Climate Transition Risk in Currency Markets

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Abstract

This paper investigates the transmission of climate transition risks to currency markets. Using panel data on 35 developed and emerging economies and leveraging portfolio-sorting methods and asset pricing tests, we find that higher country-level transition risk is associated with elevated equity risk premia. The findings suggest that a channel by which these premia spill over into currency returns are cross-border portfolio reallocations by international investors. The impact of climate transition risk on currencies is concentrated in emerging markets where climate policies are more uncertain and has strengthened since the 2015 Paris Agreement. Although transition risk tends to induce local currency depreciation, the resulting equity premia more than offset these losses, creating a new channel for systematic deviations from Uncovered Equity Parity (UEP). Overall, our findings indicate that climate transition risk has become a priced source of macro-financial risk, shaping international capital flows and currency valuations.
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"*Uneven progress on climate transition policies across countries may increase cross-border capital flow volatility, with implications for currency markets and global financial stability*." — ECB Financial Stability Review (European Central Bank, 2023)

1. Introduction

The Paris COP21 Agreement in December 2015 marked a turning point in global climate policy, with nearly 200 nations committing to net-zero emissions by mid-century. This accelerated the transition toward a low-carbon global economy and heightened exposure to climate transition risk — losses from policy shifts, technological change, and changing market sentiment. Recognition of these risks has led central banks and institutional investors, particularly sovereign wealth funds and reserve managers, to integrate transition exposures into their international asset allocation frameworks. Managing trillions of dollars in cross-border assets, their portfolio decisions now shape global capital flows and foreign exchange markets (NGFS, 2019).[1] In this paper, we test whether climate transition risks influence currencies through equity flows.

Climate transition risk is global in scope but heterogeneous across countries, reflecting differences in carbon intensity, institutional quality, and policy credibility. In a world of mobile capital, such heterogeneity can trigger cross-border portfolio reallocations, as investors demand higher risk premia to hold equities from more exposed countries. These premia compensate for heightened uncertainty, not improved fundamentals, and can redirect flows away from high-transition-risk economies toward those less exposed. We conjecture that this mechanism is transmitted to exchange rates, generating systematic deviations from uncovered equity parity (UEP)—the equity-market analogue of uncovered interest parity.

We test this conjecture using data on equity indices, climate transition risk measures, and bilateral exchange rates against the US dollar for 35 developed and emerging economies from

[1] The Network for Greening the Financial System (NGFS), an alliance of over 119 central banks and financial regulators, acknowledges that climate risks can exacerbate systemic risk along various dimensions (e.g., credit risk, market risks, operational risks, underwriting risk, and liquidity risk) via the micro channel trough the responses of households and businesses, and the macro channel through the impact on the labour market, interest rates, and exchange rates, inter alia.

January 2000 to September 2024. Applying portfolio-sorting methods and estimating international asset pricing models with macro-financial controls, we show that higher transition risk at the country level is associated with higher equity returns, and that this premium is transmitted to FX markets via international portfolio rebalancing. The premium demanded by investors for elevated transition risk more than offsets depreciation pressure on local currencies, yielding positive excess returns for foreign investors—a novel channel of UEP violations.

Splitting the sample into emerging markets (EMs) and developed markets (DMs), we find that the pricing of climate transition risk in equities is driven entirely by EMs. International investors perceive EMs as subject to greater policy uncertainty and transition exposure, and hence demand significant premia to hold their assets. By contrast, no evidence of transition risk pricing appears in DMs, likely reflecting their deeper financial markets, stronger policy frameworks, and lower climate-policy uncertainty. This asymmetry is consistent with frictions and limits to capital mobility that constrain international investor access to EM assets.

Re-estimating over subsamples around the COP21 Agreement, we find the transmission of transition risk into currencies among EMs is particularly strong in the post-COP21 period. Although most post-COP21 policy initiatives originated in DMs, investors anticipate higher long-run adjustment costs in EMs, where economies remain more carbon-intensive. The global signalling effect of COP21 reinforced the perception of EMs as "policy laggards," exposing them to greater stranded-asset risk as transition measures expand beyond DMs. Consequently, EM assets are particularly sensitive to transition premia in the post-COP21 environment, with global portfolio reallocations reflecting concerns about delayed policy alignment.

Several robustness tests support our main finding on the transmission of transition risk to FX returns. The results survive when we use alternative proxies for transition risk, different MSCI indices, and alternative rebalancing frequencies. We further show that the EM-specific pricing of transition risk is not driven by exposure to physical climate shocks.

Our paper engages three strands of the literature. First, it contributes to climate finance by extending firm-level evidence on transition premia (Bolton and Kacperczyk, 2021, 2023; Pástor et al., 2022; Hsu et al., 2023) to the aggregate country level and tracing their transmission to FX markets. Second, it enriches international finance research on UEP violations (Hau and Rey, 2006; Curcuru et al., 2014), by showing that climate transition risk is a new and systematic source of such deviations, concentrated in EMs where limits to capital mobility reduce arbitrage. Third, it relates to the literature on cross-country financial heterogeneity (Bekaert and Harvey, 1997; Lesmond, 2005; Zhang, 2025), by providing the first evidence that climate transition premia are priced more strongly in EMs, particularly after COP21, consistent with weaker policy credibility.

For central banks and regulators, our findings imply that climate-related vulnerabilities propagate across borders through capital flows, with consequences for exchange rate stability and financial conditions. This underscores the need to integrate cross-country climate exposures into macroprudential surveillance. For institutional investors and reserve managers, the results highlight the importance of incorporating transition risk into international asset allocation and currency hedging strategies. These implications are especially acute for EMs, where weaker institutions and higher capital-flow sensitivity magnify the transmission of climate shocks into exchange rate volatility and depreciation pressures. More broadly, our evidence supports calls by supranational institutions such as the IMF and NGFS for enhanced disclosure, and stronger policy coordination to reduce regulatory uncertainty, which is a key source of market volatility and mispricing.

The remainder of this paper unfolds as follows. Section 2 introduces the theoretical framework. Section 3 describes the data and methodology, and Section 4 discusses the main findings. Section 5 presents robustness tests and additional analysis. Section 6 concludes.

2. Conceptual Framework

The conceptual framework for our analysis is presented from the perspective of a US investor holding a diversified portfolio of domestic and foreign equities. Thus in what follows, *local* (or *foreign*) currency refers to each country's own currency, while *domestic* (or *home*) refers to the US. Also hereafter the exchange rate is defined as US$ units per unit of foreign currency. Excess returns on foreign equities is the difference between the returns on foreign equity and the returns on domestic equity with returns defined as the change in logarithmic prices in local currency.

In this section, we begin by outlining the uncovered equity parity (UEP) theory, which provides a foundational baseline for the relationship between equity returns and currency movements. The theory rests on three core assumptions (Hau and Rey, 2006). First, investors allocate wealth between domestic and foreign equities and riskless bonds to maximize expected utility; for example, a U.S. investor buying U.K. stocks must convert dollars into pounds, so returns depend on both asset prices and exchange rates. Second, the supply of foreign currency is imperfectly elastic, so investor allocations influence exchange rate fluctuations as currency demand and supply balance. Third, investors cannot perfectly hedge foreign exchange risk, such that changes in risk exposure trigger portfolio rebalancing. These international portfolio reallocations generate net order flows in FX markets, thereby linking equity returns with currency movements—a mechanism that is necessary (though not alone sufficient) for the UEP condition to hold in practice. Hau and Rey (2006) derive the UEP relation, which asserts that, in equilibrium, differences in equity returns between two countries should be offset by movements in their exchange rates, so that excess returns on foreign equities are neutralized by currency depreciation relative to the home (i.e., US) country. Formally, UEP can be stated as

$$E_t\left[r_{t+1}^f - r_{t+1}^h + \Delta s_{t+1}\right] = 0 \tag{1}$$

where r_{t+1}^f and r_{t+1}^h represent the foreign and local equity returns defined as log change in local currency equity prices, respectively, and $\Delta s_{t+1} = \ln(S_{t+1}/S_t)$ is the log change in the spot

exchange rates. The UEP condition predicts a perfect negative relation between local-currency equity return differentials and FX returns,

$$corr\left[(r^f_{t+1} - r^h_{t+1}), \Delta s_{t+1}\right] = -1 \tag{2}$$

that is, if an international investor earns higher returns on local-currency equities abroad, $r^f_{t+1} - r^h_{t+1} > 0$, the foreign currency is expected to depreciate, $\Delta s_{t+1} < 0$, sufficiently to eliminate any extra gain from investing in foreign equities relative to domestic equities.

However, numerous empirical studies provide evidence against the UEP hypothesis. Foreign versus domestic equity market differentials have been found to comove negatively but imperfectly, or even positively correlate, with FX returns (Chabot et al., 2014; Cenedese et al., 2016; Fuertes et al., 2019). The mechanism behind a positive correlation, $corr\left[(r^f_{t+1} - r^h_{t+1}), \Delta s_{t+1}\right] > 0$, is *return chasing* behavior, namely, as investors inject more capital into foreign equities that have performed well, they are bidding up both the foreign equity price and the foreign currency value.

As shown by Cenedese et al. (2016), ex ante deviations from UEP can be conceptualized as:

$$E_t(retx_{t+1}) = rp^f_{t+1} - rp^h_{t+1} \tag{3}$$

where rp^f_{t+1} is the foreign equity risk premium which is determined by the covariance between the domestic investor's stochastic discount factor and foreign equity returns, and rp^h_{t+1} is the domestic equity risk premium determined by the covariance between the domestic investor's stochastic discount factor and domestic equity returns. While the risk premia provide an *ex-ante* measure of the UEP deviation, the *ex-post* measure is the realized foreign equity excess return

$$retx_{t+1} \equiv r^f_{t+1} - r^h_{t+1} + \Delta s_{t+1,} \tag{4}$$

that is, the observed change in value (in units of home currency) from time t to time $t+1$ of the portfolio of foreign and home equity held by the representative (US) investor.

Our paper studies the pricing of climate transition risk within the UEP framework. Global warming is a global phenomenon that requires global action in the form of policies and regulation inter alia. Because countries' corporations have on the aggregate different carbon emission

intensities, there are differences in aggregate transition risk at country level (Bolton and Kacperczyk, 2023). Moreover, there are also cross-country differences in the pricing of climate risk as shifts in investors preferences, policy tightness and cash flow shocks can differ across countries – these factors have, in fact, been shown to drive the cross-country carbon return variation or differences in the brown-minus-green return differential across countries (Zheng, 2025). Both cross-sectional variation in transition risk exposure and its pricing can create disparities in international equity risk premia which can be another source of UEP deviations.

We conjecture that, as international equity investors care about transition risk, different exposures (or perceptions) to this risk can trigger capital flows that, in turn, influence currency markets. Ultimately, cross-country variation in transition risk acts can induce currency appreciation or depreciation. As a byproduct, we present novel evidence on the UEP condition.

3. Data and methodology

3.1. Data description

The empirical analysis uses monthly data from January 2000 to September 2024 for 35 countries, classified by the IMF as either DMs (Australia, Austria, Canada, Denmark, Finland, France, Germany, Hong Kong, Japan, Norway, Singapore, South Korea, Sweden, Switzerland, and the United Kingdom) or EMs (Argentina, Brazil, Bulgaria, Chile, mainland China, Colombia, Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Romania, South Africa, Thailand, and Turkey). The selection criterion is currency transaction volume according to the Bank for International Settlements (BIS) 2022 Triennial Survey. Specifically, we start with the 47 countries included in the survey, then we filter out those countries with a fixed exchange rate regime or without climate transition index data.

We obtain data on equity indices in local currency and bilateral FX rates (quoted as local currency per US$ unit) for the last day of each month from Datastream. For our analysis, we

convert the FX rates to US$ units per unit of local currency. We calculate international equity index returns and FX returns as the change in the logarithmic values from month to month.

To measure climate transition risk, we employ country-level indicators constructed quarterly by LSEG Sovereign Sustainability Solutions, also available via Datastream, and interpolate them to monthly frequency. The LSEG index captures transition risk along two dimensions: (i) greenhouse gas (GHG) emissions relative to GDP, benchmarked to net-zero pathways, and (ii) nationally determined contributions (NDCs), reflected in implied temperature rise estimates. The GHG-to-GDP component measures the gap between current emissions and those required for carbon neutrality, while the NDC component evaluates alignment with the Paris 1.5°C target. LSEG constructs a composite climate transition risk index as the average of the GHG-to-GDP and NDC subindices. The index ranges from 0 to 100, with higher values indicating *lower* transition risk. For interpretability, we invert the scale (100 minus the index), so that higher values denote greater transition risk. Appendix B provides further details on the country level data.

Accounting for delays in carbon emission data release has been highlighted as critical in climate finance research to avoid look-ahead bias (Zhang, 2025). As the LSGE transition risk indices require GHG emissions and economic activity (GDP) data which are released with lags, following Zhang (2025), we match the equity indices and FX rates on month t with the lagged transition index at $t-3$. In robustness tests, we increase the transition risk lags to two, three and five quarters.

