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CLIMATE RISKS AND FDI

Abstract

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JEL Classification: F21, F23, F64

Keywords: weather, Foreign direct investments

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Climate Risks and FDI

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January 18, 2023

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Keywords: climate change, weather, climate policy, emission productivity, foreign direct investment

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1 Introduction

It is well documented in the climate science literature that the frequency of extreme weather events is increasing due to climate change (Hsiang and Kopp, 2018). Events that once were thought to be extraordinary have become an annual occurrence. Every occurrence of extreme weather events increases perceived risks of climate change, both physical risks, due to the destructive effects of such events, and transition risks which arise from increased awareness of these risks and political will to mitigate them.[1] Is this change in the distribution of weather event occurrence, which we can interpret as an increase in physical risks due to climate change, incorporated into the behavior of multinational companies? Moreover, do firms react to climate transition risks, such as increased probabilities of climate mitigation policies? In this paper, we evaluate the response of foreign direct investments (FDI) to extreme weather events and climate-related policies.

As physical manifestations of climate change are becoming more apparent, so is the attention to climate-related risks. Recent studies of financial market responses consistently find that the Paris Climate Accord of 2015 is a turning point for the markets to incorporate climate risks into their behavior.[2] This, of course, presents difficulties for the empirical analysis, because even today we would not expect the majority of the private sector to fully incorporate climate risks in their decisions. For this reason, we first construct a theoretical framework to discipline our empirical analysis and then conduct a comprehensive set of empirical tests, distinguishing pre- and post-Paris Accord, advanced and emerging economies, and different levels of country-industry emission efficiency and firm climate risks.

We construct a model in which a multinational enterprise (MNE) chooses how much FDI and how many affiliates to allocate in a target country, fully taking into account climate risks, both physical and transition risks, with rational expectations. This model provides a benchmark for what we should expect to find in the data if climate risks were fully reflected in firms' behavior. We then confront the question with the data, relying on all possible levels of aggregation and available data sources to span a long time period, including as many countries as possible, and exploring heterogeneity as much as possible. We find that, while most of the robust empirical results are consistent with model predictions, very few effects are statistically significant, and are mostly small in terms of magnitude. We do not find a robust significant increase in response to climate risks following Paris Climate Accord using aggregate data. However, using country-industry data and firm-level data we do find some supportive evidence for climate risk effects that are also consistent with our model predictions.

While many models of MNE location decision could incorporate climate risks, we construct a

[1] Choi et al. (2020) demonstrate that rising temperatures increase attention to climate change, while Pankratz (2019) estimates that increasing heat exposure of firms reduces their financial performance, but is not yet fully incorporated in analysts' forecasts.

[2] For example, Degryse et al. (2021); Ehlers et al. (2022); Kacperczyk and Peydró (2021); Mueller and Sfrappini (2021); Reghezza et al. (2021) find a change in syndicated loan pricing or quantity to firms exposed to climate risks following COP21.

simple partial equilibrium theoretical framework that includes both physical and policy shocks, has predictions about FDI flows on both intensive and extensive margins and has predictions on how emission productivity (inverse of emission intensity) affects the response of FDI to climate risks.[3] Our model is very tractable and has predictions that easily map into our empirical analysis. In our two-country model, emissions are modeled as a factor of production, physical risks as expectations of future destructive events, and transition risks as exogenous policies that raise the costs of emissions. The model shows that higher physical and transition risks reduce FDI in the affected country on both intensive and extensive margins. In general, greener technology (higher emission productivity) has a positive direct effect on FDI but can amplify or reduce the impact of climate risks on FDI, depending on the distribution of the emission productivity, a result that we have not yet seen in the literature.[4]

The data on climate-related physical disasters is available for a longer span of time than any information on emission productivity or climate change mitigation policies. For this reason, we begin with the analysis of the effects of physical risks only, allowing for the effect to be different following Paris Climate Accord, COP21, in 2015. We conduct this analysis in eight different specifications with six different aggregation levels. We do not find consistent evidence of a decline in FDI in response to past climate-related disasters, with most effects not statistically significant and not robust across specifications, especially using aggregate data sets.

Turning to the full-scale analysis in which we also include a count of new emission-related policies from the International Energy Agency (IEA) as a proxy for transition risk, we conduct our analysis at four levels of aggregation: target country-year, country pair-year, country-industry-year, and firm-target country-year. In order to reduce the influence of spurious effects, we estimate each model with as many fixed effects as possible to allow the identification of coefficients of interest, which means that identification comes from different dimensions of heterogeneity at different levels of aggregation. For this reason, we estimate separate regressions for the main effects and for the interactions of emission productivity with physical and climate risks, where the main effects are generally absorbed by fixed effects. We find that most effects of physical and transition risks in target economies that are statistically significant are consistent with model predictions, but generally, the effects are not statistically significant.

A number of specific results stand out as relatively more consistent across specifications. In particular, country-industry evidence shows that higher emission productivity leads to higher FDI infows at both intensive and extensive margins. While the model is ambiguous regarding the effects that emission productivity has on FDI response to climate risks, country-industry evidence shows that higher emission productivity leads to higher FDI inflows in general and lower FDI outflows following extreme weather events. Between advanced and emerging countries, advanced

[3] Sanna Randaccio et al. (2017) present a different model with two countries and two firms where they only incorporate transition risks and show that both country and firm heterogeneity matter.

[4] Dijkstra et al. (2011) show in a game-theoretical model that environmental policies can have ambiguous outcomes depending on the relative effect of policies on foreign and domestic firms.

economies are more affected by transition risk; and within advanced economies, industries with higher emission productivity benefit more from transition risk, while within emerging markets, industries with higher emission productivity are hurt more by climate risks. These patterns can be rationalized by our theoretical framework. Finally, although source country climate risk effects are smaller than target country effects overall, we find that new emission policies in source countries tend to increase FDI flows to target countries (and reduce outflows from targets).[5]

Based on these results we conclude that there is little evidence in the data of consistent response of multinationals' location decisions, and therefore FDI, to climate risks.[6] If this is a matter of recognizing climate risks, we would expect firms that are more exposed or more attentive to climate risks to react more than others. Thus, at the firm level, we interact information of firm exposure to climate risk, constructed by Sautner et al. (2021) based on climate risk mentions in executive calls, with measures of physical and transition risks.[7] In a fully saturated model we find no evidence that firms that are more exposed or attentive to climate risks react more to climate-related disasters or the addition of new emission policies prior to COP21. However, after COP21 such firms were more likely to reduce FDI in countries affected by climate disasters.

One concern with our empirical analysis is that FDI flows might affect transition risks as well as reporting thresholds of natural disasters (Cole et al., 2006). If this is the case, a resulting positive correlation between FDI and climate risks may offset any negative causal effects, thus preventing us from finding expected results (Cole et al., 2017). To test for this possibility, we estimate local projection models at the target country-year level of the effects of FDI on both reported natural disasters and policies. We find only very small and not statistically significant, and generally negative, effects of FDI on climate risks in the following five years. Therefore, endogeneity-related attenuation bias is not likely to affect our results. Furthermore, looking at international spillovers of climate risks, the analysis that side-steps the endogeneity problem, we also do not find consistent and significant results across aggregations levels and specifications.

There might be several reasons why we don't find strong consistent effects of climate risks on FDI. Two main possibilities, which may both be present, are that firms do not internalize climate risks and that technological improvements make it hard to detect the effects of climate risks. We do provide some evidence of the first possibility by showing that in recent years firms that are more aware of their climate risks are more likely to have a predicted response to physical climate risks. The second mechanism may also be present, as emission productivity shows improvement over time. However, our analysis does not support the hypothesis that this improvement is due to

[5]Similarly, the adoption of Clean Air Act in the U.S. was shown to increase foreign assets and foreign production of U.S.-based multinational firms (Hanna, 2010).

[6]This negative result is consistent with the literature, for example, earlier analysis by Hoon Oh and Oetzel (2010) did not find a response to climate-related shocks for MNEs located in Europe, where there is more attention to climate change risks. Some studies found reallocation of investment within countries from affected to unaffected regions: for example Friedt and Toner-Rodgers (2022), for the case of India. In terms of transition risk, Di (2007); Lin and Sun (2016) find that, within China, firms are less likely to locate in provinces with more stringent environmental regulations. However, Kathuria (2018) does not find the same effect for India.

[7]This climate risk measure shows a strong upward trend for multinationals in our sample after 2015.

emission-related policies. A firm-level analysis that incorporates affiliate-level emission productivity, currently not available in any systematic way, would be needed to fully analyze the mechanism behind our findings.

This paper contributes to our understanding of the impact of climate risks on FDI, both empirically and theoretically, by providing multi-aggregation-level and firm-level analyses as well as a theoretical framework that incorporates both climate risks and their interactions with emissions. We make three separate contributions. First, our simple model reveals that firms' reactions to climate risks may not be straightforward in an environment where technologies become greener. Second, given little literature on this particular topic, this paper is the first to conduct a comprehensive examination of the impact of both physical and transition climate risks on FDI using a spectrum of datasets including firm-level data. Third, our results point to the importance of industry-level and firm-level studies that include interaction effects with emissions, paving the way for relevant future research.

Our paper fits into the broader literature on the effect of climate change risks on international financial markets and international capital flows. The approach of using weather shocks as a proxy for climate change exposure is not new, as summarized in the survey paper by Dell et al. (2014). Since the survey, the use of weather shocks gained further popularity in the literature due to their exogenous nature, at least in the short and medium run.[8] Substantial literature already exists in this context, but to the best of our knowledge, there is no comprehensive global-scale analysis of the effect of climate change on FDI.

Two recent papers are closely related to our analysis. In the study of FDI patterns, Barua et al. (2020) show that long-run changes in average temperatures lower FDI flows to developing countries, but increase them for developed economies. In contrast with their analysis, we look at weather disasters rather than changes in temperature trends and conduct our analysis at a more disaggregated level. Doytch (2020), using country-level analysis similar to ours but focusing more on dynamics finds that manufacturing FDI is negatively affected immediately after the disaster and positively in the longer run. For service sectors, FDI meteorological disasters have no effect, while climatological and hydrological disasters have long-lasting negative effects.[9] In a study not necessarily related to climate risks, Escaleras and Register (2011) find a reduction in FDI following natural disasters. However, Neise et al. (2022) in a sector-level panel analysis of the effects of natural disasters on FDI across countries find either no effect of disasters on FDI or a delayed positive effect.[10] Our comprehensive empirical analysis across a variety of sample and aggregation levels shows that the effects of climate-related disasters are generally not robust across these dimensions,

[8]As integrated analysis models show, economic activity affects emissions and therefore climate change, which in turn increases the frequency of weather shocks. However, due to the public "bad" nature of these effects, this feedback mechanism is not internalized by economic agents.

[9]We also tend to find more positive effects of meteorological disasters relative to climatological and hydrological ones.

[10]In a related study that provides a potential explanation for this positive effect, Wang et al. (2021) show that FDI inflows help countries recover from natural disasters.

which may explain inconsistent findings in the literature. At the firm level, Nagar and Schoenfeld (2022) study both weather and policies impact on the U.S. firms and Jia et al. (2022) find that floods reduce firm entry into affected U.S. regions, but do not have an international dimension. More generally, our paper contributes to the growing literature studying the effects of climate-related risks on international capital flows.

Less closely related are studies of the effects of climate risk on supply chains, on financial markets, and on firm financing. Of these, the most relevant is Pankratz and Schiller (2021) who show that climate-change risks as measured by extreme heat and floods affect global customer-supplier relationships. Importantly, when climate shocks exceed expectations, a substantial portion of the supplier relationships are terminated. To the extent that supply chain relationships might be within as well as across corporations, the effects on FDI location might or might not be similar. The literature on financial markets' reaction to climate change is also growing rapidly. Mallucci (2020); Klomp (2017) look at the effects of climate risks on the pricing of sovereign debt and the sovereign's access to the global capital market. Cortés and Strahan (2017); Ivanov et al. (2020) document the effect of natural disasters on bank lending, while Roncoroni et al. (2021) analyze the effects of transition risks. A number of recent papers address the pricing of climate risks and their effects on the lending amount in syndicated bank lending, including Degryse et al. (2021); Ehlers et al. (2022); Javadi and Al Masum (2021); Kacperczyk and Peydró (2021); Mueller and Sfrappini (2021); Reghezza et al. (2021). Related to firm financing, Huang et al. (2018) show that firms located in countries characterized by more severe weather are likelier to hold more cash and long-term debt so as to build resilience to climatic threats. Although such financing choices may affect firms' FDI decisions, we do not discuss this channel in this paper.

We begin our analysis with a theoretical framework in section 2, we then describe our data sources and descriptive statistics in section 3, followed by our empirical strategy in section 4. Section 5 discusses empirical results, and section 6 concludes. Given a large number of empirical results, most original regression tables are reported in the Appendix, with additional robustness test results presented as a separate Online Appendix.

2 Theoretical Framework

To discipline our priors about the effects of climate risks on FDI, we introduce a two-country partial-equilibrium model simplified from Helpman et al. (2004). The model features horizontal FDI, constant returns to scale production, overhead costs, and monopolistic competition in the goods market. It also borrows the element of mergers and acquisitions (M&A) in order to calculate FDI inflow values, with the purchasing price being determined by a bargaining problem from Razin et al. (2007).[11] We do not consider international trade or global supply chain decisions. Our

[11] In reality FDI inflows include both M&A and greenfield investment, so does the data that we use for our empirical analysis. Here in the model, however, we consider only M&A so that we can formulate purchasing prices and the number of purchases to calculate total M&A value as an approximation for FDI inflow value.

model predicts how many affiliates a multinational enterprise (MNE) allocates in a target country, how much FDI flows into the target country, and how the above measures vary with physical and transition climate risks, as well as with emission productivity. While the main predictions of our model may be obtained in a variety of settings, a more specific prediction is about how climate risks and emission productivity can interact with other each in affecting FDI.

Firms and Climate Risks

There is one MNE and N firms in each country (source or domestic country, and target or foreign country). Each MNE's affiliate location problems in the two countries are symmetrical. We start by describing the foreign affiliate location decision by the MNE from the source (or domestic) country. Prospective foreign affiliates indexed by n in target country i are endowed with a known idiosyncratic value of output per unit of emission z_{in} (we refer to it as emission productivity, which is the inverse of emission intensity more commonly used in the literature), with the distribution that can be affected by technologies.

We assume that physical disasters do not affect emission productivity distribution, that is natural disasters do not destroy technologies although they may destroy products in which those technologies are embedded. Before the realization of the target country's physical climate shock state (a disaster or no disaster) and its climate policy (e.g., emission standards) are revealed, the MNE must decide whether to purchase a prospective affiliate n in the target country i, let it produce in the future, and set the price for its unique good if producing. The set price will be applied to all goods that the affiliate produces in the future.

Production q_{in} by affiliate n in target country i is linear in emission and is characterized by the technology

$$q_{in} = z_{in} k_{in}$$

The emission productivity z_{in} is known at the time the MNE decides whether to purchase the affiliate n and what output price to charge. The quantity k_{in} is the amount of emission chosen. This can be interpreted as the choice of the amount of an input bundle that has a certain level of emission efficiency.

The MNE takes the pricing schedule and other firms' decisions as given and seeks to maximize each affiliate's expected profit. If the affiliate n is chosen to produce in the target country, it takes on an intra-period zero-interest loan to purchase the inputs and pay the associated emission costs (reflecting emission taxes, carbon trading costs, renewable subsidies, etc.) and repays the loan after production. The loan is measured in terms of emissions k_{in} at an expected unit cost $E(r_i)$ that varies across target countries but not across firms within a country. Both input costs and target country climate policies can affect r_i. We take input costs as being fixed but vary climate policies and thus vary r_i over time. Future climate policies and therefore r_i are unknown before the affiliate allocation, loan-making, and production decisions, which represents climate-related transition risk.

The affiliate also has to pay an overhead cost f_i during the production. This cost can be thought of as the costs of maintaining the affiliate and its production networks in the target country i, as well as an overhead cost of production. Importantly, this cost is subject to disasters due to physical climate-related shocks.[12] When a disaster happens, this cost goes up. This is realistic in the sense that disasters can destroy facilities, raise rents, disrupt utilities and production networks, all of which raise the overhead cost. It is similar to the usual fixed costs in the literature in that it does not vary with inputs, yet it differs in that it is repeated and not fixed in time. MNEs incur the overhead cost only while production happens; hence, it is not a sunk cost. The overhead cost is target-country specific and unknown before the affiliate allocation and production decisions, which represents climate-related physical risk.

The MNE considers potential emission costs and disasters in the target country, whose expected costs and occurrences are reflected in $E(r_i)$ and $E(f_i)$, respectively. Conditional on producing, the MNE chooses the goods price p_{in} and input k_{in} ex ante to maximize the affiliate's expected profits:

$$\max_{k_{in}} \; E(\Pi_{in}) = \beta[p_{in}(k_{in})z_{in}k_{in} - E(r_i)k_{in} - E(f_i)] \geq 0$$

where β is a constant discount factor.[13] With probability $0 < \pi < 1$, $f_{it} = f_{id}$ when there is a disaster during production, and with probability $1 - \pi$, $f_{it} = f_{i0}$ when there is no disaster during production, with $f_{id} > f_{i0} > 0$. Hence, we have $E(f_i) = \pi f_{id} + (1 - \pi)f_{i0}$.

To solve MNE's problem, we assume that all the goods produced by the affiliate are consumed in the target country (i.e., this is a horizontal FDI model).[14] As in Helpman et al. (2004), the target country's consumer preferences across varieties of products have the standard CES form, with an elasticity of substitution $\sigma > 1$. The target country's total demand is denoted as A_i, it is exogenous from the point of view of the individual supplier.

Then we solve for the optimal emission input k^*_{in} and the expected operating profit for the affiliate can be expressed as:[15]

$$E(\Pi_{in}) = \beta\left[\frac{A_i z_{in}^{\sigma-1}(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma(E(r_i))^{\sigma-1}} - E(f_i)\right] \geq 0 \tag{1}$$

[12]Burke et al. (2015) show that output productivity losses from physical climate change effects might be quite large.

[13]Our main predictions do not depend on whether MNE stockholders are risk-averse or risk-neutral, the results are qualitatively similar if a stochastic discount factor is used.

[14]The model can easily be reformulated as a vertical FDI model if the differentiated goods are considered inputs into a domestic single consumption good via a CES aggregator production function. As long as substitution elasticity $\sigma > 1$, the results will be the same. However, one can see that for complementary goods ($0 < \sigma < 1$), such as exist in disaggregated supply chains, some of the results will be reversed.

[15]See the Appendix for more mathematical details.

Hence, there exists an emission productivity threshold

$$\bar{z} = \left[\frac{\sigma E(f_i)(E(r_i))^{\sigma-1}}{A_i(1-\frac{1}{\sigma})^{\sigma-1}} \right]^{\frac{1}{\sigma-1}}$$

such that potential affiliates with $z_{in} \geq \bar{z}$ are acquired by the MNE to operate in the target country, otherwise they are not.

2.1 The Number of Foreign Affiliates

In order to measure the number of MNE's affiliates in the target country, we assume that there is a fixed number of potential affiliates (existing local firms) $N_i = \rho N$ in the target country for the MNE to consider for merger or acquisition (M&A), where $0 < \rho < 1$ is a parameter specifying the proportion of local firms open to M&A. We also assume that the potential affiliates' emission productivity z_{in} follow a Pareto distribution as in Helpman et al. (2004). The cumulative distribution function is $F(z) = 1 - (\frac{b_i}{z})^{v_i}$, where we assume that $v_i > 2$ to ensure the distribution has a finite variance.[16] The shape parameter v_i controls its dispersion: a lower v_i gives a higher dispersion of the emission productivity, and the scale parameter b_i is the lower bound of the emission productivity distribution. Here we also assume that $z > 0$ and $b_i > 0$.

With the above setup, we can write the number of MNE's affiliates M_i in the target country as

$$M_i = \begin{cases} N_i[1 - F(\bar{z})] = N_i \left(\frac{b_i}{\bar{z}}\right)^{v_i} = N_i b_i^{v_i} \left[\frac{A_i(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma E(f_i)(E(r_i))^{\sigma-1}}\right]^{\frac{v_i}{\sigma-1}} & \text{if } \bar{z} \geq b_i \\ N_i & \text{if } \bar{z} < b_i \end{cases} \tag{2}$$

Notice that the result is contingent on the relativity of $\bar{z}$ versus b_i. Climate risks can shift $\bar{z}$ while emission productivity technologies can shift b_i, both can affect the relativity of $\bar{z}$ versus b_i. In the scenario of $\bar{z} \leq b_i$, since all potential affiliates are qualified, the MNE will purchase them all.

Below we elaborate on the more interesting scenario of $\bar{z} > b_i$. The result is similar to that of Ramondo (2014): We should expect more affiliates in the target country when the expected overhead cost is lower (lower $E(f_i)$), the expected emission unit cost is lower (lower $E(r_i)$), productivity lower bound and productivity mean are higher (higher b_i), productivity dispersion is lower (higher v_i), and the target market is larger (higher A_i).

When a disaster happens after the M&As by the MNE since the cost of purchasing the foreign

[16] Boyd (2017) shows that the energy efficiency distributions of U.S. cement manufacturing, auto assembly, and wet corn refining mills resemble Pareto distribution. Bloom et al. (2010) shows that UK manufacturing firms' energy intensity displays a log-normal distribution. Its inverse distribution can provide inference to our emission productivity distribution, which would be heavy-tailed, like Pareto. Our results are robust to using other distributions, such as the Fréchet distribution used in Eaton and Kortum (2002) for productivity. More specifically, our first-order qualitative results will still hold if using Fréchet distribution, and second-order results can also hold given plausible distribution parameter values.

affiliates is a sunk cost, there is no gain for the MNE to continue any production by affiliates that now generate negative profits due to the high overhead cost f_{id}. Hence, some foreign affiliates default on their intra-period loans, and the number of foreign affiliates becomes:[17]

$$M_{id} = N_i b_i^{v_i} \left[\frac{A_i(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma f_{id}(E(r_i))^{\sigma-1}} \right]^{\frac{v_i}{\sigma-1}}$$

where $f_{id} > E(f_i)$ is the actual overhead cost during a disaster. Similarly, if the unit emission cost r_i turns out higher than expected, i.e., $r_i > E(r_i)$, after the M&As by the MNE, some of the affiliates will have negative profits and default on their intra-period loans and the number of foreign affiliates becomes:

$$M_{ir} = N_i b_i^{v_i} \left[\frac{A_i(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma E(f_i) r_i^{\sigma-1}} \right]^{\frac{v_i}{\sigma-1}}$$

where $r_i > E(r_i)$ is the actual unit emission cost.

With the above model setup, we use changes to $E(f_i)$ to reflect physical risk; as for transition risk, we refer to changes in $E(r_i)$, i.e., changes in expected climate policies. Such climate policies, in reality, include emission taxes, carbon trading schemes, renewable/R&D subsidies, and emission limits. We then interact the physical risk and transition risk with emission productivity changes.[18] We derive the following propositions to guide the interpretation of our empirical results (proofs can be found in the Appendix).

Proposition 1. Physical risk *When a target country's physical climate risk increases such that the affiliate's expected overhead cost $E(f_i)$ increases, or when a disaster is realized, the number of affiliates in the target country declines. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher physical risk has no impact on the number of MNE's affiliates.*

Proposition 2. Transition risk *When expected climate policies increase expected emission unit cost $E(r_i)$, or when a higher emission cost $r_i > E(r_i)$ realizes, the number of MNE's affiliates in the target country decreases and the effect of physical risk from Proposition 1 is smaller. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher transition risk has no impact on the number of MNE's affiliates.*

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[17] This implies that the intra-period loans are repaid by foreign affiliates after production, and are not committed by the MNE. Alternatively, we could have the MNE commit to the repayment, and thus the loan becomes a sunk cost to the MNE and the threshold for affiliate exits becomes $\bar{z}_d = [\frac{f_{id}(E(r_i))^{\sigma-1}}{A_i(1-\frac{1}{\sigma})^{\sigma-1}}]^{\frac{1}{\sigma-1}}$ (i.e., affiliates exit if $p_{in}q_{in} \leq f_{id}$). As long as $f_{id} > \sigma E(f_i)$, Propositions 1-6, and our overall model predictions still hold.

[18] Here we assume emission productivity is independent of climate risks. While climate policies and disasters may in principle affect technology innovation and thus the emission productivity, we show empirically that average emission productivity increases only minimally following an introduction of a climate policy.

Notice that in Propositions 1 and 2, climate risks have a non-zero impact on FDI only when the lower bound of the target country's emission productivity distribution is not always higher than the emission-productivity threshold. That is, $\bar{z}$ is already higher than b_i before climate risk increases, or $\bar{z}$ becomes higher than b_i after climate risk increases.

For the last result on the interaction between transition risk and physical risk in Proposition 2, the intuition is that a higher (expected) emission unit cost $E(r_i)$ can make MNE more selective about its affiliates, thus have a smaller mass of productivity-wise qualified affiliates for acquisition to start with prior to an increase of physical risk (i.e., fewer affiliates to the right of $\bar{z}$ in the distribution). And then, when physical risk increases through $E(f_i)$ or a disaster strikes, fewer of these previously-qualified affiliates will exit as $\bar{z}$ moves to the right along the Pareto distribution of productivity.

Proposition 3a. Emission Productivity *When technology becomes greener, which means the emission productivity distribution's lower bound b_i increases shifting the distribution to the right, the number of MNE's affiliates in the target country increases. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher emission productivity has no impact on the number of MNE's affiliates.*

Proposition 3b. Emission Productivity *When $\bar{z} \geq b_i \ \forall i$, higher emission productivity amplifies the effect of climate risks from Propositions 1 and 2 (hereafter we call this case Greener Loses); otherwise, higher emission productivity can have an ambiguous effect on the FDI impact of climate risks.*

The intuition for Proposition 3a is that when more emission-productive technologies raise the entire distribution's mean, and as the productivity distribution shifts right, a larger mass of affiliates will qualify to be acquired by the MNE to start with prior to an increase of climate risk if $\bar{z} \geq b_i$ always holds. Hence, we also have Proposition 3b that when physical risk increases or a disaster strikes, or when policies raise (expected) emission costs, a larger mass of previously qualified affiliates will be affected negatively and exit as $\bar{z}$ moves to the right along the Pareto distribution of productivity. While we do not take a stand on what cause the emission productivity to change over time, in the data and empirical sections, we show that average emission productivity has increased over time; and it has little to do with climate policies but such emission productivity mean change can alter the impact of climate risks on FDI according to Proposition 3b. As for the ambiguous effect of higher emission productivity mentioned in Proposition 3b when $\bar{z} \geq b_i$ does not always hold, we discuss examples of different effects that can occur in several scenarios in Section 2.3.

Assume that the source country affiliate allocation problem of the same MNE is symmetrical with the above problem. As long as the source country's physical and transition climate risks stay unchanged (or do not increase as much as the foreign country's), an increase in the foreign country's climate risks, as stated in the above propositions, may also alter the *share* of total affiliates in the foreign country in the same direction.

2.2 FDI Value

Our model can also predict how the amount of FDI, the intensive margin of FDI flows, reacts to climate risks. Note that FDI here is in the form of M&A, therefore MNE's total purchase cost of foreign affiliates is the gross FDI inflow to the target country. Let's assume that the foreign MNE has an overhead cost advantage over local firms as in Razin et al. (2007), such that $E(f_i) < E(f)$ where $E(f)$ is the expected overhead costs paid by target country's local entrepreneurs if they were to operate the same affiliate. This can be true in reality because the MNE may be endowed with superior intangible capital, or know-how, coming from its specialization or expertise in the industry.

This cost advantage implies that the foreign MNE can afford to acquire an affiliate in the target country with a price larger than the affiliate's expected profit to its original local owner. Assuming the original owners hold all the bargaining power, each potential affiliate whose $z_{in} > \bar{z}$ is purchased by the MNE at its expected profit to the MNE, which is the maximized $E(\Pi_{in})$ (equation 1).[19] Hence, the amount of FDI flow from the source country MNE to target country is:

$$FDI_i = \int_{\bar{z}}^{\infty} \beta \left[\frac{A_i z_{in}^{\sigma-1}(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma(E(r_i))^{\sigma-1}} - E(f_i) \right] f(z_{in}) dz_{in}$$

where $f(z) = \frac{v_i b_i^{v_i}}{z^{v+1}}$ is the emission productivity density function. Notice that FDI_i is the gross FDI inflow received by the target country as there is only one MNE from the source country investing in the target country. Assuming $\sigma - v_i < 1$, we can simplify the FDI amount to:[20]

$$FDI_i = \beta \frac{b_i^{v_i}(\sigma-1)}{1-(\sigma-v_i)} \frac{1}{E(f_i)^{\frac{1-(\sigma-v_i)}{\sigma-1}}} \left[\frac{A_i(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma(E(r_i))^{\sigma-1}} \right]^{\frac{v_i}{\sigma-1}} \tag{3}$$

To formalize our predictions of FDI inflows to the target country, we derive the following propositions.

Proposition 4. Physical risk *When a target country's physical climate risk increases such that the affiliate's expected overhead cost $E(f_i)$ increases, FDI inflows to the target country decline. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \; \forall i$), then higher physical risk has no impact on FDI.*

Proposition 5. Transition risk *When expected climate policies increase expected emission unit cost $E(r_i)$, FDI inflows to the target country decline, and the effect of physical risk from Proposition 4 is smaller. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold*

[19] Since by assumption only ρ share of target-country local firms are potential affiliates open to M&A, not all target-country local firms with positive profits will be purchased by the foreign MNE.

[20] Russ (2007) sets $v_i = \sigma + 0.1$, our assumption of $\sigma - v_i < 1$ is not unrealistic.

(i.e., $\bar{z} < b_i \ \forall i$), then higher transition risk has no impact on FDI.

Proposition 6a. Emission Productivity *When technology becomes greener, which means the emission productivity distribution's lower bound b_i increases shifting the distribution to the right, FDI inflows to the target country increase. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher emission productivity has no impact on FDI.*

Proposition 6b. Emission Productivity *When $\bar{z} \geq b_i \forall i$, higher emission productivity amplifies the effect of climate risks from Propositions 4 and 5 (Greener Loses); otherwise, higher emission productivity can have an ambiguous effect on the FDI impact of climate risks.*

Suppose that the problem of the other MNE from the foreign country is symmetrical with the above problem of the MNE from the domestic country. As long as the domestic country's physical and transition climate risks stay unchanged (or increase not as much as the foreign country's), an increase in the foreign country's climate risk, as stated in the above propositions, can also alter the *net* FDI inflow to the target country in the same direction.

2.3 Discussion: effects of emission productivity distribution

In a comparative static analysis for the scenario when $\bar{z} > b_i$ always holds, comparing the FDI change in a target country (or a particular industry in the target country) with higher emission productivity (the distribution to the right in Figure 1) with the FDI change in a country (or industry) with lower emission productivity (the distribution to the left in Figure 1), we find that more emission-productive countries or industries will have more exits and FDI reduction due to rising climate risks ($\bar{z}$ moves from the grey/left dash line to the green/right dash line). At first, this result appears surprising, but the intuition is straightforward: The mass of potential affiliates that are qualified for M&A and being purchased by the MNE is larger to start with (prior to an increase in climate risks) in the more emission-productive country or industry, than in the less emission-productive one. When rising climate risks raise $\bar{z}$, the mass of affiliates and FDI being reduced is also larger in the greener country or industry. We call this outcome the case of "Greener Loses," and it is the case covered in the first half of Propositions 3b and 6b.

When we examine the scenario when $\bar{z} > b_i$ does not always holds, the above result changes. We cannot exhaust all the possible cases due to the qualitative nature of the analysis, but we highlight a couple of cases useful for discussion. Suppose that $\bar{z} > b_1$ only for the target country or industry with low emission productivity distribution and $\bar{z} < b_2$ for the country or industry with high emission productivity distribution (Figure 2). In this case, the more emission-productive countries or industries experience fewer exits or less FDI reduction due to their rising climate risks than less emission-productive ones, fully reversing the predictions when $\bar{z} \geq b_i \, \forall i$ as stated in Propositions 3b and 6b that relate to the emission productivity effects on MNEs's response to climate shocks. We call this outcome the case of "Greener Wins."

