypothesis: Unit Root with Individual Process			
Im, Pesaran & Shin [Z-t-tilde]	-9.3921***b	-3.4512***a	-4.4515***a
ADF Fisher [Chi-square]	34.3598**b	121.9372***b	68.1164***b
Panel C: Null Hypothesis: Unit Root with cross-sectional dependence			
Pesaran CD test [z[t-bar]] (lag 2)	3.133**b	-3.738***b	-2.926***b
Panel D: Null hypothesis: No unit root with common unit root process			
Hadri [Z-stat.]	73.2776***a	49.4265***a	23.2064***a
Number of Cross-Sections	9	9	9
Number of Periods	41	41	41
Total Number of Observations	369	369	369

In this table, a and b denote stationarity at level and first difference, respectively. ***, ** & * imply statistical significance at the 1%, 5%, and 10% levels, respectively.

III. Results and Discussion

We perform a panel unit root test for each of the model's variables as a precondition to selecting an empirical model with large N and large T panels (see [Table 1](#)). We take into account the cross-sectional dependence test (Pesaran, 2007) as well as the Lagrange Multiplier test for stationarity (Hadri, 2000) and non-stationarity tests (Breitung, 2000; Harris & Tzavalis, 1999; Im et al., 1997; Levin et al., 2002). Except for the ADF Fisher test type, we find that the exchange rates for all the nations are integrated of order one [I(1)] regardless of the test type, although the current account balances (*cab*) and climate risk (*clr*) were largely [I(0)]. Given that the underlying framework for the analysis supports the mixed order of integration, we proceed with the analysis.

The study first estimates the models using the MG and PMG estimators to determine the most appropriate model for interpretation using the Hausman test. The results are reported in [Table 2](#), the sub-samples indicate MG as the most efficient and preferred estimator for the post-GFC period. However, pre-GFC and the full sample periods support the adoption of PMG in modeling climate risk and foreign exchange market dynamics. The study reports and discusses the results of the recommended estimator for each sub-sample.

Based on the full-sample results in [Table 2](#), we observed a significant short-term positive effect of climate risk on exchange rates in emerging Asian economies. This indicates that domestic currencies tend to strengthen relative to other currencies when there is an increase in climate risk-related events (see Deka et al., 2022). The positive impact may be further enhanced due to investors perceiving domestic currencies as a safe-haven during periods of heightened climate risk. However, this effect is only temporary because, on average, the long-term effects are negative and insignificant. In other words, the exchange rate

does not seem to adjust to changes in climate risk in the long term. Therefore, we may argue that the connection is a short-run phenomenon based on the full sample results. In the analysis, we consider two sub-samples, before and after the global financial crisis (GFC). We refer to these periods as the Tranquille and turbulent periods respectively. For the tranquillity period, we found that both the short and long-run estimates are not significant. This suggests that, on average, exchange rates did not respond to changes in climate risk during this period. However, the results from the post-GFC period were similar to the findings from the full sample analysis, indicating that the outcome is more of a short-run phenomenon.

IV. Conclusion

Using the PARDL technique, for three set of samples, we found a significant and positive relationship between climate risk and exchange rates in the short term for the full sample. However, in the pre-GFC sub-sample, we did not find a significant connection between these variables in both the short and long term. This suggests that climate risk may not have a substantial impact on exchange rates during certain periods. This finding is important for investors seeking safe havens during times of heightened climate risk. Therefore, we recommend that Asian economies policymakers should strengthen climate risk regulations and compliance, and invest in climate-resilient infrastructure and social safety nets to reduce climate risk and promote exchange rate stability.

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Table 2. Panel ARDL estimates

	Full-sample		Pre-GFC		Post-GFC	
	<i>Clr</i>	<i>Cab</i>	<i>Clr</i>	<i>Cab</i>	<i>Clr</i>	<i>Cab</i>
Panel A: Short-run dynamics						
Clr	0.0660** (0.0327)		0.0327 (0.0287)		0.0547** (0.0226)	
Cab		0.0176*** (0.00419)		0.0161*** (0.00412)		0.0169*** (0.00650)
Panel B: Long-run dynamics						
Clr	-0.395 (0.571)		1.873 (1.205)		0.0348 (0.124)	
Cab		-0.480** (0.208)		0.260 (0.369)		-0.103*** (0.0316)
ECT	-0.0196*** (0.00452)	-0.0196*** (0.00452)	-0.117*** (0.0449)	-0.117*** (0.0449)	-0.0845*** (0.0219)	-0.0845*** (0.0219)
Hausman Prob.	2.34 0.3109[pmg]	2.34 0.3109[pmg]	1.83 0.4005[pmg]	1.83 0.4005[pmg]	6.38 0.0413[mg]	6.38 0.0413[mg]
Cross-sections	9	9	9	9	9	9

In this table, a and b denote stationarity at level and first difference, respectively. ***, ** & * imply statistical significance at the 1%, 5%, and 10% levels, respectively.



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