3.2 Methodology

A. Portfolio sorts by climate transition risk.

The baseline empirical analysis conducts portfolio sorts using the country transition risk proxies. Specifically, each month of the sample period we sort the cross-section of N countries into quintiles based on their climate transition risk. Countries exhibiting the lowest transition risk are allocated to the top quintile (low; Q1) and those with the highest to the bottom quintile (high; Q5). We take a long position in Q5 and a short position in Q1. All foreign equity returns are expressed in home

currency units (US$); namely, the logarithmic returns of Q1 are calculated as $\sum_{i=1}^{J}(r_{j,t+1}^{f} + \Delta s_{j,t+1})/J$ where the sum is over the country constituents ($J = N/5$); and likewise for Q5.

A finding that this long-short strategy generates significant positive returns would imply the existence of a transition risk premium, indicating that a representative US investor requires compensation for holding equities in countries with higher level of climate transition risks. From the risk-bearing channel (Bolton and Kacperczyk, 2023), where investors demand a premium to compensate for holding stocks with greater climate-related risk, this dynamic is expected to produce a positive $r_{t+1}^{f} - r_{t+1}^{h}$ for undertaking higher transition risks. Moreover, a positive foreign equity excess return, $retx_{t+1}$, would suggest that UEP is violated, according to equation (3). Further, by decomposing these yields into stock return differentials and FX returns, the correlations between these components reveal how climate transition risks are priced in currency markets. From the long-short strategy, we expect higher climate transition risks will lead to negative FX returns, as the results of international equity flows (Hau and Rey, 2006).

In the portfolio analysis, as in Colacito et al. (2020) we adopt the half quoted bid-ask spread approach to integrate trading costs into the currency return calculations. Accordingly, the net returns on a long and short position are obtained, respectively, as

$$\widetilde{\Delta s}_{long} = (s_{t+1,b} - s_{t,a})/2 \tag{10}$$

$$\widetilde{\Delta s}_{short} = (s_{t,b} - s_{t+1,a})/2 \tag{11}$$

where b and a are bid and ask prices. The quintile portfolio (Q1) currency returns $\Delta s_{j,t+1}$ are replaced by $\widetilde{\Delta s}_{short}$, and the net returns of portfolio Q5 are replaced by $\widetilde{\Delta s}_{long}$.

We do not explicitly account for transaction costs on the equity component of our portfolio strategy. Trading costs for equity indices are generally considered negligible for developed markets and most major emerging markets, where indices are highly liquid and often accessible via ETFs (Cremers et al., 2016). However, precisely proxying country-specific equity trading costs in a global study is challenging due to variation in index composition, market structure, liquidity, and local

trading access. To address this, we perform an additional analysis using MSCI country equity indices, which are constructed with stringent size and liquidity criteria and are widely investable via liquid ETFs, even in emerging markets.

Finally, we investigate the relationship between stock return differentials, $r^f_{j,t+1} - r^h_{t+1}$ and FX returns, $\Delta s_{j,t+1}$, to distinguish between portfolio rebalancing and return-chasing. A finding of a perfect negative correlation between these two returns would fully endorse the UEP condition. More broadly, any negative correlation, even if imperfect, is consistent with portfolio rebalancing, where investors systematically hedge foreign equity exposures as part of risk management. Such rebalancing is a necessary, though not sufficient, condition for the UEP to hold. Conversely, a positive correlation would signify a strong violation of UEP, suggesting that FX markets are instead dominated by return-chasing behavior, where capital flows amplify initial equity return differentials.

B. Asset pricing tests.

In our asset pricing approach, the pricing kernel is an extension of the Fama-French-Carhart model (Fama and French, 2012; Carhart, 1997) formalized as follows:

$$E(r_{i,t+1}) = \beta_0 R_t^{CTR} + \beta_1 \mathrm{Vol}_t^{\mathrm{ST}} + \beta_2 \mathrm{Vol}_t^{\mathrm{FX}} + \beta_3 DOLLAR_t + \beta_4 (Mrk - RF)_t + \beta_5 SMB_t + \beta_6 HML_t + \beta_7 MOM_t^{ST} \quad (12)$$

where $r_{i,t+1}$ represents the returns of the *i*th test asset from month t to $t+1$, R^{CTR} is the climate transition risk factor (that is, the return of the Q5-Q1 portfolio constructed as described in the preceding analysis), the remaining variables are a set of traditional FX market risk factors and equity market risk factors as controls, and the betas β_s capture the risk exposures. Using our panel dataset for 35 countries, we construct the global stock market volatility risk factor and FX volatility risk factor as AR(1) innovations to monthly averages of daily absolute stock or currency returns ($\mathrm{Vol}_t^{\mathrm{ST}}$ and $\mathrm{Vol}_t^{\mathrm{FX}}$), and the dollar factor ($DOLLAR_t$) as the return of a basket of currencies against the US$. The stock market risk factors, market (Mrk-RF), size (SMB), value (HML) and momentum

(MOM) factors, are obtained from the Fama-French data library[2] Following Menkhoff et al. (2012a) and Cenedese et al. (2016), as test assets we consider 20 portfolios formed from our panel of 35 countries. Specifically, the returns $r_{i,t+1}, i = 1, \dots, 20$ in the left-hand-side of Equation (12) pertain to (i) five currency carry portfolios; (ii) five currency momentum portfolios; (iii) five equity momentum portfolios; and (iv) five term spread[3] portfolios. For the construction of 20 test portfolios, countries are ranked according to each specific signal and then allocated to one of five portfolios. Portfolio Q1 contains the countries with the lowest signal values, while portfolio Q5 contains those with the highest. The estimation method for the pricing kernel is the Generalized Method of Moments (GMM) of Hansen (1982). We construct Newey-West robust *t*-statistics to account for autocorrelation in errors and *J*-statistics to test the significance of pricing errors.

4 Empirical Results

4.1 Preliminary data analysis

Figure 1 illustrates the evolution of climate transition risk indices for DMs and EMs. Overall, the latter consistently exhibit higher levels of climate transition risk, with average index values above 42.5. Prior to the Paris Agreement (COP21), climate risk in EMs increased slightly, while it declined modestly in DMs. Following COP21, a sharp and sustained decline in transition risks is observed across both groups, likely reflecting increased global attention to sustainability and policy alignment around climate goals. Despite the general improvement, EMs continue to show elevated levels of transition risk relative to developed economies. This persistent gap may reflect differences in policy credibility, regulatory capacity, and investment in green technologies. There is also significant country heterogeneity in climate transition risk exposure within EMs and DMs which has implications for global investors, who may adjust their risk-return expectations accordingly.

[2] See https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[3] Term spreads are the difference in yields between 10-year government bonds and 3-month bills for individual country, where all the interest rates are sourced from DataStream

Tables 1 and 2, along with Figures 2 and 3, provide a comparative overview of stock and FX market performance across DMs and EMs. Stock markets in developed economies tend to be more stable, with lower average returns, smaller standard deviations, and limited skewness or kurtosis—suggesting greater predictability. In contrast, EMs (e.g., Argentina and Turkey) display higher average returns but also significantly higher volatility and extreme return distributions, indicating a pronounced risk–return trade-off. Cumulative equity returns generally increase over time in both groups, though we observe major downturns in the aftermath of significant events such as the early 2000s recession, the Global Financial Crisis, and the COVID-19 pandemic.

FX markets, by contrast, reveal distinct patterns. DM currencies exhibit modestly positive average returns and low volatility, while EM currencies show negative average returns with higher volatility and substantial skewness and kurtosis. Cumulative FX returns from 2000 to 2024 highlight this divergence: developed market currencies fluctuate around a flat trend, ending with cumulative log returns near 2%, whereas emerging market currencies show a steady decline. Notably, both groups experience a marked drop in FX returns following COP21, suggesting that currency markets became increasingly sensitive to climate transition risk after the agreement.

Finally, our findings challenge the UEP hypothesis, which posits that expected stock returns should be offset by currency depreciation. In practice, stock returns—particularly in EMs—consistently exceed corresponding FX losses. This pattern implies that investors may hedge currency exposure ex-ante or that FX markets possess sufficient depth to absorb cross-border capital shifts without fully offsetting equity gains. These persistent deviations from UEP, especially in EMs, underscore the influence of global climate policy on asset pricing and capital flows.

4.2 Preliminary data analysis

We begin by discussing the portfolio analysis for DMs, as shown in Table 3. Sorting quintile portfolios by climate transition risks reveals no clear monotonic relationship between the risk levels and excess foreign equity returns, while we would have expected that the excess foreign equity

returns for each portfolio are increasing with the level of climate transition risks. The foreign equity returns exhibit Sharpe ratios (SRs) ranging from -0.50 to 0.12. The quintile Q1 (lowest transition risk) delivers the highest annual return of 0.18% with an SR of 0.03, while Q5 (highest transition risk) yields -1.40% annually with an SR of -0.22. There is no evidence of compensation for climate transition risks in stock differentials, as both returns and SRs are generally negative (the only exception is Q4), whereas for the FX component both returns and SRs are generally positive. The long-short strategy, buying Q5 and selling Q1, fails to yield significant excess foreign equity returns over the full sample period (*t*-statistic of -1.08). Similarly, the decomposition of the long-short strategy returns for stock differential and FX components is statistically insignificant (*t*-statistics of -1.37 and -0.06, respectively). Overall, for DMs we find no evidence that climate transition risks are priced in foreign equity portfolios.

The portfolio analysis for EMs is presented in Table 4. In contrast to the preceding analysis for DMs, we find evidence of compensations for exposure to climate transition risks. The high transition risk quintile (Q5) achieves 4.65% annual returns with a Sharpe ratio of 0.73, compared to 3.12% annually and a Sharpe ratio of 0.43 for the low transition risk quintile (Q1). Stock and FX quintile portfolios in EMs display a different return structure: Q5 for the FX components consistently yielding the lowest returns and SR and Q1 offer the highest ones. A long-short portfolio strategy in EMs, buying Q5 and selling Q1, produces 1.53% excess foreign equity returns with statistical significance. The contribution of stock and FX markets to the total foreign equity returns is 3.72% and -2.19%, respectively. The negative correlation between returns in these two markets aligns with portfolio-rebalancing rather than return-chasing behavior. But they do not offset each other which represents a violation of the UEP hypothesis. In sum, the portfolio analysis has revealed that climate transition risk is priced in excess foreign equity returns in EMs but not in DMs. Next, we assess the question with a formal pricing model.

Tables 5 and 6 present the GMM estimation of the risk premia in Equation (11), for EMs and EMs, respectively. In the model with controls, the climate transition risk premium (R_t^{CTR}) for EMs

is approximately 0.57% per month. By contrast, for DMs the climate transition risk premium is insignificant. These results, upon controlling for additional risk factors, reinforce those from the preceding portfolio analysis: climate transition risk is priced but only for EMs.

4.3 Paris Agreement (COP21)

We now test for changes in the pricing of climate transition risk before and after the international treaty on climate change adopted on December 12, 2015 by 196 countries at the UN Climate Change Conference (COP21) in Paris. Table 7 presents the portfolio (quintile) analysis for DMs conducted separately in the two segments of our sample before and after that date. Before the agreement, the excess foreign equity returns display no monotonicity by quintiles (Q1 to Q5), and the long-short portfolio returns are clearly insignificant (*t*-statistic of 0.44), which is consistent with the findings for the whole sample period. The same applies to the underlying stock and FX components. Additionally, the post-COP21 results reveal negative excess foreign equity returns (-3.80%) which are driven by a declining stock performance (-3.21%) while the FX component is relatively muted (-0.59%). The long-short returns are also clearly insignificant (*t*-statistic of -1.32). This confirms our earlier finding that climate transition risks are not priced in DMs.

Table 8 presents the portfolio analysis for EMs, separating the pre- and post-COP21 periods. The empirical results reveal that during the pre-COP21 period, the long-short portfolio (Q5 minus Q1) yielded an insignificant excess return of 0.73%, driven by stock and FX contributions of 0.80% and –0.37%, respectively—neither of which is statistically significant. By contrast, in the post-COP21 period, the pricing pattern changes markedly. Quintile 5 excess returns dropped to –0.80%, while returns in other quintiles—particularly 1, 2, and 4—declined further, indicating differential exposure to climate risks. The long-short strategy now delivers a significant annual return of 3.96% (*t*-stat = 3.35), with decomposition showing stock and FX components contributing 10.08% (*t*-stat = 2.68) and –6.12% (*t*-stat = –2.82), respectively. Although these magnitudes are considerable, they are plausible within the context of EMs. The size of returns for stock components aligns with the findings of Cenedese et al., (2016), who focus on the cross-sectional pricing power of stock

performance metrics. However, in our case, FX components have much stronger reactions towards investors' rebalancing behavior, and generate more negative returns, since the repatriation of profits by investors from nations with high transition risks creates downward pressure on the local currencies, leading to their depreciation.

These results suggest that in the post-COP21 period, higher climate transition risks in EMs are associated with stronger equity risk premia and negative FX returns. The negative correlation between stock differentials and FX returns is consistent with portfolio rebalancing behavior: investors respond to rising stock returns by repatriating capital, putting downward pressure on foreign currencies. The fact that positive equity returns outweigh FX losses also implies a systematic violation of the UEP condition.

To further test this finding, we estimate the climate transition risk premium using a GMM approach, based on Equation (11), and report results in Tables 9 and 10. Consistent with the portfolio-based results, the estimated climate risk premia are positive and statistically significant across multiple specifications, even after controlling for dollar and global equity factors. This indicates that investors demand compensation for holding equities in countries with high transition risks, particularly in EMs after COP21.