In a different case, $\bar{z}$ may be so low relative to b_i (this could be due to a low $E(r_i)$ or a high A_i, or highly emission-productive countries or industries), that $\bar{z} < b_i$ for both types of countries or industries (Figure 3). In this case, all ρN local firms that are open to M&A are acquired by the MNE. Here, a target country or industry emission productivity does not matter for the impact of climate risks on its received FDI, until its $\bar{z}$ is eventually raised higher than b_i. We call this outcome the case of "No Effect."

Figure 1: Comparative Statics: Emission Productivity Distribution: Greener Loses

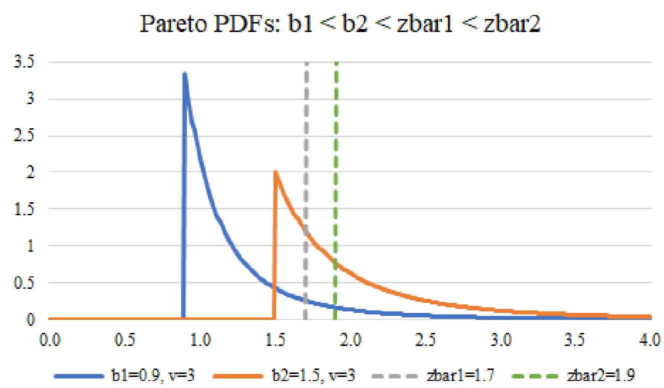


Figure 2: Comparative Statics: Emission Productivity Distribution: Greener Wins

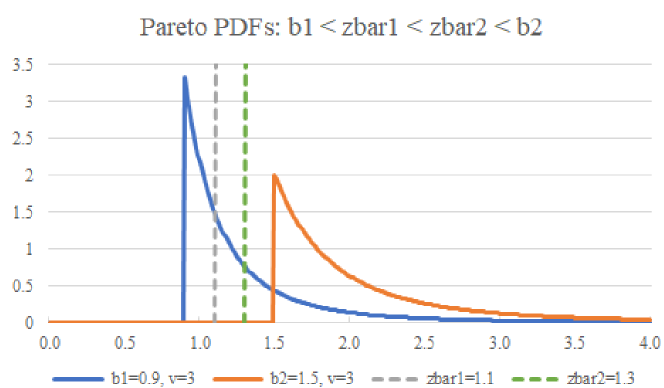
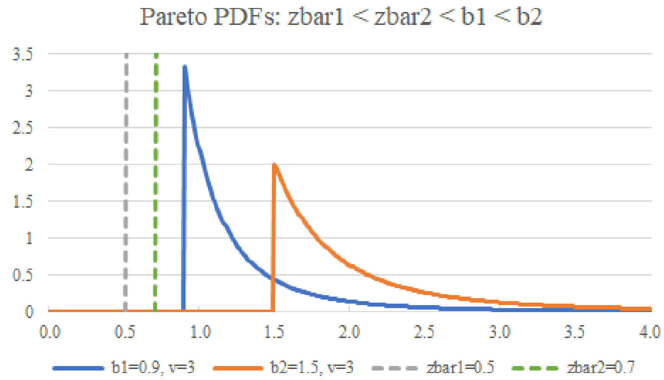


Figure 3: Comparative Statics: Emission Productivity Distribution: No Effect



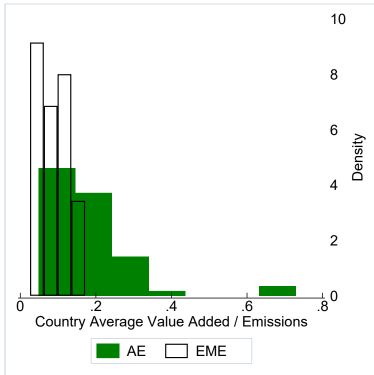
Which case does the data suggest? To answer this question, we need data on emission productivity. Because we do not have access to comprehensive world-wide firm-level emission productivity data, it is difficult to get a detailed picture of the distribution and thus to discuss theoretically what kind of industries and firms belong to the "Greener Wins" or "Greener Loses" case within a country. However, we do have country-industry level emission productivity data, we can attempt to get an idea about which country group (advanced vs emerging economies) belongs to the "Greener Wins" or "Greener Loses" case across countries.

Hence, using our data on emission productivity (see the next section for the details on data sources and calculations), we plot the histogram of country-average emission productivity across industries and years for each country in the group of advanced countries and those in emerging economies (Figure 4). On average, advanced countries have higher emission productivity than emerging economies. Although Figure 4 is not exactly the same as the z's Pareto distribution in the model,[21] it indicates that on average the distribution of "firm" emission productivity for advanced economies is likely to the right of that for emerging economies. Given that the advanced economies b_{AE} is likely to be higher than the emerging economies' b_{EME} and the gap between the two and their distances to zero are small, the chance of $\bar{z}$ falling below b_{AE} would be small. Therefore, between advanced and emerging economies, "Greener Loses" case is most likely (i.e., the first part of Proposition 3b), that is, advanced countries' FDI inflows on average are more likely to be hurt by climate risk than emerging countries' FDI are. Of course, this is not a clear-cut prediction because emission productivity dispersion can also play a role.

[21] This is a distribution of average z across countries, not the distribution of z in a given country or industry across firms, as in the model.

Figure 4: Histogram of Country Average Emission Productivity by Group

Notes: Distribution of average emission productivity across countries in a country group (emerging or advanced economies). Emission productivity for each country-industry-year is computed as a ratio of real value added of the industry in a given country and given year to the emission-relevant total energy use minus energy use from nuclear and renewable resources for that industry, country, and year. Both series are from WIOD 16.



Overall, the model predicts a direct negative impact of rising target country physical and transition risks on the number of foreign affiliates, their share in the total number of affiliates for an MNE, and on the FDI inflows to the target country. Transition risk may reduce the impact of physical risk on FDI. Moreover, higher emission productivity can have a positive effect on FDI directly and can amplify or reduce the impact of climate risk on FDI depending on the relative position of $\bar{z}$ and b_i, with amplification being a more likely scenario.

In our empirical analysis, we proxy for physical risk with data on past hydrological, meteorological, and climatological disasters, and proxy for transition risk with information on emission policies around the world. We examine country-level climate risk and industry-level emission productivity effects on FDI inflows to target countries at country, country-pair, and country-industry levels of aggregation, and then investigate the impact on the number of foreign affiliates at the firm level. In the firm-level analysis, we also include firms' exposure or attention to climate risks. We can consider the effect of firm climate risk exposure similar to the effect of emission intensity (the inverse of emission productivity)—both measure how sensitive firms are to climate risks. We would expect firms that are more exposed or more attentive to climate risks to react more negatively than others.

3 Data and Descriptives

We combine multiple data sources to measure climate-related risks, both physical, by looking at extreme weather events, and transition, by looking at country-level emission policies as well as country-industry level emission productivity. Moreover, we use firm-level climate risk exposure data constructed by Sautner et al. (2020) who scrape executive calls data for the mentions of climate risk. This firm-level measure reflects firm exposure, but also the firm's attention to climate-related risks. We combine these data with information on FDI flows, at the target country, source country-target country pair, and target country-industry levels. We also construct firm-level data set, where for each multinational enterprise we count the number of affiliates in each foreign country. In addition, we conduct various robustness checks with alternative climate risk proxies (e.g., climate vulnerability index, environmental protection policies, CO2 taxes) and macroeconomic control variables. Most of the data sets are described in detail below, while the data sets used for some of the robustness tests are detailed in the Online Appendix.

3.1 Climate data

Ideally, in order to study the impact of climate risk on FDI one needs to directly measure the actual climate risk or perceived future climate risk. However, direct measurement can be challenging to obtain. Here we use data on past climate disasters to approximate the (perceived) future physical risk and past climate-related policy changes to approximate the (perceived) future transition risk. Occurrences of extreme weather events and relevant policy changes can increase perceived climate risks;[22] and the data are more readily available at country, industry, as well as firm levels. However, we acknowledge that these approximations have their limitations, which may weaken our empirical results. We conduct robustness tests to ensure that no individual data source drives our results, using alternative measures of both physical and transition risks.

Extreme weather events

Our first data source is The Emergency Events Database (EM-DAT) housed at the Centre for Research on the Epidemiology of Disasters (CRED), University of Louvain. It provides data on disaster events worldwide from 1900 to the present. To be included in the data, at least one of the following criteria must be fulfilled: 10 or more human deaths; 100 or more people injured or left homeless; declaration by the country of a state of emergency and/or an appeal for international assistance.[23]

This data set provides a monthly count of events by disaster subgroups: geophysical, meteorological, hydrological, climatological, and biological, of which we retain climate-related disaster events: climatological, which includes wildfire and drought; meteorological, which includes extreme temperatures and storms; hydrological, which includes flood. The dataset also includes the monthly number of deaths, the number of people affected, and economic losses in USD. We aggregate these data to country-year level, and for country-years where no disasters are reported, we assume that

[22] Sharma (2023) shows that climate-related disaster events do indeed increase individuals' assessment of climate risks magnitude.

[23] This data set has been used in a related study by Feng and Li (2021) and is also the main source for the World Meteorological Organization Atlas of Mortality and Economic Losses from Weather, Climate, and Weather Extremes (1970-2019).

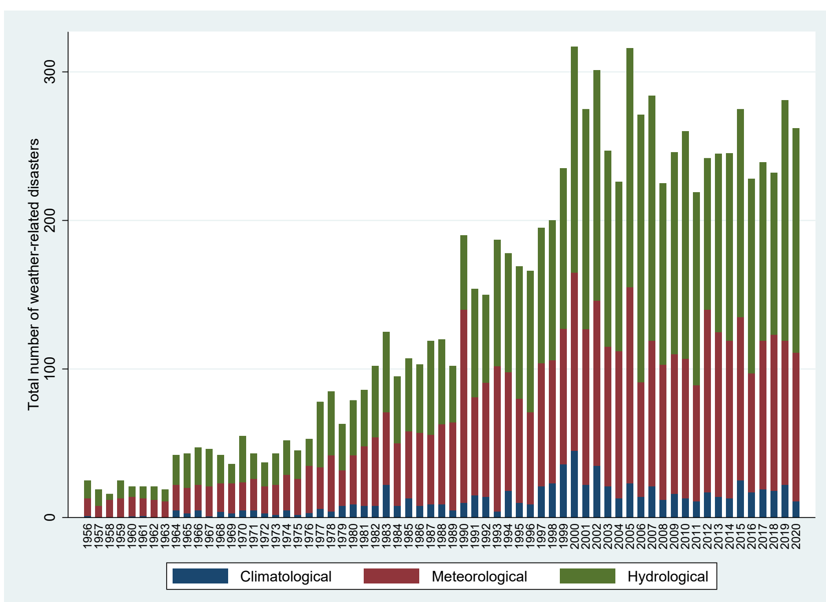
all indicators are zero — no events. To measure disaster severity, we express economic losses from in real USD, by dividing the amount by the U.S. CPI.

Table 1: Summary Statistics of Climate Disaster Event Counts and Severity per Year

		All disasters	Climatological	Meteorological	Hydrological	Deaths (thousands)
AE:	Mean	1.36	0.15	0.81	0.40	0.07
	Stdev	3.34	0.59	2.29	0.98	0.75
EME:	Mean	1.47	0.10	0.49	0.88	0.15
	Stdev	3.23	0.35	1.50	1.98	1.30
LIC:	Mean	1.10	0.07	0.36	0.67	0.83
	Stdev	1.84	0.27	1.06	1.09	11.57
All:	Mean	1.37	0.11	0.56	0.69	0.24
	Stdev	3.08	0.43	1.74	1.60	4.94

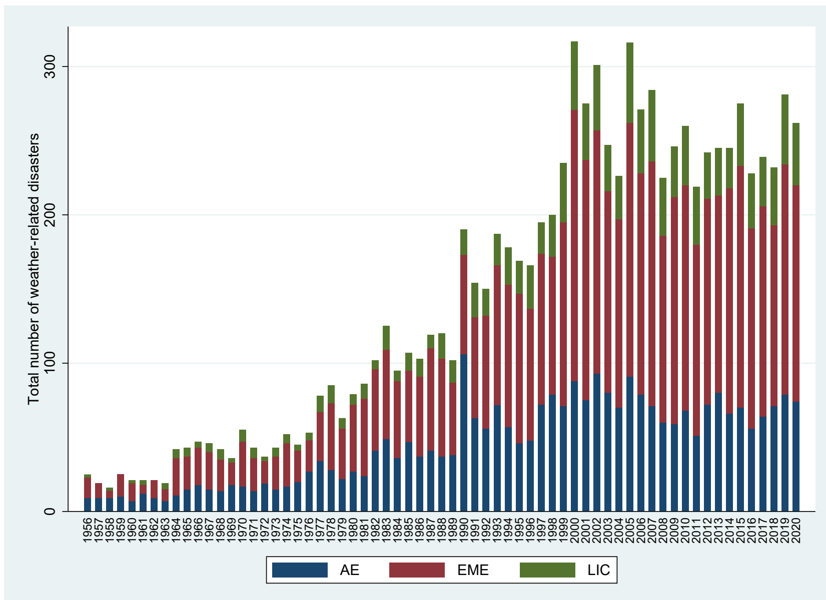
Table 1 provides for different country groups (advanced, emerging, and low-income countries) the summary statistics of the main weather events and severity data that we are using for our empirical analysis. Here, we use the total number of deaths due to those events per year to measure the severity of the disaster events.

Figure 5: Climate-related disaster events by type



Figures 5 and 6 show the total number of events in the world that is reported in our data, by year. Figure 5 breaks down the total into the event types as described above, while Figure 6 breaks it down by advanced, emerging, and low-income economies. We can see a rapid increase in the number of events, for all types of disasters and all groups of countries, until the early 2000s, after which the number stabilized. It is possible that the number of countries covered in the data and the degree of coverage increase over time, leading to an overall increase in the total number of events. For this reason, in our regression analysis, we include year fixed effects that capture any common trends. However, it is worth noting that the share of events by the country group has not changed over time and that the increase in climate-related disasters frequency is substantially larger than for other disasters obtained from the same data source, as shown in Hale (2023). Figure A.1 shows the distribution of the total number of disaster events across countries.

Figure 6: Climate-related disaster events by country group

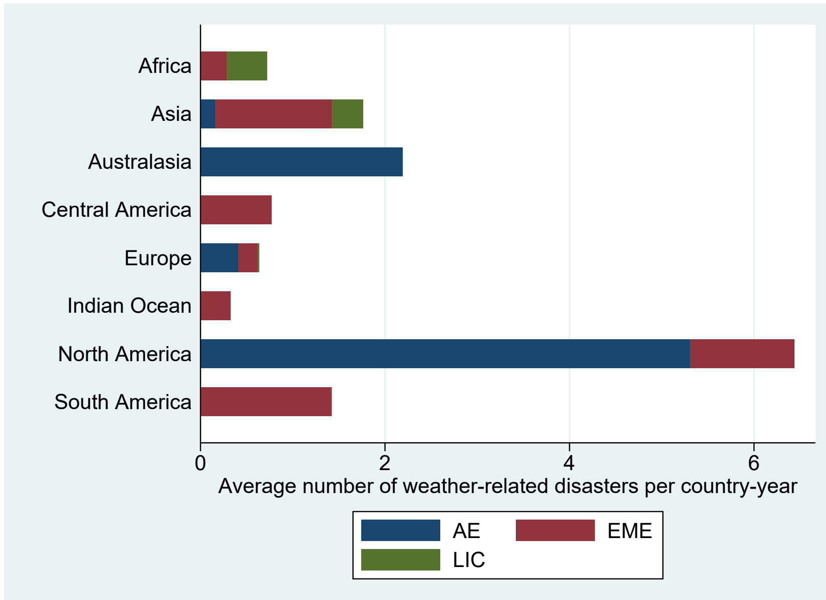


Hsiang (2016) and Lemoine (2021) demonstrate that weather data, when used appropriately, identify the effects of climate change. While these studies are focusing on average weather characteristics, such as temperature, precipitation, and humidity, we believe the occurrence of extreme weather events shows the impact of climate change in a more transparent and catastrophic way and, therefore, is more likely to raise investors' and firms' attention and affect their behavior. We think of it as a proxy for physical risk. We observe that there is a substantial variation in the frequency of climate-related events across regions. Figure 7 shows country-year averages of event occurrence across broad geographical regions, broken down by country group.

Among the different components of the three types of climate-related disasters we consider, we find that the most impactful events are drought, which drives the climatological event result, and flood, which drives the hydrological event result. We do not conduct such detailed breakdown in the bulk of our analysis, but we demonstrate this breakdown in the target country-level regression for the full sample reported in Table 3.

We supplement these data with the Notre Dame-Global Adaptation Index (ND-GAIN) climate vulnerability index. This index, while constructed to reflect climate change exposure, sensitivity, and adaptive capacity, as well as economic, governance, and social components is empirically highly correlated with the incidence of climatological disasters in our data. For this reason, we only include it as a separate proxy for the physical risk and not together with disaster measures.

Figure 7: Frequency of climate-related disaster events by region



Climate policy data

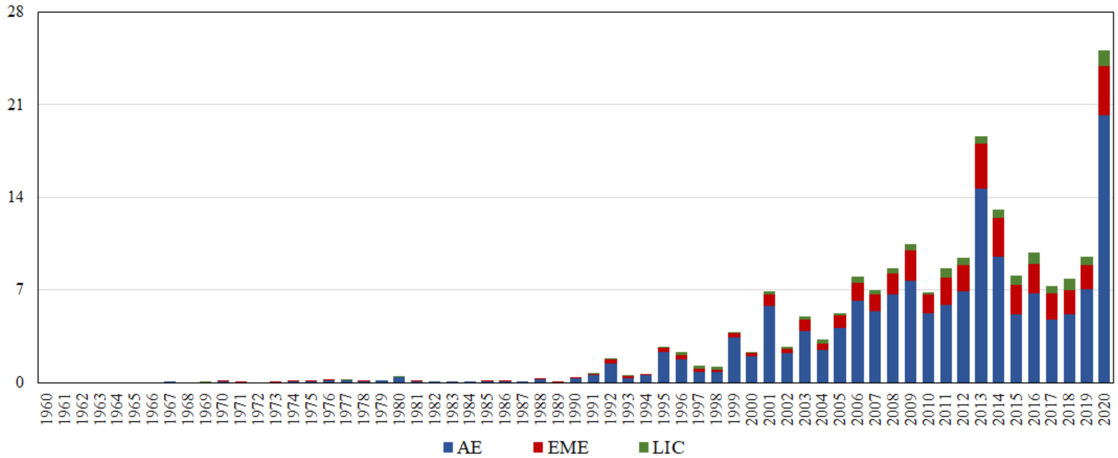
We obtain detailed emission policy data at the country level from International Energy Agency (IEA) for 1960-2020.[24] The IEA's database provides access to information on past, existing, and planned government policies and measures to reduce greenhouse gas emissions, improve energy efficiency and support the development and deployment of clean energy technologies. Types of policies include but are not limited to taxation, grants, regulations, transfers, codes, and education. Although this database is not exhaustive (e.g., limited information on actions taken by provincial or regional governments), the policy information has been periodically collected from national governments, international organizations, and IEA's own analysis.

For our paper's purpose, for each country each year, we calculate the total count of national policies and relevant international policies (e.g., EU-wide policies for EU countries) that are in force or announced, and then compute the annual change to policy counts for each country. Higher values of the IEA policy change variable are interpreted as higher transition risk, as they indicate more aggressive government measures to mitigate climate change effects. Figure 8 shows the distribution of emission policy changes over years across country groups. All country groups have had larger policy increases since the early 2000s. In particular, advanced countries tend to have more aggressive

[24] We also explored the data availability for border carbon adjustment tax, but this policy has not been implemented in most countries.

policy increases, while emerging markets and low-income countries are less aggressive in introducing emission policies.

Figure 8: IEA Policy Changes Over Time



Country-industry emissions data

Some industries may be more sensitive to transition risk than others, as they have different emission levels and climate policies tend to heavily target emissions. We obtain data on emissions by country-industry and year from World Input-Output Database version 2016 (WIOD 16) environmental accounts (2000-2016) from Timmer et al. (2015). These accounts report energy use by fuel type. We construct our emissions measure as emission-relevant total energy use (in Terajoule) minus energy use from nuclear and renewable resources (in Terajoule). For our analysis, we construct a measure of "emission productivity" consistent with our theoretical model by dividing the real country-industry-year value added (PPI adjusted) by the same country-industry-year emissions. We also compute country-year emission productivity by dividing real GDP by the same country-year emission. Specific formulations can be seen below, where i is for country, k is for industry, and t is for year:

$$\text{Country-industry-year emission productivity } z_{ikt} = Real\ VA_{ikt}/Emission_{ikt}$$
$$\text{Country-year emission productivity } z_{it} = RGDP_{it}/\sum_k Emission_{ikt}$$

To examine how the emission productivity varies by country group, Figure 4 plots the overall distribution of productivity across industries, countries, and years for each country group. The emission productivity of advanced countries has a much longer right tail than that of emerging markets, and the former also has a slightly higher level for the distribution's lower bound than the latter. As discussed earlier in the theoretical model section, this has some implications for the model predictions.

Figure A.3 shows the average emission productivity for each industry over time and across countries in a country group. The sectors from top to bottom are ordered by the advanced countries' average emission productivity. As expected, for both country groups many service industries have the highest emission productivity, while many manufacturing industries have the lowest, with the lowest of all being the energy and transportation sectors.

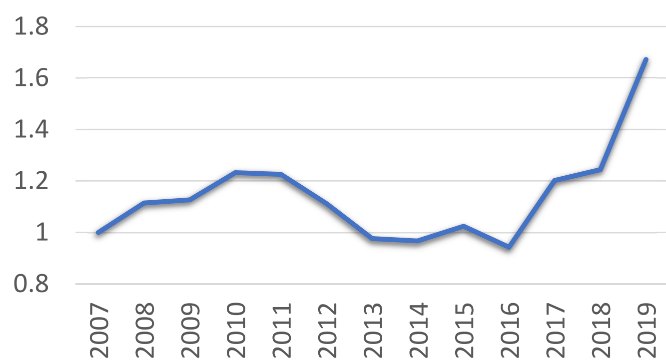
With the exception of the target-country-industry analysis, we use emission productivity aggregated to source country-year or target country-year level. Thus, the most reliable empirical results in terms of emission productivity come from country-industry regressions, since other levels of aggregation are subject to composition effects.

Firm climate risk exposure data

Sautner et al. (2021) report climate change exposure index for publicly traded firms, with ISIN numbers (2002-2019). In our firm-level analysis, we merge this information with the firms in our data set, at the headquarters level. If we replace rational expectations with exogenous attention to climate risks in the model, it will predict that firms with higher attention to climate risk are more reactive to both physical and transition risks in the target countries where their affiliates are located.

Figure 9: Climate Change Risk Index

Notes: Climate change risk index from Sautner et al. (2021) is averaged across all MNEs in the sample for each year.



Sautner et al. (2021) construct measures of positive and negative climate change sentiments as well as a measure of climate change risk (CCR).[25] In our analysis, we convert the CCR into a binary indicator of climate risk being above the median in the full sample of firms and years to remove unnecessary noises in the measure. We intentionally do not construct year-specific medians of this measure, to capture growing attention to climate risks over time. Figure 9 shows that the

[25] Although we do not have firm-level emission productivity, the firm-level climate risk variable also reflects a firm's sensitivity to climate risks, similar to emission productivity.

average measure of climate risk increased over the available sample time, with a notable increase following Paris Climate Accord.

3.2 FDI data

We gather information on FDI from a variety of sources. The longest time series at annual frequency are available from World Bank's World Development Indicators (WDI) at the country level. For the country-industry level data, we turn to the OECD database. Finally, we obtain firm-level data from ORBIS.

Target country level

Country-level data (both FDI and other macro variables) are from WDI and start in 1960 for most of the 96 countries in the sample. The last year for which we observe the data is 2020. According to the World Bank, FDI in our data are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. It shows net inflows (new investment inflows less disinvestment) in the target economy from foreign investors and is divided by GDP. In the appendix, Figure A.2 shows the log of average annual percentage change in net FDI inflow to GDP ratio in 2010-2020 (not including offshore financial centers).

Country-pair level

We obtain country-pair panel data on FDI flows from the IMF's Coordinated Direct Investment Survey (CDIS) data set. CDIS records bilateral FDI flows at the gross-net level (thus flows can be positive or negative, but they are not netted out within a country pair), by residency principle. The data are available for 2010-2019 and cover the most advanced and emerging economies. Because of the bilateral nature of the data, there is a large number of zeros, which leads us to use the Poisson Pseudo Maximum Likelihood (PPML) approach proposed by Silva and Tenreyro (2015), adapted to the panel data.

Country-industry level

Different industries have different exposures to climate change risks. Therefore, we would expect that the sensitivity of FDI inflows to climate risks revealed by weather disasters and climate policies vary by industry. Country-industry data on FDI inflows are obtained from OECD International Direct Investment Statistics Yearbooks for 2005-2019. The industry classification corresponds to

ISIC4 codes, and the aggregation level with the most available public data is generally corresponding to a 2-digit level (49 industries).

Firm (MNE) level

Firm-level data are obtained from ORBIS. We use the data for 2007 through 2019. To properly classify all affiliates of multinationals, we rely on vintage ownership data collected for each year. We restrict our analysis to firms with total assets in excess of 1 billion USD for a given year. This gives us an unbalanced firm-year panel with 5915 firms from 66 countries with affiliates across 206 countries with a total of over a million firm-target country-year observations.

For each firm, we aggregate information on affiliates by affiliate country and year and construct two measures: an intensive margin, which is the number of affiliates in a given country in a given year as a share of the total number of affiliates around the world that the firm has in that year (we use the change of this share in the regressions); and an extensive margin, which is an indicator (1/0) of whether a firm has more (or fewer) affiliate in a given country in a given year.[26] For each firm we retain information on the country of its headquarters and its industry.

Obviously, most observations drop out in the regression analysis due to missing climate variables or due to the inclusion of fixed effects (for example, if only one firm has affiliates in a given country in a given year, this observation will be dropped due to firm-year fixed effects). We also exclude offshore financial centers (OFCs) as target countries but do keep firms with headquarters in OFCs. Our regression analysis, therefore, includes up to 369,864 observations, with 4040 MNEs located in 58 countries (13 OFCs) and affiliates in 95 countries in disaster-only regressions and 140,133 observations, with 2220 MNEs located in 33 countries (4 OFCs) and affiliates in 37 countries (12 EMEs, 25 AEs) in main regressions.

3.3 Summary Statistics and Basic Correlation

Table 2 presents the descriptive statistics of all the key variables. And before we turn to the formal econometric analysis, it is instructive to show some basic correlation between FDI inflows and climate-related disasters. Figure 10 presents this correlation at the country level and reveals a weak negative correlation between FDI and climate disasters, which we will examine more closely using econometric analysis in the later sections.

It is worth noting that, for the key variables, the sample shares of different country groups have not changed much over time. In particular, the share of non-missing observations for advanced, emerging, and low-income countries, respectively, has not changed from prior to 1990 to the post-1990 period, and this is true for the variables of extreme weather event, FDI to GDP ratio, and IEA (and its changes). However, as shown above, the reported disasters, FDI to GDP ratio, and IEA (and its changes) all have been rising over time for all country groups. These trends are controlled by the year fixed effects in the following empirical analysis.

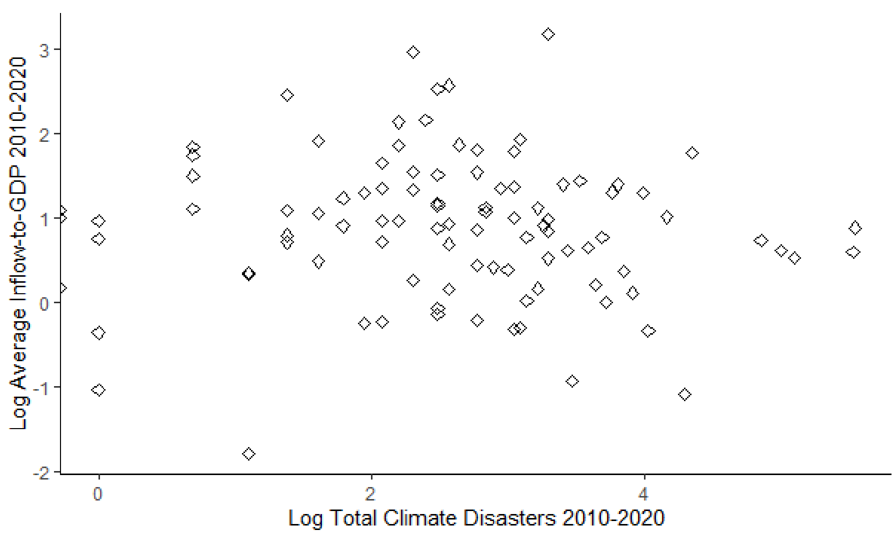
[26]Total assets are not reported for all affiliates, thus, we decided to rely on the count of affiliates for data completeness.

Table 2: Summary Statistics: Annual Country-level Data

Variable	Obs	Mean	Std. dev.	Min	Max
FDI Inflow/GDP (%)	4,519	3.26	9.76	-58.32	280.13
FDI Inflow/VA (ind-level)	5,538	0.17	1.97	-58.21	65.13
Climatological	6,649	0.11	0.43	0.00	9.00
Meteorological	6,649	0.56	1.74	0.00	27.00
Hydrological	6,649	0.69	1.60	0.00	26.00
Deaths (thousands)	6,649	0.24	4.94	0.00	300.32
Policies (IEA)	6,134	12.09	32.00	0.00	359.00
Policy changes (D.IEA)	6,032	1.19	3.28	0.00	44.00
Emission Productivity	697	0.15	0.12	0.01	0.93
Vulnerability	2,585	0.41	0.08	0.25	0.62
Firm climate risk	581,293	0.19	0.39	0.00	1.00
Trade/GDP (%)	4,989	72.33	47.30	0.17	442.62
PPI Inflation (%)	5,182	31.7	333	-98.7	15,444
Real GDP Growth (%)	5,204	3.84	5.70	-56.31	88.96

Figure 10: Country-Level Disasters and FDI Inflow/GDP Ratios

Notes: Horizontal axis plots the log of the total number of climate-related disasters for each country in a sample over the 2010-2020 time period with all three types of disasters we consider included in the count. The vertical axis plots average FDI inflows to GDP ratio for each country over the same time period.



4 Empirical Specifications

We conduct our empirical analysis at different levels of aggregation, which allow us to include different sets of controls and fixed effects. In particular, the climate risk effects may vary across industries and firms, while country-level analysis would miss such disaggregated effects. We also analyze both intensive and extensive margins, with most regressions estimated by OLS (linear probability model in the case of the extensive margins). For cases with many zeros, we also use Poisson Pseudo Maximum Likelihood (PPML) approach proposed by Silva and Tenreyro (2015), adapted to the panel data. We keep as many specification features as possible the same across all aggregation levels, but we also include as many fixed effects as reasonable at each aggregation level. As a result, the source of identification varies across aggregation levels. In addition, due to data constraints, different aggregation levels have different country and time coverage.

Because we observe FDI flows at the annual frequency, we lag all climate variables by one year. This is mainly because natural disasters, policy changes, etc. may occur late in the year and because FDI decisions likely incur substantial lags. For the climate policies, we include IEA policy counts for each country over time. We also consider previous years' climate policy counts a good indicator for later years' climate policy counts, i.e., a good indicator for transition risk. The autocorrelation of annual climate policy increases (i.e., the change of IEA policy count) is 70%. Moreover, we include macroeconomic control variables — trade/GDP, PPI inflation, and real GDP growth — also lagged by one year for the same reason and to avoid any reverse causality.[27] In all cases, we include as many fixed effects as possible given the aggregation level of explanatory variables.[28] We cluster standard errors as appropriate in all regressions.