There are two likely explanations for the timing and market-specific effects of transition risk pricing. First, the Paris Agreement may have acted as a coordination mechanism, prompting greater investor attention to climate-related financial risks. In Ems, where volatility is higher and regulatory responses less mature, investors may have reacted more strongly to the increased salience of transition risks following COP21. To capture this dynamic, we estimate the climate risk premium using a one-year rolling GMM window for EMs. As shown in Figure 4, risk premia become positive and statistically significant only after 2015, stabilizing around 0.8% with 95% confidence. Before COP21, climate transition risks were not priced in EM equity returns, as the premia are indistinguishable from zero.

Second, the muted effects in DMs may reflect both lower average climate transition risk exposure and more robust policy frameworks. Developed economies typically exhibit higher coverage of climate-related financial regulation, such as carbon pricing and Emissions Trading Systems (ETS). According to World Bank data[4], before COP21, regulatory coverage in DMs stood at approximately 80%, compared to just 15% in EMs. These figures have since then risen to 93% and 45%, respectively. Stronger and more credible climate policy frameworks in DMs may have reduced uncertainty and mitigated the pricing impact of transition risks. In contrast, persistent policy uncertainty in EMs continues to influence investor expectations and risk premia (Hambel and Van Der Ploeg, 2025).

4.4 Stock Differentials and FX Returns

Following Camanho et al. (2022), we further test the portfolio rebalancing behavior of international equity investors by estimating the fixed-effect model:

$$\mathrm{FX_{it}} = \beta_1 \Delta S_{it} + \beta_2 CTR_{it} + \beta_3 \Delta S_{it} * CTR_{it} + \beta_4 CTR_{it} * COP21 + \beta_5 \Delta S_{it} * CTR_{it} * COP21 + \alpha_i + \alpha_t + \epsilon_{it} \quad (13)$$

where i and t represent country and time. ΔS_{it} and FX_{it} are instantaneous returns, and CTR_{it} is the value of climate transition risk index. The variable $COP21$ is a dummy that equals unity for periods after December 2015 and zero otherwise. The model incorporates country-fixed effects (α_i), time-fixed effects (α_t), and the error term (ϵ_{it}). This panel approach complements the previous analysis by directly linking the two markets to provide extra evidence of portfolio rebalancing behavior.

From Table 11, Column (1) and (4) are consistent with the finding of Cenedese et al. (2016). In the absence of climate transition risks, FX returns are independent to stock differentials, with the insignificant estimation of -0.0112 (t = -0.59) and 0.0155 (t = 1.14) for β_1. For Column (2), with

[4] World Bank website: Price | Carbon Pricing Dashboard. The coverage ratios are based on our sample countries and associated calculations.

climate transition risk, stock and FX components are negatively correlated with the coefficient of -0.0589 for the interaction term ($\Delta S * CTR$), implying the portfolio rebalancing behavior from investors in EMs. Column (3) reinforces our findings from portfolio sorting analysis that the impact of climate transition risk will be much stronger for EMs after COP21, since the risk premia for the whole period are mainly driven by the period after COP21, and we have the estimation of -0.0244 for $\Delta S * CTR * COP21$ with t = -3.60. For DMs, the estimations from Column (4) to Column (6) show that the FX returns are unrelated to the stock differentials, even after considering the interactions with climate transition risks and the event of COP21. Therefore, the fixed-effect model shows again the channel that higher climate transition risks will generate negative FX returns via the stock markets, and such impact are more pronounced for EMs after COP21.

5 Robustness Tests and Additional Analyses

We carry out various robustness checks on the main findings by considering: (1) Alternative proxies for climate transition risks; (2) Alternative sub-portfolio grouping; (3) MSCI stock indices and additional control variables; (4) Alternative rebalancing frequencies;(5) Alternative countries, and (6) Two-step Fama-MacBeth (FMB) analysis. In addition, we further analyse: (1) Confounding role of climate physical risk and (2) Delayed responses from investors.

5.1 Alternative climate transition risk proxies

Existing studies (e.g., Bolton and Kacperczyk, 2023; Aswani et al., 2024; Zhang, 2025) propose that alternative measures—such as actual carbon emissions and emission intensity—can serve as valid proxies for climate transition risk. To assess the robustness of our results, we replace the baseline climate transition index with actual carbon emission intensity[5] data. As shown in Table 12, the EMs results remain consistent: after COP21, the long-short strategy yields statistically significant excess returns of 1.84% per annum (*t*-stat = 2.28), even with the alternative proxy.

[5] Carbon intensity is the ratio for carbon emission over GDP for individual country. It indicates how much carbon a country emits relative to the size of its economy, reflecting the efficiency and sustainability of its energy use and production processes.

In contrast, for DMs, results remain statistically insignificant regardless of the proxy, indicating that climate transition risks are not priced in these economies. Overall, this robustness check confirms that the observed pricing effects in EMs post-COP21 persist when actual carbon emission intensity is used as the transition risk measure.

5.2 Alternative sub-portfolio groupings

To evaluate the sensitivity of our portfolio-sorting strategy, we vary the number of climate risk portfolios from three to six, following Cenedese et al. (2016), instead of the baseline five-quintile grouping. The goal is to test whether different groupings affect the qualitative conclusions regarding return patterns across emerging and developed markets.

As shown in Table 13, the results remain robust. In DMs, the long-short strategies continue to yield no statistically significant excess returns before or after COP21, and neither the stock, nor FX components are sensitive to portfolio grouping. In contrast, for EMs, the long-short returns remain consistently positive and statistically significant in the post-COP21 period, while being insignificant prior to the event. These findings confirm that portfolio performance is not driven by how countries are grouped, and that the pricing of climate transition risk is an EM-specific phenomenon that became salient after the Paris Agreement.

5.3 MSCI stock indices and additional controls

To better reflect the perspective of global investors, we substitute local stock indices with MSCI country indices, which are widely used benchmarks for internationally tradable equity investments. These indices are often linked to ETFs and mutual funds and are more liquid, mitigating issues related to capital controls and market accessibility. Due to data unavailability, Russia is excluded from this part of the analysis, leaving 34 countries (15 DMs and 19 EMs).

We also incorporate additional control variables in the GMM framework, including FX momentum (MOM^{FX}), carry (CARRY), and long-term yield differentials (LT), as defined in Lustig et al. (2011), Asness et al. (2013), and Ang and Chen (2010). The carry factor is proxied by the 1-

month forward premium, momentum by lagged 1-month FX returns, and the long-term yield by the interest rate differential between U.S. and foreign 10-year government bonds.

Tables 14 and 15 report the results. The portfolio sorting approach continues to yield positive and significant long-short returns, though magnitudes are slightly lower. The GMM estimates remain robust, with the climate transition risk premium estimated at 0.4166 (Newey-West *t*-stat = 2.63), consistent with our baseline findings. These results confirm that the pricing of climate transition risk in EMs is not an artifact of the index choice or omitted factors.

5.4 Rebalancing Frequencies

We test the sensitivity of our results to different investment horizons by altering the rebalancing frequency from monthly to quarterly, semi-annual, and annual holding periods. Table 16 shows that for EMs, significant long-short excess returns persist at quarterly and semi-annual frequencies post-COP21. However, the annual holding period dilutes the significance of the returns.

The negative correlation between stock and FX components across these horizons supports the interpretation that climate transition risk is transmitted via international portfolio rebalancing. In DMs, results remain unchanged, with no evidence of risk pricing across any rebalancing horizon. These findings reinforce the presence of a time-sensitive and EM-specific climate transition risk premium.

5.5 Country-level exclusion analysis

To verify that our results are not driven by any single emerging market, we conduct a leave-one-out robustness check. Equation (12) is re-estimated using GMM, sequentially omitting one country at a time from the EM sample. Figure 6 reports the resulting estimates.

Across all iterations, the estimated climate transition risk premia remain stable (ranging from 0.76% to 0.86%) and statistically significant, with Newey-West *t*-stats consistently between 3.22 and 3.32. These findings confirm that no single country drives the observed pricing effect and that the results are robust to changes in the EM sample composition.

5.6 Two-step Fama-MacBeth analysis

As in extant studies (Menkhoff et al., 2012a, 2012b; Colacito et al., 2020), we complement the GMM approach by deploying the two-step Fama–MacBeth regression (Fama and MacBeth, 1972) approach to obtain OLS estimates of the cross-sectional pricing of climate transition risk. In the first stage, time-series regressions yield factor loading estimates. Subsequently, cross-sectional regressions of average excess returns generate risk premia estimates. This provides an alternative test using average risk premia over time.

Tables 17–20 present the results. Consistent with our GMM findings, climate transition risks are significantly priced only in EMs. Post-COP21, the estimated risk premium is 0.4789 (Newey-West t-stat = 2.96), while in the pre-COP21 period, the estimate is higher in magnitude (1.5105) but not statistically significant (t-stat = 1.18). For the full EM sample, the estimated premium is 0.3161 (t-stat = 2.24). DMs show no statistically significant pricing effect. These results support the conclusion that climate transition risks became financially material in EMs after COP21.

5.7 Climate physical risk as a confounder

To assess whether our results are driven by climate physical risks rather than transition risks, we use the ND-GAIN vulnerability index as an alternative sorting variable, following Cheema-Fox et al. (2022). This index captures a country's susceptibility to physical climate disruptions such as floods and wildfires.[6]

Table 21 reports that in EMs, long-short portfolio returns are positive but statistically insignificant when sorted on physical risk. DMs again show no evidence of priced risk. This suggests that the effects observed in our main results are specific to climate transition risks and not confounded by physical vulnerability. Furthermore, COP21 does not appear to influence pricing patterns in relation to physical risks.

[6] Link for ND-GAIN climate vulnerability index: Country Index // Notre Dame Global Adaptation Initiative // University of Notre Dame

5.8 Delayed investor reaction to climate transition risk

Recent studies suggests that investor responses to climate risks may be delayed, either due to slow-moving information, or reporting lags (Hong et al., 2019; Pastor et al., 2022). There is also the issue of climate-related data released with lags which inappropriately accounted for can induce forward-looking bias (Zhang, 2025). To account for this, we re-estimate our portfolio-sorting strategy using lagged values (up to 12 months) of the climate transition risk index.

Table 22 shows that lags of up to three months still yield statistically significant long-short returns with the expected sign that positive stock differentials and negative FX returns. This supports continued evidence of portfolio rebalancing. For lags beyond three months, excess returns remain positive but lose statistical significance (e.g., 2.01% for a 6-month lag with $t = 1.55$; 1.13% for a 12-month lag with $t = 1.60$). This suggests that investors update their risk assessments using relatively recent data, and that the pricing of climate transition risk is driven by more immediate market responses.

6 Conclusions

This study investigates whether climate transition risks are priced in foreign exchange (FX) markets, focusing on the transmission channel through international equity markets. Using monthly data for 35 countries, including 15 developed and 20 emerging over the period 2000 to 2024, we analyze how climate risks affect FX returns via the portfolio rebalancing behavior of international equity investors. We find that higher climate transition risks are associated with higher equity risk premia and negative FX returns. These components move in opposite directions, indicating a transmission mechanism that reflects investors' risk-adjusted reallocation decisions and leads to systematic deviations from the UEP condition.

Importantly, this transmission channel is significant in EMS but not in developed ones. One possible explanation lies in differing levels of market depth, regulatory maturity, and climate policy credibility. Investors may perceive greater uncertainty and policy risk in EMs, making climate

transition risk more salient in asset pricing. In contrast, DMs may already have stronger institutional frameworks and clearer transition pathways, reducing the marginal impact of transition risk on pricing.

Our findings suggest that climate transition risk has become a priced factor in international financial markets, especially in economies more vulnerable to regulatory or technological shifts in the transition to a low-carbon economy. This has important implications for investors managing FX exposures and for policymakers aiming to design effective and marke*t*-sensitive climate strategies. Future research could explore the role of capital controls and institutional quality in shaping the pricing of transition risks across countries.

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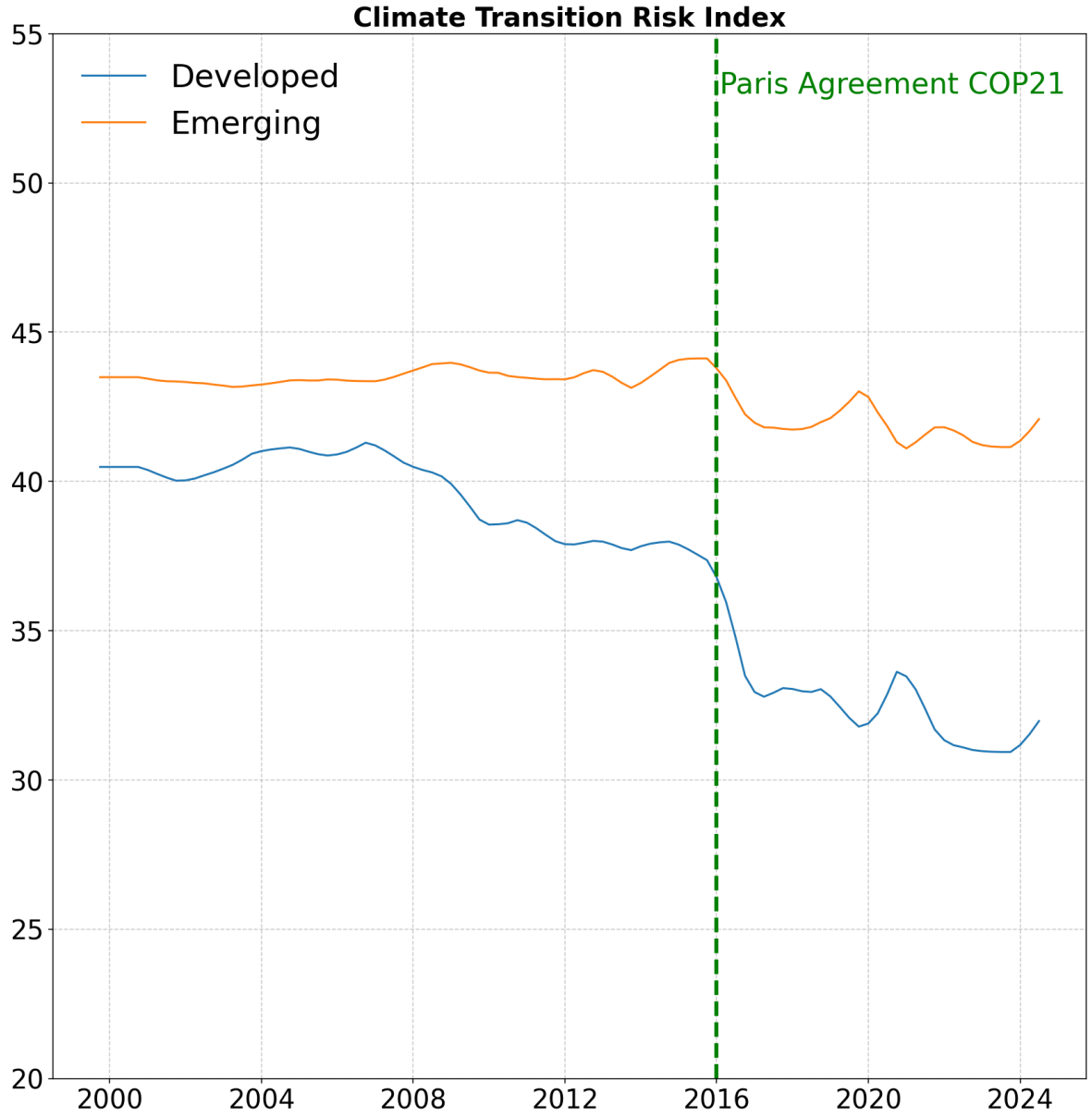
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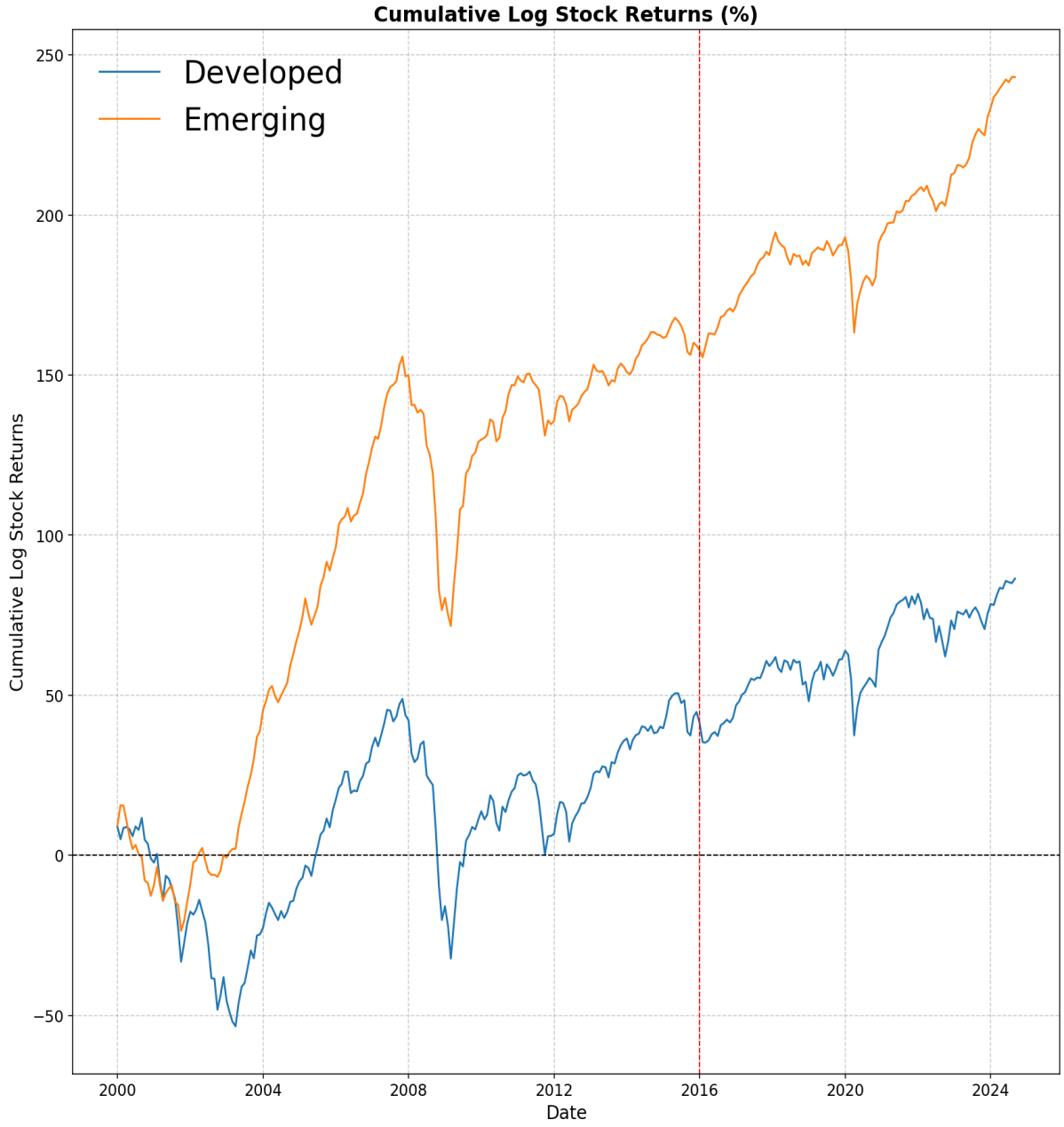
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Figure 1: Climate Transition Index



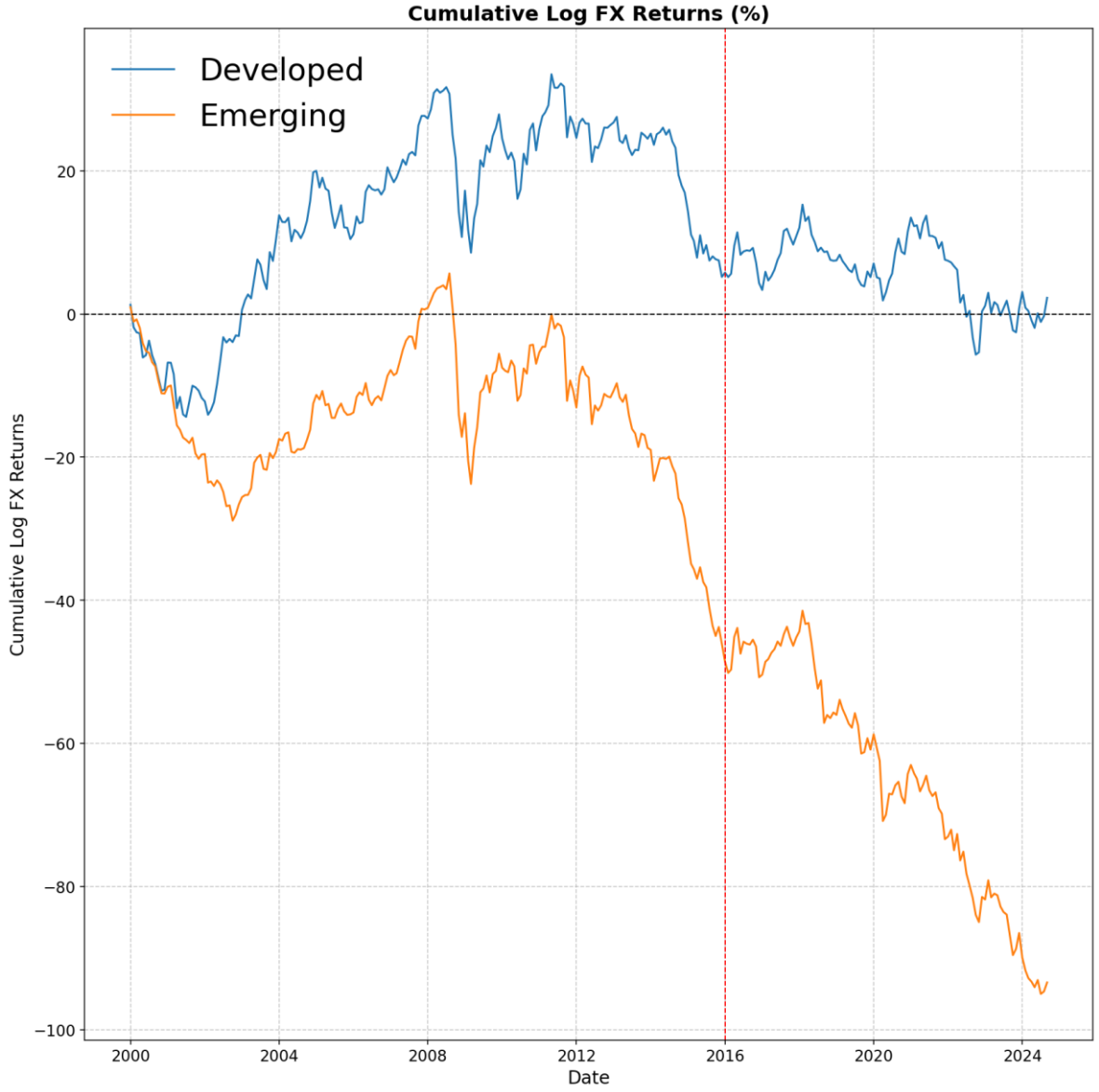
This graph plots the quarterly Climate Transition Risk Index for both developed markets (blue line) and emerging markets (yellow line) market groups from Q1 2000 through Q3 2024. The red line marks the event of the Paris Agreement, which divides the sample into two sub-periods. For better interpretability, the risk index is obtained by subtracting 100 from the original values so that higher values now correspond to higher levels of transition risk. The obtained values for each market group represent the average index calculated across its individual constituents.

Figure 2: Cumulative Log Stock Returns



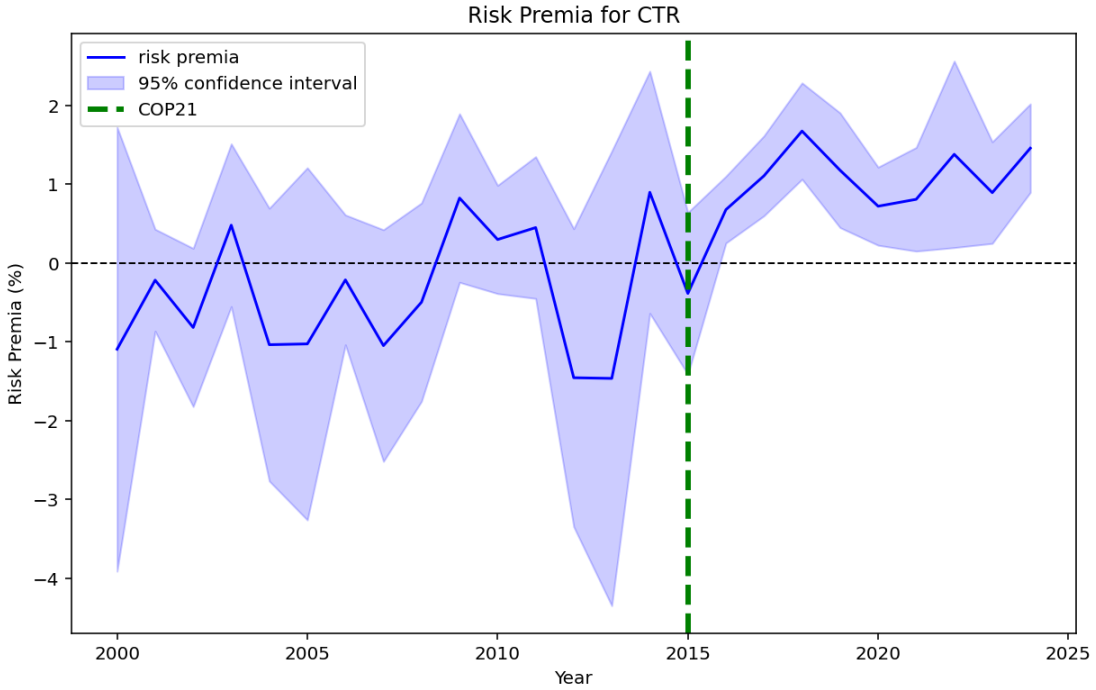
This graph plots the cumulative log stock returns for both developed markets (DMs) (blue line) and emerging markets (yellow line), from January 2000 to September 2024, with 297 observations each. The red line represents the Paris Agreement that separates our sample into two sub-periods.