We conduct our analysis for the full panel as well as for the subsets of countries. In a recent study, Cevik and ao Tovar Jalles (2020) demonstrate that the impact of climate risks on sovereign credit ratings is larger for developing countries than for advanced economies. They conjecture that this is due to lower-income countries having less fiscal space for technological greening and abatement measures. We believe these differences can play an important role in the sensitivity of foreign investors to climate risks of FDI target countries, which is consistent with findings by Barua et al. (2020). Through pre-testing, we find that it is useful to define three sets of countries: advanced, emerging, and low-income, which we classify according to the IMF definition. We do not separately report the effects for low-income countries (LICs) in the bulk of our analysis because in most data sets these countries are missing. However, we can see from the basic regression specification in Table 3 that the effects of climate disasters on LICs are different from the effects on other countries, though without statistical significance.

Controls, reported in the full regressions in the Appendix, generally have expected effects and vary in terms of their statistical significance, which is not surprising given that different specifications include different sets of fixed effects.

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[27]We have also considered other macroeconomic controls, such as corporate tax, credit ratings, real exchange rate changes, and GDP per capita. The first three variables greatly reduce the sample size and the last one is highly correlated with the existing macroeconomic variables. We put some results of using these additional controls in the Appendix: Robustness tables.

[28]We acknowledge that including many fixed effects could attenuate the estimated climate-risk impact. Hence, our findings are the lower bounds of the impact. However, the contrasting negative and positive signs of the impact cannot be attributed to the inclusion of many fixed effects.

Table 3: Country-level regressions: Extreme weather disasters

Notes: Dependent variable is net FDI inflows as a share of GDP in year t. "Any disaster" only includes climate-related disasters. *Hydro*, *Meteo*, and *Climat* are numbers of hydrological, meteorological, and climatological disasters from EM Data. *Severity* is disaster severity measured as the number of total deaths (in 1000s) from the disasters. The sample has total 97 countries, 28 advanced economies, 52 emerging economies, and 17 low-income countries, for 1970-2019. All RHS variables are lagged by one year. All regressions include country, year, and country-group (AE/EME/LIC) fixed effects are estimated by OLS. Clustered (at region) standard errors are in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	(1) Full sample	(2) AEs	(3) EMEs	(4) LICs	(5) Full sample	(6) Full sample
Any disaster	-0.0558**	-0.101*	-0.0397	0.00468		
	(0.0155)	(0.0426)	(0.0276)	(0.0270)		
Climat					-0.203**	
					(0.0579)	
Meteo					0.0111	
					(0.0214)	
Hydro					-0.0920**	
					(0.0315)	
Drought						-0.400**
						(0.121)
Fire						-0.0943
						(0.125)
Temp						0.262
						(0.301)
Storm						-0.0171
						(0.0438)
Flood						-0.0967**
						(0.0367)
Severity	0.00133	-0.0264	0.0319	-0.00109	0.00186	0.00121
	(0.00311)	(0.0424)	(0.0202)	(0.00397)	(0.00280)	(0.00238)
Trade/GDP	0.0330**	0.0375*	0.0273**	0.0394	0.0328***	0.0328***
	(0.00830)	(0.0123)	(0.00628)	(0.0219)	(0.00815)	(0.00786)
PPI Inflation	-0.000271	0.106***	-0.000238	-0.00283	-0.000268	-0.000266
	(0.000136)	(0.0152)	(0.000136)	(0.00160)	(0.000135)	(0.000140)
Real GDP Growth	0.0537**	0.0378	0.0611***	0.0207	0.0530**	0.0530**
	(0.0139)	(0.0697)	(0.00922)	(0.0169)	(0.0140)	(0.0139)
N	3774	1142	2031	601	3774	3774
R^2	0.361	0.308	0.365	0.551	0.361	0.362

4.1 Target country-level regressions

All country-level regressions include year t, country i, and country-group (advanced, emerging, or low-income economies) times time fixed effects and standard errors are clustered at regional level (Africa, Asia, Australasia, Europe, North America, and South America). As a result, fixed effects absorb all common trends and fluctuations, time-invariant country characteristics, as well as any country-group-specific trends and fluctuations. Thus, identification in these regressions is coming from changes that occur within a given country relative to its country-group average over time. To control for country-time confounding factors, we include a number of macroeconomic control variables.

The intensive margin $FDIY$ is measured by the net FDI flow as a share of GDP. Because at that aggregation level we do not have many zeros, we do not measure extensive margin. The intensive margin regression equation for target country-level analysis is as follows:

$$FDIY_{igt} = \alpha_i + \alpha_t + \alpha_{gt} + \underset{(-)}{CD'_{it-1}\boldsymbol{\beta}_1} + \underset{(-)}{\beta_2 D.IEA_{it-1}} + \underset{(+)}{\beta_3 z_{it-1}} + M'_{it-1}\boldsymbol{\gamma} + \varepsilon_{it},$$

where α_i, α_t, and α_{gt} are target country, year, and country-group times year fixed effects, CD is a matrix of the variables for climate disasters: climatological, meteorological, and hydrological, and their severity, with the corresponding vector of coefficients $\boldsymbol{\beta}_1$, $D.IEA$ is the change of IEA emission policy counts, z is emission productivity, and M is a matrix of macroeconomic control variables mentioned above. Standard errors ε are robust and clustered at the region level. According to the theoretical model, we expect $\boldsymbol{\beta}_1$ and β_2 to be negative and β_3 to be positive.

In addition, we estimate a similar specification for regressions where all disaster and policy variables are interacted with target-country emission productivity. The interaction coefficients are expected to bear either (+) or (-) signs, according to the theory.

Because emission productivity and climate policies data are limiting the sample size, we also estimate this regression with only climate disasters and controls on the right-hand side, including interactions with post-COP21 (post-2015) indicator $Post$. Alternatively, we replace all the climate disaster variables with the ND-GAIN climate vulnerability index V. In addition, we also conduct target country-level analysis in the cross-section, by computing country average FDI flow across years, separately before and after 2015 $\overline{FDI_{igT}}$, where T takes on two values - before COP21 and after. For this analysis level, we compute sums of the number of disaster events and average values of macroeconomic controls $\overline{M_{iT}}$, also before and after 2015. All three specifications are estimated with standard errors ε clustered at the region level, and their specifications are listed below:

$$\begin{aligned}
FDIY_{igt} &= \alpha_i + \alpha_t + \alpha_{gt} + CD'_{it-1}\boldsymbol{\beta}_1 + Post * CD'_{it-1}\boldsymbol{\beta}_2 + M'_{it-1}\boldsymbol{\gamma} + \varepsilon_{it}, \\
FDIY_{igt} &= \alpha_i + \alpha_t + \alpha_{gt} + \beta_1 V_{it-1} + \beta_2 Post * V_{it-1} + M'_{it-1}\boldsymbol{\gamma} + \varepsilon_{it}, \\
\overline{FDIY_{igT}} &= \alpha_g + \underset{(-/0)}{(\sum_{t<=2015} CD'_{it})\boldsymbol{\beta}_1} + \underset{(-)}{(\sum_{t>2015} CD'_{it})\boldsymbol{\beta}_2} + \beta_3 Post + \overline{M_{iT}}'\boldsymbol{\gamma} + \varepsilon_{iT}.
\end{aligned}$$

For the above three regressions, we expect $\boldsymbol{\beta}_1$ (or β_1) to be negative (or zero) if the climate risk effect was (not) present prior to 2015, and $\boldsymbol{\beta}_2$ (or β_2) to be negative if the effect has increased post-COP21.

4.2 Bilateral level regressions

Bilateral regressions are also estimated as a panel, in the main specification, as well as cross-section averages, for disaster-only analysis. For the intensive margin and similar to the firm-level analysis, FDI are measured as a change in the FDI position going to target country i from source country j scaled by total FDI position from country j in the previous year, or put it in another way, the change of target country i's FDI share among all FDI from source country j.

$$\Delta fdi_{ijt} = \frac{FDI_{ijt} - FDI_{ijt-1}}{\sum_i FDI_{ijt-1}}.$$

For the extensive margins, we use an indicator $\mathrm{I}(\Delta fdi_{ijt} > 0)$ as a 0/1 measure of inflows and $\mathrm{I}(\Delta fdi_{ijt} < 0)$ as a 0/1 measure of outflows. We estimate intensive margin by OLS and PPML and we estimate extensive margin by linear probability model.[29]

In the bilateral panel specification, we include country-pair and year fixed effects when estimated by OLS and PPML. Note that country-pair fixed effects absorb all standard gravity variables. Because country-pair fixed effects also span both source and target country sets of fixed effects, they also absorb any time-invariant country-specific factors. Year fixed effects absorb any common trends. Thus, identification in these regressions comes from within-pair variation, but could also be affected by country-specific trends and fluctuations. In the main specification, we do not include source- and target-country-year fixed effects because they would absorb the effects of variables of interest. Instead, we include macroeconomic control variables for both source and target countries. When possible, we do include such fixed effects as described below. Standard errors are clustered on country-pair (OLS) and target country's region (PPML), respectively.

We denote the source country as j and the target country as i (that is, FDI flows are measured $j \longrightarrow i$. We include all variables of interest as well as macro controls for both source and target countries. For both OLS and PPML specifications we thus have the following:

$$\begin{aligned}\Delta fdi_{ijt} = {} & \alpha_{ij} + \alpha_t + \underset{}{\overset{(-)}{CD'_{it-1}\boldsymbol{\beta}_{i1}}} + CD'_{jt-1}\boldsymbol{\beta}_{j1} + \overset{(-)}{\beta_{i2}}D.IEA_{it-1} + \beta_{j2}D.IEA_{jt-1} \\ & + \underset{(+)}{\beta_{i3}}z_{it-1} + \beta_{j3}z_{jt-1} + M'_{it-1}\boldsymbol{\gamma_i} + M'_{jt-1}\boldsymbol{\gamma_j} + \varepsilon_{ijt}.\end{aligned}$$

We expect that the target country coefficients $\boldsymbol{\beta}_{i1}$ and β_{i2} to be negative and β_{i3} to be positive, according to the theory. The theory, however, does not speak on spillovers, i.e., the source country coefficients; but the theory does have implications for "relative" climate risks between countries, which we will discuss in the later firm-level empirical section and the Appendix's robustness section.

Specification for extensive margins is the same with the indicators $\mathrm{I}(\Delta fdi_{ijt} > 0)$ and $\mathrm{I}(\Delta fdi_{ijt} >$

[29]Probit regressions are not identified for models with a large number of fixed effects, while logit regressions do not always converge.

0) replacing Δfdi_{ijt}. In addition, we estimate a similar set of regressions for the intensive and extensive specifications with interactions with the emission productivity of a target country. For these interaction specifications, we include country-pair and source-year fixed effects in OLS to focus more on the target country effects; and include country-pair and only year fixed effects but add source climate and macroeconomic controls in PPML regressions.

For disaster-only regressions, we repeat the approach described earlier for the country level, now including disaster and vulnerability measures for both source and target countries. Again we use both OLS and PPML estimators, with different sets of fixed effects as in the above interaction specifications.

Finally, we construct bilateral cross-country panels for the periods before and after 2015, in a similar way to the target country panel. In all regressions, we include country-pair fixed effects and cluster standard errors on the target country's region.

4.3 Country-industry level regressions

We next turn to regression analysis of FDI at the industry level. It is worth noting that climate risks faced by different industries can vary, hence the industry-level analysis is especially important. In particular, in our industry analysis specifications, we interact country-level climate risks with country-industry-level emission productivity to control for various industries' sensitivity to climate risks. Now we describe our entire country-industry analysis setup.

Country-industry level data are only available for target countries i. The measure of FDI we use for intensive margin is similar to the target-country panel regressions, except we scale country-industry FDI by country-industry value added. As before, we construct 0/1 indicators of inflows and outflows for extensive margins as FDI inflows being positive or negative, respectively. All regressions are estimated by OLS with country-industry and industry-year fixed effects. Standard errors are clustered at the country-industry level.

In the main specification, we include country-industry and industry-time fixed effects which absorb any variation that comes from composition effects that do not vary over time and from any industry-specific global trends and fluctuations. We do not include country-time fixed effects in the main specification because they would absorb the effects of variables of interest. As before, we include macroeconomic control variables. Thus, the identification comes from both, country-time variation and country-industry-time variation in FDI. In the regression with interactions with emission productivity, we include also country-time fixed effects for a fully saturated model and focus on the interaction effects only. These are identified entirely from country-industry-time variation and no longer reflect country-time differences as previously described main-effect regressions.

Disaster, policy, and macro variables are only available at the country-year level, while emission productivity varies by country, industry, and year. Thus, the regression equation becomes

$$FDIVA_{ikt} = \alpha_{ik} + \alpha_{kt} + \underset{(-)}{CD'_{it-1}\boldsymbol{\beta}_1} + \underset{(-)}{\beta_2} D.IEA_{it-1} + \underset{(+)}{\beta_3} z_{ikt-1} + M'_{it-1}\boldsymbol{\gamma} + \varepsilon_{ikt},$$

where k is the industry indicator. Again, according to the theoretical model, we expect $\boldsymbol{\beta}_1$ and β_2 to be negative and β_3 to be positive.

For disaster-only analysis, we do not include the interaction with $Post$ because the data from WIOD are only available through 2016.

Most importantly, for the regressions with interactions with emission productivity, we are able to estimate a fully saturated model with country-industry, country-year, and industry-year fixed effects. The main effects of all country-year-level climate variables are absorbed by country-year fixed effects. The only variables that vary at country-industry-year level are emission productivity and its interactions with disaster and policy measures:

$$FDIVA_{ikt} = \alpha_{ik} + \alpha_{kt} + \alpha_{it} + (z_{ikt-1}CD_{it-1})'\underset{(-/+)}{\boldsymbol{\beta}_1} + \underset{(-/+)}{\beta_2} z_{ikt-1}D.IEA_{it-1} + \underset{(+)}{\beta_3} z_{ikt-1} + \varepsilon_{ikt}.$$

We expect the interaction coefficients $\boldsymbol{\beta}_1$ and β_2 to bear either positive or negative signs as discussed in the model discussion section, and β_3 to have a positive sign.

4.4 Firm-level regressions

Finally, we turn to the firm-level analysis, which allows us to control for the climate risks of both the source country and the target country as well as for characteristics of individual MNEs. In this analysis, the dependent variable is either a change in the share of the total number of a given MNE's affiliates located in a given target country i in a given year (conditional on affiliates being present in both prior and current year), for the intensive margin; a 0/1 indicator of whether a given MNE has new affiliates in a given target country in a given year (whereas there were no affiliates in this country in the previous), for the extensive margin of inflows; or a 0/1 indicator of whether a given MNE closed all its affiliates in a given target country between previous and current year, for the extensive margin of outflows.

In these regressions, when we want to study the effects of disasters and policies at both source and target country levels, we only include firm (MNE), target country, year, and affiliate industry fixed effects. Thus, identification comes from the MNE-time dimension as well as from the target-country-time dimension. Emission productivity in these regressions is measured at a source-country and target-country level.[30] We include a firm-level measure of climate change risk CCR_{ft}, which

[30]Because industry classification in ORBIS data is substantially different from WIOD classification, there is no clear way to match industry-level emissions data to firm data. More importantly, multinationals' operations frequently

varies by firm and year. Standard errors are clustered two-way, at firm and target country levels.

The regression for the main effects of disaster and policy variables is as follows:

$$\Delta Naff_{fjikt} = \alpha_f + \alpha_i + \alpha_k + \alpha_t + CD'_{it-1}\underset{(-)}{\boldsymbol{\beta}_{i1}} + CD'_{jt-1}\underset{(-)}{\boldsymbol{\beta}_{j1}} + \beta_{i2}D.IEA_{it-1}$$
$$+ \beta_{j2}D.IEA_{jt-1} + \underset{(+)}{\beta_{i3}} z_{it-1} + \beta_{j3}z_{jt-1} + \underset{(-)}{\beta_4}CCR_{ft-1} + M'_{it-1}\boldsymbol{\gamma_i} + \varepsilon_{fit},$$

where $Naff_{fjitk}$ is the number of affiliates MNE f headquartered in country j has in target country i industry k in year t. As before, we use the same specification for the regression with interactions with emission productivity of the target country, except we include firm-year fixed effects α_{ft} which absorb all main effects of source-country variables as well as the main effects of the firm-level climate risk exposure. We expect the disaster variable coefficients $\boldsymbol{\beta}_1$ and β_2 to be negative, and β_3 to be positive, according to our theory. Moreover, although the theoretical model does not have a specific prediction for CCR, CCR reflects a firm's sensitivity to climate risks, we can consider it affecting the expectation about the overhead cost $E(f_i)$ in the model and thus has a negative impact on FDI. Hence, we expect β_4 to be negative; that is, when a firm has larger climate risks, it reduces FDI.

In disaster-only regressions and in regressions with emission productivity interactions, because we are not looking at source country effects, we replace firm and year fixed effects with firm times year fixed effects α_{ft}. In these regressions identification only comes from target country-time variation, where we continue to control for macroeconomic variables.

To further study whether firm-level climate risk exposure CCR leads to differential effects of climate disasters and policies, we also estimate the following interaction regression that includes firm-target country, firm-year, target country-year, and target industry fixed effects. In these regressions, therefore, identification only comes from MNE-target country-year variation and is not affected by any trends and fluctuations at the firm or target-country level. Hence, all main effects are absorbed by fixed effects, with only interactions estimated off the firm-target country-time variance. Since we focus on target-country effects, only interactions with target-country disaster variables are included.

$$\Delta Naff_{fjikt} = \alpha_{fi} + \alpha_{ft} + \alpha_{it} + \alpha_k + (CCR_{ft-1} * CD_{it-1})'\underset{(-)}{\boldsymbol{\beta}_1} + \underset{(-)}{\beta_2}CCR_{ft-1}D.IEA_{it-1} + \varepsilon_{ijt}.$$

Since CCR reflects a firm's sensitivity to climate risks, we expect the impact of climate risks to increase with a higher sensitivity CCR. Hence, we expect $\boldsymbol{\beta}_1$ and β_2 to be negative.

Similar regressions are estimated for the extensive margins of inflows and outflows, as well as

span multiple industries making any classification quite noisy.

for the more recent effect with an interaction of the post-Paris Accord indicator. In addition to advanced and emerging economies subsamples, we also estimate all regressions for the subsample of MNEs with headquarters located in offshore financial centers (OFCs).

5 Results

In general, while most of the robust empirical results are consistent with model predictions, only a few effects are statistically significant and are mostly small in terms of magnitude. However, the results do vary across the types of data we use. At the country or bilateral level, we find little consistent and significant evidence for the impact of climate risks on FDI. However, at country-industry and firm levels, there is some evidence that is consistent with model predictions. To reach such conclusions and verify the null hypothesis, we have run a large number of specifications to exhaust the possibilities of finding any impact. While in general, the results do not paint a very clear picture, there are some patterns that consistently arise from the analysis. We summarize these patterns in the context of our theoretical framework as follows:

- At aggregate levels, we do not find a significant increase in response to climate risks, even following Paris Climate Accord. — *This result is unexpected from a theoretical perspective but understandable in that aggregation can reduce the signal-to-noise ratio in the data.*

- Firm-level evidence suggests firms with high climate risk exposure are more likely to reduce FDI in response to the target country's physical climate risks following Paris Climate Accord. — *This result is as expected (Propositions 1 and 4).*

- Country-industry evidence, the most reliable in terms of emission productivity, shows that higher emission productivity leads to higher FDI inflows at both intensive (not statistically significant) and extensive (statistically significant) margins. — *This result is as expected (Propositions 3a and 6a).*

- Country-industry main-effect results show that, between advanced and emerging countries, advanced economies are more negatively affected by transition risk. — *Between country groups, the main-effect result is consistent with the case of "Greener Loses" where the "Greener" refers to advanced countries with higher emission productivity (Propositions 3b and 6b).*

- Both Country-industry and Firm evidence show that countries and industries with higher emission productivity are less likely to experience FDI outflows following extreme weather events. — *This result is consistent with the case of "Greener Wins" in the model discussion section.*

It is important to emphasize that we do not view our empirical analysis as testing model predictions. The model provides a structure that helps us organize the interpretation of the results. However, the model makes an important assumption that MNEs fully internalize climate-related risks in their affiliate location decisions. Given that our emissions data and therefore the majority of our regressions only go as far as 2016 (except for regressions with disaster variables only), we do not expect most firms to be attentive to such risks. Therefore, we view our model predictions as an "ideal world" benchmark for the firms' expected reaction to climate-related shocks.

In the following subsections, we summarize our empirical results first in terms of significance and sign and then in terms of magnitudes. We focus on both intensive and extensive margins and we conduct our analysis for the subsamples of advanced and emerging economies. We summarize the main effects of physical and transition risks as well as the effects of their interactions with emission productivity, to confront our model predictions. Full regressions are reported in the Appendix.

5.1 Significance and signs

We begin by summarizing our results relative to model predictions. The results are reported in Table 4 for main effects as well as for emission interactions. We first list the sign of model predictions and then report the count of significant positive and significant negative coefficients, with the third number in each cell listing the total number of specifications available. The larger the share of results with a particular sign, the more robust we consider the impact direction of climate risk on FDI. We also mark cells green if a substantial share of specifications is consistent with model predictions; red if a substantial share of specifications contradicts model predictions; blue if a substantial share of specifications has a clear effect for the cases where the model predicts an ambiguous effect.

We can see that in most cases we do not find significant effects of climate disasters, regardless of their types. However, whenever the effects are significant, most of them are consistent with model predictions: for example, climatological disasters consistently have a negative and significant effect on FDI inflows in the following year on the extensive margin (and to a smaller extent on the intensive margin) for AEs; hydrological disasters consistently have a significant positive effect on FDI outflows from EMEs. Importantly, we do not observe predominantly significant results that contradict model predictions in terms of physical risk, with the exception of the effects of disaster severity, which generally reduce FDI outflows from AEs. We do not see a consistent significant effect of emission policies, with the exception of the extensive margin for AEs — new policies in target countries consistently increase FDI outflows from these countries in the following year, as predicted by the model.[31]

[31]We also estimated the coefficients of the interaction between the physical risk variables and the transition risk variables at country level, they turn out largely insignificant.

Table 4: Summary of the results: count of significant coefficients

Notes: First two numbers in each cell are the number of positive and negative significant coefficients across specifications, and the last number is the number of all specifications considered ($+/-/\#$). We count all specifications: those reported in Figures 11, 12, and 13 as well as robustness tests that include alternative policy measures or control for corporate tax rates, which are reported in the Online Appendix. Cells are in green if a substantial share of specifications is consistent with model predictions; in red if a substantial share of specifications contradicts model predictions; in blue, if a substantial share of specifications has a clear effect for the cases where the model predicts an ambiguous effect.

	Main effects			Interactions with emission productivity		
	Model	AEs	EMEs	Model	AEs	EMEs
Effect on FDI (intensive margin)						
Target:						
Climatological	< 0	2 / 7 / 28	2 / 4 / 28	< 0 or > 0	2 / 2 / 12	0 / 0 / 12
Meteorological	< 0	4 / 1 / 22	0 / 4 / 22	< 0 or > 0	2 / 2 / 12	3 / 2 / 12
Hydrological	< 0	3 / 7 / 28	4 / 0 / 26	< 0 or > 0	1 / 2 / 12	1 / 1 / 12
Severity	< 0	3 / 1 / 16	3 / 0 / 16	< 0 or > 0	1 / 1 / 8	2 / 0 / 8
Policy Change	< 0	1 / 0 / 8	0 / 1 / 8	< 0 or > 0	1 / 2 / 8	2 / 0 / 8
Emission Productivity	> 0	0 / 4 / 12	0 / 3 / 12	> 0	2 / 4 / 12	1 / 3 / 8
Effect on FDI (extensive: inflow)						
Target:						
Climatological	< 0	0 / 7 / 16	2 / 0 / 16	< 0 or > 0	3 / 0 / 9	0 / 0 / 9
Meteorological	< 0	1 / 1 / 16	2 / 1 / 16	< 0 or > 0	0 / 3 / 9	3 / 2 / 9
Hydrological	< 0	2 / 2 / 16	3 / 1 / 16	< 0 or > 0	0 / 0 / 9	0 / 2 / 9
Severity	< 0	0 / 0 / 9	1 / 1 / 9	< 0 or > 0	0 / 0 / 6	2 / 0 / 6
Policy Change	< 0	0 / 2 / 6	0 / 0 / 6	< 0 or > 0	0 / 0 / 6	0 / 0 / 6
Emission Productivity	> 0	2 / 0 / 10	1 / 0 / 7	> 0	1 / 0 / 9	2 / 0 / 9
Effect on FDI (extensive: outflow)						
Target:						
Climatological	> 0	0 / 2 / 16	2 / 1 / 16	< 0 or > 0	0 / 0 / 9	2 / 0 / 9
Meteorological	> 0	0 / 0 / 16	1 / 3 / 16	< 0 or > 0	0 / 3 / 9	0 / 1 / 9
Hydrological	> 0	0 / 1 / 16	4 / 0 / 16	< 0 or > 0	0 / 2 / 9	0 / 0 / 9
Severity	> 0	0 / 3 / 9	1 / 1 / 9	< 0 or > 0	0 / 2 / 6	0 / 2 / 6
Policy Change	> 0	3 / 0 / 6	0 / 0 / 6	< 0 or > 0	0 / 2 / 6	0 / 0 / 6
Emission Productivity	< 0	1 / 2 / 10	1 / 2 / 10	< 0	1 / 0 / 9	0 / 0 / 9

Emission productivity has a negative effect on FDI at the intensive margin, contrary to model predictions, in regressions without interactions. This tendency persists, but is less robust, in the interaction regressions. On the extensive margin, emission productivity generally does not have a significant effect. However puzzling this result is, it is important to notice that most of the confounding effects are estimated from regressions using target country-level emission productivity (as in level specifications) while using country-industry-level emission productivity tends to generate model-consistent signs for the coefficient (as in country-industry specifications).

Looking at the interactions of climate risks with emission productivity, we see no differential effects for policy changes, but we find some differences in the effects of physical risk. In particular, we find that for high emission productivity countries/industries, FDI outflows in response to climate disasters are consistently less severe, especially for advanced economies. The effects on inflows are less significant and are generally mixed.

5.2 Magnitudes

Most of our climate-risk variables are either 0/1 indicators, or distributed between 0 and 1, or have a mean between 0 and 1. Table 2 reports summary statistics for these variables in our target-country data set. Thus, we can compare the regression coefficients directly, without standardizing them. One exception is the change of IEA (D.IEA) which varies between 0 and 44 with a mean of 1.19.

We summarize the magnitudes of the effects in two ways. On the one hand, we combine all the coefficients from different regression specifications in the same table. We present these for three sets of specifications: first, only looking at the effects of climate-related disasters in target countries, which allows us to have a long enough time span to include interaction with the post-COP21 dummy (Figure 11); second for the main effects of all variables included together in the regressions (Figure 12); third for the interactions with emission productivity, where we do not report main effects (except for emission productivity) that are not captured by the fixed effects (Figure 13). Coefficients in bold are the ones that are statistically significant at 10% level at the least. It is important to keep in mind that the identification comes from different sources of variation in different levels of aggregation, as described in the empirical specification section.

On the other hand, we construct plots of the changes in FDI as predicted by the regressions that include interactions of emission productivity with climate policies and disasters. Since the specification with the most meaningful interactions with emission productivity is the one at the industry level, we base the plots on these estimates for illustrative purposes. The plots are reported in Figure 14.

Disasters before and after Paris Climate Accord

Figure 11 summarizes the results of specifications in which we only include target country physical risk measured as climate disasters and interact climate disaster counts, when possible, with an indicators *Post* that takes on a value of 1 post-COP21 (from the year 2016 on).[32] Green up-arrows

[32]In Appendix Figure A.4 we report the results where climate disasters are replaced by the ND-GAIN vulnerability index. The effects of vulnerability measures appear to be reversed as frequently as amplified following COP21, across specifications.

indicate positive coefficients larger than 0.001, red down-arrows indicated negative coefficients below -0.001, and yellow rectangles indicate all the coefficients in between.

Eight different aggregation levels are included: (1) target country cross-section averages before and after 2015; (2) country-pair cross-section averages before and after 2015 estimated by OLS; (3) country-pair cross-section averages before and after 2015 estimated by PPML; (4) target country panel; (5) country-pair panel estimated by OLS; (6) country-pair panel estimated by PPML; (7) target country-industry panel; (8) firm-level panel. Dependent variables as well as fixed effects and sample years included in each specification are listed for each aggregation level. Because country-industry intensive margin data are not available after 2016 (due to missing information on value added), this specification does not include interactions with $Post$.

We do observe a number of specifications in which the effects of climate disasters on FDI are negative, as the model predicts, and in some cases, these effects are stronger after COP21. However, this pattern is not robust across specifications.

It is also important to note that the effects are generally small. Consider target country panel regressions (top right segment of Figure 11), where the effects are the largest. The 2019 median FDI inflow to GDP share among advanced countries in our sample is 2.5 percent, while for emerging economies it is 2.2 percent. A climatological or a hydrological disaster in an advanced economy would reduce this share by 0.3 percentage points to 2.2 percent, while in an emerging economy one of such events will reduce the share by 0.1 percentage points to 2.1 percent.

One paper in the literature which allows us to make a direct comparison of the magnitudes of the effects in our analysis is Escaleras and Register (2011). This study is using a collapsed cross-section of FDI inflows across countries, which corresponds to our cross-section target country regression (top left specification in Figure 11). The authors find that one additional natural disaster, which may not be climate-related, reduces FDI inflows by 0.02-0.06 percent of GDP. In our cross-sectional target-country regressions we see an additional climatological disaster associated with an increase in FDI inflows to the target country by 0.03 percent of GDP on average, while a hydrological disaster is associated with a decline in FDI inflows by 0.01 percent of GDP. Thus, the magnitudes of the effects we find are similar to those in the literature.[33]

[33] In the robustness analysis, we replace disaster indicators with the ND-GAIN climate vulnerability index.

Figure 11: Interactions with Post-COP21

Notes: Reported are the coefficients from regressions at eight different aggregation levels as indicated. *Post* that takes on a value of 1 post-COP21 (from year 2016 on). Green up-arrows indicate positive coefficients larger than 0.001, red down-arrows indicated negative coefficients below -0.001, and yellow rectangles indicate all the coefficients in between. The coefficients in bold are significant at the 10% level at least. Dependent variables as well as fixed effects and sample years included in each specification are listed for each aggregation level. TC stands for the target country, SC for the source country, CG for the country group, and TI for the target country-industry. Full regressions are reported in the Appendix Tables A.9- A.28.