Figure 3: Cumulative Log FX Returns



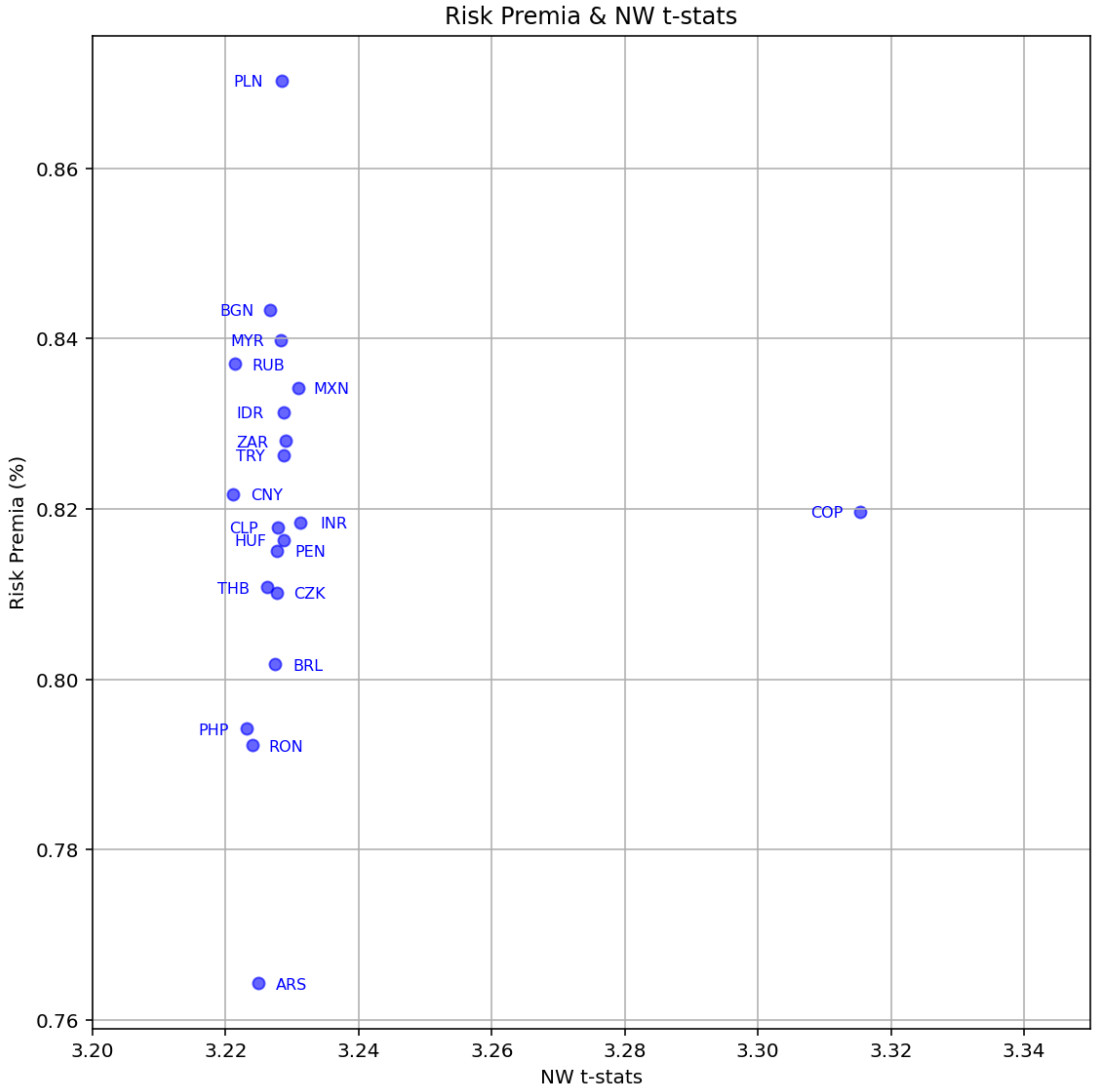
This graph plots the cumulative log FX returns for both developed markets (blue line) and emerging markets (yellow line), from January 2000 to September 2024, with 297 observations. The red line represents the Paris Agreement that separates our sample into two sub-periods.

Figure 4: Rolling Window Estimation of R_t^{CTR}



This plot repeats the estimations of Equation (12) with every 12 months for the whole sample periods of EMs. The risk premia for CTR, R_t^{CTR}, and confidence interval at 95% are reported, and the green dashed line represents the event of COP21, which separates the sample and provides the trends of how R_t^{CTR} develop overtime.

Figure 5. Climate transition risk premia excluding one EM country at a time.



This plot shows the risk premia for climate transition risks for EMs after COP21 and the NW *t*-stats when excluding one country at a time. For example, ARS means that Argentina is being omitted for the estimation. The estimation is conducted via Equation (12). The list of countries and codes is provided in Appendix B.

Table 1. Summary statistics for stock indices

	count	mean	std	min	25%	50%	75%	max	skewness	kurtosis
Panel A. Developed Markets										
Australia	297	0.34	4.02	-19.51	-2.16	1.10	2.97	10.37	-0.85	-2.27
Austria	297	0.40	6.53	-35.61	-1.86	1.37	3.86	22.34	-1.40	-5.67
Canada	297	0.38	4.47	-22.72	-1.51	0.98	2.82	16.39	-1.12	-4.35
Denmark	297	0.76	4.83	-18.76	-1.54	1.14	4.14	14.53	-0.88	-1.92
Finland	297	-0.03	7.02	-29.11	-3.25	0.50	3.80	30.34	-0.30	-3.34
France	297	0.12	5.34	-23.72	-2.54	0.69	3.51	17.38	-0.72	-1.72
Germany	297	0.39	6.07	-23.09	-2.49	0.89	4.13	18.29	-0.78	-1.80
Hong Kong	297	0.05	6.13	-22.79	-3.48	0.57	3.70	19.64	-0.27	-0.93
Japan	297	0.25	5.70	-28.17	-2.73	0.74	3.90	13.97	-0.69	-1.71
Norway	297	0.69	5.10	-35.34	-1.35	1.37	3.87	16.54	-2.03	-10.21
Singapore	297	0.14	5.32	-22.49	-2.39	0.75	3.09	21.47	-0.58	-3.04
Korea	297	0.33	6.26	-24.30	-2.73	0.69	3.78	19.34	-0.36	-1.27
Sweden	297	0.30	5.51	-16.87	-2.43	0.79	3.76	14.90	-0.48	-0.79
Switzerland	297	0.17	4.02	-16.09	-1.72	0.68	2.64	12.21	-0.73	-1.40
UK	297	0.08	4.13	-19.89	-2.09	0.66	2.56	12.14	-0.88	-2.47
Developed	297	0.29	4.31	-17.49	-1.73	0.86	3.03	11.51	-0.90	-2.02
Panel B. Emerging Markets										
Argentina	297	2.72	11.70	-45.80	-3.97	2.17	10.08	40.96	-0.21	-1.85
Brazil	297	0.69	7.06	-35.53	-3.49	0.80	5.87	16.48	-0.74	-2.48
Bulgaria	286	0.71	7.54	-50.93	-1.93	0.28	3.73	28.59	-1.28	-10.31
Chile	297	0.63	4.55	-22.30	-2.48	0.44	3.79	16.42	-0.06	-2.34
China	297	0.22	7.55	-28.77	-3.75	0.65	4.21	24.25	-0.61	-2.52
Colombia	200	0.17	5.40	-32.12	-2.83	0.56	3.50	13.37	-1.47	-6.99
Czech	297	0.41	6.02	-31.52	-2.32	0.79	3.83	19.57	-0.91	-4.05
Hungary	297	0.77	6.68	-30.82	-2.48	0.94	4.58	19.00	-0.82	-3.45
India	297	1.05	7.41	-30.56	-2.00	1.57	5.11	31.64	-0.60	-3.04
Indonesia	297	0.86	5.80	-30.36	-1.72	1.12	4.07	16.82	-0.72	-3.14
Malaysia	297	0.28	3.93	-13.04	-1.63	0.51	2.31	12.91	-0.19	-1.38
Mexico	297	0.72	5.54	-22.44	-2.34	0.97	4.10	17.69	-0.31	-1.71
Peru	297	0.93	7.57	-36.95	-3.25	0.70	5.32	36.71	0.05	-4.61
Philippines	297	0.42	5.73	-23.79	-2.86	1.20	4.26	17.13	-0.51	-1.64
Poland	297	0.51	6.04	-27.45	-2.85	0.60	4.36	18.84	-0.35	-1.54
Romania	297	1.20	8.02	-37.80	-1.59	1.51	4.77	36.23	-0.43	-4.59
Russia	297	0.88	7.93	-35.70	-2.98	1.52	5.38	28.52	-0.81	-3.13
SA	297	0.81	4.81	-17.01	-2.32	1.25	3.61	14.33	-0.13	-0.82
Thailand	297	0.39	6.29	-28.02	-2.71	0.60	3.73	20.51	-0.57	-3.22
Turkey	297	1.60	10.67	-56.80	-5.06	1.77	7.53	67.28	0.37	-7.46
Emerging	297	0.82	3.92	-22.31	-0.92	1.13	2.93	13.18	-1.10	-5.77

This table summarizes the monthly log return statistics for stock indices across 35 sample countries from January 2000 to September 2024. The statistics presented include the count, the mean, or average monthly return of the stock indices, and the standard deviation (std), capturing the variability or volatility in the returns. The table includes the minimum and maximum monthly returns, along with the percentiles (25%, 50%, and 75%) that describe the distribution of returns across quartiles. Skewness is reported to show the asymmetry of the return distribution, and kurtosis is also provided.

Table 2. Summary Statistics for FX returns

	count	mean	std	min	25%	50%	75%	max	skewness	kurtosis
Panel A. Developed Markets										
ATS/USD	297	0.03	2.70	-9.30	-1.50	0.15	1.65	9.86	-0.11	1.07
AUD/USD	297	0.02	3.52	-15.21	-1.90	-0.03	2.55	10.66	-0.33	1.29
CAD/USD	297	0.03	2.45	-11.57	-1.32	0.04	1.67	9.27	-0.36	2.27
CHF/USD	297	0.21	2.88	-13.99	-1.55	0.18	1.92	12.86	0.04	2.91
DEM/USD	297	0.03	2.70	-9.30	-1.50	0.15	1.66	9.86	-0.11	1.07
DKK/USD	297	0.03	2.69	-9.08	-1.50	0.13	1.64	9.93	-0.09	1.06
FIM/USD	297	0.03	2.70	-9.30	-1.50	0.15	1.65	9.86	-0.11	1.07
FRF/USD	297	0.03	2.70	-9.30	-1.50	0.15	1.65	9.86	-0.11	1.07
GBP/USD	297	-0.07	2.62	-11.08	-1.65	-0.11	1.73	10.06	-0.28	1.65
HKD/USD	297	0.00	0.15	-0.66	-0.06	0.00	0.04	0.91	1.12	8.16
JPY/USD	297	-0.12	2.78	-8.99	-1.82	-0.03	1.55	8.58	-0.13	0.57
KRW/USD	297	-0.05	3.02	-13.15	-1.46	0.09	1.38	13.41	-0.24	4.58
NOK/USD	297	-0.09	3.37	-11.91	-2.12	-0.13	2.02	8.48	-0.18	0.33
SEK/USD	297	-0.06	3.29	-10.58	-2.02	-0.05	1.91	11.04	0.05	0.42
SGD/USD	297	0.08	1.59	-8.57	-0.81	0.07	1.04	6.09	-0.52	3.29
Developed	297	0.01	2.14	-7.51	-1.20	-0.04	1.19	6.48	-0.10	0.91
Panel B. Emerging Market										
ARS/USD	297	-2.31	7.72	-80.65	-2.29	-0.88	0.03	10.13	-6.58	55.59
BGN/USD	297	0.03	2.73	-10.27	-1.51	0.13	1.60	10.27	-0.19	1.40
BRL/USD	297	-0.36	4.58	-16.08	-2.73	-0.05	2.23	12.75	-0.44	1.22
CLP/USD	297	-0.18	3.51	-16.43	-2.12	-0.15	2.28	7.55	-0.64	1.81
CNY/USD	297	0.07	0.98	-3.89	-0.08	0.00	0.39	5.13	-0.16	5.19
COP/USD	297	-0.26	3.89	-16.60	-2.33	-0.15	2.18	11.02	-0.43	1.08
CZK/USD	297	0.16	3.48	-13.67	-1.93	0.22	2.32	9.53	-0.36	1.17
HUF/USD	297	-0.12	4.05	-19.87	-2.17	0.28	2.32	10.28	-0.89	3.36
IDR/USD	297	-0.26	3.10	-14.94	-1.55	-0.12	1.01	16.22	0.00	6.22
INR/USD	297	-0.22	2.00	-8.60	-0.98	-0.04	0.64	8.14	-0.28	3.10
MXN/USD	297	-0.25	3.32	-22.25	-1.90	0.13	1.46	10.92	-1.36	8.33
MYR/USD	297	-0.05	1.89	-7.82	-0.70	0.00	1.00	7.27	-0.36	3.19
PEN/USD	297	-0.03	1.53	-5.18	-0.95	0.02	0.65	5.45	0.16	1.53
PHP/USD	297	-0.11	1.73	-10.07	-1.10	-0.03	0.84	5.33	-0.67	3.39
PLN/USD	297	0.03	3.84	-16.76	-2.34	0.03	2.52	10.87	-0.69	2.27
RON/USD	297	-0.31	3.00	-16.07	-1.98	-0.18	1.22	10.56	-0.40	3.32
RUB/USD	297	-0.41	5.04	-34.48	-1.65	-0.09	1.55	23.57	-1.18	10.95
THB/USD	297	0.04	2.04	-7.83	-1.12	0.15	1.13	8.14	-0.04	1.31
TRY/USD	297	-1.41	5.44	-40.63	-3.40	-0.92	1.29	11.12	-2.59	14.56
ZAR/USD	297	-0.36	4.72	-19.58	-3.25	-0.13	2.67	11.49	-0.50	1.32
Emerging	297	-0.31	2.12	-9.82	-1.62	-0.13	1.00	5.06	-0.78	2.46

This table presents a summary of monthly log return statistics for foreign exchange (FX) rates against the US Dollar (local currency). The data spans from January 2000 to September 2024, covering 297 observations for each currency pair. The table includes: the count, the mean, the standard deviation (std), the minimum and maximum monthly returns observed during the period, the percentiles (25%, 50%, and 75%) skewness, and kurtosis.