Aggregation level:	**X-section TC**		**X-section Bilateral**		**X-section bilateral PPML**		**Target country**	
	AE	EME	AE	EME	AE	EME	AE	EME
Sample years	pre/post 2015 aggregate		pre/post 2015 aggregate		pre/post 2015 aggregate		1970(96)-2019	
FEs	Country group		TC, SC		TC, SC		TC, Year, CG*Year	
LHS	TC inflow/GDP		D.FDI/Total FDI from SC		D.FDI/Total FDI from SC		TC inflow/GDP	
Effect on FDI (intensive margin)								
Climatological	**0.04**	-0.02	0.11	**-0.01**	0.04	**-0.24**	-0.33	-0.11
Meteorological	-- omitted due to Mcollin		-- omitted due to Mcollin		-- omitted due to Mcollin		0.01	0.01
Hydrological	-0.03	0.00	-0.04	0.00	**-0.07**	**0.04**	**-0.31**	-0.09
Severity	-0.01	0.00	**-0.06**	0.00	**0.36**	**0.01**	-0.02	0.03
Post*C	0.20	-0.17	0.11	0.00	0.01	0.08	1.44	-0.12
Post*M	-- omitted due to Mcollin		-- omitted due to Mcollin		-- omitted due to Mcollin		-0.34	**-0.08**
Post*H	0.06	0.02	-0.07	0.00	**-0.15**	-0.01	0.86	0.13
Post*Severity	0.02	0.06	0.28	**0.01**	**1.65**	**0.45**	-0.06	0.62

Aggregation level:	**Bilateral OLS**		**Bilateral-PPML**		**Target Country-industry**		**Firm**	
	AE	EME	AE	EME	AE	EME	AE	EME
Sample years	2011-2019		2011-2019		2006-2014(19)		2008-2019	
FEs	TC*SC, SC*Year		TC*SC, Year		TC*TI, TI*Year		Firm*Year, TC, TI	
LHS	D.FDI / Total FDI from SC		D.FDI / Total FDI from SC		TC Inflow/VA		D.Aff in TC/Total aff	
Effect on FDI (intensive margin)								
Target:								
Climatological	0.00	-0.01	-0.30	-0.01	0.09	-0.35	**-0.006**	0.002
Meteorological	**0.04**	0.00	-0.11	-0.01	0.00	0.08	**0.001**	**-0.001**
Hydrological	-0.03	0.00	**0.18**	**0.20**	-0.01	0.00	0.001	0.000
Severity	-0.54	**0.00**	0.03	0.00	-0.06	-2.19	0.000	**0.000**
Post*C	0.01	0.01	0.30	**1.05**			0.002	**-0.002**
Post*M	0.00	0.00	0.04	-0.04			**-0.001**	0.000
Post*H	-0.05	0.00	**-0.20**	-0.01			-0.002	**0.000**
Post*Severity	0.55	0.01	0.03	**-0.34**			**-0.002**	0.000
Effect on FDI (extensive: inflow)								
	I(D.FDI / Total FDI from SC>0)				I(TC Inflow/VA>0)		I(new affiliates in TC)	
Climatological	0.05	0.01			0.004	0.022	**-0.011**	**0.010**
Meteorological	-0.01	0.00			-0.005	-0.003	0.001	-0.003
Hydrological	0.00	0.00			0.010	0.001	-0.001	0.000
Severity	-0.02	0.00			-0.092	-0.076	0.000	0.000
Post*C	-0.05	-0.01			-0.020	**-0.126**	0.005	**-0.012**
Post*M	0.01	0.00			0.004	0.014	-0.002	0.001
Post*H	-0.01	0.00			-0.024	0.010	-0.001	**-0.002**
Post*Severity	0.01	0.01			0.084	-0.012	**-0.010**	0.001
Effect on FDI (extensive: outflow)								
	I(D.FDI / Total FDI from SC<0)				I(TC Inflow/VA<0)		I(no more affiliates in TC)	
Climatological	0.01	0.02			-0.003	-0.032	**-0.001**	0.001
Meteorological	-0.01	0.00			-0.004	0.002	0.000	**-0.001**
Hydrological	0.01	0.01			-0.006	0.001	0.000	**0.001**
Severity	0.00	0.00			0.046	0.053	**-0.001**	**0.000**
Post*C	-0.03	0.02			-0.006	**0.139**	0.001	0.000
Post*M	**0.01**	0.00			0.000	-0.014	0.000	0.000
Post*H	-0.03	-0.01			0.018	-0.005	**-0.003**	0.000
Post*Severity	-0.02	**-0.03**			-0.035	0.004	0.001	**-0.002**

Main effects and interactions with emission productivity

Figure 12 reports the results of the specifications with only the main effects of climate-risk measures included, while Figure 13 reports interactions with emission productivity as well as main effect of emission productivity, with other main effects not reported or absorbed by fixed effects. We conduct this analysis at four aggregation levels: (1) target country panel; (2) country-pair panel estimated by PPML (for intensive margins) and OLS (for extensive margins); (3) target country-industry panel; (4) firm-level panel.

The most reliable results come from country-industry specification, in which we use country-industry level emission productivity, while in other specifications we aggregate emission productivity to the country level (as a weighted average). In country-industry regressions, we find that FDI inflows to advanced and emerging economies increase with emission productivity along intensive margin, although this effect is not statistically significant. Along extensive margin, FDI flows to advanced economies increase (inflows increase and outflows decline) for industries with higher emission productivity, which is consistent with model Proposition 3a. For emerging economies, however, the results for extensive marge are the opposite without significance.

In other levels of aggregation, we find that the effect of negative emission productivity on FDI is negative, which is contrary to model predictions. This, however, can be due to composition effects: for example, service industries have high emission productivity but tend to have less FDI than manufacturing industries. In bilateral and firm-level regressions we also consider the effects of source country emission productivity. We find that emission productivity in the source country has a very small impact on FDI flows and the sign changes depending on specification.

To compare the effects of physical and transition risk, refer to Table 2 to see that the occurrence of disasters and policy changes in the sample is quite similar, which is why we can compare coefficients directly. We observe that policy changes tend to have an even smaller effect than climate disasters in terms of magnitude. Climatological and hydrological disasters in the source country tend to reduce FDI on both intensive and extensive margins, while meteorological disasters have the opposite effect. Emission policies in source countries appear to increase FDI flows to target countries (and reduce outflows from targets), which is consistent with a spillover effect of climate policies from source to target countries.[34]

Between advanced and emerging economies, policy changes have a more negative impact on the extensive margin for advanced than for emerging economies. Since emission productivity is generally lower in emerging economies (as shown in Figure 4), these effects of policy changes on FDI are broadly consistent with model Proposition 3b (the case of "Greener Loses").

[34] This is consistent with the finding in the literature that MNEs in industrial countries, like the U.S., "export" their emissions (López et al., 2019).

Figure 12: Main Results Summary

Notes: Reported are the coefficients from regressions at four different aggregation levels as indicated. Green up-arrows indicate positive coefficients larger than 0.001, red down-arrows indicated negative coefficients below -0.001, and yellow rectangles indicate all the coefficients in between. The coefficients in bold are significant at the 10% level at least. Dependent variables as well as fixed effects and sample years included in each specification are listed for each aggregation level. TC stands for the target country, SC for the source country, CG for the country group, and TI for the target industry. Full regressions are reported in the Appendix Tables A.12- A.33.

Aggregation level:	**Target Country**		**Bilateral-PPML**		**Target Country-industry**		**Firm**	
	AE	EME	AE	EME	AE	EME	AE	EME
Sample years	2001-2017		2011-2017		2007-2014	2010-14	2008-2016	
FEs	TC, Year, CG*Year		TC*SC, Year		TC*TI, TI*Year		Firm, Year, TC, TI	
LHS	TC inflow/GDP		D.FDI / Total FDI from SC		TC Inflow/VA		D.Aff in TC/Total aff	
Effect on FDI (intensive margin)								
Source:								
Climatological			**-0.23**	**-0.28**			**-0.004**	-0.002
Meteorological			**-0.03**	**0.31**			0.000	0.000
Hydrological			**0.10**	**0.15**			**-0.001**	-0.001
Severity			**0.00**	-0.02			**0.000**	0.000
Change in policies			**0.11**	**0.08**			0.000	0.000
Emission productivity			**-8.82**	-9.79			0.058	**0.054**
Climate risk							-0.001	0.001
Target:								
Climatological	0.01	-0.12	**-0.32**	0.11	0.174	-0.333	**-0.017**	0.002
Meteorological	-0.01	0.04	-0.15	-0.09	-0.009	0.090	0.001	**-0.001**
Hydrological	**-0.26**	-0.12	0.12	0.29	-0.038	-0.019	**-0.002**	0.000
Severity	0.05	0.03	**0.20**	**0.01**	-0.019	-2.188	0.000	0.000
Change in policies	0.00	-0.02	**0.03**	0.00	-0.010	0.000	0.000	0.000
Emission productivity	**-28.6**	7.30	**-7.51**	**-16.17**	1.002	18.970	-0.186	**-0.126**
Effect on FDI (extensive: inflow)			Bilateral-Linear					
Sample years			2011-2017		2007-2014	2010-14	2008-2016	
LHS			I(D.FDI / Total FDI from SC>0)		I(TC Inflow/VA>0)		I(new affiliates in TC)	
Source:								
Climatological			-0.001	0.002			-0.005	-0.008
Meteorological			0.000	-0.003			0.002	0.002
Hydrological			0.004	0.001			-0.001	0.001
Severity			0.000	-0.001			-0.001	**-0.003**
Change in policies			0.000	-0.001			0.000	-0.001
Emission productivity			0.056	0.051			0.159	**0.412**
Climate risk							0.000	0.002
Target:								
Climatological			**-0.011**	-0.006	-0.014	0.034	**-0.007**	0.003
Meteorological			0.005	**0.003**	-0.005	-0.023	0.000	0.000
Hydrological			0.002	0.000	**0.017**	0.002	0.000	**-0.003**
Severity			-0.001	-0.001	-0.042	-0.025	-0.001	0.000
Change in policies			0.000	-0.001	**-0.006**	0.009	0.000	-0.001
Emission productivity			-0.458	0.139	**3.401**	-9.622	0.056	-0.046
Effect on FDI (extensive: outflow)								
LHS			I(D.FDI / Total FDI from SC<0)		I(TC Inflow/VA<0)		I(no more affiliates in TC)	
Source:								
Climatological			**0.012**	0.011			0.006	0.004
Meteorological			-0.005	-0.003			-0.001	-0.002
Hydrological			0.003	-0.002			0.002	0.004
Severity			0.000	-0.001			0.001	0.001
Change in policies			-0.001	0.002			0.000	0.000
Emission productivity			0.079	-0.138			-0.059	0.005
Climate risk							0.004	-0.002
Target:								
Climatological			0.004	0.002	0.007	-0.022	-0.001	**0.005**
Meteorological			0.000	-0.001	0.000	0.015	0.000	0.000
Hydrological			0.002	0.004	-0.004	-0.005	**-0.001**	0.000
Severity			-0.012	0.000	0.026	0.047	**-0.001**	0.000
Change in policies			0.000	-0.001	**0.007**	-0.006	0.000	0.000
Emission productivity			-0.175	0.234	**-1.682**	9.849	**0.028**	**-0.078**

Turning to emission productivity interaction effects, we find that climate policies in source countries generally increase FDI in emission-productive target countries, which is an intuitive finding of emission policy spillovers. Meanwhile, in country and bilateral-level results, emission policies in target countries tend to reduce FDI into emission-productive target countries at the intensive margin, especially for advanced economies. This finding is consistent with the model case of "Greener Loses" where countries with high emission productivity are more negatively affected by climate risks. The results for emerging markets are mixed. And the results from the country-industry and firm levels are not consistent with the more aggregated level results above.

To better see the combined effects of policies, emission productivity, and disasters, including all main effects and interactions, we construct illustrative charts that are based on the results of country-industry panel data, the specification that has the most accurate measure of emission productivity, at the industry level. The results are presented in Figure 14 for advanced and emerging economies. The effects of control variables and fixed effects are all set to zero.

FDI flows in this regression are measured as FDI inflows as a share of value added of that country-industry-year. One standard deviation of this measure for advanced economies in the sample is 0.5, and for emerging economies, it is 0.7. In this context, we can see that the effects of emission productivity and of policy changes can be quite large.

The first obvious observation is that for advanced economies the relative effect of physical risks, compared to the effects of emission productivity or policy changes, is negligible in magnitude, regardless of disaster type. In the absence of new emission policies, emission productivity increase is associated with larger FDI inflows, which is consistent with the model. In addition, stricter emission policies tend to increase FDI in advanced economies, especially for industries with high emission productivity. This suggests that, within advanced countries, industry outcomes are consistent with the case of "Greener Wins" in the model discussion section.

For emerging economies we see a substantially larger effect of climate disasters, mostly coming from disaster severity (and therefore resulting in similar effects for all climate disaster types). The effect of climate disasters (the gap between the two planes) is larger for industries with high emission productivity, which suggests that within emerging countries, industry outcomes are consistent with the "Greener Loses" case of Propositions 3b and 6b. Consistently with the model predictions, we also find that introduction of new policies reduces FDI, especially for industries with high emission productivity (again, the "Greener Loses" case). In fact, while in the absence of the policies, higher emission productivity increases FDI, as the model predicts, this relationship is weakened and eventually reversed if emission policies are introduced, also consistent with the "Greener Loses" case once more.

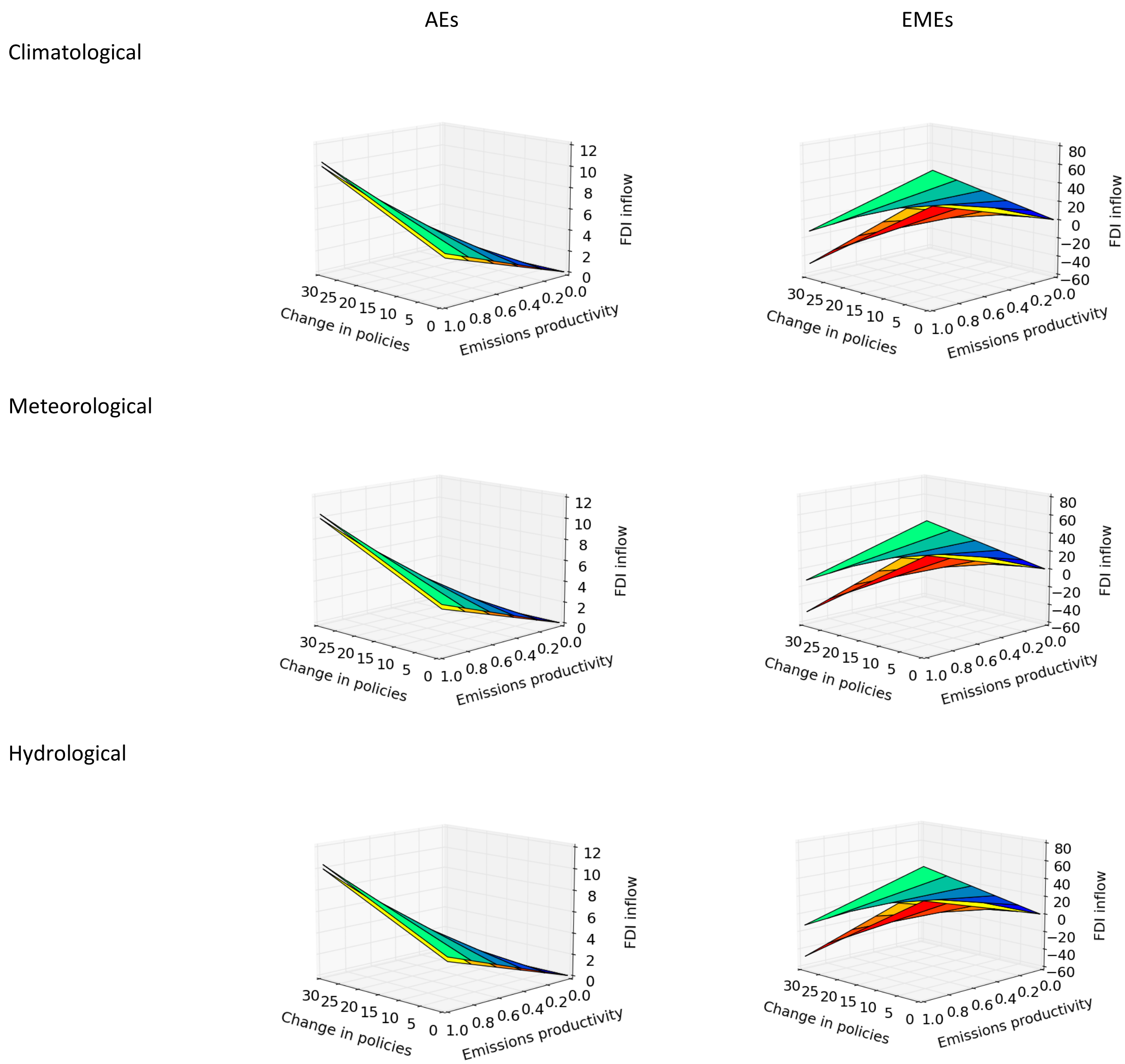
Figure 13: Interactions with Emission Productivity Summary

Reported are the coefficients from regressions at four different aggregation levels as indicated, all reported coefficients are those on interactions with emission productivity of the target country, for which the main effect is reported as well. Green up-arrows indicate positive coefficients larger than 0.001, red down-arrows indicated negative coefficients below -0.001, and yellow rectangles indicate all the coefficients in between. Coefficients in bold are significant at 10% level at least. Dependent variables as well as fixed effects and sample years included in each specification are listed for each aggregation level. TC stands for the target country, SC for the source country, CG for the country group, and TI for the target industry. Full regressions are reported in the Appendix Tables A.12- A.34.

Aggregation level:	**Target Country**		**Bilateral-PPML**		**Target Country-industry**		**Firm**	
	AE	EME	AE	EME	AE	EME	AE	EME
Sample years	2001-2017		2011-2017		2007-2014	2010-14	2008-2016	
FEs	TC, Year, CGYear		TCSC, Year		TCTI, TIYear, TCYear		FirmYear, TC, TI	
LHS	TC inflow/GDP		D.FDI / Total FDI from SC		TC Inflow/VA		D.Aff in TC/Total aff	
Effect on FDI (intensive margin)								
Source:								
Climatological			▲ **4.56**	▲ 2.76			▼ **-0.016**	▬ 0.000
Meteorological			▼ **-3.86**	▼ **-6.17**			▲ **0.003**	▼ -0.001
Hydrological			▲ 0.07	▼ -2.60			▼ -0.001	▲ 0.002
Severity			▼ **-0.16**	▼ -0.53			▼ -0.004	▲ 0.002
Change in policies			▲ **0.66**	▲ 0.40			▬ 0.000	▲ **0.003**
Emission productivity			▼ **-5.58**	▼ -31.21			▼ -0.016	▲ 0.032
Climate risk							▼ **-0.020**	▼ **-0.009**
Target:								
Climatological	▲ 5.399	▼ -5.977	▼ -2.08		▲ 7.91	▼ -64.29	▲ 0.048	▲ 0.034
Meteorological	▼ **-3.7**	▼ -0.59	▲ **1.09**	▲ **4.35**	▼ -6.24	▲ 22.51	▲ 0.012	▼ -0.029
Hydrological	▲ 2.157	▼ -0.393	▲ **3.96**	▼ -0.22	▼ -6.07	▼ -7.29	▲ 0.005	▲ 0.007
Severity	▼ **-4.6**	▲ 38.71	▲ **6.98**	▼ -5.03	▼ -6.94	▼ -582.7	▬ 0.000	▬ 0.001
Change in policies	▼ **-0.8**	▲ 0.544	▼ **-0.16**	▼ -0.47	▲ 0.20	▼ -3.09	▬ 0.000	▬ 0.000
Emission productivity	▼ **-17.8**	▼ -6.505	▼ **-21.5**	▲ 2.60	▲ 4.54	▲ 79.10	▼ **-0.155**	▼ -0.184
Effect on FDI (extensive: inflow)			Bilateral-Linear Probability					
Sample years			2011-2017		2007-2014	2010-14	2008-2016	
FEs			TCSC, SCYear		TCTI, TIYear, TCYear		FirmYear, TC, TI	
LHS			I(D.FDI / Total FDI from SC>0)		I(TC Inflow/VA>0)		I(new affiliates in TC)	
Source:								
Climatological			▼ -0.03	▼ -0.08			▼ -0.020	▲ 0.024
Meteorological			▼ -0.01	▼ **-0.05**			▲ 0.004	▼ -0.005
Hydrological			▲ **0.07**	▼ -0.03			▲ 0.002	▼ -0.010
Severity			▬ 0.00	▼ 0.00			▬ 0.000	▬ -0.001
Change in policies			▼ 0.00	▲ 0.01			▬ 0.000	▲ 0.004
Emission productivity			▲ 1.63	▼ -0.65			▲ 0.039	▲ 0.083
Climate risk							▼ -0.009	▲ 0.010
Target:								
Climatological			▲ 0.10	▼ -0.02	▲ 1.222	▼ -17.25	▲ **0.098**	▼ **-0.190**
Meteorological			▼ **-0.07**	▲ 0.12	▲ 0.572	▲ 12.08	▲ 0.017	▲ 0.048
Hydrological			▼ -0.01	▲ **0.05**	▲ 0.993	▼ -0.572	▲ 0.022	▼ **-0.057**
Severity			▲ 0.29	▼ -0.13	▲ 0.018	▼ -162.2	▼ -0.006	▲ 0.002
Change in policies			▲ 0.01	▲ 0.00	▲ 0.0154	▼ -1.813	▬ -0.001	▼ -0.001
Emission productivity			▼ **-0.84**	▲ 0.03	▲ **2.69**	▲ 25.62	▼ -0.119	▲ **0.605**
Effect on FDI (extensive: outflow)								
LHS			I(D.FDI / Total FDI from SC<0)		I(TC Inflow/VA<0)		I(no more affiliates in TC)	
Source:								
Climatological			▼ **-0.19**	▲ 0.09			▼ -0.011	▲ 0.003
Meteorological			▲ **0.03**	▼ -0.04			▲ **0.005**	▬ -0.001
Hydrological			▼ -0.01	▲ 0.03			▼ -0.002	▼ -0.003
Severity			▲ 0.01	▼ -0.02			▲ 0.003	▲ 0.003
Change in policies			▲ 0.01	▼ 0.00			▼ -0.001	▲ 0.002
Emission productivity			▲ 1.09	▼ -0.41			▲ **0.084**	▲ 0.064
Climate risk							▲ 0.007	▼ **-0.053**
Target:								
Climatological			▼ -0.06	▲ 0.24	▲ 0.88	▲ 16.91	▲ 0.015	▲ 0.044
Meteorological			▼ -0.06	▲ 0.03	▼ **-0.78**	▼ -11.80	▼ -0.005	▼ -0.015
Hydrological			▼ -0.10	▲ 0.03	▼ -0.45	▲ 0.77	▬ 0.000	▼ -0.006
Severity			▲ 0.57	▼ -0.11	▲ 1.12	▲ 163.8	▼ **-0.003**	▬ 0.000
Change in policies			▬ 0.00	▼ -0.01	▼ **-0.07**	▲ 1.82	▬ 0.000	▬ 0.000
Emission productivity			▼ -0.28	▲ 0.17	▼ -0.30	▼ -26.60	▲ 0.005	▼ -0.026

Figure 14: Effects on FDI: Industry-level regression results

Blue-green plane shows the effects in absence of climate disasters. Red-yellow plane adds one disaster of a given type and a mean severity of a disaster. The specification is from regressions reported in Table A.15.



5.3 The role of firm-level climate exposure

Our interpretation of the results so far is that, while we find some evidence in support of model predictions and therefore of firms reactions to climate risks, the effects are generally small and not very robust. This implies the decisionmakers in MNEs do not fully take into account the effects of climate risks, and perhaps firm-specific features matter. To test this implication, we consider interactions of physical and transition risk measures in target countries with firm-level measure of climate risk (CCR). We expect firms that are more exposed to climate risks to react more to climate risks.

The results are reported in Table 5, where we include firm-target country, firm-year, target country-year, and target industry fixed effects so that all main effects and controls are absorbed. In addition, we include interaction terms with the Post-COP21 time period indicator, to allow for a different effect at a time when climate change awareness is more common.

We find that prior to 2016 (COP21), the reaction of FDI to climate-related disasters or policies did not vary systematically with firms' exposure to climate risks (CCR). One exception is meteorological disasters, for which higher sensitivity to climate risks is associated with larger FDI inflows and smaller outflows from countries. For high CCR firms, disaster severity does have a significantly negative impact on EME FDI at the intensive margin and advanced countries' FDI inflow but it also the latter's outflow. Emission policies also reduce high-CCR firms' overall FDI, but not specifically for advanced or emerging target countries.

Following COP21, however, we observe that firms that are more sensitive or more exposed to physical climate risks are more likely to reduce their FDI on intensive as well as extensive margins following climatological or meteorological disasters in advanced target countries.[35] The reaction to transition risk is, however, minimal or even slightly reversed. This finding is interesting because it suggests that in recent years firms that are exposed to climate risks have recently been shifting their affiliates out of the countries that are subject to physical climate risk but they do not change their FDI reacting more to transition risk.

While not all these results are clear-cut, they generally show that firms that recognize their climate exposure are less likely to locate affiliates in countries with higher physical risks, especially in recent years, and are no more or less likely to choose destinations with stricter emission policies. Interestingly, MNEs that are exposed to climate risks with headquarters located in OFCs did not seem to have changed their behavior significantly following COP21.

[35]The full effect is measured by the sum of the coefficients on the main effect and the interaction with *Post* indicator.

Table 5: Firm-level regressions: Climate exposure, policies, and disasters

Notes: An observation is a firm-target country-year cell. Dependent variables are either Intensive margin, measured as a change in the share of total firm's affiliates located in a given target country in a given year, or Extensive margin, measured as an indicator of whether a firm has an affiliate in a new given target country (inflow) or whether a firm has closed all affiliates in a given target country (outflow). CCR is a measure of firm exposure to climate risks as discussed in executive calls provided in Sautner et al. (2021) and discussed in Sautner et al. (2020). $Hydro$, $Meteo$, and $Climat$ are numbers of hydrological, meteorological, and climatological disasters from EM Data, at the country-year level, for target countries. $Policy^T$ is the change in the target-country energy policy from IEA. $Post$ is a 0/1 indicator of the Post-COP21 time period (including years 2016 and later). T indicates target country, S indicates source country. All RHS variables are lagged by one year. All regressions include firm-target country, firm-year, target country-year, and affiliate industry fixed effects. Robust standard errors are clustered two-way by firm and target country. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Intensive Margin				Inflows				Outflows			
	Full	AE^T	EME^T	OFC^S	Full	AE^T	EME^T	OFC^S	Full	AE^T	EME^T	OFC^S
$CCR * Climat$	0.00078	0.0017	0.0008	0.00082	0.0027	0.0026	0.0012	0.0113	0.00026	0.0036**	-0.0035	0.000293
	(0.0006)	(0.0013)	(0.00057)	(0.0036)	(0.0027)	(0.0033)	(0.0054)	(0.0082)	(0.0018)	(0.0014)	(0.0026)	(0.0028)
$CCR * Meteo$	0.00052***	0.00062**	0.0002*	-0.000011	-0.00019	-0.00037	-0.00096	-0.0001	-0.00031	-0.0012**	-0.00034	-0.00027
	(0.00017)	(0.00029)	(0.00011)	(0.00092)	(0.00059)	(0.00073)	(0.0011)	(0.0018)	(0.000430)	(0.00046)	(0.00072)	(0.0008)
$CCR * Hydro$	-0.00019	-0.00088	0.000024	-0.0000039	0.00075	0.0019	0.0011	-0.00078	-0.00068*	-0.00057	-0.000025	-0.0004
	(0.00014)	(0.00064)	(0.000075)	(0.00058)	(0.00065)	(0.0014)	(0.00088)	(0.0018)	(0.0003)	(0.001)	(0.00043)	(0.0011)
$CCR * Severity$	-0.00011*	0.00016	-0.00014**	-0.000092	-0.00028	-0.0013***	0.000049	-0.00075	0.0001	-0.00048**	0.00034	0.0001
	(0.00006)	(0.00016)	(0.000057)	(0.00017)	(0.00032)	(0.00036)	(0.00047)	(0.00066)	(0.00027)	(0.00018)	(0.00031)	(0.00034)
$CCR * Policy$	-0.00014*	-0.00015	0.000046	-0.000026	0.00033	-0.00013	0.00082	0.0027**	0.00058**	0.00015	0.000558	0.00087
	(0.000078)	(0.00013)	(0.000054)	(0.00023)	(0.00036)	(0.00038)	(0.00069)	(0.0011)	(0.00026)	(0.00027)	(0.00045)	(0.00064)
$Post*$..												
$CCR * Climat$	-0.0021**	-0.0026*	-0.00054	-0.0025	-0.0021	-0.0022	-0.00092	-0.013	0.00041	-0.0043**	0.0056	0.0031
	(0.00081)	(0.0013)	(0.00077)	(0.0055)	(0.0031)	(0.0041)	(0.0068)	(0.011)	(0.0023)	(0.002)	(0.0036)	(0.0058)
$CCR * Meteo$	-0.00073***	-0.00076*	-0.00018	-0.000082	-0.00032	-0.0013	0.00075	0.00025	0.00054	0.0022**	-0.00014	0.00083
	(0.00024)	(0.00044)	(0.00015)	(0.0012)	(0.00072)	(0.00097)	(0.0013)	(0.0028)	(0.00065)	(0.00084)	(0.00098)	(0.0020)
$CCR * Hydro$	0.00019	0.00029	-0.000079	-0.00049	-0.0011	0.0033	-0.0012	-0.00022	0.00053	0.00044	-0.00052	0.0005
	(0.00022)	(0.0014)	(0.000097)	(0.00054)	(0.00084)	(0.0034)	(0.0011)	(0.0025)	(0.0006)	(0.0025)	(0.00062)	(0.0027)
$CCR * Severity$	0.0011**	0.0029***	0.00066**	0.0045**	-0.0018	-0.00058	-0.002	0.0038*	-0.0026	-0.0018	-0.004	-0.002
	(0.00057)	(0.00098)	(0.00029)	(0.0021)	(0.0015)	(0.0028)	(0.002)	(0.0023)	(0.0018)	(0.0029)	(0.0024)	(0.0026)
$CCR * Policy$	0.0002*	0.00037	-0.000069	-0.00018	0.00057	0.00033	-0.0003	-0.0013	-0.00031	-0.000026	0.00043	-0.0013
	(0.00011)	(0.00023)	(0.000087)	(0.00055)	(0.00045)	(0.0007)	(0.00091)	(0.0016)	(0.0004)	(0.00054)	(0.00066)	(0.0014)
Observations	251587	132899	104765	18522	329985	173648	137453	23838	306466	161510	127096	22101
R^2	0.421	0.434	0.525	0.452	0.633	0.695	0.636	0.717	0.700	0.741	0.698	0.784

5.4 Endogeneity concerns

One concern that may arise about our approach, at least for some level of aggregation, is the endogeneity of climate outcomes to FDI flows. In terms of transition risks, FDI might have an influence on policies, either by influencing governments to tighten environmental standards to allow for a level playing field for foreign firms that might be subject to stricter standards, or, in contrast, by pressuring to delay any tightening of the regulation (Cole et al., 2006). A survey by Cole et al. (2017) demonstrates that not only FDI can impact environmental policies, but that controlling for this endogeneity does affect the findings of the effect of policies on FDI. In terms of physical risks, while actual disasters are exogenous,[36] their reporting could be endogenous to the scale of economic activity in the region. We address these concerns in two ways: first, we test for the presence of the described mechanisms in the data, using the local projections model; second, we consider the effects of physical and transition risks in one country on FDI to other countries (the spillover effect). As a preview, we do not find these endogeneity concerns arise in our analysis.

Local projections to test endogeneity

One way to see whether endogeneity of natural disasters reporting and of the policies is likely to create an attenuation bias in our data, we estimate local projection models at a target country level.[37] The regressions are estimated at the annual frequency with robust standard errors clustered two-way by country and year. Impulse responses from these regressions are reported in Figure A.5 in the Appendix. We do not observe any sizeable or significant effects of FDI on either policy measures or on disaster measures. In fact, the magnitudes of the effects are very small and are never significantly positive. Thus, while we cannot formally rule out endogeneity in principle, we can see that even if it is present, it is unlikely to affect our results.

Climate risk spillovers

An alternative way to alleviate endogeneity concerns is to see whether there are significant spillovers from climate risks in a given country to FDI inflows to other countries. If our estimates of the effects of climate risks on FDI are biased towards zero due to endogeneity and FDI inflows do in fact respond strongly to these risks, we should observe the relocation of these FDI flows to other countries that do not experience the same shocks in the same year.[38]

[36]Greenhouse gas emissions might be endogenous to FDI (Wang et al., 2020). However, because global climate change is a result of global emission concentration, actual climate-related disasters could not be linked to a specific emission increase.

[37]Since disasters and policies are observed at the country level, the same results would apply to other levels of aggregation. The benefit of the target country-level data is a sufficiently long time dimension to meaningfully estimate impulse responses at the annual frequency level.

[38]There is evidence of such leakages in the literature as surveyed recently by Cole et al. (2017). One of the mechanisms by which firms might try to relocate to less regulated countries is through the availability of bank

We test for spillovers from source to target countries in our main specifications for which bilateral FDI data are available (see Figures 12 and 13). If there are spillover effects, we would expect coefficients on source-country variables to be positive, the more physical and transition risks, the higher FDI outflows from these source countries. We do observe positive effects of meteorological and hydrological disasters as well as of climate policies introduction on the intensive margin of FDI flows to emerging markets. These effects are, however, small in magnitude and are not robust across specifications.

We also test for the spillover effects from one target country to another by evaluating the response of FDI to a given country to physical and transition risks in other countries, at different level of aggregation. The results are reported in Tables A.35, A.36, and A.37 in the Appendix for the country panel, country-industry panel, and firm-level regressions. If there is a spillover effect, we should expect the coefficients on other countries' climate risk variables to be positive and the coefficients on target country's climate risk variables to be negative. We find that while in some cases there is an increase in FDI flows to the target country following a climate disaster or a policy change in other countries, there is not a consistent pattern across disaster types, aggregation levels, or specifications. In addition, we have conducted similar regressions using bilateral data set, the results are similarly insignificant and thus not reported.

5.5 Discussion on possible mechanisms

What might be the reasons we are not finding the effects of climate risks on FDI consistently as predicted by the model? Given that we considered a large number of specifications and aggregation levels, we do not think it is a matter of a sample or aggregation bias. Given that we are looking for a global effect, it is possible that the data are just too noisy to observe robust patterns, which may be the case, but is not a satisfactory explanation. There are two other possibilities.

First is that MNEs in their affiliate location decisions do not respond to climate disasters due to inattention or insufficient weight put on these risks. We do observe some evidence consistent with this explanation in our firm-level regressions where we find that in recent years, when climate risks are more accepted in mainstream discussions, firms with higher exposure or attention to climate risks react differently to climate risks.

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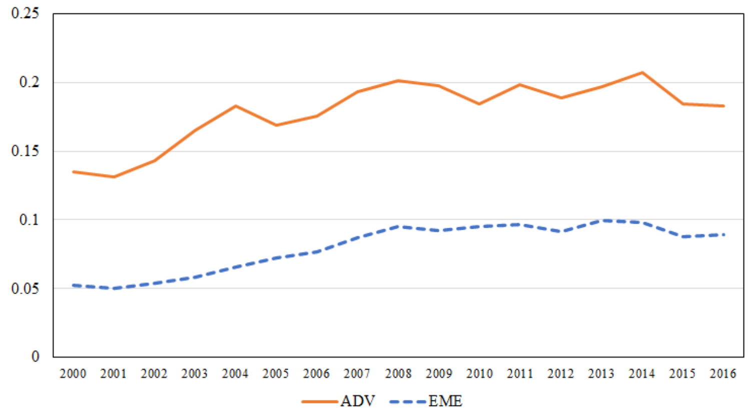
funding (Laeven and Popov, 2021).

Figure 15: Emission Productivity Over time



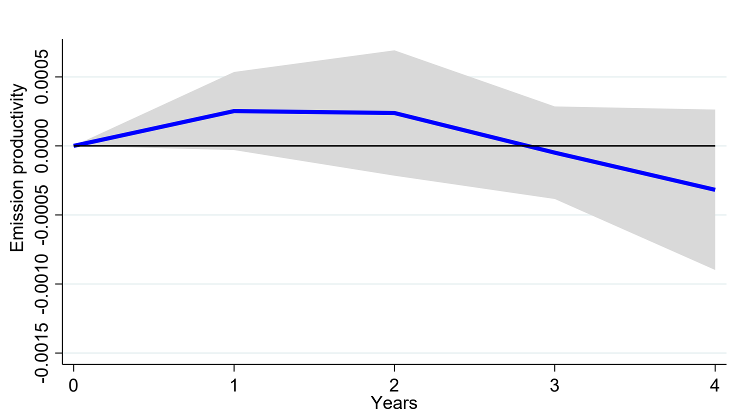
Another possible explanation is rising emission productivity due to technological improvements. Figure 15 shows that in both advanced and emerging economies emission productivity increased, especially earlier in our sample. According to our theoretical model, the rising emission productivity may increase or decrease the impact of climate risks on FDI (i.e., the cases of Greener Loses, Greener Wins, and No Effect). Although in all regressions we control for emission productivity either at the country level or country-industry level and its interactions with climate risks, the interaction effects can still be differentiated at the firm level and hence washed out at the industry or country level. Future research calls for more detailed firm-level emission productivity measurements.[39]

Then the next question to ask is: what has caused the rise in emission productivity? Did emission policy contribute to the cause? After all, Figure 8 shows that emission policies have been tightening throughout our sample, which could lead to greener technologies. We test this mechanism directly by estimating the response of emission productivity to the introduction of new emission policies. We do this by estimating at the country level a local projection model. The results are reported in Figure 16. There is a tiny positive response of emission productivity to the introduction of new emission policies, but it is not persistent, is borderline statistically significant, and very small in magnitude.

[39]Some sources that now produce firm-level emissions data are the Carbon Disclosure Project (CDP), MSCI ESG Research, and Trucost. But these datasets are limited in time periods and geographic coverage for our study of FDI.

Figure 16: The Impact of Policy Changes on Emission Productivity (Local Projection)

NOtes: Response of emission productivity emi to changes in energy policies IEA, estimated by local projections for a country-year panel. The following equation was estimated: $emi_{it+h} = \alpha_i + \alpha_t + \sum_{\tau=1}^{3} \rho_\tau emi_{it-\tau} + \sum_{\tau=1}^{3} \beta_\tau \Delta IEA_{it-\tau}, \quad h \in [0,4]$. Standard errors are clustered by country and by year.



This result implies that the emission productivity improvement may be driven by other policies or, more likely, by non-policy-driven technological innovations, such as stockholder opinions. To answer this better, it calls for endeavors for a future research project.

6 Conclusion

We can now return to the question we posed at the beginning of the paper: Do multinational firms incorporate physical and transition climate risks into their location decisions? By comparing the predictions of our theoretical framework with our empirical results, we can see that the answer is "No quite" or "Not yet." Our comprehensive empirical analysis finds only weak evidence of firms' responses to climate-related risks in the direction predicted by the model.

One of our contributions to the literature is a model that reveals that firms' reactions to climate risks may not be straightforward in an environment where technologies become greener. Although in our data we find little evidence for policy's impact on technology greening to date, greener technologies can be driven by other forces in the market, and going forward this model result may become important for future empirical analysis. We also find that since the attention of multinationals to climate-related risks started to rise following Paris Climate Accord, firms with more climate risk exposure and awareness react differently to climate risks than those with less exposure and awareness.

Taken together, our results imply that in the future one should expect increased attention of the firms to climate risks that may lead to a substantial reallocation of global capital and production as climate-related shocks intensify. In fact, the lack of consistent or sizeable response of FDI to climate shocks in the data suggests a potential for large and abrupt changes going forward, especially if stricter climate mitigation policies are adopted around the world.

One methodological implication of our analysis is that affiliate-level emission productivity is likely important to properly analyze whether firms react in a predicted way to climate risks. Historically, these data do not exist. However, increasingly, emission information at the firm level is entering the list of reporting requirements in many countries. We hope that future studies can make use of such data in conjunction with our results to uncover more consistent patterns.

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A Appendix

Appendix A.1 Additional model results

Demand and Solution

All the goods produced by the affiliate are consumed in the target country (i.e., this is a horizontal FDI model).[40] As in Helpman et al. (2004), the target country's consumer preferences across varieties of products have the standard CES form, with an elasticity of substitution $\sigma > 1$ and share parameters α_{mi}, where m indexes a unique variety produced by each firm m, including MNE's affiliates, domestic firms, and the foreign MNE producing in target country i, for the total of $N+1$ firms. These preferences generate a demand function $A_i p_{im}^{-\sigma}$, where $A_i = \frac{\alpha_{mi}^{\sigma} C_i}{P_i^{1-\sigma}}$, C_i is the total expenditure of the target country, and $P_i = (\sum_{m=1}^{N+1} \alpha_{mi}^{\sigma} p_{mi}^{1-\sigma})^{\frac{1}{1-\sigma}}$ is target country's price index. The demand level A_i is exogenous from the point of view of the individual supplier.

We solve for the optimal emission input as:

$$k_{in} = \frac{A_i z_{in}^{\sigma-1}(1-\frac{1}{\sigma})^{\sigma}}{[E(r_i)]^{\sigma}}$$

with price $p_{in} = \frac{E(r_i)}{z_{in}(1-\frac{1}{\sigma})}$ and quantity $q_{in} = \frac{A_i z_{in}^{\sigma}(1-\frac{1}{\sigma})^{\sigma}}{[E(r_i)]^{\sigma}}$.

The expected operating profit for the affiliate is:

$$E(\Pi_{in}) = \beta[\frac{A_i z_{in}^{\sigma-1}(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma(E(r_i))^{\sigma-1}} - E(f_i)] \geq 0 \tag{4}$$

Hence, there exists an emission productivity threshold

$$\bar{z} = [\frac{\sigma E(f_i)(E(r_i))^{\sigma-1}}{A_i(1-\frac{1}{\sigma})^{\sigma-1}}]^{\frac{1}{\sigma-1}}$$

such that potential affiliates with $z_{in} \geq \bar{z}$ are acquired by the MNE to operate in the target country, otherwise they are not.

Proofs

Proposition 1. Physical risk *When a target country's physical climate risk increases such that the affiliate's expected overhead cost $E(f_i)$ increases, or when a disaster is realized, the number*

[40] The model can easily be reformulated as a vertical FDI model if the differentiated goods are considered inputs into a domestic single consumption good via a CES aggregator production function. As long as substitution elasticity $\sigma > 1$, the results will be the same. However, one can see that for complementary goods ($0 < \sigma < 1$), such as exist in disaggregated supply chains, some of the results will be reversed.

of affiliates in the target country declines. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher physical risk has no impact on the number of MNE's affiliates.

Proof: Since $\sigma > 1$, we can see from equation (2) that $\frac{\partial M_i}{\partial E(f_i)} < 0$. And during a disaster, since the realized overhead cost $f_{id} > E(f_i)$, M_i will decrease from the level prior to the disaster and the absolute change $M_i - M_{id} \equiv \Delta M_i = N_i b_i^{v_i} \frac{f_{id}^{\frac{v_i}{\sigma-1}} - E(f_i)^{\frac{v_i}{\sigma-1}}}{f_{id}^{\frac{v_i}{\sigma-1}} E(f_i)^{\frac{v_i}{\sigma-1}}} [\frac{B}{(E(r_i))^{\sigma-1}}]^{\frac{v_i}{\sigma-1}} > 0$, where $B = \frac{A_i(1-\frac{1}{\sigma})^{\sigma-1}}{\sigma}$. □

Proposition 2. Transition risk *When expected climate policies increase expected emission unit cost $E(r_i)$, or when a higher emission cost $r_i > E(r_i)$ realizes, the number of MNE's affiliates in the target country decreases and the effect of physical risk from Proposition 1 is smaller. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher transition risk has no impact on the number of MNE's affiliates.*

Proof: Since $\sigma > 1$, we can see from equation (2) that $\frac{\partial M_i}{\partial E(r_i)} < 0$. In addition, $\frac{\partial^2 M_i}{\partial E(f_i)\partial E(r_i)} = N_i b_i^{v_i} \frac{v_i^2}{\sigma-1} [E(f_i)]^{-\frac{v_i}{\sigma-1}-1} [E(r_i)]^{-v_i-1} B^{\frac{v_i}{\sigma-1}} > 0$. To show how the policies affect the impact of an actual disaster, we see that $\frac{\partial \Delta M_i}{\partial E(r_i)} < 0$ and thus the policies reduces ΔM_i upon a disaster. □

Proposition 3a. Emission Productivity *When technology becomes greener, which means the emission productivity distribution's lower bound b_i increases shifting the distribution to the right, the number of MNE's affiliates in the target country increases. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher emission productivity has no impact on the number of MNE's affiliates.*

Proposition 3b. Emission Productivity *When $\bar{z} \geq b_i \ \forall i$, higher emission productivity amplifies the effect of climate risks from Propositions 1 and 2 (hereafter we call this case Greener Loses); otherwise, higher emission productivity can have an ambiguous effect on the FDI impact of climate risks.*

Proof: First, consider the case of $\bar{z} < b_i \ \forall i$: no matter how b_i changes all potential affiliates are qualified for M&A, that is $\frac{\partial M}{\partial b_i} = 0$. Now consider the rest of the cases: Since $\sigma > 1$, we can see from equation (2) that $\frac{\partial M}{\partial b_i} > 0$. In addition, when $b_i \leq \bar{z} \ \forall i$, $\frac{\partial^2 M}{\partial E(f_i)\partial b_i} = N_i v_i b_i^{v_i-1} \frac{v_i}{\sigma-1} E(f_i)^{-\frac{v_i}{\sigma-1}-1} [\frac{B}{(E(r_i))^{\sigma-1}}]^{\frac{v_i}{\sigma-1}} < 0$. To show how emission productivity affects the impact of an actual disaster, we see that $\frac{\partial \Delta M_i}{\partial b_i} > 0$ and thus it increases ΔM_i upon a disaster. Similarly, $\frac{\partial^2 M}{\partial E(r_i)\partial b_i} < 0$ and thus higher emission productivity with a higher b_i can severe the impact of transition risk on FDI. When $\bar{z} \geq b_i \ \forall i$ does not always hold, various scenarios can emerge as illustrated and discussed in section 2.3. □

Proposition 4. Physical risk *When a target country's physical climate risk increases such that the affiliate's expected overhead cost $E(f_i)$ increases, FDI inflows to the target country decline.*

However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher physical risk has no impact on FDI.

Proof: Since $\sigma > 1$ and $\sigma - v_i < 1$, we can see from equation (3) that $\frac{\partial FDI_i}{\partial E(f_i)} < 0$. □

Proposition 5. Transition risk *When expected climate policies increase expected emission unit cost $E(r_i)$, FDI inflows to the target country decline, and the effect of physical risk from Proposition 4 is smaller. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher transition risk has no impact on FDI.*

Proof: Since $v_i > 0$, we can see from equation (3) that $\frac{\partial FDI_i}{\partial E(r_i)} < 0$. In addition, $\frac{\partial^2 FDI_i}{\partial E(f_i)\partial E(r_i)} > 0$. □

Proposition 6a. Emission Productivity *When technology becomes greener, which means the emission productivity distribution's lower bound b_i increases shifting the distribution to the right, FDI inflows to the target country increase. However, if the lower bound of the target country's emission productivity distribution is so high that all potential affiliates always satisfy the emission-productivity threshold (i.e., $\bar{z} < b_i \ \forall i$), then higher emission productivity has no impact on FDI.*

Proposition 6b. Emission Productivity *When $\bar{z} \geq b_i \forall i$, higher emission productivity amplifies the effect of climate risks from Propositions 4 and 5 (Greener Loses); otherwise, higher emission productivity can have an ambiguous effect on the FDI impact of climate risks.*

Proof: First, consider the case of $\bar{z} < b_i \ \forall i$: no matter how b_i changes all potential affiliates are qualified for M&A and FDI does not change, that is $\frac{\partial FDI_i}{\partial b_i} = 0$. Now consider the rest of the cases: Since $v_i > 0$, $\sigma > 1$ and $\sigma - v_i < 1$, we can see from equation (3) that $\frac{\partial FDI_i}{\partial b_i} > 0$. In addition, when $b_i \leq \bar{z} \ \forall i$, we have $\frac{\partial^2 FDI_i}{\partial E(f_i)\partial b_i} < 0$ and $\frac{\partial^2 FDI_i}{\partial E(r_i)\partial b_i} < 0$. When $\bar{z} \geq b_i \ \forall i$ does not always hold, various scenarios can emerge as illustrated and discussed in section 2.3. □

Appendix A.2 Summary Statistics and Maps

The tables below provide summary statistics of our detailed weather events data for advanced and emerging economics separately. 1 is for advanced countries, 2 is for emerging economies, and 3 is for low-income countries.

Table A.1: Summary Statistics of Climate Disaster Events: Five Categories

	drought_m	temperature_m	flood_m	storm_m	wildfire_m
1					
mean	0.03	0.12	0.41	0.78	0.13
sd	0.18	0.37	1.02	2.37	0.53
2					
mean	0.06	0.10	0.78	0.41	0.04
sd	0.25	0.35	1.74	1.45	0.24
3					
mean	0.06	0.04	0.60	0.32	0.01
sd	0.25	0.21	1.00	0.98	0.09
Total					
mean	0.05	0.09	0.64	0.50	0.06
sd	0.23	0.34	1.45	1.70	0.33

Figure A.1: Climate-related disaster events

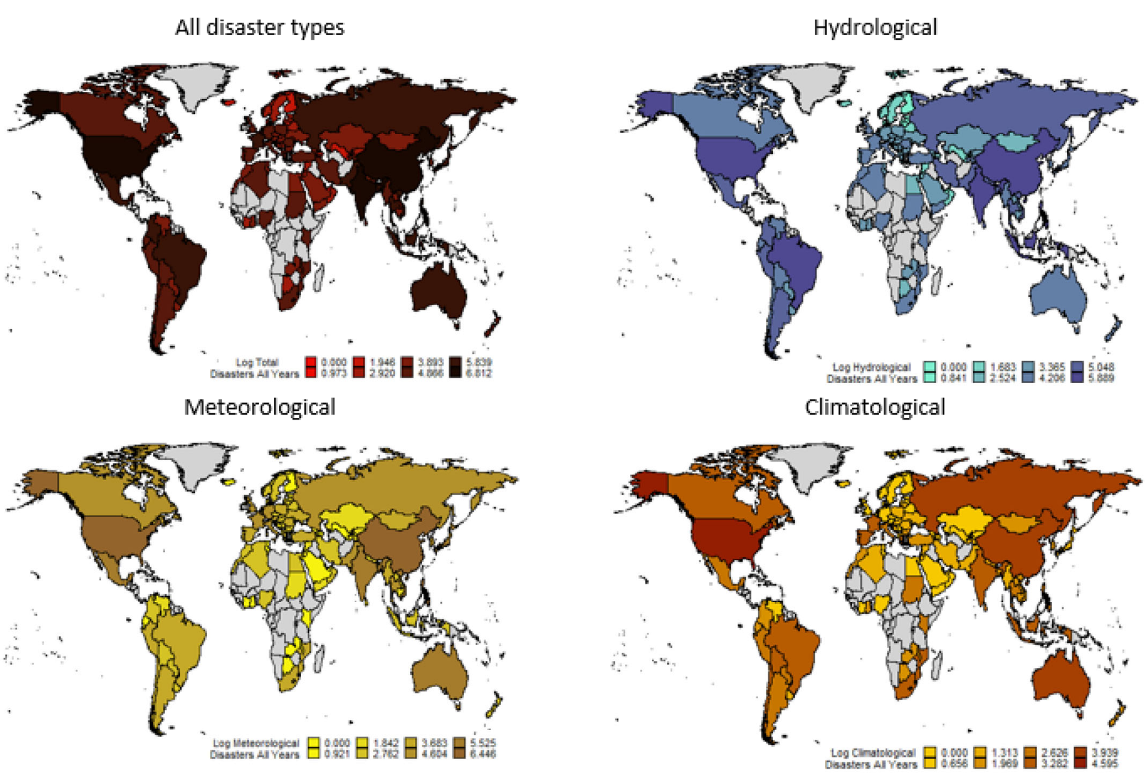


Figure A.2: Average annual change in net FDI inflows

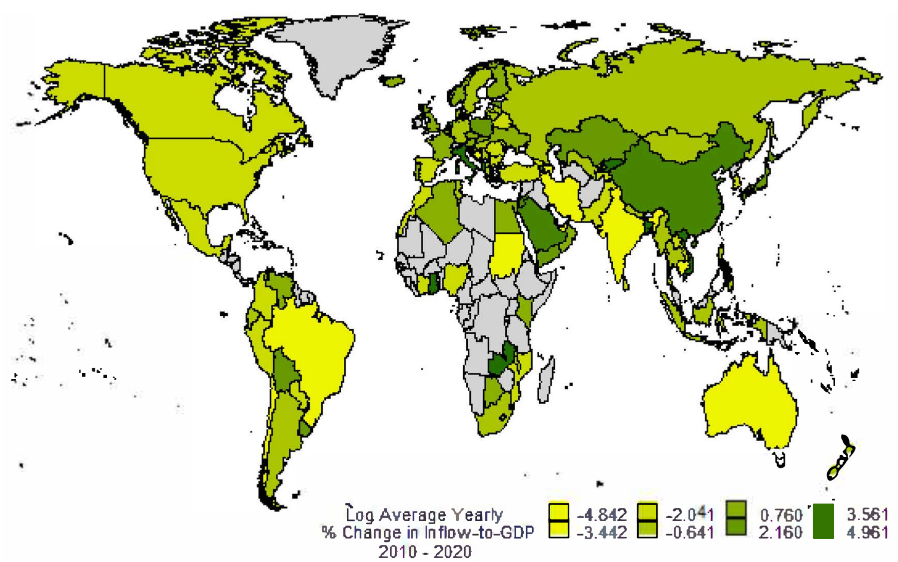
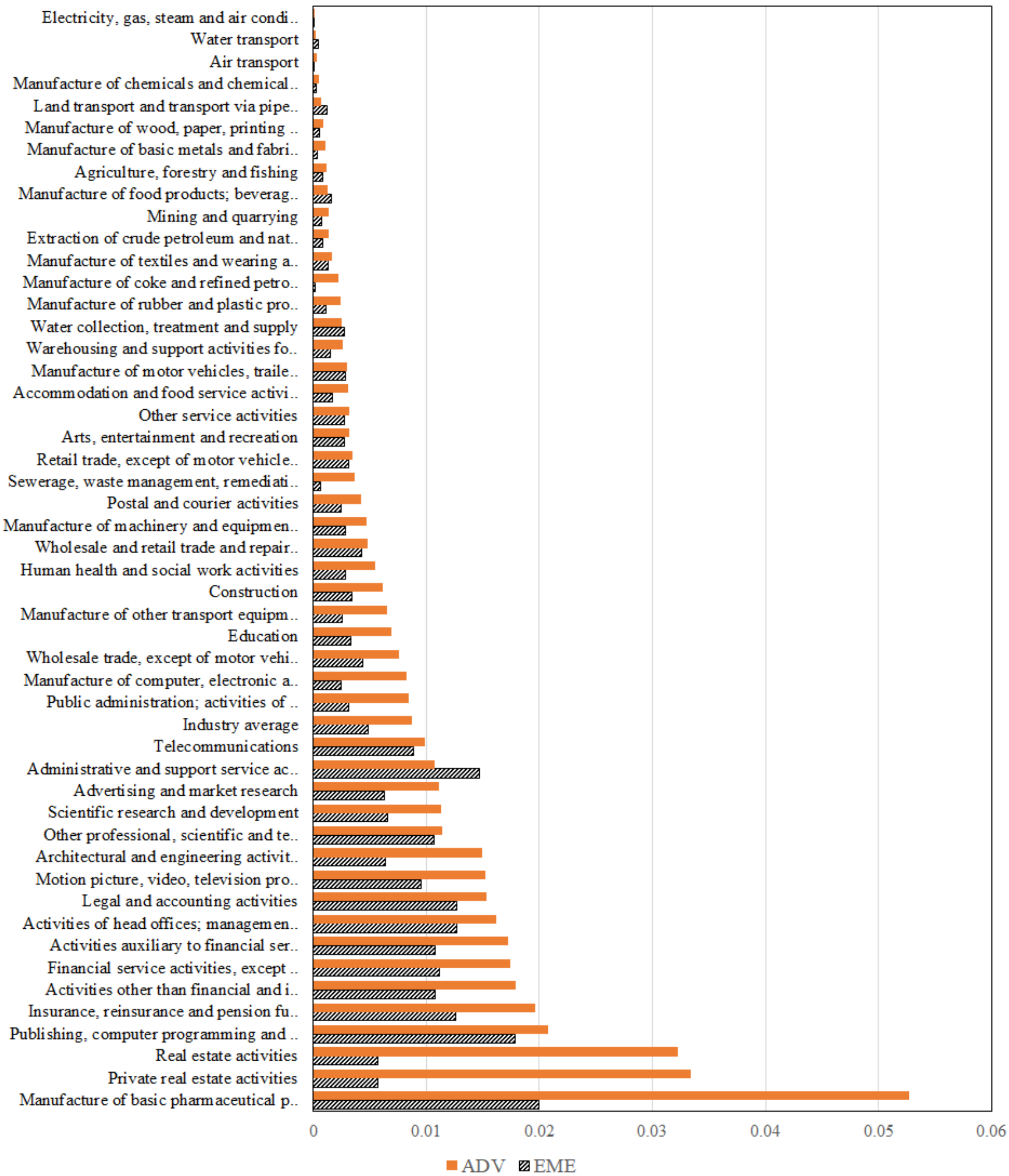


Figure A.3: Emission Productivity by Industry and Country Group

Notes: The bars represent average emission productivity in a given industry over time across countries in a country group (emerging or advanced economies). Emission productivity for each country-industry-year is computed as a ratio of real value added of the industry in a given country and given year to the emission-relevant total energy use minus energy use from nuclear and renewable resources for that industry, country, and year. Both series are from WIOD 16.



Appendix A.3 Selected robustness tests tables

In this section of the Appendix, we report tables for some of the robustness tests that we conducted. Additional robustness tests are reported in the Online Appendix. Here we report three tests: first, replacing climate disasters with ND-GAIN vulnerability index in benchmark regressions summarized in Figure 11; second, controlling for additional factors that may affect FDI flows but are not included in the benchmark regressions because they limit the sample due to data availability constraints: changes to corporate tax rates, exchange rates, or sovereign credit ratings; third, considering target-source relative emission policies.

Figure A.4: Interactions with Post-COP21: Vulnerability index

Notes: Reported are the coefficients from regressions at eight different aggregation levels as indicated. *Post* that takes on a value of 1 post-COP21 (from year 2016 on). Green up-arrows indicate positive coefficients larger than 0.001, red down-arrows indicated negative coefficients below -0.001, and yellow rectangles indicate all the coefficients in between. The coefficients in bold are significant at the 10% level at least. Dependent variables as well as fixed effects and sample years included in each specification are listed for each aggregation level. TC stands for the target country, SC for the source country, CG for the country group, and TI for the target country-industry. Full regressions are reported in the Appendix Tables A.9- A.28.

Aggregation level:	**X-section TC**			**X-section Bilateral**			**X-section bilateral PPML**			**Target country**		
	Full	AE	EME	Full	AE	EME	Full	AE	EME	Full	AE	EME
Sample years	pre/post 2015 aggregate			pre/post 2015 aggregate			pre/post 2015 aggregate			1970(96)-2019		
FEs	Country group			TC, SC			TC, SC			TC, Year, CG*Year		
LHS	TC inflow/GDP			D.FDI / Total FDI from SC			D.FDI / Total FDI from SC			TC inflow/GDP		
Effect on FDI (intensive margin)												
reg2												
Vulnerability	**-3.7**	17.55	-3.51	4.42	16.23	**0.89**	9.29	-42.35	-10.49	-23.8	4.8	-34.5
Post*Vulnerability	**12.4**	-16.10	**5.71**	0.54	2.07	**0.09**	**5.98**	**13.04**	6.29	6.0	-15.1	**15.7**

Aggregation level:	**Bilateral OLS**			**Bilateral-PPML**			**Target Country-industry**			**Firm**		
	Full	AE	EME	Full	AE	EME	Full	AE	EME	Full	AE	EME
Sample years	2011-2019			2011-2019			2006-2014(19)			2008-2019		
FEs	TC*SC, SC*Year			TC*SC, Year			TC*TI, TI*Year			Firm*Year, TC, TI		
LHS	D.FDI / Total FDI from SC			D.FDI / Total FDI from SC			TC Inflow/VA			D.Aff in TC/Total aff		
Effect on FDI (intensive margin)												
Vulnerability	1.817	11.09	-1.783	42.48	**107**	**-89**	5.19	5.71	-27.31	-0.146	-0.040	0.176
Post*Vulnerability	0.364	1.17	0.065	**5.70**	**9.71**	2.26				**0.028**	-0.028	0.009
Effect on FDI (extensive: inflow)												
Vulnerability	2.78	5.10	4.18				-1.120	-1.755	-12.020	-0.655	-0.130	-0.372
Post*Vulnerability	0.21	-0.06	**-0.48**				0.025	-0.036	**1.137***	**0.077**	-0.037	0.012
Effect on FDI (extensive: outflow)												
Vulnerability	**3.47**	3.02	1.47				2.488	2.339	10.98	-0.156	-0.127	0.034
Post*Vulnerability	0.15	-0.14	0.03				**-0.773**	-0.769	-0.979	**0.023**	0.002	-0.011

In the tables below Lclimate, Lmeteo, Lhydro are indicators of climatological, meteorological, and hydrological disasters in the previous year, respectively; Ldeath is the number disaster-related deaths, Ldiea (or Lreldiea) are changes in (target relative to source country) policies, Lemission is emission productivity, Ltrade_gdp is trade to GDP ratio, Lppig is PPI inflation, Lrgdpg is real GDP growth. All independent variables are lagged one year in all regressions. Standard errors and fixed effects are the same as in the benchmark specification.