Table 3: Climate Transition Risk Portfolios for DMs

UEP	Climate Transition Risk		
Quintile	UEP	ΔStock	FX
1			
retx	0.18	-0.52	0.69
sigma	5.76	6.06	3.16
SR	0.03	-0.08	0.22
2			
retx	-3.67	-4.04	0.37
sigma	7.39	7.79	2.98
SR	-0.50	-0.52	0.12
3			
retx	0.15	-0.19	0.35
sigma	7.27	7.42	2.71
SR	0.02	-0.03	0.13
4			
retx	0.90	0.22	0.68
sigma	7.44	7.84	2.80
SR	0.12	0.03	0.24
5			
retx	-1.40	-1.52	0.12
sigma	6.35	7.10	2.54
SR	-0.22	-0.21	0.05
5-1	-1.58	-1.01	-0.57
NW *t*-stats	-1.08	-1.37	-0.06

This table reports the performance of quintile portfolios for developed markets (DMs) sorted by Climate Transition Risk index (CTR) under Uncovered Equity Parity (UEP). The lowest CTR countries are grouped into Quintile 1, while the highest are in Quintile 5, where 5-1 means the excess returns for the long-short strategy. The table shows excess returns (*retx*), standard deviation (*sigma*), and Sharpe ratio (*SR*) for each quintile. Statistical significance is shown by using Newey-West *t*- statistics (NW *t*-stats). The sample period is January 2000 to September 2024.

Table 4: Climate Transition Risk Portfolios for EMs

UEP	Climate Transition Risk		
Quintile	UEP	ΔStock	FX
1			
retx	3.12	3.66	-0.54
sigma	7.31	7.59	4.10
SR	0.43	0.48	-0.13
2			
retx	3.52	4.27	-0.75
sigma	7.74	8.00	3.18
SR	0.45	0.53	-0.23
3			
retx	2.38	4.43	-2.05
sigma	7.35	7.27	3.57
SR	0.32	0.61	-0.58
4			
retx	2.57	3.39	-0.82
sigma	8.12	8.34	2.18
SR	0.32	0.41	-0.38
5			
retx	4.65	7.38	-2.73
sigma	6.33	6.55	2.08
SR	0.73	1.13	-1.31
5-1	1.53	3.72	-2.19
NW *t*-stats	2.47	1.97	-1.88

This table reports the performance of quintile portfolios for emerging markets (EMs) sorted by Climate Transition Risk index (CTR) under Uncovered Equity Parity (UEP). The lowest CTR countries are grouped into Quintile 1, while the highest are in Quintile 5, where 5-1 means the excess returns for the long-short strategy. The table shows excess returns (*retx*), standard deviation (*sigma*), and Sharpe ratio (*SR*) for each quintile. Statistical significance is shown by using Newey-West *t*- statistics (NW *t*-stats). The sample period is January 2000 to September 2024.

Table 5: GMM Tests for EMs

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	2.0568	1.8779	1.8662	2.1041	1.9377	1.7363	2.0013	1.9564	0.5730
	(3.54)	(3.48)	(1.64)	(3.88)	(5.11)	(3.33)	(2.64)	(2.59)	(2.81)
DOLLAR	0.5874								1.2691
	(3.45)								(0.69)
Mkt-RF		0.8746							-0.5260
		(3.16)							(-0.15)
SMB			0.4363						2.0403
			(0.31)						(1.47)
HML				1.1037					0.1342
				(2.33)					(-0.06)
MOM					-1.1356				-5.1318
					(-1.09)				(-0.32)
Vol_t^{ST}						-0.8489			-0.7102
						(-1.55)			(-0.22)
Vol_t^{FX}							-0.5969		-0.2490
							(-1.23)		(-0.17)
Adj R^2	0.3286	0.3347	0.0782	0.0808	0.0918	0.1706	0.0897	0.0642	0.4063
J-statistics	5.4014	170.5941	32.8572	10.1659	16.8435	62.0579	25.6138	9.5164	12.9842
P-value	0.14	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.16

This table presents the Generalized Method of Moments (GMM) estimation results for excess foreign equity returns of emerging markets (EMs). The estimates of climate transition risk (CTR) premia are reported. Following Equation (12), the control variables include Fama-French-Carhart four factors (Mkt-RF, SMB, HML, MOM), dollar factor (DOLLAR), and global volatility proxies (Vol_t^{ST}, Vol_t^{FX}) for both equity and FX markets. The regression coefficients and Newey-West t-statistics (in parenthesis) are reported. J-statistics, and P-value are reported for the null hypothesis that the pricing errors equal to zero. Adj R^2 are provided for each regression specification.

Table 6: GMM Tests for DMs

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	0.3308	0.3172	-0.2669	-0.3472	-0.1746	0.4473	0.1250	-0.2375	1.3927
	(0.38)	(0.34)	(-0.43)	(-0.58)	(-0.28)	(0.42)	(0.15)	(-0.34)	(0.90)
DOLLAR	0.3394								0.1784
	(1.31)								(2.41)
Mk*t*-RF		0.4436							0.0439
		(1.27)							(0.03)
SMB			0.4397						0.3275
			(0.95)						(0.45)
HML				0.2453					-0.3550
				(0.32)					(-0.36)
MOM					-0.3240				2.4993
					(-0.48)				(1.02)
Vol_t^{ST}						-0.2936			-0.6013
						(-1.02)			(-1.03)
Vol_t^{FX}							-0.1094		-0.1201
							(-0.73)		(-0.42)
Adj R^2	-0.0847	-0.0318	-0.0815	-0.0947	-0.0886	-0.0385	-0.0637	-0.0914	-0.0138
J-statistics	14.7494	64.7196	29.4906	16.8313	19.4708	25.4999	18.2671	14.2436	50.9861
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

This table presents the Generalized Method of Moments (GMM) estimation results for excess foreign equity returns of developed markets (DMs). The estimates of climate transition risk (CTR) premia are reported. Following Equation (12), the control variables include Fama-French-Carhart four factors (Mkt-RF, SMB, HML, MOM), dollar factor (DOLLAR), and global volatility proxies ($\text{Vol}_t^{ST}, \text{Vol}_t^{FX}$) for both equity and FX markets. The regression coefficients and Newey-West t-statistics (in parenthesis) are reported. J-statistics, and P-value are reported for the null hypothesis that the pricing errors equal to zero. Adj R^2 are provided for each regression specification.

Table 7: Climate Transition Risk Portfolios for DMs pre- and post-COP21

UEP	Pre COP21			Post COP21		
Quintile	UEP	ΔStock	FX	UEP	ΔStock	FX
1						
retx	3.01	1.83	1.18	-5.42	-4.95	-0.47
sigma	5.97	3.34	3.34	9.00	6.01	2.80
SR	0.51	0.55	0.35	-0.60	-0.82	-0.17
2						
retx	-1.49	-2.88	1.39	-6.57	-6.27	-0.30
sigma	7.72	3.30	3.30	8.94	7.34	2.30
SR	-0.19	-0.87	0.42	-0.74	-0.85	-0.13
3						
retx	3.81	3.11	0.70	-4.99	-5.25	0.26
sigma	7.27	2.98	2.98	8.39	7.57	2.14
SR	0.52	1.05	0.23	-0.59	-0.69	0.12
4						
retx	3.09	1.52	1.57	-9.22	-8.16	-1.06
sigma	7.28	3.17	3.17	8.51	8.14	1.93
SR	0.42	0.48	0.50	-1.08	-1.00	-0.55
5						
retx	3.09	1.52	1.57	-9.22	-8.16	-1.06
sigma	6.23	2.65	2.65	7.72	7.53	2.31
SR	0.50	0.57	0.59	-1.19	-1.08	-0.46
5-1	0.08	-0.31	0.39	-3.80	-3.21	-0.59
NW *t*-stats	0.44	-0.09	0.09	-1.32	-1.19	-0.06

This table reports the performance of quintile portfolios for developed markets (DMs) sorted by Climate Transition Risk index (CTR) under Uncovered Equity Parity (UEP) for pre- and post- the Paris COP21 agreement. The lowest CTR currencies are grouped into Quintile 1, while the highest are in Quintile 5. The table shows excess returns (retx), standard deviation (sigma), and Sharpe ratio (SR) for each quintile. The last row presents Newey-West *t*-statistics for the significance of the extreme top-bottom quintile differential.

Table 8: Climate Transition Risk Portfolios for EMs pre- and post-COP21

UEP	Pre COP21			Post COP21		
Quintile	UEP	ΔStock	FX	UEP	ΔStock	FX
1						
retx	7.06	7.94	-0.88	-4.76	-4.42	-0.34
sigma	23.52	7.70	1.07	7.02	7.37	0.98
SR	0.30	1.03	-0.82	-0.68	-0.60	-0.34
2						
retx	7.88	8.28	-0.40	-4.80	-4.31	-0.49
sigma	24.75	8.01	1.10	7.57	7.96	1.07
SR	0.32	1.03	-0.36	-0.63	-0.54	-0.46
3						
retx	2.35	4.42	-2.07	-1.05	-4.24	3.18
sigma	25.38	7.91	1.96	5.91	5.90	1.39
SR	0.09	0.56	-1.05	-0.18	-0.72	2.30
4						
retx	7.55	8.92	-1.36	-6.62	-5.91	-0.71
sigma	29.28	9.48	1.67	5.31	5.56	1.44
SR	0.26	0.94	-0.82	-1.25	-1.06	-0.49
5						
retx	7.79	8.75	-0.96	-0.80	5.66	-6.46
sigma	19.68	6.32	2.03	6.54	7.00	2.06
SR	0.40	1.38	-0.47	-0.12	0.81	-3.14
5-1	0.73	0.80	-0.07	3.96	10.08	-6.12
NW *t*-stats	0.16	0.31	-0.37	3.35	2.68	-2.82

This table reports the performance of quintile portfolios for emerging markets (EMs) sorted by Climate Transition Risk index (CTR) under Uncovered Equity Parity (UEP) for pre- and post-the Paris COP21 agreement. The lowest CTR currencies are grouped into Quintile 1, while the highest are in Quintile 5. The table shows excess returns (retx), standard deviation (sigma), and Sharpe ratio (SR) for each quintile. The last row presents Newey-West *t*-statistics for the significance of the extreme top-bottom quintile differential.

Table 9: GMM Tests for EMs pre-COP21

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	0.0685	-0.0482	0.0370	0.2329	0.0319	0.0799	0.6150	0.0483	0.3119
	(0.17)	(-0.12)	(0.09)	(0.39)	(0.09)	(2.16)	(3.10)	(1.12)	(1.56)
DOLLAR	0.0118								0.3173
	(0.05)								(0.66)
Mkt-RF		-0.4744							0.6107
		(-0.81)							(0.55)
SMB			0.8100						1.0746
			(1.81)						(1.85)
HML				0.1840					0.3415
				(0.71)					(-0.84)
MOM					0.9684				0.3829
					(1.49)				(-0.49)
Vol_t^{ST}						-0.7836			-1.4246
						(-1.18)			(-2.34)
Vol_t^{FX}							-0.5328		-0.3681
							(-1.76)		(-1.35)
Adj R^2	-0.5688	-0.0618	-0.6426	-0.1837	-0.7651	-0.1757	-0.1902	-0.8554	-0.0304
J -statistics	6.0764	37.4991	15.1592	8.0574	6.0064	6.4568	11.2193	10.0097	29.195
P-value	0.11	0.00	0.00	0.04	0.11	0.09	0.01	0.01	0.00

This table presents the results of Generalized Method of Moments (GMM) estimates for excess foreign equity returns of emerging markets (EMs) before COP21. The estimates of climate transition risk (CTR) premia are reported. Following Equation (12), the control variables include Fama-French-Carhart four factors (Mkt-RF, SMB, HML, MOM), dollar factor (DOLLAR), and global volatility proxies (Vol_t^{ST}, Vol_t^{FX}) for both equity and FX markets. The regression coefficients and Newey-West t-statistics (in parenthesis) are reported. J-statistics, and P-value are reported for the null hypothesis that the pricing errors equal to zero. Adj R^2 are provided for each regression specification.