Table A.2: Robustness: with Corporate Tax

	(1) Full sample	(2) AEs	(3) EMEs	(4) Full sample	(5) AEs	(6) EMEs
Lclimat	0.0265	-0.0103	1.700	-0.781*	-0.621*	-20.78
	(0.288)	(0.217)	(2.005)	(0.295)	(0.230)	(32.08)
Lmeteo	0.0192	0.0199	-1.882	0.468	0.530*	0.272
	(0.0478)	(0.0530)	(1.104)	(0.372)	(0.213)	(2.615)
Lhydro	-0.230	-0.219*	-0.976	-0.493	-0.567*	2.751
	(0.118)	(0.0704)	(0.929)	(0.342)	(0.240)	(13.14)
Ldeath	0.0659	0.0561	41.63	1.248***	1.038***	-44.00
	(0.0418)	(0.0383)	(19.18)	(0.196)	(0.137)	(88.59)
Ldiea	0.0136	-0.00281	0.269	0.117	0.107	0.350
	(0.0431)	(0.0379)	(0.210)	(0.0653)	(0.0555)	(0.455)
Lemission	-24.92**	-23.48**	-51.86	-17.71**	-15.30*	-54.15
	(5.377)	(6.097)	(30.96)	(5.020)	(5.605)	(50.60)
Ltrade_gdp	-0.0262**	-0.0328**	0.110**	-0.0274*	-0.0345**	0.0314
	(0.00685)	(0.00748)	(0.0231)	(0.0100)	(0.00967)	(0.0747)
Lppig	-0.00378	-0.0528	-0.111	-0.00289	-0.0614	-0.240
	(0.0500)	(0.0282)	(0.171)	(0.0542)	(0.0274)	(0.521)
Lrgdpg	-0.0222	0.00863	-0.162	-0.0198	0.0170	0.0217
	(0.0479)	(0.0491)	(0.117)	(0.0430)	(0.0370)	(0.208)
Ldcorptax	0.136*	-0.0674**	1.408*	0.118	-0.0784**	1.169
	(0.0544)	(0.0128)	(0.370)	(0.0546)	(0.0221)	(0.475)
Lemissionclimat				6.275**	4.564	200.8
				(1.528)	(2.480)	(278.5)
Lemissionmeteo				-2.895	-3.094*	-15.50
				(2.033)	(1.262)	(18.20)
Lemissionhydro				1.913	2.360	-31.71
				(1.743)	(1.250)	(121.3)
Lemissiondeath				-5.392***	-4.476***	856.2
				(0.624)	(0.380)	(643.3)
Lemissioniea				-0.589**	-0.602***	0.736
				(0.125)	(0.0811)	(3.862)
N	464	400	64	464	400	64
r2	0.523	0.568	0.513	0.526	0.571	0.536

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Robustness: with Exchange Rate Changes

	(1) Full sample	(2) AEs	(3) EMEs	(4) Full sample	(5) AEs	(6) EMEs
Lclimat	-0.0781	-0.0548	-0.243	0.0148	-1.080	0.194
	(0.151)	(0.121)	(0.359)	(0.332)	(0.632)	(0.492)
Lmeteo	0.0548	-0.0369*	0.0880	0.0437	-0.173	0.00646
	(0.0870)	(0.0131)	(0.144)	(0.0971)	(0.126)	(0.222)
Lhydro	-0.100	-0.157	-0.0998	-0.256*	-0.167	-0.110
	(0.118)	(0.112)	(0.139)	(0.111)	(0.383)	(0.243)
Ldeath	0.0274	-0.610	0.0377	-0.361	3.116***	-1.319
	(0.0310)	(0.323)	(0.0360)	(0.323)	(0.420)	(1.734)
Ldiea	-0.0258	-0.0419	0.0168	0.0418	0.0679	0.00716
	(0.0133)	(0.0319)	(0.0299)	(0.0409)	(0.0379)	(0.0348)
Lemission	6.315	-3.617	19.81	6.637	0.805	8.342
	(10.68)	(7.476)	(13.59)	(11.30)	(10.83)	(9.818)
Ltrade_gdp	-0.0323**	-0.0191	-0.0386	-0.0282***	-0.0182	-0.0412
	(0.00826)	(0.0145)	(0.0222)	(0.00545)	(0.0110)	(0.0193)
Lppig	0.0263	0.0686*	0.0244	0.0222	0.0696*	0.00836
	(0.0144)	(0.0227)	(0.0120)	(0.0192)	(0.0232)	(0.0146)
Lrgdpg	0.115	-0.0136	0.300**	0.110	-0.0130	0.289**
	(0.0928)	(0.0726)	(0.0725)	(0.0972)	(0.0638)	(0.0671)
Lrexrg_perusd	0.0243	-0.0117	0.0725*	0.0256	-0.0111	0.0758*
	(0.0143)	(0.00661)	(0.0240)	(0.0148)	(0.00519)	(0.0248)
Lemissionclimat				-0.218	9.624	-7.323
				(4.159)	(5.499)	(12.39)
Lemissionmeteo				-0.146	1.026	0.979
				(0.879)	(0.962)	(5.391)
Lemissionhydro				1.739	0.0721	-0.963
				(0.882)	(2.390)	(5.388)
Lemissiondeath				11.86	-27.70***	42.01
				(10.73)	(1.227)	(55.25)
Lemissioniea				-0.563**	-0.863**	0.170
				(0.133)	(0.213)	(0.720)
N	418	223	195	418	223	195
r2	0.390	0.589	0.345	0.393	0.599	0.353

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Robustness: with Sovereign Rating

	(1) Full sample	(2) AEs	(3) EMEs	(4) Full sample	(5) AEs	(6) EMEs
Lclimat	-0.176	-0.286	0.0101	-0.0652	-1.203**	0.574
	(0.141)	(0.248)	(0.247)	(0.229)	(0.288)	(0.509)
Lmeteo	-0.0142	-0.115	0.0779	0.229	0.567*	0.107
	(0.0323)	(0.103)	(0.127)	(0.214)	(0.226)	(0.131)
Lhydro	-0.111	-0.207**	-0.135	-0.295*	-0.521	-0.0798
	(0.113)	(0.0610)	(0.135)	(0.116)	(0.299)	(0.163)
Ldeath	0.0402	0.0759	0.0109	0.0311	1.167***	-1.253
	(0.0298)	(0.0406)	(0.0248)	(0.0213)	(0.109)	(1.487)
Ldiea	0.00320	-0.000685	-0.0104	0.0991	0.161**	-0.151
	(0.0447)	(0.0366)	(0.0395)	(0.0745)	(0.0496)	(0.107)
Lemission	-18.07*	-23.46**	5.040	-9.780	-9.755	-10.70
	(8.029)	(4.944)	(12.81)	(5.847)	(4.391)	(4.912)
Ltrade_gdp	-0.0335***	-0.0207*	-0.00919	-0.0351***	-0.0259**	-0.0171
	(0.00566)	(0.00764)	(0.0107)	(0.00221)	(0.00733)	(0.0165)
Lppig	-0.0122	-0.0413	0.0338	-0.00970	-0.0450	0.0242
	(0.0200)	(0.0274)	(0.0230)	(0.0184)	(0.0304)	(0.0167)
Lrgdpg	0.0727	0.0362	0.134	0.0737	0.0511*	0.119
	(0.0529)	(0.0288)	(0.0577)	(0.0478)	(0.0175)	(0.0527)
Lrating	-0.0539	-0.188**	0.548***	-0.0783	-0.230**	0.637***
	(0.0835)	(0.0436)	(0.0908)	(0.0842)	(0.0514)	(0.0501)
Lemissionclimat				-1.248	7.155**	-10.81
				(2.987)	(1.693)	(10.80)
Lemissionmeteo				-2.441	-4.048*	-0.184
				(1.445)	(1.548)	(3.515)
Lemissionhydro				1.700*	2.025	-1.939
				(0.652)	(1.268)	(4.020)
Lemissiondeath				0.0182	-4.966***	39.03
				(0.159)	(0.265)	(47.16)
Lemissioniea				-0.728***	-0.904***	1.868
				(0.141)	(0.0633)	(1.118)
N	618	414	204	618	414	204
r2	0.489	0.557	0.343	0.491	0.561	0.351

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Bilateral Intensive Robustness: with Relative Policy

	(1) Full Sample	(2) AEs	(3) EMEs	(4) HQ in Offshore
Lclimat	0.00473	0.0102*	-0.00888	0.00134**
	(0.00573)	(0.00549)	(0.0104)	(0.000555)
Lmeteo	0.000156	-0.00177	-0.00219	-0.000388
	(0.00123)	(0.00288)	(0.00329)	(0.000338)
Lhydro	0.00315**	0.00718**	0.00118	0.000109
	(0.00155)	(0.00296)	(0.00239)	(0.000138)
Ldeath	-0.000168	0.00992**	0.000984	-0.000113
	(0.000281)	(0.00448)	(0.000678)	(0.0000847)
Lreldiea	0.000260	-0.000371	0.000686	-0.00000614
	(0.000387)	(0.000404)	(0.000493)	(0.0000666)
Lemission	0.0955	0.309	0.416	-0.0305
	(0.167)	(0.231)	(0.390)	(0.0244)
Ltrade_gdp	-0.000945	-0.000214	-0.00304	-0.00000890
	(0.000965)	(0.000335)	(0.00272)	(0.0000490)
Lppig	0.00430***	0.00497*	0.00414*	0.000234**
	(0.00142)	(0.00246)	(0.00199)	(0.0000723)
Lrgdpg	-0.000845	0.000602	-0.00247	0.0000191
	(0.00139)	(0.000888)	(0.00255)	(0.000124)
N	33677	22029	11648	1995
r2	0.0374	0.00382	0.125	0.0822

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Bilateral Extensive Robustness: with Relative Policy

	(1) Inflows				(2) Outflows			
	Full Sample	AEs	EMEs	HQ in Offshore	Full Sample	AEs	EMEs	HQ in Offshore
Lclimat	-0.00206	-0.0162**	0.0119	-0.0143	-0.00617	-0.0141	-0.00128	0.00426
	(0.00528)	(0.00698)	(0.0108)	(0.0120)	(0.00607)	(0.0125)	(0.00918)	(0.0101)
Lmeteo	-0.000345	0.00440	-0.00144	0.00221	0.00496*	0.00553	0.00380	0.00235
	(0.00122)	(0.00358)	(0.00268)	(0.00282)	(0.00292)	(0.00689)	(0.00348)	(0.00274)
Lhydro	0.00186	0.00558	-0.000887	0.00678	-0.00841	-0.00702	-0.0115	-0.0000305
	(0.00253)	(0.00509)	(0.00202)	(0.00394)	(0.00541)	(0.00622)	(0.00842)	(0.00170)
Ldeath	-0.000904	-0.00651	-0.00192*	0.000116	-0.0000773	0.00154	-0.000479	-0.000398
	(0.000714)	(0.00914)	(0.000995)	(0.000676)	(0.000625)	(0.0134)	(0.000704)	(0.000660)
Lreldiea	-0.0000266	0.000163	-0.000505	0.0000382	0.00155	0.000462	0.00309	-0.000485
	(0.000660)	(0.000926)	(0.000869)	(0.000751)	(0.00116)	(0.00109)	(0.00198)	(0.000697)
Lemission	-0.0307	-0.169	0.575	-0.399	-0.820	-1.095	-0.388	0.0483
	(0.313)	(0.320)	(0.421)	(0.320)	(0.600)	(0.922)	(0.442)	(0.0989)
Ltrade_gdp	0.000491	0.000205	0.0000806	0.00108	0.000273	-0.0000642	0.000394	0.00148
	(0.000715)	(0.000855)	(0.00154)	(0.000948)	(0.000580)	(0.000978)	(0.000780)	(0.000909)
Lppig	0.00509	-0.00325	0.00769	0.00365*	0.000220	0.00510	-0.00284	-0.00149
	(0.00510)	(0.00484)	(0.00644)	(0.00163)	(0.00218)	(0.00586)	(0.00258)	(0.00203)
Lrgdpg	-0.000946	0.00115	-0.00596	-0.00286	0.00583	0.00698	0.00271	0.00492
	(0.00291)	(0.00331)	(0.00443)	(0.00218)	(0.00368)	(0.00541)	(0.00278)	(0.00433)
N	31819	20630	11189	1935	31837	20699	11138	1936
r2	0.195	0.191	0.217	0.190	0.195	0.193	0.203	0.187

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: Bilateral Intensive Robustness: with Relative Policy and Emission Prod. Interactions

	(1) Full Sample	(2) AEs	(3) EMEs	(4) HQ in Offshore
Lcounter_climatEMI	0.0331	0.0271	0.0594	-0.00298
	(0.0443)	(0.0509)	(0.0651)	(0.00982)
Lcounter_meteoEMI	-0.0435	-0.0523	-0.0351	-0.00103
	(0.0365)	(0.0410)	(0.0411)	(0.00696)
Lcounter_hydroEMI	-0.0822	-0.0796	-0.0114	0.00296
	(0.0701)	(0.0691)	(0.0247)	(0.00551)
Lcounter_deathEMI	-0.00155	-0.00128	-0.00104	-0.782
	(0.00419)	(0.00384)	(0.00369)	(1.296)
LclimatEMI	-0.0592	-0.191	-0.00693	-0.0206
	(0.144)	(0.140)	(0.210)	(0.0208)
LmeteoEMI	0.0173	-0.0169	0.138**	-0.00117
	(0.0178)	(0.0547)	(0.0537)	(0.0108)
LhydroEMI	0.0173	0.0585	-0.0346	-0.00150
	(0.0137)	(0.0578)	(0.0368)	(0.00359)
LdeathEMI	-0.0419	-0.133	0.0655	0.0143
	(0.0254)	(0.150)	(0.0831)	(0.00787)
LreldieaEMI	0.000323	0.00282	-0.0107*	-0.000660
	(0.00389)	(0.00577)	(0.00589)	(0.000914)
Lreldiea	0.0000680	-0.000724	0.000749	0.0000429
	(0.000755)	(0.00135)	(0.00116)	(0.000159)
Lemission	0.320	0.536	0.382	-0.0132
	(0.370)	(0.529)	(0.280)	(0.0152)
Lclimat	0.00308	0.0194	-0.00746	0.00376
	(0.0203)	(0.0221)	(0.0255)	(0.00269)
Lmeteo	-0.000584	0.00449	-0.0111**	-0.000270
	(0.00280)	(0.0113)	(0.00390)	(0.001000)
Lhydro	-0.000199	-0.00555	0.00559	0.000177
	(0.00187)	(0.0109)	(0.00468)	(0.000500)
Ldeath	0.00119	0.0306	-0.00123	-0.000671**
	(0.00108)	(0.0415)	(0.00275)	(0.000223)
Ltrade_gdp	-0.000207	-0.000254	-0.000244	-0.00000645
	(0.000252)	(0.000334)	(0.000540)	(0.0000412)
Lppig	0.00438**	0.00614	0.00336*	0.000266*
	(0.00205)	(0.00409)	(0.00183)	(0.000128)
Lrgdpg	-0.00133	0.0000736	-0.00260	-0.0000126
	(0.00112)	(0.00123)	(0.00227)	(0.000151)
N	23555	15484	8071	1995
r2	0.0188	0.0355	0.104	0.106

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.8: Bilateral Extensive Robustness: with Relative Policy and Emission Prod. Interactions

	(1) Inflows				(2) Outflows			
	Full Sample	AEs	EMEs	HQ in Offshore	Full Sample	AEs	EMEs	HQ in Offshore
Lcounter_climatEMI	-0.0390	-0.0146	-0.253	-0.00273	0.0320	0.0385	0.0425	-0.308
	(0.0636)	(0.0597)	(0.148)	(0.197)	(0.0585)	(0.0904)	(0.0817)	(0.207)
Lcounter_meteoEMI	0.00565	-0.00332	-0.0226	0.0233	0.00873	-0.0177	0.0500	-0.0258
	(0.0190)	(0.0261)	(0.0369)	(0.0891)	(0.0154)	(0.0192)	(0.0396)	(0.0773)
Lcounter_hydroEMI	0.0199	0.0265	0.00617	-0.0573	0.00287	0.0347	-0.0422	-0.00977
	(0.0199)	(0.0293)	(0.0263)	(0.0756)	(0.0282)	(0.0336)	(0.0459)	(0.0405)
Lcounter_deathEMI	0.00160	0.000402	0.00825	-24.19	-0.00550	-0.00178	0.00319	-0.209
	(0.00463)	(0.00383)	(0.0130)	(13.30)	(0.00724)	(0.00990)	(0.0102)	(10.32)
LclimatEMI	-0.0854	0.177	-0.310**	-0.0167	-0.137	-0.0347	-0.201	-0.0738
	(0.0669)	(0.255)	(0.108)	(0.114)	(0.122)	(0.380)	(0.254)	(0.194)
LmeteoEMI	0.00255	0.0228	-0.0588	0.0620	0.0456	0.0741	0.0157	0.0235
	(0.0248)	(0.0507)	(0.0495)	(0.0451)	(0.0335)	(0.0704)	(0.126)	(0.0207)
LhydroEMI	0.0295	-0.0695	0.0149	-0.0194	0.0269	0.136*	-0.0478	0.00815
	(0.0350)	(0.0608)	(0.0442)	(0.0447)	(0.0322)	(0.0738)	(0.0708)	(0.0156)
LdeathEMI	-0.000120	0.116	-0.0724	-0.0249	0.0490	-0.403	0.362	0.0142
	(0.0161)	(0.347)	(0.149)	(0.0316)	(0.0323)	(0.513)	(0.302)	(0.0322)
LreldieaEMI	0.0130**	0.0148**	-0.00545	0.0116	-0.00822	-0.00160	0.00305	-0.0129
	(0.00509)	(0.00648)	(0.0153)	(0.0128)	(0.00615)	(0.00740)	(0.0120)	(0.0109)
Lreldiea	-0.00193*	-0.00249	-0.000531	-0.000578	0.00333*	0.00149	0.00417	0.00189
	(0.000999)	(0.00192)	(0.00175)	(0.00231)	(0.00166)	(0.00176)	(0.00312)	(0.00172)
Lemission	-0.302	-0.397	0.508	-0.446	-0.651	-1.068	-0.598	0.0768
	(0.382)	(0.383)	(0.442)	(0.336)	(0.522)	(0.813)	(0.745)	(0.123)
Lclimat	0.00464	-0.0404	0.0277*	-0.0135	0.0137	0.000761	0.00954	0.0121
	(0.00936)	(0.0370)	(0.0134)	(0.0136)	(0.0130)	(0.0524)	(0.0146)	(0.0260)
Lmeteo	0.00112	0.00103	0.00568	-0.00445	-0.00154	-0.00976	0.00163	-0.000332
	(0.00305)	(0.00951)	(0.00500)	(0.00273)	(0.00396)	(0.0119)	(0.0103)	(0.00282)
Lhydro	-0.00103	0.0169	-0.00313	0.00950	-0.0101	-0.0300**	-0.00573	-0.00203
	(0.00537)	(0.00994)	(0.00484)	(0.00853)	(0.00620)	(0.0143)	(0.00963)	(0.00289)
Ldeath	-0.000443	-0.0363	0.000438	0.00118	-0.00217	0.122	-0.0124	-0.00107
	(0.00109)	(0.0996)	(0.00499)	(0.00106)	(0.00145)	(0.149)	(0.0101)	(0.00178)
Ltrade_gdp	0.000263	0.000140	-0.0000743	0.000989	0.000557	0.000112	0.00114	0.00139
	(0.000654)	(0.000913)	(0.00114)	(0.000936)	(0.000653)	(0.000987)	(0.000878)	(0.000928)
Lppig	0.00374	-0.00465	0.00606	0.00323	-0.000220	0.00567	-0.00394	-0.00144
	(0.00403)	(0.00509)	(0.00481)	(0.00202)	(0.00208)	(0.00618)	(0.00260)	(0.00191)
Lrgdpg	0.000724	0.00187	-0.00266	-0.00230	0.00306	0.00296	0.00397	0.00491
	(0.00220)	(0.00270)	(0.00294)	(0.00243)	(0.00291)	(0.00435)	(0.00277)	(0.00402)
N	22291	14515	7776	1935	22282	14541	7741	1936
r2	0.223	0.237	0.287	0.212	0.223	0.235	0.271	0.208

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix A.4 Tables reflected in summaries in Figures 11, 12, and 13.

The tables below provide detailed regression results that are used to construct the result heatmap and summaries in the main text.

Table A.9: Country-level: Cross section. Intensive margin

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.0270**	0.0408	-0.0162			
	(0.0103)	(0.0198)	(0.0449)			
(mean) hydro_sum	-0.00597	-0.0279	-0.000878			
	(0.00335)	(0.0161)	(0.00760)			
(mean) death_sum	-0.00207	-0.00809	0.00137			
	(0.00110)	(0.00743)	(0.0167)			
postclimat	0.252	0.198	-0.169			
	(0.154)	(0.157)	(0.114)			
posthydro	0.0195	0.0554	0.0200			
	(0.0315)	(0.0932)	(0.0203)			
postdeath	-0.0805	0.0161	0.0567			
	(0.0648)	(0.106)	(0.0925)			
post	-0.909	-3.024*	-0.650	-5.528**	3.005	-2.748
	(1.432)	(1.023)	(1.125)	(1.739)	(1.301)	(1.919)
(mean) trade_gdp_mean	0.0395***	0.0289*	0.0414*	0.0388***	0.0242**	0.0412*
	(0.00776)	(0.0102)	(0.0159)	(0.00606)	(0.00463)	(0.0178)
(mean) ppig_mean	0.00503	-0.157*	0.00688	0.00554	-0.150**	0.00702
	(0.0101)	(0.0513)	(0.0108)	(0.00963)	(0.0345)	(0.0106)
(mean) rgdpg_mean	-0.0386	-0.0716	-0.107	-0.0663	-0.208	-0.0803
	(0.118)	(0.166)	(0.137)	(0.106)	(0.219)	(0.132)
Vulnerability				-3.674*	17.55	-3.509
				(1.766)	(10.68)	(5.646)
postvul				12.38***	-16.10	5.713*
				(2.473)	(7.020)	(2.375)
N	192	56	102	192	56	102
r2	0.216	0.213	0.201	0.216	0.171	0.199

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.10: Bilateral: Cross section. Intensive margin

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.0123	0.107	-0.00593*			
	(0.0200)	(0.102)	(0.00217)			
(mean) hydro_sum	-0.00179	-0.0365	0.000153			
	(0.00264)	(0.0279)	(0.0000816)			
(mean) death_sum	-0.00102	-0.0587*	0.000276			
	(0.00159)	(0.0231)	(0.000194)			
postclimat	0.0150	0.107	-0.00334			
	(0.0152)	(0.0865)	(0.00218)			
posthydro	-0.000708	-0.0655	-0.000319			
	(0.00108)	(0.0435)	(0.000291)			
postdeath	0.000658	0.280	0.00901***			
	(0.00800)	(0.225)	(0.00117)			
post	-0.0330	-0.203	0.00136	-0.219	-0.744	-0.0326**
	(0.0391)	(0.172)	(0.00139)	(0.232)	(0.958)	(0.0108)
(mean) trade_gdp_mean	0.0000125	0.00820	-0.000201	0.000294	0.00977	-0.000382*
	(0.000657)	(0.0115)	(0.000166)	(0.00108)	(0.0169)	(0.000138)
(mean) ppig_mean	-0.00255	-0.106	0.000333	-0.000644	-0.103	0.000261
	(0.00371)	(0.112)	(0.000363)	(0.00170)	(0.161)	(0.000225)
(mean) rgdpg_mean	0.000493	0.0271	0.000259	0.00571	0.00873	0.000774***
	(0.00566)	(0.0129)	(0.000615)	(0.00537)	(0.0144)	(0.000160)
Vulnerability				4.418	16.23	0.891**
				(4.449)	(20.14)	(0.217)
postvul				0.544	2.072	0.0898**
				(0.566)	(2.787)	(0.0281)
N	28580	9992	14502	28580	9992	14502
r2	0.00783	0.0250	0.0244	0.00784	0.0242	0.0243

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.11: Bilateral: Cross section. Intensive margin: PPML

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.00233	0.0410	-0.237***			
	(0.0279)	(0.0733)	(0.0520)			
(mean) hydro_sum	0.00689	-0.0720***	0.0396***			
	(0.00732)	(0.0201)	(0.0127)			
(mean) death_sum	-0.00253	0.358***	0.0130**			
	(0.00373)	(0.133)	(0.00607)			
postclimat	-0.0730***	0.0133	0.0764			
	(0.0122)	(0.0512)	(0.0966)			
posthydro	-0.00609	-0.148**	-0.00640			
	(0.0120)	(0.0608)	(0.00816)			
postdeath	0.345***	1.646***	0.449***			
	(0.0785)	(0.249)	(0.0296)			
post	0.112	-0.638***	-0.235**	-2.146***	-4.737***	-2.511
	(0.0694)	(0.115)	(0.113)	(0.292)	(0.878)	(2.168)
(mean) trade_gdp_mean	-0.0262	-0.0963***	0.0232	-0.0129	-0.0281	-0.00752
	(0.0178)	(0.0181)	(0.0171)	(0.0124)	(0.0219)	(0.0137)
(mean) ppig_mean	0.0529***	0.610***	0.0160	0.0350*	0.329***	-0.00704
	(0.0135)	(0.0805)	(0.0255)	(0.0208)	(0.125)	(0.0366)
(mean) rgdpg_mean	0.236***	0.567***	-0.0235	0.265***	0.448***	0.0395
	(0.0355)	(0.0523)	(0.0260)	(0.0466)	(0.0911)	(0.0453)
Vulnerability				9.285	-42.35	-10.49
				(32.46)	(32.58)	(46.73)
postvul				5.979***	13.04***	6.294
				(0.814)	(3.504)	(5.281)
N	28580	9952	14502	28580	9952	14502
r2	0.356	0.367	0.416	0.360	0.358	0.403

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.12: Country-level: Main and Interaction Effects. Intensive margin

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	-0.0226	0.00766	-0.118	0.0166	-0.662*	0.255
	(0.121)	(0.185)	(0.258)	(0.285)	(0.218)	(0.482)
Lmeteo	0.0238	-0.0144	0.0421	0.239	0.589*	0.0587
	(0.0301)	(0.0820)	(0.145)	(0.237)	(0.231)	(0.149)
Lhydro	-0.138	-0.260**	-0.124	-0.309**	-0.584	-0.158
	(0.101)	(0.0669)	(0.150)	(0.110)	(0.285)	(0.172)
Ldeath	0.0302	0.0539	0.0286	0.0248	1.055***	-1.223
	(0.0248)	(0.0409)	(0.0264)	(0.0151)	(0.132)	(1.635)
Ldiea	-0.00254	0.00106	-0.0194	0.0832	0.135	-0.0588
	(0.0436)	(0.0372)	(0.0561)	(0.0605)	(0.0601)	(0.0400)
Lemission	-19.24	-28.55**	7.299	-12.62*	-17.78*	-6.505
	(9.236)	(7.641)	(10.76)	(5.722)	(5.931)	(7.447)
Ltrade_gdp	-0.0343***	-0.0285**	-0.0401*	-0.0357***	-0.0339**	-0.0431**
	(0.00478)	(0.00542)	(0.0138)	(0.00216)	(0.00867)	(0.0133)
Lppig	-0.0131	-0.0641*	0.0239	-0.0108	-0.0696*	0.00926
	(0.0199)	(0.0233)	(0.0120)	(0.0172)	(0.0263)	(0.0202)
Lrgdpg	0.0678	0.0175	0.165*	0.0669	0.0274	0.143
	(0.0660)	(0.0446)	(0.0614)	(0.0638)	(0.0329)	(0.0649)
Lemissionclimat				-0.391	5.399	-5.977
				(3.933)	(2.916)	(10.34)
Lemissionmeteo				-2.060	-3.706*	-0.590
				(1.524)	(1.495)	(4.096)
Lemissionhydro				1.578	2.157	-0.393
				(0.742)	(1.308)	(4.283)
Lemissiondeath				-0.0248	-4.559***	38.71
				(0.190)	(0.331)	(51.82)
Lemissioniea				-0.656***	-0.750***	0.544
				(0.0867)	(0.105)	(0.653)
N	629	425	204	629	425	204
r2	0.489	0.554	0.333	0.491	0.558	0.341

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.13: Country-level: Disasters only. Intensive margin

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	-0.311***	-0.334	-0.114			
	(0.0756)	(0.243)	(0.112)			
Lmeteo	0.0134	0.00678	0.00829			
	(0.0225)	(0.0318)	(0.0332)			
Lhydro	-0.112**	-0.310*	-0.0850			
	(0.0323)	(0.103)	(0.0578)			
Ldeath	0.00248	-0.0234	0.0340			
	(0.00285)	(0.0410)	(0.0222)			
post15Lclimat	0.989**	1.442	-0.117			
	(0.379)	(1.092)	(0.532)			
post15Lmeteo	-0.113***	-0.336	-0.0785*			
	(0.0263)	(0.262)	(0.0358)			
post15Lhydro	0.148***	0.858	0.132			
	(0.0212)	(0.422)	(0.126)			
post15Ldeath	0.283	-0.0643	0.622			
	(0.194)	(0.109)	(0.993)			
Ltrade_gdp	0.0337**	0.0427*	0.0278**	0.0350**	-0.0363*	0.0554*
	(0.00838)	(0.0137)	(0.00636)	(0.0126)	(0.0144)	(0.0224)
Lppig	-0.000272	0.108***	-0.000238	-0.00233	-0.0190	-0.000813
	(0.000138)	(0.0176)	(0.000138)	(0.00168)	(0.0265)	(0.00296)
Lrgdpg	0.0530**	0.0269	0.0606***	0.0450	-0.0333	0.0676
	(0.0138)	(0.0733)	(0.00941)	(0.0488)	(0.0508)	(0.0375)
Lvul				-23.83	4.780	-34.50
				(17.87)	(12.87)	(27.65)
post15Lvul				6.029	-15.11	15.66*
				(7.615)	(18.17)	(5.721)
N	3774	1142	2031	2252	663	1193
r2	0.363	0.313	0.366	0.369	0.370	0.347

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.14: Target-Country-Industry-level: Main Effects.

	(1) Intensive Magin			(2) Extensive: inflows			(3) Extensive: outflows		
	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.0535	0.174	-0.333	0.00861	-0.0138	0.0338	-0.0122	0.00691	-0.0217
	(0.0581)	(0.146)	(0.384)	(0.0258)	(0.0291)	(0.101)	(0.0179)	(0.0231)	(0.102)
Lmeteo	-0.0239	-0.00924	0.0901	-0.00919	-0.00480	-0.0228	0.00311	0.000407	0.0145
	(0.0231)	(0.0450)	(0.175)	(0.00692)	(0.00962)	(0.0574)	(0.00736)	(0.00761)	(0.0580)
Lhydro	-0.0219	-0.0377	-0.0188	0.00443	0.0167*	0.00247	0.00520	-0.00362	-0.00498
	(0.0254)	(0.0465)	(0.0349)	(0.00619)	(0.00799)	(0.0180)	(0.00541)	(0.00590)	(0.0182)
Ldeath	-0.0811	-0.0193	-2.188	-0.0489	-0.0419	-0.0245	0.0212	0.0259	0.0467
	(0.0884)	(0.0738)	(2.567)	(0.0398)	(0.0536)	(0.709)	(0.0342)	(0.0495)	(0.709)
Ldiea	-0.00234	-0.00955	0	0.000505	-0.00626*	0.00855	0.000490	0.00722**	-0.00648
	(0.00410)	(0.0121)	(.)	(0.00360)	(0.00320)	(0.0243)	(0.00365)	(0.00283)	(0.0244)
L.emissionx	3.049	1.002	18.97	2.882***	3.401***	-9.622	-1.127**	-1.682**	9.849
	(3.450)	(4.356)	(31.22)	(0.331)	(0.588)	(16.38)	(0.472)	(0.724)	(16.30)
Ltrade_gdp	-0.00915	-0.0111	0	-0.0000926	0.00121	0	-0.000116	-0.00173	0
	(0.00869)	(0.00983)	(.)	(0.00110)	(0.00164)	(.)	(0.00121)	(0.00144)	(.)
Lppig	-0.00635	-0.00663	0	-0.00374	-0.00202	0	0.00455	0.00229	0
	(0.0117)	(0.0120)	(.)	(0.00406)	(0.00514)	(.)	(0.00316)	(0.00399)	(.)
Lrgdpg	0.0108	0.0121	0	0.00255	0.00147	0	-0.00221	-0.000316	0
	(0.0123)	(0.0141)	(.)	(0.00494)	(0.00533)	(.)	(0.00471)	(0.00507)	(.)
N	2890	2282	450	3510	2808	540	3510	2808	540
r2	0.631	0.625	0.834	0.553	0.564	0.710	0.386	0.396	0.693

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.15: Target-Country-Industry-level: Interactions with emission productivity

	(1) Intensive Magin			(2) Extensive: inflows			(3) Extensive: outflows		
	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological$*EP^T$	5.369	7.908	-64.29	0.685	1.222	-17.25	1.366	0.876	16.91
	(4.793)	(7.527)	(91.88)	(1.198)	(1.179)	(10.24)	(0.820)	(0.670)	(10.26)
L.emissionmeteo	-5.251	-6.235	22.51	0.693	0.572	12.08	-0.936**	-0.778***	-11.80
	(5.533)	(7.519)	(40.17)	(0.495)	(0.435)	(4.392)	(0.301)	(0.159)	(4.405)
L.emissionhydro	-5.002	-6.071	-7.285	1.171*	0.993	-0.572	-0.689*	-0.446	0.772
	(5.244)	(7.208)	(5.952)	(0.547)	(0.627)	(3.744)	(0.348)	(0.379)	(3.767)
L.emissiondeath	-6.895	-6.943	-582.7	0.358	0.0180	-162.2	0.700	1.120	163.8
	(7.729)	(7.614)	(622.9)	(1.164)	(1.363)	(53.32)	(1.056)	(0.944)	(53.50)
L.emissiondiea	0.114	0.200	-3.087	-0.0508	0.0154	-1.813	0.00137	-0.0741*	1.816
	(0.301)	(0.471)	(3.838)	(0.0881)	(0.0774)	(1.336)	(0.0502)	(0.0403)	(1.356)
L.emissionx	6.938	4.544	79.10	3.028**	2.685*	25.62	-0.687	-0.295	-26.60
	(4.318)	(3.009)	(108.3)	(1.001)	(1.241)	(48.78)	(0.544)	(0.966)	(49.31)
N	2888	2280	450	3507	2805	540	3507	2805	540
r2	0.640	0.635	0.842	0.567	0.580	0.720	0.400	0.410	0.703

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.16: Target-Country-Industry-level: Disasters only. Intensive margin

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.0163	0.0893	-0.351			
	(0.0281)	(0.0765)	(0.393)			
Lmeteo	-0.0139	-0.00182	0.0833			
	(0.0183)	(0.0244)	(0.122)			
Lhydro	-0.00474	-0.0148	-0.00116			
	(0.0169)	(0.0223)	(0.0402)			
Ldeath	-0.0859	-0.0617	-2.194			
	(0.0929)	(0.0685)	(2.352)			
	(7.60e-22)	(3.09e-15)	(.)	(0.00000500)	(0.000000608)	(0.00000395)
Ltrade_gdp	-0.0121	-0.0141	-0.00701	-0.0129	-0.0141	0.00802
	(0.0103)	(0.0118)	(0.0234)	(0.0111)	(0.0125)	(0.00662)
Lppig	-0.00838	-0.00837	0	-0.00852	-0.00740	-0.0589
	(0.0119)	(0.0118)	(.)	(0.0117)	(0.0109)	(0.0488)
Lrgdpg	0.0150	0.0152	0	0.0157	0.0153	0.0523
	(0.0142)	(0.0152)	(.)	(0.0152)	(0.0148)	(0.0500)
Lvul				5.186	5.713	-27.31
				(4.128)	(3.501)	(62.94)
post15Lvul				0	0	0
				(0.000000762)	(0.00000520)	(2.90e-09)
N	3517	2815	540	3517	2815	540
r2	0.645	0.644	0.840	0.645	0.644	0.838

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.17: Target-Country-Industry-level: Disasters only. Extensive margin: inflows

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	0.00943	0.00357	0.0217			
	(0.0185)	(0.0214)	(0.0453)			
Lmeteo	-0.00728	-0.00548	-0.00347			
	(0.00574)	(0.00750)	(0.0126)			
Lhydro	0.00529	0.0100	0.00148			
	(0.00671)	(0.0118)	(0.0127)			
Ldeath	-0.0781	-0.0921	-0.0761			
	(0.0645)	(0.0688)	(0.172)			
post15Lclimat	-0.0325*	-0.0200	-0.126*			
	(0.0175)	(0.0207)	(0.0596)			
post15Lmeteo	0.00515	0.00413	0.0139			
	(0.00448)	(0.00657)	(0.0161)			
post15Lhydro	-0.0122	-0.0239	0.0104			
	(0.0103)	(0.0155)	(0.0168)			
post15Ldeath	0.0696	0.0836	-0.0123			
	(0.0664)	(0.0704)	(0.328)			
Ltrade_gdp	-0.00161*	-0.00142	-0.00205	-0.00170*	-0.00169*	-0.00123
	(0.000900)	(0.000962)	(0.00201)	(0.000904)	(0.000989)	(0.00236)
Lppig	-0.00162	0.00160	-0.00939	-0.00147	0.00170	-0.000634
	(0.00358)	(0.00422)	(0.00810)	(0.00344)	(0.00424)	(0.00591)
Lrgdpg	0.00363	0.00119	0.0133*	0.00374	0.00152	0.0147*
	(0.00285)	(0.00301)	(0.00518)	(0.00264)	(0.00283)	(0.00591)
Lvul				-1.120	-1.755	-12.02
				(3.265)	(4.137)	(9.604)
post15Lvul				0.0252	-0.0361	1.137*
				(0.345)	(0.460)	(0.477)
N	11581	9629	1800	11581	9629	1800
r2	0.499	0.492	0.564	0.498	0.491	0.563

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.18: Target-Country-Industry-level: Disasters only. Extensive margin: outflows

	Full Sample	AEs	EMEs	Full Sample	AEs	EMEs
Climatological	-0.0147	-0.00277	-0.0315			
	(0.0148)	(0.0141)	(0.0423)			
Lmeteo	0.000181	-0.00442	0.00238			
	(0.00632)	(0.00779)	(0.0119)			
Lhydro	0.00153	-0.00643	0.00102			
	(0.00708)	(0.0102)	(0.0127)			
Ldeath	0.0302	0.0462	0.0532			
	(0.0338)	(0.0372)	(0.174)			
post15Lclimat	0.0220	-0.00605	0.139**			
	(0.0172)	(0.0154)	(0.0516)			
post15Lmeteo	-0.00476	-0.000333	-0.0137			
	(0.00464)	(0.00621)	(0.0143)			
post15Lhydro	0.00404	0.0184	-0.00459			
	(0.0123)	(0.0136)	(0.0145)			
post15Ldeath	-0.0158	-0.0346	0.00390			
	(0.0377)	(0.0412)	(0.311)			
Ltrade_gdp	0.00138	0.00159	-0.000481	0.00136	0.00138	-0.000821
	(0.000994)	(0.00108)	(0.00205)	(0.000888)	(0.000943)	(0.00266)
Lppig	0.00644*	0.00624	0.00796	0.00684**	0.00591	-0.000323
	(0.00331)	(0.00477)	(0.00745)	(0.00337)	(0.00454)	(0.00680)
Lrgdpg	-0.00492*	-0.00401	-0.0123*	-0.00556**	-0.00447	-0.0142
	(0.00247)	(0.00303)	(0.00578)	(0.00221)	(0.00269)	(0.00710)
Lvul				2.488	2.339	10.98
				(3.322)	(3.841)	(8.876)
post15Lvul				-0.773**	-0.769	-0.979
				(0.360)	(0.495)	(0.548)
N	11581	9629	1800	11581	9629	1800
r2	0.321	0.329	0.513	0.322	0.329	0.512

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.19: Bilateral: Main Effects. Intensive margin: PPML

	Full Sample	AEs	EMEs
Source:			
Climatological	-0.258***	-0.230***	-0.281***
	(0.0211)	(0.0186)	(0.0575)
Lcounter_meteo	0.0602***	-0.0328***	0.305***
	(0.0163)	(0.00199)	(0.0515)
Lcounter_hydro	0.112***	0.0970***	0.151**
	(0.0122)	(0.00831)	(0.0641)
Lcounter_death	-0.00770**	-0.00437*	-0.0202
	(0.00325)	(0.00230)	(0.0232)
Ldcounter_iea	0.107***	0.110***	0.0769***
	(0.00818)	(0.00368)	(0.00650)
Lcounter_emission	-9.195***	-8.821***	-9.790
	(2.869)	(1.246)	(8.506)
Lclimat	-0.345**	-0.317***	0.107
	(0.149)	(0.0141)	(0.249)
Lmeteo	-0.0887	-0.154	-0.0927
	(0.121)	(0.165)	(0.0747)
Lhydro	0.278	0.116	0.294
	(0.189)	(0.201)	(0.188)
Ldeath	0.0308***	0.203**	0.0132***
	(0.00950)	(0.0934)	(0.00488)
Ldiea	0.0256	0.0331***	-0.000784
	(0.0173)	(0.00578)	(0.0353)
Lemission	-11.79***	-7.505***	-16.17***
	(1.164)	(1.180)	(4.011)
Ltrade_gdp	-0.00429	-0.0251*	0.0296*
	(0.00389)	(0.0138)	(0.0157)
Lppig	0.0930***	0.101***	0.0350
	(0.0221)	(0.00848)	(0.0801)
Lrgdpg	-0.0594*	0.0617***	-0.0993
	(0.0320)	(0.0216)	(0.106)
Lcounter_trade_gdp	-0.0327***	-0.0354***	-0.0300***
	(0.00591)	(0.00780)	(0.00559)
Lcounter_ppig	-0.0400***	-0.0252**	-0.0723***
	(0.00985)	(0.0119)	(0.0238)
Lcounter_rgdpg	0.190***	0.195***	0.126***
	(0.0245)	(0.0190)	(0.0119)
N	9807	6531	3276
r2			

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.20: Bilateral: Main Effects. Extensive margin

	(1) Inflows				(2) Outflows			
	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Source:								
Climatological	-0.0000609	-0.00116	0.00173	0	-0.0117***	-0.0118**	-0.0114	0
	(0.00370)	(0.00638)	(0.00391)	(.)	(0.00401)	(0.00425)	(0.00907)	(.)
Lcounter_meteo	-0.000949	-0.0000253	-0.00281	0.00150	0.00440*	0.00529	0.00262	0.00476
	(0.00199)	(0.00281)	(0.00232)	(0.0114)	(0.00253)	(0.00313)	(0.00266)	(0.00402)
Lcounter_hydro	0.00318	0.00409	0.00116	-0.0214	-0.00137	-0.00291	0.00153	0.0511*
	(0.00281)	(0.00344)	(0.00277)	(0.0130)	(0.00244)	(0.00393)	(0.00166)	(0.0211)
Lcounter_death	-0.000251	0.000209	-0.00121	-1.225	0.000224	-0.000119	0.000999	-2.584
	(0.000430)	(0.000551)	(0.000837)	(1.368)	(0.000429)	(0.000534)	(0.000770)	(1.551)
Ldcounter_iea	-0.000752	-0.000494	-0.00127	0.000244	0.000450	0.00147	-0.00156	0.000780
	(0.000701)	(0.000971)	(0.000873)	(0.000998)	(0.000756)	(0.000957)	(0.00101)	(0.000750)
Lcounter_emission	0.0579	0.0555	0.0505	-0.00842	-0.00433	-0.0791	0.138	-0.0817
	(0.0872)	(0.120)	(0.0889)	(0.0834)	(0.113)	(0.161)	(0.143)	(0.115)
Lclimat	-0.00729***	-0.0109**	-0.00588	-0.00822	-0.00176	-0.00396	-0.00243	0.00320
	(0.00193)	(0.00495)	(0.00434)	(0.00967)	(0.00480)	(0.00768)	(0.00474)	(0.0173)
Lmeteo	0.00291*	0.00461	0.00344**	-0.00264	0.000652	-0.000274	0.000839	-0.00211
	(0.00143)	(0.00327)	(0.00133)	(0.00213)	(0.00182)	(0.00385)	(0.00180)	(0.00285)
Lhydro	0.000589	0.00243	-0.000466	0.00214	-0.00263	-0.00204	-0.00405	-0.000746
	(0.00135)	(0.00337)	(0.00143)	(0.00219)	(0.00245)	(0.00400)	(0.00384)	(0.00264)
Ldeath	-0.0000569	-0.000611	-0.000598	0.000341	0.000141	0.0118	-0.000111	-0.000340
	(0.000331)	(0.00817)	(0.000408)	(0.000871)	(0.000377)	(0.00718)	(0.000294)	(0.000983)
Ldiea	-0.000745	-0.000363	-0.00105	0.000374	0.000548	-0.000000141	0.00136	-0.000229
	(0.000506)	(0.000750)	(0.000982)	(0.000630)	(0.000797)	(0.000782)	(0.00138)	(0.000694)
Lemission	-0.288	-0.458	0.139	-0.201	0.0708	0.175	-0.234	0.228
	(0.232)	(0.277)	(0.253)	(0.191)	(0.283)	(0.380)	(0.276)	(0.212)
Ltrade_gdp	-0.0000567	-0.000549	0.000463	-0.000641	0.000616	0.000844	0.000247	0.00128
	(0.000403)	(0.000509)	(0.000579)	(0.000854)	(0.000523)	(0.000790)	(0.000436)	(0.00148)
Lppig	0.00225	-0.00263	0.00439	0.00386	0.000289	0.000796	-0.00177	0.000236
	(0.00246)	(0.00314)	(0.00291)	(0.00327)	(0.00117)	(0.00360)	(0.00146)	(0.00124)
Lrgdpg	0.00190	0.00279	-0.000362	0.00103	-0.00108	-0.000578	0.000177	0.00172
	(0.00120)	(0.00170)	(0.00184)	(0.00187)	(0.00223)	(0.00348)	(0.00168)	(0.00345)
Lcounter_trade_gdp	-0.000297	-0.000371	-0.000159	-0.00000470	0.000160	0.0000982	0.000288	-0.000267*
	(0.000312)	(0.000363)	(0.000355)	(0.000242)	(0.000319)	(0.000414)	(0.000210)	(0.000105)
Lcounter_ppig	0.0000917	-0.00153	0.00342	0.00349	-0.000890	-0.00154	0.000484	-0.00461
	(0.00102)	(0.00117)	(0.00192)	(0.00262)	(0.00116)	(0.00141)	(0.00184)	(0.00310)
Lcounter_rgdpg	0.00135	0.00296**	-0.00167	-0.000124	-0.00203	-0.00223	-0.00170	0.00114
	(0.000840)	(0.00113)	(0.00106)	(0.000622)	(0.00149)	(0.00222)	(0.00160)	(0.00109)
Observations	9740	6446	3294	1011	9729	6446	3283	1013
R^2	0.221	0.221	0.220	0.173	0.224	0.225	0.210	0.200

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.21: Bilateral: Interactions with emission productivity. Intensive margin: PPML

	Full Sample	AEs	EMEs
Source:			
Climatological$*EP^T$	4.903***	4.562***	2.763
	(0.393)	(0.333)	(8.489)
Lcounter_meteoEMI	-4.427***	-3.855***	-6.170***
	(0.194)	(0.167)	(1.288)
Lcounter_hydroEMI	-0.423**	0.0666	-2.599
	(0.200)	(0.0732)	(1.929)
Lcounter_deathEMI	-0.169***	-0.163***	-0.525
	(0.0229)	(0.0305)	(0.346)
Ldcounter_ieaEMI	0.654***	0.659***	0.400
	(0.0802)	(0.0353)	(0.425)
Lcounter_emiEMI	-30.30**	-5.580**	-31.21
	(14.68)	(2.655)	(80.73)
LclimatEMI	-3.257***	-2.080	-0.401
	(0.684)	(1.984)	(2.792)
LmeteoEMI	0.655***	1.091**	4.351*
	(0.224)	(0.488)	(2.271)
LhydroEMI	-0.297	3.963***	-0.216
	(0.782)	(1.272)	(1.763)
LdeathEMI	0.872***	6.980***	-5.027
	(0.155)	(2.568)	(7.328)
LdieaEMI	0.0361	-0.163***	-0.466
	(0.0490)	(0.0409)	(0.460)
Lcounter_climat	-0.907***	-0.876***	-0.450
	(0.0781)	(0.0537)	(0.865)
Lcounter_meteo	0.691***	0.612***	0.806***
	(0.0174)	(0.0382)	(0.152)
Lcounter_hydro	0.213***	0.120***	0.396
	(0.0281)	(0.0162)	(0.266)
Lcounter_death	0.0154***	0.0149**	0.0272
	(0.00487)	(0.00582)	(0.0456)
Ldcounter_iea	-0.00463	-0.0111	0.0394
	(0.0114)	(0.00683)	(0.0290)
Lcounter_emission	-4.467	-7.287***	-8.968
	(4.067)	(0.678)	(16.10)
Lclimat	0.0773	0.289	0.119
	(0.0968)	(0.246)	(0.392)
Lmeteo	-0.0928	-0.334**	-0.393***
	(0.121)	(0.154)	(0.0539)
Lhydro	0.264	-0.733**	0.313
	(0.240)	(0.337)	(0.208)
Ldeath	-0.0245**	-1.671**	0.182
	(0.0108)	(0.723)	(0.234)
Ldiea	0.0127	0.0622***	0.0143
	(0.0125)	(0.00425)	(0.0207)
Lemission	-15.16***	-21.47***	2.603
	(2.466)	(2.768)	(12.15)
Ltrade_gdp	0.0134***	-0.0255**	0.0239
	(0.00182)	(0.0116)	(0.0285)
Lppig	0.0670**	0.174***	0.0578
	(0.0271)	(0.0235)	(0.0866)
Lrgdpg	-0.0412	0.0773**	-0.0957
	(0.0406)	(0.0303)	(0.125)
Lcounter_trade_gdp	-0.0352***	-0.0366***	-0.0337***
	(0.00491)	(0.00959)	(0.00810)
Lcounter_ppig	-0.0221***	-0.0163**	-0.0617**
	(0.00553)	(0.00748)	(0.0249)
Lcounter_rgdpg	0.168***	0.167***	0.134***
	(0.0165)	(0.0206)	(0.00983)
N	9807	6531	3276

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.22: Bilateral: Interactions with emission productivity. Extensive margin

	(1) Inflows				(2) Outflows			
	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Source:								
Climatological$*EP^T$	-0.0201	-0.0251	-0.0780	0	0.119	0.193*	-0.0924	0
	(0.0557)	(0.0551)	(0.0931)	(.)	(0.0734)	(0.108)	(0.153)	(.)
Lcounter_meteoEMI	-0.00812	-0.00596	-0.0452*	0.0919	-0.00516	-0.0309*	0.0387	-0.123
	(0.0146)	(0.0197)	(0.0208)	(0.0592)	(0.0104)	(0.0174)	(0.0492)	(0.128)
Lcounter_hydroEMI	0.0522**	0.0666**	-0.0290	-0.156	-0.0102	0.0100	-0.0326	0.147
	(0.0197)	(0.0316)	(0.0275)	(0.0719)	(0.0262)	(0.0298)	(0.0591)	(0.0763)
Lcounter_deathEMI	0.000514	0.000822	-0.00277	-6.259	-0.00888	-0.00999	0.0150	6.278
	(0.00492)	(0.00302)	(0.0121)	(4.857)	(0.00601)	(0.00730)	(0.0114)	(6.466)
Ldcounter_ieaEMI	0.0000732	-0.00451	0.0133	0.00263	0.00456	-0.00682	0.00161	-0.00381
	(0.00532)	(0.00617)	(0.0117)	(0.00577)	(0.00959)	(0.0125)	(0.0142)	(0.00624)
Lcounter_emiEMI	1.187	1.629	-0.654	1.145	-0.910	-1.092	0.412	-0.709
	(0.803)	(1.102)	(0.974)	(0.926)	(0.972)	(1.243)	(0.899)	(0.462)
LclimatEMI	0.0314	0.101	-0.0233	-0.0121	-0.107	0.0589	-0.235	-0.0250
	(0.0646)	(0.159)	(0.0840)	(0.0533)	(0.0859)	(0.275)	(0.140)	(0.0635)
LmeteoEMI	-0.0405**	-0.0654*	0.119	-0.00943	0.0265	0.0553	-0.0333	0.00822
	(0.0196)	(0.0369)	(0.0783)	(0.0214)	(0.0249)	(0.0436)	(0.0815)	(0.0194)
LhydroEMI	0.0334	-0.00585	0.0484*	0.0185	0.0222	0.101	-0.0315	-0.0333
	(0.0258)	(0.0346)	(0.0268)	(0.0151)	(0.0283)	(0.0670)	(0.0386)	(0.0207)
LdeathEMI	0.00728	0.290	-0.125	0.0130	0.0290*	-0.566	0.110	0.0255
	(0.0281)	(0.203)	(0.125)	(0.0187)	(0.0162)	(0.367)	(0.180)	(0.0245)
LdieaEMI	0.00861	0.0109	0.00120	-0.0152	-0.00354	0.000138	0.00989	0.0100
	(0.00619)	(0.00859)	(0.0183)	(0.0124)	(0.00562)	(0.00870)	(0.0125)	(0.00910)
Lclimat	-0.00897	-0.0224	-0.00243	-0.00657	0.0105	-0.0135	0.0148	0.00556
	(0.00751)	(0.0233)	(0.00557)	(0.00744)	(0.00839)	(0.0366)	(0.00989)	(0.0189)
Lmeteo	0.00732***	0.0145**	-0.00471	-0.00181	-0.00198	-0.0100	0.00411	-0.00293
	(0.00195)	(0.00674)	(0.00538)	(0.00366)	(0.00332)	(0.00853)	(0.00662)	(0.00442)
Lhydro	-0.00353	0.00354	-0.00387	-0.000815	-0.00590	-0.0197	-0.00262	0.00348
	(0.00326)	(0.00701)	(0.00305)	(0.00200)	(0.00493)	(0.0124)	(0.00564)	(0.00267)
Ldeath	-0.000421	-0.0802	0.00335	-0.000191	-0.00120	0.170	-0.00418	-0.00129
	(0.000950)	(0.0590)	(0.00393)	(0.00114)	(0.000730)	(0.107)	(0.00609)	(0.00152)
Ldiea	-0.00181*	-0.00206	-0.00121	0.00251	0.00107	0.000141	0.000378	-0.00160
	(0.000950)	(0.00167)	(0.00173)	(0.00229)	(0.00122)	(0.00149)	(0.00191)	(0.00174)
Lemission	-0.688*	-0.839*	0.0346	-0.562	0.169	0.278	-0.168	0.544
	(0.394)	(0.488)	(0.499)	(0.401)	(0.462)	(0.612)	(0.600)	(0.392)
Ltrade_gdp	-0.00000980	-0.000425	0.000754	-0.000656	0.000622	0.000739	0.000217	0.00127
	(0.000380)	(0.000552)	(0.000517)	(0.000865)	(0.000505)	(0.000743)	(0.000458)	(0.00142)
Lppig	0.00213	-0.00260	0.00421	0.00382	0.00000676	0.00111	-0.00185	0.000397
	(0.00243)	(0.00349)	(0.00284)	(0.00347)	(0.00137)	(0.00408)	(0.00175)	(0.00121)
Lrgdpg	0.00208	0.00289*	0.000402	0.000860	-0.00112	-0.000553	0.000239	0.00200
	(0.00126)	(0.00158)	(0.00192)	(0.00171)	(0.00240)	(0.00359)	(0.00181)	(0.00350)
N	9740	6446	3294	1011	9729	6446	3283	1013
r2	0.248	0.260	0.313	0.192	0.246	0.261	0.273	0.213

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.23: Bilateral: Disasters only. Intensive margin

	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Climatological	-0.00335	0.00319	-0.0119	0.000685**				
	(0.00938)	(0.0189)	(0.00845)	(0.000218)				
Lmeteo	0.0136	0.0362*	0.00409	0.0000238				
	(0.00953)	(0.0197)	(0.00363)	(0.000200)				
Lhydro	-0.00898	-0.0267	-0.000686	0.000260				
	(0.00700)	(0.0187)	(0.00137)	(0.000232)				
Ldeath	-0.000224	-0.540	0.00106*	-0.0000948				
	(0.000591)	(0.415)	(0.000559)	(0.0000780)				
post15Lclimat	0.00319	0.0124	0.0136	0.000627				
	(0.0101)	(0.0253)	(0.00904)	(0.000643)				
post15Lmeteo	-0.000779	0.00183	0.00132	-0.000311				
	(0.00639)	(0.0342)	(0.00453)	(0.000304)				
post15Lhydro	-0.000388	-0.0535	-0.00292	0.000342				
	(0.00333)	(0.0750)	(0.00363)	(0.000554)				
post15Ldeath	0.0213	0.554	0.0141	-0.00157				
	(0.0178)	(0.430)	(0.0171)	(0.00226)				
Ltrade_gdp	0.0000384	-0.000145	-0.000000870	0.0000124	0.000136	0.000349	0.0000455	0.0000112
	(0.000122)	(0.000883)	(0.000338)	(0.00000759)	(0.000132)	(0.00150)	(0.000310)	(0.00000789)
Lppig	0.0000272	0.00324	-0.000260	0.00000649	0.000117	-0.00135	-0.000289	0.00000157
	(0.000198)	(0.00390)	(0.000404)	(0.0000206)	(0.000157)	(0.00433)	(0.000400)	(0.0000201)
Lrgdpg	-0.00101	0.00801	-0.00300	0.0000115	-0.000373	0.00696	-0.00338	-0.0000209
	(0.00146)	(0.00523)	(0.00277)	(0.0000703)	(0.00139)	(0.00524)	(0.00305)	(0.0000777)
Lvul					1.817	11.09	-1.783	-0.0694
					(2.149)	(10.49)	(1.793)	(0.0553)
post15Lvul					0.364	1.170	0.0647	-0.00866*
					(0.395)	(1.266)	(0.0832)	(0.00397)
N	142692	49960	72718	7550	142692	49960	72718	7550
r2	0.0941	0.129	0.0609	0.0486	0.0941	0.129	0.0609	0.0472

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.24: Bilateral: Disasters only. Intensive margin: PPML

	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Source:								
Climatological	0.0130	-0.300	-0.00867	0.199**				
	(0.261)	(0.210)	(0.268)	(0.0970)				
Lmeteo	-0.0625***	-0.108	-0.0100	0.0646				
	(0.0224)	(0.180)	(0.0924)	(0.0534)				
Lhydro	0.169***	0.184*	0.198***	0.0668				
	(0.0562)	(0.0949)	(0.0558)	(0.0452)				
Ldeath	0.00721	0.0326	0.00165	-0.0360***				
	(0.0126)	(0.287)	(0.0109)	(0.0131)				
post15Lclimat	0.344*	0.295	1.050**	0.316***				
	(0.177)	(0.374)	(0.470)	(0.101)				
post15Lmeteo	-0.0434	0.0364	-0.0441	-0.128***				
	(0.0391)	(0.150)	(0.111)	(0.0361)				
post15Lhydro	0.00112	-0.196**	-0.0108	0.173***				
	(0.0206)	(0.0959)	(0.0736)	(0.0278)				
post15Ldeath	-0.00438	0.0296	-0.340***	-0.338***				
	(0.116)	(0.260)	(0.0644)	(0.128)				
post15	-0.605*	-0.633	-1.065**	-1.393***	0.0439	1.395	-1.199	-0.466
	(0.323)	(0.647)	(0.459)	(0.379)	(0.858)	(1.985)	(1.484)	(1.659)
Ltrade_gdp	0.00246	-0.00300	0.00208	0.0389***	-0.000877	-0.0133	-0.00111	0.0323**
	(0.00548)	(0.0126)	(0.00712)	(0.00864)	(0.00367)	(0.0177)	(0.00625)	(0.0131)
Lppig	0.0296***	0.0911***	0.0109	0.0473**	0.0262***	0.00806	0.00847	0.0396
	(0.00761)	(0.0140)	(0.0105)	(0.0210)	(0.00773)	(0.0216)	(0.0122)	(0.0266)
Lrgdpg	0.00129	0.111	-0.0156	0.0652***	0.00929	0.0570	-0.0197	0.0799**
	(0.0199)	(0.0808)	(0.0124)	(0.0117)	(0.0276)	(0.0723)	(0.0160)	(0.0314)
Lcounter_climat	-0.0255	-0.659***	0.181	0.368				
	(0.219)	(0.0842)	(0.513)	(0.371)				
Lcounter_meteo	-0.284**	-0.541***	0.153	-0.265*				
	(0.142)	(0.0732)	(0.131)	(0.137)				
Lcounter_hydro	0.147	0.155	0.214***	-0.191				
	(0.0928)	(0.133)	(0.0766)	(0.175)				
Lcounter_death	0.0322***	0.0812***	0.00137	22.45				
	(0.0116)	(0.0124)	(0.0234)	(36.18)				
post15Lcounter_climat	-0.269	0.0517	-0.158	-0.468				
	(0.335)	(0.103)	(0.564)	(0.595)				
post15Lcounter_meteo	0.286***	0.406***	0.129	0.755***				
	(0.0781)	(0.0636)	(0.120)	(0.183)				
post15Lcounter_hydro	-0.134**	-0.185*	-0.0888	0.0887				
	(0.0576)	(0.0964)	(0.128)	(0.273)				
post15Lcounter_death	-0.285	-0.559	0.0331	-23.28				
	(0.400)	(0.639)	(0.386)	(56.49)				
Lcounter_trade_gdp	0.0104***	-0.00243	0.0185***	0.00961***	0.0142***	0.00290	0.0204***	0.00481
	(0.00366)	(0.00584)	(0.00101)	(0.00287)	(0.00302)	(0.00388)	(0.00231)	(0.00399)
Lcounter_ppig	-0.0182***	-0.0237***	-0.00612	-0.0405	-0.0225***	-0.0333***	-0.00599	-0.0627
	(0.00511)	(0.00374)	(0.00623)	(0.0469)	(0.00588)	(0.000904)	(0.00771)	(0.0707)
Lcounter_rgdpg	-0.0217	-0.0247**	0.0309***	-0.00667	-0.00900	-0.0114	0.0301*	0.0151
	(0.0201)	(0.0108)	(0.0114)	(0.0156)	(0.0167)	(0.00973)	(0.0175)	(0.0341)
Lvul					42.48	106.6***	-89.14***	-11.63
					(29.26)	(34.93)	(26.54)	(24.53)
post15Lvul					5.695***	9.705**	2.255	-2.113
					(1.528)	(3.810)	(2.723)	(2.085)
Lcounter_vul					13.20	10.73	32.19*	50.84
					(16.09)	(19.25)	(18.16)	(49.81)
post15Lcounter_vul					-6.456***	-10.12***	-0.823	1.575
					(2.143)	(2.318)	(2.277)	(3.027)
N	54252	20554	26888	6542	53182	20184	26356	5472
r2								

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.25: Bilateral: Disasters only. Extensive margin: inflows

	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Climatological	0.0230	0.0468	0.00795	0.0105				
	(0.0253)	(0.0460)	(0.0258)	(0.0175)				
Lmeteo	-0.00700**	-0.0130	-0.00318	-0.00397				
	(0.00351)	(0.00978)	(0.00307)	(0.00251)				
Lhydro	-0.00125	-0.00103	-0.00468	0.000793				
	(0.00289)	(0.00933)	(0.00421)	(0.00256)				
Ldeath	-0.000612	-0.0195	-0.000317	-0.000537				
	(0.00124)	(0.0435)	(0.00142)	(0.000901)				
post15Lclimat	-0.0243	-0.0537	-0.00842	-0.0139				
	(0.0219)	(0.0424)	(0.0251)	(0.0144)				
post15Lmeteo	0.00296	0.0140	-0.000715	0.00308				
	(0.00404)	(0.00889)	(0.00442)	(0.00223)				
post15Lhydro	0.00121	-0.00736	0.00236	0.000989				
	(0.00476)	(0.0106)	(0.00590)	(0.00340)				
post15Ldeath	-0.00564	0.0116	0.00672	-0.0134				
	(0.0148)	(0.0435)	(0.0214)	(0.00949)				
Ltrade_gdp	0.000183	-0.000657	0.00223*	0.000794	0.000211	-0.000714	0.00178*	0.000698
	(0.000826)	(0.000932)	(0.00124)	(0.000534)	(0.000749)	(0.00118)	(0.00101)	(0.000533)
Lppig	0.000679	0.00625	0.000895	0.0000730	0.000742	0.00495	0.00116	0.0000734
	(0.000967)	(0.00470)	(0.00120)	(0.000576)	(0.000959)	(0.00488)	(0.000985)	(0.000571)
Lrgdpg	-0.00201	0.00358	-0.00698	-0.00136	-0.00135	0.00445	-0.00575	-0.00120
	(0.00316)	(0.00427)	(0.00531)	(0.00190)	(0.00331)	(0.00546)	(0.00527)	(0.00198)
Lvul					2.775	5.100	4.175	1.878
					(2.080)	(3.648)	(3.838)	(1.117)
post15Lvul					0.205	-0.0623	-0.479**	-0.00332
					(0.188)	(0.312)	(0.212)	(0.0851)
N	133809	46919	68431	7264	133809	46919	68431	7264
r2	0.148	0.190	0.176	0.161	0.148	0.187	0.179	0.161

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.26: Bilateral: Disasters only. Extensive margin: outflows