Table 10: GMM Tests for EMs post-COP21

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	2.3940	2.1762	2.3113	2.3866	1.8441	2.0202	2.3270	2.3131	0.8602
	(3.19)	(5.13)	(2.80)	(3.33)	(3.05)	(3.41)	(3.43)	(3.79)	(3.49)
DOLLAR	0.4795								1.3908
	(1.11)								(0.78)
Mkt-RF		1.1961							2.0376
		(4.24)							(0.85)
SMB			-0.1070						-1.0114
			(-0.04)						(-0.51)
HML				0.6900					-2.7541
				(0.80)					(-1.75)
MOM					-2.0182				-5.0487
					(-1.22)				(-0.90)
Vol_t^{ST}						-0.9533			-2.1707
						(-1.48)			(-2.66)
Vol_t^{FX}							0.0689		-0.8220
							(0.07)		(-2.48)
Adj R^2	0.2280	0.2130	0.2381	0.2311	0.2301	0.2125	0.2323	0.2344	0.2109
J-statistics	7.5358	11.7921	6.7052	7.0947	13.5186	8.5205	9.9986	6.6071	11.4535
P-value	0.16	0.01	0.08	0.07	0.00	0.04	0.02	0.04	0.25

This table presents the results of Generalized Method of Moments (GMM) estimates for excess foreign equity returns of emerging market group after COP21. The estimates of climate transition risk (CTR) premia are reported. Following Equation (12), the control variables include Fama-French-Carhart four factors (Mkt-RF, SMB, HML, MOM), dollar factor (DOLLAR), and global volatility proxies (Vol_t^{ST}, Vol_t^{FX}) for both equity and FX markets. The regression coefficients and Newey-West *t*-statistics (in parenthesis) are reported. *J*-statistics, and *P*-value are reported for the null hypothesis that the pricing errors equal to zero. Adj R^2 are provided for each regression specification.

Table 11: Stock Differentials and FX Returns

Variable	Emerging Markets (EMs)			Developed Markets (DMs)		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔS_{it}	-0.0112	0.2109	0.2081	0.0155	0.0193	0.0220
	(-0.59)	(2.78)	(2.68)	(1.14)	(0.45)	(0.59)
CTR_{it}		0.3431	0.3106		0.0820	-0.0108
		(0.53)	(0.50)		(0.79)	(0.08)
$\Delta S_{it} * CTR_{it}$		-0.0589	-0.0502		-0.0011	-0.0029
		(-2.97)	(-2.41)		(-0.08)	(-0.19)
$CTR_{it} * COP21$			-0.2053			0.0481
			(-0.56)			(1.41)
$\Delta S_{it} * CTR_{it} * COP21$			-0.0244			0.0041
			(-3.60)			(0.70)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4572	4572	4572	3560	3560	3560
$Adj\ R^2$	-0.0692	-0.0649	-0.0583	-0.0869	-0.0874	-0.0876

The table reports the relationship between stock differentials (ΔS_{it}) and FX returns for both EMs (Column 1 to Column 3) and DMs (Column 4 to Column 6), via Equation (13). The table presents estimates for β coefficients for stock differentials (ΔS_{it}), climate transition risk (CTR_{it}), dummy for the event of $COP21$, and interaction terms, along with their *t*-statistics (in parentheses). The standard errors are clustered by country. Additionally, the table includes the number of observations (N) and the Adjusted R^2 statistic.

Table 12: Carbon Emission Intensity Long-Short Strategy

Long-Short Strategy	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Post COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
5-1	-2.11	-2.11	0.00	1.84	4.51	-2.66	-0.79	-0.05	-0.74	-2.70	-2.17	-0.53
NW *t*-stats	-0.51	-0.54	0.00	2.28	1.88	-1.98	-0.32	-0.02	-0.44	-0.68	-0.58	-0.35

This table reports the long-short (5-1) strategy returns for climate transition risk using the carbon emission intensity data, and the Newey-West *t*-statistic is also included. Results for both EMs and DMs are presented, and to further show the robustness over the effect from COP21 agreement, the sample period again is divided into the pre- and post-COP21.

Table 13: Alternative Groupings of UEP Portfolio

Long-Short Strategy	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Pre COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
3-1	0.34	1.58	-1.24	3.38	7.60	-4.23	1.29	1.27	0.02	-1.53	-1.52	0.00
NW *t*-stats	1.24	0.79	-1.27	2.40	1.84	-2.57	0.30	0.45	0.04	-0.67	-0.78	0.01
4-1	0.27	1.79	-1.52	4.23	8.21	-3.98	1.24	1.25	-0.01	-3.49	-2.27	-1.22
NW *t*-stats	0.43	0.20	-0.52	3.41	2.75	-2.88	0.10	0.12	-0.03	-0.88	-1.28	-0.31
6-1	1.49	2.93	-1.44	5.12	8.96	-3.84	-0.49	0.44	-0.93	-2.31	-2.62	-0.31
NW *t*-stats	0.11	0.14	-0.38	2.27	2.19	-1.89	-0.40	0.41	-0.16	-1.23	-1.95	-0.92

This table reports the long-short strategy returns for climate transition risk portfolios with 3, 4, 6 number of portfolios, and the Newey-West *t*-statistic is also included. Results are presented for both EMs and DMs over the pre- and post-COP21 periods.

Table 14: Long-Short Strategies Under MSCI Stock Index

Long-Short Strategy	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Pre COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
5-1	0.53	0.19	0.34	3.46	8.72	-5.26	0.08	-0.79	0.87	-4.30	-3.88	-0.42
NW *t*-stats	0.32	0.31	0.05	3.08	2.68	-3.57	0.03	-0.37	0.09	-0.56	-1.59	-0.06

This table reports the long-short (5-1) strategy returns for climate transition risk quintile portfolios by using MSCI country stock index, and the Newey-West *t*-statistic is also included. Results are presented for both EMs and DMs over the pre- and post-COP21 periods.

Table 15: GMM Tests for EMs post-COP21 (MSCI)

	Risk premia											
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CTR	1.3946	1.3052	1.3198	0.9863	1.1615	1.2269	1.1653	1.2233	1.0308	1.2886	1.2706	0.4166
	(2.51)	(2.50)	(2.80)	(1.89)	(1.99)	(2.89)	(2.50)	(2.57)	(2.13)	(3.61)	(2.98)	(2.63)
DOLLAR	0.1408											-0.8533
	(0.43)											(-2.70)
CARRY		-0.2694										-1.2471
		(-0.28)										(-0.46)
LT			-0.4499									-1.6092
			(-0.65)									(-0.65)
MOM^{FX}				-0.7234								-1.6560
				(-0.71)								(-0.62)
Mkt-RF					1.0684							-5.4272
					(1.12)							(-1.24)
SMB						0.6327						1.1722
						(1.10)						(0.54)
HML							0.2182					3.2039
							(0.34)					(0.84)
MOM^{ST}								-0.1062				-0.8809
								(-0.16)				(-0.26)
Vol_t^{ST}									-1.2127			-2.0528
									(-1.82)			(-1.91)
Vol_t^{FX}										0.1125		0.1669
										(0.28)		(0.14)
Adj R^2	-0.0500	-0.1665	-0.2020	-0.2032	-0.0018	-0.2061	-0.1152	-0.2550	-0.1697	-0.2510	-0.2480	0.1005
J-statistics	6.0531	7.5948	5.6071	21.9053	9.003	5.188	24.4544	5.3928	27.2454	6.6348	4.9044	17.0498
P-value	0.11	0.06	0.13	0.00	0.03	0.16	0.00	0.15	0.00	0.08	0.09	0.15

This table presents the results of Generalized Method of Moments (GMM) estimates for excess foreign equity returns via MSCI stock index of emerging market group after COP21. CARRY, LT, MOM^{FX} are included as additional controls for Equation (11). The regression coefficients, Newey-West *t*-statistics (in parenthesis), $Adj\ R^2$, *J*-statistics and *P*-value (for null hypothesis that the pricing errors equal to zero) are provided.

Table 16: Rebalancing Frequencies

Long-Short Strategy	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Pre COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
3M	-0.17	0.13	-0.29	4.99	8.05	-3.06	-0.66	-0.62	-0.04	-1.13	-1.15	0.02
NW *t*-stats	0.05	0.04	-0.57	2.53	3.14	-2.82	-0.36	-0.32	-0.09	-1.12	-0.98	0.04
6M	-0.29	-0.14	-0.15	4.92	7.69	-2.76	-0.52	-0.50	-0.02	-1.28	-1.29	0.01
NW *t*-stats	-0.11	-0.05	-0.37	3.71	3.88	-1.85	-0.32	-0.30	-0.09	-1.06	-1.36	0.06
12M	0.04	0.11	-0.07	5.22	7.74	-2.53	-0.34	-0.33	-0.01	-0.73	-0.74	0.01
NW *t*-stats	0.02	0.06	-0.33	1.49	5.50	-1.46	-0.24	-0.24	-0.09	-1.11	-1.14	0.06

This tables report the long-short strategy returns for different rebalancing frequencies (3-month, 6-month and 12-month), and the Newey-West *t*-statistic is also included. Results are presented for both EMs and DMs over the pre- and post-COP21 periods.

Table 17: FMB Tests for EMs

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	0.5936	1.9562	0.0567	0.4024	1.6217	0.8867	3.7352	1.0429	0.3161
	(2.07)	(4.36)	(1.95)	(5.38)	(5.04)	(2.21)	(2.81)	(1.96)	(2.24)
DOLLAR	2.3838								0.3524
	(2.75)								(1.05)
Mkt-RF		0.5646							-2.0693
		(4.59)							(-0.31)
SMB			-0.2081						2.4208
			(-0.70)						(1.95)
HML				0.1904					-0.5894
				(1.96)					(-1.44)
MOM					-2.7216				-3.5110
					(-0.41)				(-0.22)
Vol^{ST}						-2.0428			-0.5104
						(-0.28)			(-0.04)
Vol_t^{FX}							-0.7975		-1.3023
							(-1.82)		(-0.13)
Adj R^2	0.0187	0.0016	0.0106	0.0169	0.0115	0.0135	0.0022	0.0201	0.0075
χ^2_{SH}	10.6251	12.3121	18.0990	19.9947	20.2496	11.2487	10.2564	19.0201	8.0075
P-value	0.91	0.83	0.45	0.39	0.32	0.88	0.92	0.37	0.76

This table presents the results of Fama-MacBeth (FMB) for excess foreign equity returns of emerging market group for all sample period. CTR represents climate transition risk factor. Control variables include DOLLAR, Mkt-RF, SMB, HML, MOM, Vol^{ST} and Vol^{FX}. The regression coefficients, Newey-West *t*-statistics (in parenthesis), $Adj\ R^2$, χ^2_{SH} and *P*-value are provided for each regression model, where χ^2_{Sh} tests for whether pricing errors are equal to 0 and SH stands for Shanken (1992).

Table 18: FMB Tests for DMs

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	0.3308	0.3172	-0.2669	-0.3472	-0.1746	0.4473	0.1250	-0.2375	-0.3927
	(0.38)	(0.34)	(-0.43)	(-0.58)	(-0.28)	(0.42)	(0.15)	(-0.34)	(-0.90)
DOLLAR	0.3394								0.1784
	(1.31)								(2.41)
Mkt-RF		0.4436							0.0439
		(1.27)							(0.03)
SMB			0.4397						0.3275
			(0.95)						(0.45)
HML				0.2453					-0.3550
				(0.32)					(-0.36)
MOM					-0.3240				2.4993
					(-0.48)				(1.02)
Vol_t^{ST}						-0.2936			-0.6013
						(-1.02)			(-1.03)
Vol_t^{FX}							-0.1094		-0.1201
							(-0.73)		(-0.42)
Adj R^2	-0.0847	-0.0318	-0.0815	-0.0947	-0.0886	-0.0385	-0.0637	-0.0914	-0.0138
χ^2_{SH}	14.4613	28.7374	24.0407	14.5741	16.3622	15.2265	11.301	29.4362	26.6692
P-value	0.70	0.05	0.09	0.69	0.57	0.65	0.88	0.03	0.01

This table presents the results of Fama-MacBeth (FMB) regression estimates for excess foreign equity returns of developed market group for all sample period. CTR represents climate transition risk factor. Control variables include DOLLAR, Mkt-RF, SMB, HML, MOM, Vol^{ST} and Vol^{FX}. The regression coefficients, Newey-West *t*-statistics (in parenthesis), $Adj\ R^2$, χ^2_{SH} and *P*-value (for the null hypothesis that pricing errors are equal to 0) are provided for each regression model.

Table 19: FMB Tests for EMs pre-COP21

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	1.2371	-1.3857	1.5712	1.8161	-1.0438	0.5814	0.1347	0.9832	1.5105
	(-0.32)	(-0.69)	(0.58)	(0.90)	(-0.64)	(2.96)	(2.70)	(0.44)	(1.18)
DOLLAR	1.8352								2.1346
	(1.34)								(2.08)
Mkt-RF		-1.6085							-0.2206
		(-0.90)							(-0.07)
SMB			1.0147						3.0195
			(1.95)						(0.53)
HML				1.9044					1.5665
				(0.30)					(0.96)
MOM					1.1717				1.4406
					(1.34)				(0.21)
Vol_t^{ST}						-2.0543			-3.3832
						(-0.54)			(-2.21)
Vol_t^{FX}							-1.3897		-1.5202
							(-1.43)		(-0.83)
Adj R^2	-0.0059	-0.0201	-0.0117	-0.0119	-0.0142	-0.0121	-0.0168	-0.0028	-0.0137
χ^2_{SH}	8.9039	15.6243	33.0135	38.259	11.152	16.3758	22.9127	34.7992	17.8474
P-value	0.96	0.62	0.01	0.01	0.89	0.57	0.06	0.01	0.12

This table presents the results of Fama-MacBeth (FMB) estimates for excess foreign equity returns of emerging market group before COP21. CTR represents climate transition risk factor. Control variables include DOLLAR, Mkt-RF, SMB, HML, MOM, Vol^{ST} and Vol^{FX}. The regression coefficients, Newey-West *t*-statistics (in parenthesis), $Adj\ R^2$, χ^2_{SH} and *P*-value (for the null hypothesis that pricing errors are equal to 0) are provided for each regression model.

Table 20: FMB Tests for EMs post-COP21

	Risk premia								
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CTR	0.8608	2.0189	4.017	2.5870	2.3289	3.1656	1.2727	0.5394	0.4789
	(4.52)	(4.18)	(1.96)	(2.77)	(3.84)	(3.52)	(3.83)	(3.67)	(2.24)
DOLLAR	1.9407								3.0015
	(1.81)								(0.04)
Mkt-RF		2.6524							-0.2572
		(4.25)							(-0.27)
SMB			-1.4757						-2.3821
			(-1.20)						(0.21)
HML				-1.9361					-3.5681
				(-0.27)					(-1.95)
MOM					-1.6978				-3.3479
					(-0.25)				(-1.63)
Vol_t^{ST}						-2.7541			-0.2085
						(-1.35)			(-3.64)
Vol_t^{FX}							1.4311		-1.6991
							(0.33)		(-2.49)
Adj R^2	0.0061	0.0154	0.0150	0.0071	0.0091	0.0201	0.0179	0.0206	0.0046
χ^2_{SH}	9.9754	10.5401	21.0143	21.8821	17.6116	25.5786	13.6127	23.3328	5.0639
P-value	0.93	0.91	0.28	0.24	0.48	0.11	0.75	0.18	0.96

This table presents the results of Fama-MacBeth (FMB) estimates for excess foreign equity returns of emerging market group after COP21. CTR represents climate transition risk factor. Control variables include DOLLAR, Mkt-RF, SMB, HML, MOM, Vol^{ST} and Vol^{FX}. The regression coefficients, Newey-West *t*-statistics (in parenthesis), $Adj\ R^2$, χ^2_{SH} and *P*-value (for the null hypothesis that pricing errors are equal to 0) are provided for each regression model.

Table 21: Climate Physical Risk

Long-Short Strategy	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Pre COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
5-1	-1.45	-2.10	0.65	-1.19	-1.22	0.03	-1.91	-1.24	-0.67	2.38	1.81	0.57
NW *t*-stats	-0.33	-0.49	0.55	-0.28	-0.29	0.03	-0.83	-0.57	-0.64	0.69	0.63	0.40

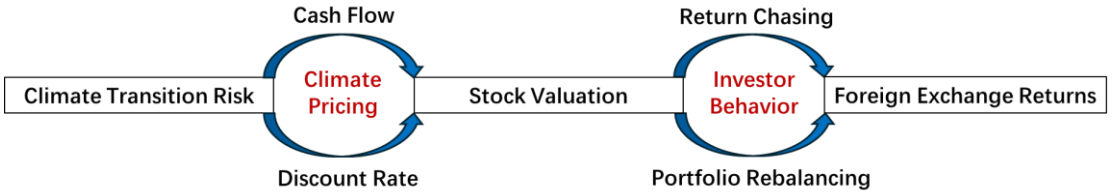
This table reports the long-short (5-1) strategy returns for climate transition risk quintile portfolios by MSCI country stock index, and the Newey-West *t*-statistic is also included. Results for both EMs and DMs are presented, and to further show the robustness over the effect from COP21 agreement, the sample period again is divided into the pre- and post-COP21.

Table 22. Longer lags for climate transition risk index.

	Emerging Markets (EMs)						Developed Markets (DMs)					
	Pre COP21			Post COP21			Pre COP21			Post COP21		
	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX	UEP	Stock	FX
6M	2.40	2.96	-0.56	2.98	8.46	-5.48	-0.94	-0.81	-0.13	-3.09	-3.07	-0.02
NW *t*-stat	0.55	0.67	-0.37	2.33	2.61	-2.74	-0.44	-0.37	-0.09	-1.24	-1.44	0.00
9M	-0.86	-0.77	-0.09	2.01	7.35	-5.33	-0.71	-0.56	-0.15	-1.32	-1.77	0.46
NW *t*-stat	-0.23	-0.22	-0.06	1.55	2.73	-1.61	-0.33	-0.26	-0.10	-0.58	-0.93	0.43
15M	-1.68	-2.15	0.77	1.13	6.25	-5.12	-1.07	-0.76	-0.31	-0.16	-0.65	0.50
NW *t*-stat	-0.44	-0.60	0.32	1.60	1.65	-1.59	-0.49	-0.34	-0.20	-0.06	-0.32	0.43

The table reports the long-short portfolio returns when the climate transition risk index is lagged two, three or five quarters (6, 9 or 15 months) with respect to the FX rate and equity index observed at each portfolio formation time *t*. NW *t*-stat is the Newey-West heteroskedasticity and autocorrelation robust t-statistic for the significance of returns. Results are presented separately for EMs and DMs over the pre- and post-COP21 periods.

Appendix A. Transmission mechanism of climate transition risks to FX returns.



This figure shows the transmission mechanism of the impact of climate transition risks to foreign exchange returns via the stock market valuation.

Appendix B. Sample countries and main variables.

This table lists the countries in the study and corresponding codes from Datastream for the main variables. Columns 2 and 3 report spot and (one-month) forward exchange rates against the US dollar. Columns 4 and 5 report, respectively, each country's primary domestic equity benchmark (as defined by the main local exchange) and the corresponding MSCI country index constructed using MSCI's standardized methodology. The last column reports the LSGE transition risk index.

Country	Spot	Forward	Equity	MSCI	Transition risk
Panel A: Developed markets (DMs)					
Australia	AUSTDOI	BBAUD1F USAUD1F	ASX200I	MSAUSTL	OESOVABAR
Austria	AUSTSC$	USATS1F	ATXINDX	MSASTRL	CNSOVABAR
Canada	NDOLL$	USCAD1F	TTOSP60	MSCNDAL	FRSOVABAR
Denmark	DANISH$	USDKK1F	COSEASH	MSDNMKL	SPSOVABAR
Finland	FRENFR$	USFIM1F	HEXINDX	MSFIND	KOSOVABAR
France	FINMAR$	USFRF1F	FRCAC40	MSFRNCL	SDSOVABAR
Germany	DMARKE$	USDEM1F	DAXINDX	MSGERML	SWSOVABAR
Hongkong	HKDOLL$	USHKD1F	HNGKNGI	MSHGKGL	UKSOVABAR
Japan	JAPAYE$	JE1MUSD	JAPDOWA	MSJPANL	CLSOVABAR
Norway	NORKRO$	USNOK1F TDNOK1M	NWSHRPRCF	MSNWAYL	CZSOVABAR
Singapore	SINGDO$	USSGD1F	SNGPORI	MSSINGL	PESOVABAR
Korea	TDRUBSP	USKRW1F	KORCOMP	MSKOREL	POSOVABAR
Sweden	SWEKRO$	TDSEK1M	SWEDOMX	MSSWDNL	RSSOVABAR
Switzerland	SWISSF$	USCHF1F	SWISSMI	MSSWITL	RMSOVABAR
UK	UKDOLLR	UKUSD1F	FTSE100	MSUTDKL	TKSOVABAR
Panel: Emerging markets (EMs)					
Argentina	TDARSSP	USARS1F	ARGMERV	MSARGTL	AUSOVABAR
Brazil	TDBRLSP	USBRL1F	BRSHRPRCF	MSBRAZL	DKSOVABAR
Bulgaria	TDBGNSP	USBGN1F	BSSOFIX	MSBLGNL	FNSOVABAR
Chile	TDCLPSP	USCLP1F	IGPAGEN	MSCHILL	BDSOVABAR
China	TDCNYSP	TDCNY1M	CHSASHR	MSCHINL	HKSOVABAR
Columbia	TDCOPSP	USCOP1F	CBSHRPRCF	MSCOLML	JPSOVABAR
Czech	TDCZKSP	USCZK1F	CZPXIDX	MSCZCHL	NWSOVABAR
Hungary	TDHUFSP	USHUF1F	BUXINDX	MSHUNGL	AGSOVABAR
India	TDINRSP	USINR1F	ICRI500	MSINDIL	BRSOVABAR
Indonesia	TDIDRSP	USIDR1F	JAKCOMP	MSINDFL	BLSOVABAR
Malaysia	TDMYRSP	MYUSN1M	FBMKLCI	MSMALFL	CHSOVABAR
Mexico	TDMXNSP	USMXN1F	MXIPC35	MSMEXFL	CBSOVABAR
Peru	TDPENSP	USPEN1F	PEGENRL	MSPERU$	HNSOVABAR
Philippines	TDPHPSP	USPHP1F	PSECOMP	MSPHLFL	INSOVABAR
Poland	TDPLNSP	USPLN1F	POSHRPRCF	MSPLNDL	IDSOVABAR
Russia	TDKRWSP	USRUB1F	RS:MOC	-	MYSOVABAR
Romania	TDRONSP	USRON1F	RMBETRL	MSROMNL	MXSOVABAR
South Africa	TDZARSP	USZAR1F	JSEOVER	MSSARFL	PHSOVABAR
Thailand	TDTHBSP	USTHB1F	BNGKSET	MSTHAFL	SASOVABAR
Turkey	TDTRYSP	USTRY1F	TRKIST	MSTURKL	THSOVABAR

Appendix C. Risk factors in GMM and FMB specifications

This table presents the FX market risk factors and stock market risk factors used as control variables in the GMM and FMB estimation. The subscript t denotes months. The FX market risk factors are constructed with data from the 35 countries in our sample. Apart from $DOLLAR, VOL^{ST}$ and VOL^{FX}, other factors are constructed using a long-short strategy based on quintile sorting. Countries are ranked according to a specific signal and then allocated to one of five portfolios. Portfolio Q1 contains the countries with the lowest signal values, while portfolio Q5 contains those with the highest. The long-short factor is subsequently formed by taking a long position in the top quintile (Q5) and a short position in the bottom quintile (Q1). The constructions of all risk factors are described below.

Name	Definition	Formula & signal	Key references & sources
	FX Market		
$DOLLAR$	Monthly Average returns of our full-sample currencies ($K = 35$) against the US$.	$\frac{\sum_{k=1}^{K} \Delta s_{k,t}^{f}}{K}$	Lustig et al. (2011)
$CARRY$	Monthly returns of a portfolio that goes long currencies with highest interest rate differentials and short currencies with lowest interest rate differentials. According to Covered Interest Rate Parity (CIP), we can use one-month forward premium ($\frac{S_t - F_t}{S_t}$) to proxy interest rate differentials.	$\frac{S_t - F_t}{S_t}$	Lustig et al. (2011)
LT	Monthly returns of a portfolio that is long currencies from countries with the highest 10y interest rate, minus 10y Treasury bond differential, and short currencies with the lowest.	$i_{10y,t}^{f} - i_{10y,t}^{US}$	Ang and Chen (2010)
MOM^{FX}	Monthly returns of a portfolio that is long currencies with highest past 1-month returns (winners) and short currencies with lowest past 1-month returns (losers).	$r_{k,t-1}^{FX}$	Menkoff et al. (2012b)

VOL^{FX}	Monthly residuals of AR(1) model fitted to the time-series of monthly mean absolute daily returns (T_t days per month) for our full-sample currencies ($K = 35$) against the US$.	$\mathrm{Vol}_t^{\mathrm{FX}} = \frac{1}{T_t}\sum_{d=1}^{T_t}\left[\sum_{k=1}^{K}\left(\frac{\lvert\Delta s_{k,d}\rvert}{K}\right)\right]$	Menkoff et al. (2012a)
	Stock Market		
SMB	Monthly returns of a portfolio of stocks with small market capitalization minus large-cap stocks.	$r_t^{large} - r_t^{small}$	Kenneth R. French - Data Library
HML	Monthly returns of a portfolio of high book-to-market (value) stocks minus a portfolio of low book-to-market (growth) stocks.	$r_t^{high\ BM} - r_t^{low\ BM}$	Kenneth R. French - Data Library
$Mkt - RF$	Monthly returns of the broad, value-weighted stock market portfolio minus the risk-free rate.	$r_t^{mkt} - r_t^{rf}$	Kenneth R. French - Data Library
MOM^{ST}	Monthly returns of a portfolio that is long stocks with highest past 1-month returns (winners) and short stocks with lowest past 1-month returns (losers).	$r_{k,t-1}^{ST}$	Asness et al. (2013)
VOL^{ST}	Monthly residuals of AR(1) model fitted to the time-series of monthly mean absolute daily returns (T_t days per month) for stocks indices ($K = 5$), containing SP500, FTSE 100, NIKKEI 225, DAX, and CAC 40.	$\mathrm{Vol}_t^{\mathrm{ST}} = \frac{1}{T_t}\sum_{d=1}^{T_t}\left[\sum_{k=1}^{K}\left(\frac{\lvert r_{s,\tau}^{k}\rvert}{K}\right)\right]$	Cenedese et al. (2016)