	Full Sample	AEs	EMEs	HQ Offshore	Full Sample	AEs	EMEs	HQ Offshore
Climatological	-0.0234	-0.00728	-0.0156	-0.0129				
	(0.0255)	(0.00971)	(0.0474)	(0.0155)				
Lmeteo	0.00189	0.00830	-0.00372	0.00418				
	(0.00539)	(0.00634)	(0.00768)	(0.00455)				
Lhydro	-0.00806	-0.00823	-0.00502	-0.00283				
	(0.00511)	(0.00741)	(0.00675)	(0.00228)				
Ldeath	0.00104	0.00436	0.000669	0.000786				
	(0.00131)	(0.0398)	(0.00238)	(0.000787)				
post15Lclimat	0.0220	0.0257	-0.0180	0.00351				
	(0.0291)	(0.0153)	(0.0755)	(0.0203)				
post15Lmeteo	-0.00949	-0.0143**	-0.00478	-0.00183				
	(0.00587)	(0.00682)	(0.00734)	(0.00349)				
post15Lhydro	0.0116***	0.0257	0.00710	0.00173				
	(0.00426)	(0.0161)	(0.00599)	(0.00206)				
post15Ldeath	0.0216*	0.0200	0.0317**	0.0130				
	(0.0120)	(0.0441)	(0.0130)	(0.00981)				
Ltrade_gdp	0.000625	0.000394	-0.00125	0.000200	0.000489	0.000380	-0.00157	0.000240
	(0.00116)	(0.00113)	(0.00218)	(0.000558)	(0.00112)	(0.00122)	(0.00206)	(0.000533)
Lppig	-0.000827	-0.00797*	-0.00111	-0.000365	-0.000915	-0.00667	-0.00106	-0.000373
	(0.000947)	(0.00414)	(0.00154)	(0.000468)	(0.000942)	(0.00452)	(0.00157)	(0.000481)
Lrgdpg	0.00169	0.000537	0.00236	0.00138	0.000967	0.000238	0.00259	0.00122
	(0.00270)	(0.00471)	(0.00423)	(0.00155)	(0.00265)	(0.00460)	(0.00418)	(0.00157)
Lvul					-3.474*	-3.022	-1.465	-1.634
					(2.001)	(3.095)	(3.939)	(0.966)
post15Lvul					-0.149	0.137	-0.0275	0.0228
					(0.196)	(0.267)	(0.329)	(0.0683)
N	134916	47048	69110	7278	134916	47048	69110	7278
r2	0.152	0.164	0.183	0.179	0.150	0.162	0.179	0.178

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.27: Firm-level regressions with physical risk only

	Full sample			Advanced Economies			Emerging Economies		
	ΔShare	New	(-1)*Closed	ΔShare	New	(-1)*Closed	ΔShare	New	(-1)*Closed
Lhydro	-0.000240	-0.00123*	-0.0000190	0.00115	-0.000849	0.000211	-0.0000714	-0.000266	-0.000514**
	(0.000281)	(0.000703)	(0.000211)	(0.000762)	(0.00183)	(0.000376)	(0.000106)	(0.000519)	(0.000195)
Lmeteo	0.000388	0.000259	-0.0000490	0.00135***	0.00121	0.00000474	-0.00102**	-0.00267	0.000744**
	(0.000439)	(0.00121)	(0.000182)	(0.000426)	(0.00170)	(0.000273)	(0.000406)	(0.00173)	(0.000295)
Lclimat	-0.00367*	-0.00785*	0.0000627	-0.00555*	-0.0114***	0.00128***	0.00160	0.00961**	-0.00132
	(0.00213)	(0.00459)	(0.000668)	(0.00288)	(0.00388)	(0.000462)	(0.00112)	(0.00424)	(0.000834)
Ldeath	0.000112	0.000174	-0.0000157	0.0000117	-0.000459	0.000541***	0.000147***	0.000213	-0.0000454**
	(0.0000689)	(0.000234)	(0.0000191)	(0.000114)	(0.000296)	(0.0000658)	(0.0000350)	(0.000256)	(0.0000225)
Lhydro_post	0.000531**	0.000262	-0.000136	-0.00191	-0.00123	0.00299***	-0.000468*	-0.00220***	0.000314
	(0.000224)	(0.000634)	(0.000207)	(0.00134)	(0.00260)	(0.000929)	(0.000255)	(0.000526)	(0.000216)
Lmeteo_post	-0.000877**	-0.00168***	0.000501**	-0.00136**	-0.00195	0.0000439	0.000392	0.000732	0.00000233
	(0.000343)	(0.000626)	(0.000245)	(0.000531)	(0.00120)	(0.000317)	(0.000258)	(0.000805)	(0.000298)
Lclimat_post	-0.000530	0.000693	-0.000000962	0.00229	0.00502	-0.00141	-0.00194*	-0.0121**	-0.0000346
	(0.000927)	(0.00395)	(0.000782)	(0.00203)	(0.00532)	(0.00100)	(0.00115)	(0.00577)	(0.00150)
Ldeath_post	-0.000519	-0.00314	0.000762	-0.00191***	-0.00989***	-0.000791	0.000260	0.000699	0.00150***
	(0.000747)	(0.00266)	(0.000580)	(0.000680)	(0.00313)	(0.000662)	(0.000621)	(0.00156)	(0.000555)
L.trade_gdp	0.000110**	-0.0000302	-0.000000611	0.000254*	-0.000121	-0.000122	-0.0000610**	-0.0000916	0.000113**
	(0.0000470)	(0.000173)	(0.0000384)	(0.000129)	(0.000350)	(0.0000739)	(0.0000297)	(0.000174)	(0.0000472)
L.rgdpg	-0.000320*	-0.0000805	0.000110	-0.000426	0.000414	-0.0000785	-0.000209	0.000146	-0.0000865
	(0.000188)	(0.000432)	(0.000123)	(0.000321)	(0.000881)	(0.000242)	(0.000197)	(0.000404)	(0.000146)
L.PPI inflation	-0.0000686	-0.000601***	0.000128*	-0.000211	-0.00102	0.000410	-0.00000247	-0.000206	0.0000681
	(0.0000525)	(0.000217)	(0.0000724)	(0.000384)	(0.000757)	(0.000369)	(0.0000329)	(0.000203)	(0.0000753)
N	369864	655845	618846	199750	355469	336052	149900	262303	246176
r2	0.401	0.619	0.700	0.414	0.683	0.738	0.497	0.628	0.699

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.28: Firm-level regressions with physical risk only: vulnerability

	Full sample			Advanced Economies			Emerging Economies		
	ΔShare	New	(-1)*Closed	ΔShare	New	(-1)*Closed	ΔShare	New	(-1)*Closed
Lvul	-0.146	-0.655	0.156	-0.0397	-0.130	0.127	0.176	-0.372	-0.0344
	(0.224)	(0.480)	(0.113)	(0.468)	(0.956)	(0.243)	(0.185)	(0.548)	(0.178)
Lvul_post	0.0275***	0.0770*	-0.0229*	-0.0275	-0.0370	-0.00205	0.00858	0.0120	0.0110
	(0.00965)	(0.0403)	(0.0126)	(0.0557)	(0.124)	(0.0375)	(0.00736)	(0.0499)	(0.0150)
L.trade_gdp	0.000141**	0.000132	-0.0000365	0.000326*	-0.00000541	-0.000164**	0.0000505	0.000315	0.0000564
	(0.0000580)	(0.000176)	(0.0000411)	(0.000161)	(0.000340)	(0.0000679)	(0.0000312)	(0.000225)	(0.0000479)
L.rgdpg	-0.000342	0.00000619	0.0000652	-0.000311	0.000418	-0.0000177	-0.000141	0.000235	-0.0000677
	(0.000211)	(0.000486)	(0.000122)	(0.000317)	(0.000866)	(0.000265)	(0.000145)	(0.000475)	(0.000155)
L.PPI inflation	-0.0000395	-0.000433**	0.0000858	-0.000147	-0.00114	0.000382	0.0000271	-0.000138	0.0000482
	(0.0000529)	(0.000218)	(0.0000721)	(0.000363)	(0.000797)	(0.000361)	(0.0000336)	(0.000192)	(0.0000747)
N	369864	655845	618846	199750	355469	336052	149900	262303	246176
r2	0.400	0.619	0.700	0.413	0.683	0.738	0.496	0.628	0.699

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.29: Firm-level regressions: full sample

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	0.000292	-0.000206	0.0000616
	(0.000297)	(0.000360)	(0.000149)
Dhqiea	0.000142	-0.000386	0.000249
	(0.000120)	(0.000711)	(0.000516)
Lclimat	-0.0102**	-0.00441	-0.00120
	(0.00499)	(0.00286)	(0.00119)
Lmeteo	0.000253	-0.00104	0.000116
	(0.000749)	(0.000847)	(0.000203)
Lhydro	-0.000800*	-0.00172	0.000110
	(0.000453)	(0.00120)	(0.000435)
Ldeath	0.0000746	0.000292	-0.0000148
	(0.000180)	(0.000396)	(0.0000562)
Lhq_climatological_m	-0.00295*	-0.00565	-0.00526
	(0.00174)	(0.00662)	(0.00347)
Lhq_meteorological_m	-0.000488*	0.00217	0.00138
	(0.000275)	(0.00226)	(0.00131)
Lhq_hydrological_m	-0.00116***	-0.000688	-0.00231
	(0.000386)	(0.00292)	(0.00220)
Lhqdeath	-0.000389***	-0.00177	-0.00111
	(0.000114)	(0.00112)	(0.000759)
Lemi	-0.206	0.0269	-0.00774
	(0.130)	(0.143)	(0.0145)
Lhq_emi	0.0558	0.233	0.0389
	(0.0413)	(0.168)	(0.108)
Lccrh	-0.000726	0.000833	-0.00183
	(0.000900)	(0.00747)	(0.00545)
L.trade_gdp	0.000183	-0.000219	-0.000132*
	(0.000239)	(0.000310)	(0.0000735)
L.rgdpg	-0.0000736	-0.000822	-0.0000218
	(0.000475)	(0.000801)	(0.000148)
L.PPI inflation	-0.000616	0.0000511	0.000542**
	(0.000497)	(0.000689)	(0.000250)
N	140133	211294	195113
r2	0.111	0.162	0.145

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.30: Firm-level regressions: full sample. Interactions with emission productivity

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	-0.0000891	-0.000808	0.000296
	(0.000486)	(0.000850)	(0.000293)
Diea_em	0.0000729	0.00477	-0.00136
	(0.00222)	(0.00580)	(0.00125)
Dhqiea_em	0.000484	-0.000409	0.000760
	(0.000788)	(0.00138)	(0.000954)
Lclimat	-0.0123	-0.0243***	0.00316
	(0.0105)	(0.00806)	(0.00294)
Lmeteo	-0.00134	-0.00128	-0.00155*
	(0.00175)	(0.00277)	(0.000807)
Lhydro	-0.00172	-0.00297	0.000361
	(0.00185)	(0.00567)	(0.00106)
Lclimat_em	0.0404	0.0705	-0.0111
	(0.0846)	(0.0501)	(0.0166)
Lmeteo_em	0.00866	0.0163	0.00818**
	(0.0102)	(0.0166)	(0.00389)
Lhydro_em	0.0103	0.00643	0.00330
	(0.0122)	(0.0298)	(0.00553)
Ldeath_em	-0.0000748	-0.00577	0.00266***
	(0.00143)	(0.00443)	(0.000505)
Lhq_climatological_m_em	-0.0181*	-0.0237	0.00928
	(0.00945)	(0.0304)	(0.00621)
Lhq_meteorological_m_em	0.00321*	0.00528	-0.00463***
	(0.00167)	(0.00500)	(0.00157)
Lhq_hydrological_m_em	-0.000637	-0.000643	0.00500
	(0.00214)	(0.00804)	(0.00516)
Lhqdeath_em	-0.00500**	-0.00164	0.0000162
	(0.00242)	(0.00487)	(0.00258)
Lemi	-0.167*	-0.101	-0.0120
	(0.0901)	(0.323)	(0.0418)
Lhqemi_em	-0.0142	0.0289	-0.0727**
	(0.0119)	(0.0679)	(0.0350)
Lccrh_em	-0.0182***	-0.00120	-0.0108
	(0.00584)	(0.0151)	(0.0134)
L.trade_gdp	0.000205	0.0000459	-0.000226**
	(0.000139)	(0.000470)	(0.0000863)
L.rgdpg	-0.000757*	0.000443	0.000113
	(0.000426)	(0.000947)	(0.000246)
L.PPI inflation	0.000350	-0.000901	0.000700*
	(0.000478)	(0.00109)	(0.000384)
Drelcorptax	0.000663	-0.000672	-0.000446
	(0.000677)	(0.00182)	(0.000380)
N	109969	165775	152892
r2	0.361	0.667	0.712

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.31: Firm-level regressions: AEs

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	0.0000481	0.000144	0.000165
	(0.000410)	(0.000409)	(0.000181)
Dhqiea	0.000172	-0.000151	0.000206
	(0.000148)	(0.000714)	(0.000524)
Lclimat	-0.0165***	-0.00658*	0.00124
	(0.00524)	(0.00332)	(0.000773)
Lmeteo	0.000951	0.0000352	0.000292
	(0.00122)	(0.00112)	(0.000310)
Lhydro	-0.00177*	-0.000401	0.00121**
	(0.00100)	(0.00245)	(0.000582)
Ldeath	0.000317	-0.000825	0.00110***
	(0.000423)	(0.000516)	(0.0000625)
Lhq_climatological_m	-0.00364*	-0.00483	-0.00566
	(0.00210)	(0.00685)	(0.00356)
Lhq_meteorological_m	-0.000416	0.00218	0.00133
	(0.000311)	(0.00237)	(0.00132)
Lhq_hydrological_m	-0.00149**	-0.00128	-0.00170
	(0.000549)	(0.00307)	(0.00216)
Lhqdeath	-0.000387**	-0.00141	-0.00112
	(0.000144)	(0.00115)	(0.000691)
Lemi	-0.186	0.0558	-0.0277**
	(0.157)	(0.179)	(0.0103)
Lhq_emi	0.0580	0.159	0.0592
	(0.0564)	(0.168)	(0.108)
Lccrh	-0.00131	0.000289	-0.00352
	(0.00109)	(0.00736)	(0.00558)
L.trade_gdp	0.000406	-0.000428	-0.000199**
	(0.000299)	(0.000376)	(0.0000934)
L.rgdpg	-0.00115	-0.000116	0.000593***
	(0.000824)	(0.000839)	(0.000181)
L.PPI inflation	0.000433	-0.00172*	0.000354
	(0.000974)	(0.000984)	(0.000489)
N	97948	147777	136705
r2	0.120	0.166	0.147

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.32: Firm-level regressions: AE. Interactions with emission productivity

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	-0.000182	-0.000775	0.000381
	(0.000558)	(0.000886)	(0.000301)
Diea_em	0.000366	0.00525	-0.00137
	(0.00230)	(0.00575)	(0.00131)
Dhqiea_em	0.000148	-0.000359	0.00129
	(0.000791)	(0.00140)	(0.000866)
Lclimat	-0.0138	-0.0287***	0.00384
	(0.0113)	(0.00667)	(0.00317)
Lmeteo	-0.00197	-0.00168	-0.000845
	(0.00188)	(0.00290)	(0.000984)
Lhydro	-0.000568	-0.00665	0.00138
	(0.00262)	(0.00641)	(0.00156)
Lclimat_em	0.0477	0.0981**	-0.0147
	(0.0871)	(0.0446)	(0.0183)
Lmeteo_em	0.0115	0.0171	0.00470
	(0.0111)	(0.0164)	(0.00441)
Lhydro_em	0.00468	0.0221	-0.000325
	(0.0138)	(0.0316)	(0.00790)
Ldeath_em	-0.0000329	-0.00591	0.00281***
	(0.00160)	(0.00437)	(0.000622)
Lhq_climatological_m_em	-0.0160*	-0.0195	0.0107
	(0.00897)	(0.0300)	(0.00721)
Lhq_meteorological_m_em	0.00288*	0.00385	-0.00465***
	(0.00167)	(0.00513)	(0.00159)
Lhq_hydrological_m_em	-0.00123	0.00198	0.00164
	(0.00161)	(0.00613)	(0.00449)
Lhqdeath_em	-0.00350	-0.000121	-0.00250
	(0.00229)	(0.00446)	(0.00342)
Lemi	-0.155*	-0.119	-0.00506
	(0.0902)	(0.327)	(0.0421)
Lhqemi_em	-0.0160	0.0385	-0.0840**
	(0.0130)	(0.0725)	(0.0375)
Lccrh_em	-0.0201***	-0.00916	-0.00735
	(0.00630)	(0.0158)	(0.0138)
L.trade_gdp	0.000241	-0.0000108	-0.000248**
	(0.000162)	(0.000510)	(0.0000921)
L.rgdpg	-0.00117**	0.000450	0.000246
	(0.000519)	(0.00120)	(0.000273)
L.PPI inflation	0.000248	-0.00121	0.000661
	(0.000456)	(0.00120)	(0.000392)
N	96208	145093	133911
r2	0.363	0.676	0.722

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.33: Firm-level regressions: EMEs.

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	-0.000137	-0.000669	-0.0000145
	(0.000153)	(0.000425)	(0.000206)
Dhqiea	0.0000459	-0.000825	0.000343
	(0.000121)	(0.000812)	(0.000562)
Lclimat	0.00211	0.00285	-0.00543***
	(0.00157)	(0.00369)	(0.00155)
Lmeteo	-0.00130***	-0.000338	0.000216
	(0.000282)	(0.000864)	(0.000170)
Lhydro	-0.000250	-0.00293**	-0.000332
	(0.000310)	(0.00113)	(0.000223)
Ldeath	0.00000165	0.000215	0.00000964
	(0.0000456)	(0.000334)	(0.0000331)
Lhq_climatological_m	-0.00227	-0.00812	-0.00424
	(0.00151)	(0.00733)	(0.00354)
Lhq_meteorological_m	-0.000371	0.00247	0.00150
	(0.000443)	(0.00265)	(0.00143)
Lhq_hydrological_m	-0.000603	0.00102	-0.00352
	(0.000401)	(0.00315)	(0.00248)
Lhqdeath	-0.000302	-0.00288**	-0.00105
	(0.000237)	(0.00129)	(0.00111)
Lemi	-0.126***	-0.0463	0.0782***
	(0.0324)	(0.104)	(0.0216)
Lhq_emi	0.0542**	0.412**	-0.00487
	(0.0245)	(0.182)	(0.117)
Lccrh	0.000733	0.00213	0.00203
	(0.000917)	(0.00837)	(0.00576)
L.trade_gdp	-0.0000309	0.000143	-0.000132*
	(0.000157)	(0.000314)	(0.0000662)
L.rgdpg	0.000279	-0.00154*	-0.000396
	(0.000326)	(0.000815)	(0.000246)
L.PPI inflation	-0.0000646	0.00143***	0.000603
	(0.000262)	(0.000454)	(0.000407)
N	42091	63483	58372
r2	0.107	0.160	0.150

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.34: Firm-level regressions: EMEs. Interactions with emission productivity

	Change in affiliate share	New affiliates	(-1)*Closed affiliates
Diea	0.000101	-0.00127	0.000466
	(0.000169)	(0.00109)	(0.000424)
Diea_em	-0.000918	0.00176	-0.00602
	(0.00156)	(0.0124)	(0.00462)
Dhqiea_em	0.00324**	0.00427	-0.00155
	(0.00121)	(0.00393)	(0.00152)
Lclimat	-0.000243	0.0167***	0.00138
	(0.00105)	(0.00462)	(0.00201)
Lmeteo	0.00109	-0.00517	-0.000674
	(0.00164)	(0.00415)	(0.000827)
Lhydro	-0.00132	0.00353	-0.00167
	(0.00110)	(0.00244)	(0.000967)
Lclimat_em	0.0340	-0.190***	-0.0441
	(0.0280)	(0.0467)	(0.0332)
Lmeteo_em	-0.0288	0.0481	0.0146
	(0.0247)	(0.0504)	(0.0109)
Lhydro_em	0.00735	-0.0565***	0.00574
	(0.00995)	(0.0153)	(0.00910)
Ldeath_em	0.000970	0.00151	-0.000403
	(0.00141)	(0.00396)	(0.000747)
Lhq_climatological_m_em	0.000432	0.0239	-0.00342
	(0.00465)	(0.0367)	(0.0129)
Lhq_meteorological_m_em	-0.00133	-0.00518	0.000995
	(0.00104)	(0.00800)	(0.00395)
Lhq_hydrological_m_em	0.00238	-0.00999	0.00262
	(0.00314)	(0.0145)	(0.00521)
Lhqdeath_em	0.00245	-0.000629	-0.00285
	(0.00147)	(0.00874)	(0.00389)
Lemi	-0.184	0.605***	0.0262
	(0.108)	(0.187)	(0.0833)
Lhqemi_em	0.0315	0.0829	-0.0644
	(0.0296)	(0.0955)	(0.0779)
Lccrh_em	-0.00895*	0.0102	0.0525**
	(0.00485)	(0.0310)	(0.0181)
L.trade_gdp	-0.000128	0.000898	-0.000245*
	(0.000128)	(0.000552)	(0.000133)
L.rgdpg	0.0000883	-0.0000129	-0.000540*
	(0.000210)	(0.000648)	(0.000294)
L.PPI inflation	0.0000550	0.00126	0.000307
	(0.000126)	(0.00102)	(0.000314)
N	40528	60922	55655
r2	0.476	0.691	0.718

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix A.5 Endogeneity tests and Spillover results

Figure A.5: Endogeneity tests

Notes: Response of emission productivity (emi), policy and disaster measures to FDI, estimated by local projections for a country-year panel. diea is the change in IEA measure of emission policies, eps is the Environmental Protection Score from OECD, tax is CO2 tax indicator from OECD, climat, meteo, hydro are the count of climatological, meteorological, and hydrological disasters in any given country and year, and vul is an OECD measure of climate vulnerability. The following equation was estimated for each of the response variables: $z_{it+h} = \alpha_i + \alpha_t + \sum_{\tau=1}^{3} \rho_\tau z_{it-\tau} + \sum_{\tau=1}^{3} \beta_\tau FDI_{it-\tau}, \quad h \in [0, 5]$. Standard errors are clustered by country and by year.

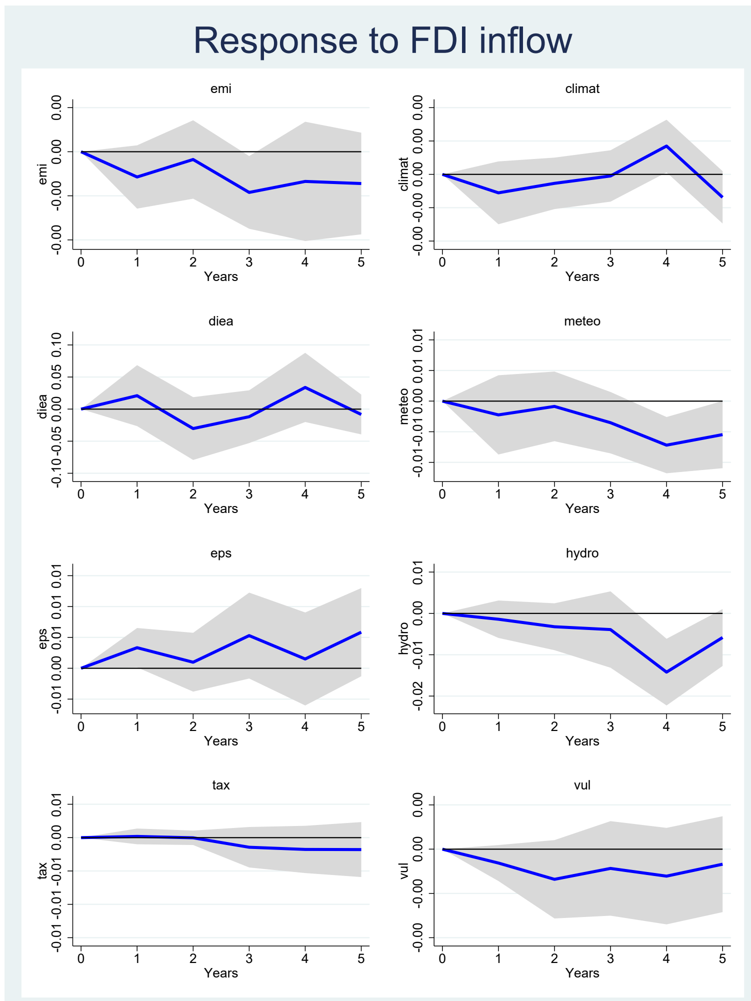


Table A.35: FDI spillovers: Country panel

Notes: Dependent variable is net FDI inflows as a share of GDP in year t. *Severity* is disaster severity measured as the number of total deaths (in 1000s) from the disasters. A particular disasters in any AE are the total number of the corresponding disaster in the advanced countries excluding the target country if the target country is also advanced. A particular disasters in any EME are the total number of the corresponding disaster in the emerging markets excluding the target country if the target country is also emerging. First two columns report main effects of variables as indicated. Last two columns report the interaction effects of the climate-risk variables with emission productivity (no interactions with the macro controls). The interaction regressions also include the main effects from climate and emission variables, whose results are not reported in this table due to space limitation and are available upon request. All RHS variables are lagged one year. All regressions include year-trend, country fixed effects, and are estimated by OLS. Clustered (at region) standard errors are in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Main Effects		Interact w/ Emission prod.	
	(1) AEs	(2) EMEs	(3) AEs	(4) EMEs
Climatological	0.084	-0.361	3.200	-1.991
	(0.084)	(0.325)	(2.757)	(6.210)
Meteorological	0.130	-0.165	-4.240	-1.965
	(0.064)	(0.071)	(2.073)	(7.402)
Hydrological	-0.347*	0.017	1.060	-1.511
	(0.146)	(0.106)	(1.252)	(4.624)
Severity	-0.011	-0.018	-4.430***	56.760
	(0.010)	(0.026)	(0.061)	(59.910)
Change in policy	-0.022	0.001	-0.149*	0.429
	(0.041)	(0.070)	(0.062)	(1.600)
Emission productivity	-22.320**	11.030	-16.310**	-79.250*
	(6.938)	(8.874)	(3.972)	(27.720)
Climatological in any AE	3.753	6.529	9.372*	95.350
	(1.635)	(6.514)	(3.196)	(96.520)
Meteorological in any AE	5.525*	9.431	8.289**	126.000
	(2.064)	(6.568)	(1.934)	(116.400)
Hydrological in any AE	-3.093	-4.515	-5.312	-49.930
	(1.527)	(2.648)	(4.401)	(34.630)
Severity in any AE	-2.326	-2.240	-7.257**	-38.880
	(0.993)	(1.528)	(2.073)	(38.060)
Change in policy in any AE	-0.622	-0.531	1.630**	-8.513
	(0.310)	(0.485)	(0.385)	(9.766)
Climatological in any EME	-5.620**	-1.491	-14.30 ***	52.390
	(1.278)	(1.153)	(1.161)	(54.210)
Meteorological in any EME	-8.960*	-11.340	-14.800**	-169.800
	(3.213)	(8.343	(3.902)	(175.900)
Hydrological in any EME	5.443**	8.532	23.260***	73.330
	(1.002)	(5.095)	(1.208)	(43.040)
Severity in any EME	-0.320	-2.748*	-3.225***	-32.040
	(0.206)	(1.164)	(0.425)	(21.100)
Change in policy in any EME	1.577	0.537	-14.000***	19.160
	(0.672)	(0.601)	(2.253)	(24.960)
Trade/GDP	-0.0148*	-0.022	-0.0475*	-0.019
	(0.006)	(0.021)	(0.017)	(0.012)
PPI Inflation	-0.0661**	0.0380*	-0.064	0.007
	(0.020)	(0.015)	(0.038)	(0.022)
Real GDP growth	0.118***	0.302**	0.164**	0.314**
	(0.019)	(0.088)	(0.030)	(0.087)
Trend	-0.162	0.018	0.180***	-0.058
	(0.078)	(0.044)	(0.028)	(0.117)
Observations	425	204	425	204
R^2	0.540	0.300	0.534	0.303

Table A.36: Country-industry Spillover with Emission Productivity Interactions

Notes: Dependent variable is net FDI inflows as a share of GDP in year t. *Severity* is disaster severity measured as the number of total deaths (in 1000s) from the disasters. A particular disasters in any AE are the total number of the corresponding disaster in the advanced countries excluding the target country if the target country is also advanced. A particular disasters in any EME are the total number of the corresponding disaster in the emerging markets excluding the target country if the target country is also emerging. The first column reports the results for advanced target countries' FDI. The second column reports the results for emerging target countries' FDI. All RHS variables are lagged one year. All regressions include target country-industry, industry-year, and target country-year fixed effects, and are estimated by OLS. All main effects and macro effects are absorbed by target country-year fixed effects. Clustered (at target country-industry) standard errors are in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	(1) AEs	(2) EMEs
Emission productivity * Climatological	1.302	-734.4
	(7.880)	(333.1)
Emission productivity * Meteorological	-10.82	465.1
	(12.79)	(204.5)
Emission productivity * Hydrological	-37.64	-77.23
	(41.84)	(38.33)
Emission productivity * Severity	100.5	-5952.4
	(126.2)	(2658.7)
Emission productivity * Policy change	0.980	-60.65
	(2.057)	(26.56)
Emission productivity	757.1	-2510.8
	(873.1)	(1131.8)
Emission productivity * Climatological in any AE	-536.5	5422.7
	(639.4)	(2624.6)
Emission productivity * Meteorological in any AE	69.82	168.5
	(91.36)	(84.16)
Emission productivity * Hydrological in any AE	-861.3	3549.3
	(1035.9)	(1780.7)
Emission productivity * Severity in any AE	3258.9	-4515.9
	(4268.7)	(6128.7)
Emission productivity * Policy change in any AE	3.734	
	(5.869)	
Emission productivity * Climatological in any EME	1141.5	
	(1444.2)	
Emission productivity * Meteorological in any EME	-680.1	
	(765.8)	
Observations	2280	450
R^2	0.637	0.847

Table A.37: Firm-level Spillovers

Dependent varialbe is a 0/1 indicator of whether an MNE with an affiliate in target country T in given year reported new affiliates in countries other than T in a year following natural disaster or policy changes in country T. T is target country, S is source country. CCR is firm climate risk. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Full sample	AEs	EMEs
Change in number affiliates in T	-1.018***	-0.973***	-1.519***
	(0.142)	(0.141)	(0.260)
Change in policy in T	-0.000919	-0.00206**	0.000158
	(0.000974)	(0.000915)	(0.00101)
Change in policy in S	-0.000176	-0.000468	0.0000847
	(0.000852)	(0.000896)	(0.000943)
Climatological in T	-0.0208*	-0.0335***	0.00438
	(0.0118)	(0.0110)	(0.00400)
Meteorological in T	0.00476*	-0.000599	0.00467***
	(0.00268)	(0.00366)	(0.00114)
Hydrological in T	-0.00172	-0.0178***	0.00688**
	(0.00473)	(0.00446)	(0.00230)
Severity T	-0.000149	-0.00583***	-0.000539**
	(0.000627)	(0.00169)	(0.000208)
Climatological in S	0.00545	0.00555	0.00213
	(0.00482)	(0.00483)	(0.00564)
Meteorological in S	-0.00263	-0.00261	-0.00309
	(0.00221)	(0.00229)	(0.00257)
Hydrological in S	0.00408	0.00202	0.00575
	(0.00290)	(0.00299)	(0.00326)
Severity in S	0.00212*	0.00225*	0.00167
	(0.00120)	(0.00118)	(0.00154)
Emission productivity in T	0.141	0.301	-0.454*
	(0.204)	(0.270)	(0.235)
Emission productivity in S	0.0593	0.126	-0.0572
	(0.165)	(0.173)	(0.193)
CCR of the firm	0.00358	0.00618	-0.00211
	(0.00844)	(0.00883)	(0.00837)
Trade/GDP	0.000185	0.000580	0.000852
	(0.000792)	(0.000991)	(0.000625)
Real GDP growth	0.0000817	-0.000742	-0.000670
	(0.00151)	(0.00186)	(0.00138)
PPI inflation	-0.00215	-0.00102	-0.0000820
	(0.00150)	(0.00257)	(0.00160)
Observations	140133	97948	42091
R^2	0.179	0.192	0.183