Climate Risk and Firm-Level FDI in Latin America and the Caribbean – A Preliminary Analysis

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1. Introduction

Foreign direct investment (FDI) plays a significant role in funding investments within the global economy. The onset of globalisation created a new economic landscape that Multinational Corporations (MNCs) sought to capitalise on. The advantages provided by international markets in terms of production and distribution have encouraged these MNCs to expand throughout the global economy. These investments have facilitated significant economic benefits, both for these MNCs and their host country. Numerous studies have demonstrated that FDI has the potential to generate positive economic outcomes for host economies, including increased growth, reduced unemployment, improved standards of living, and technological transfers. (Bengoa and Sanchez-Robles 2003; Chaudhury, Nanda, and Tyagi 2020; Blomstrom, Lipsey, and Zejan 1992; Abor and Harvey 2008) In the absence of alternative sources of investments, global economies have eagerly sought to encourage FDI in order to obtain these associated benefits. However, the increasing frequency and severity of climate-related events present significant challenges to the FDI landscape. Climate change has increased the occurrence of adverse weather events and has elucidated the potential risks associated with these phenomena. Hence, it has become increasingly important to ask whether climate risk impacts the probability of firms to attract inward FDI. Climate risk encompasses both physical risks from weather events and transitional risks associated with the shift toward a low-carbon economy (US EPA 2024). While both can undermine the stability and predictability that investors seek, in this study, we focus on the impact of physical risk associated with climate events on inward FDI.

Several studies have reported that severe climatic events can have negative impacts on asset pricing, returns on investments, and cash flow levels (Huang, Kerstein, and Wang 2018; Zhang 2022). It is thus reasonable to assume that the threat of these severe climatic events may potentially impact a firm's propensity to attract FDI. According to Dunning's (1977;1979) eclectic theory of FDI, investors seek to invest in locations with an advantage over their domestic markets. Hence, unless foreign entities stand to reap profits in excess of what would be obtained domestically, the probability of inward FDI is likely to decrease. It follows that foreign entities will only invest in firms located in countries with high climate risk if they believe they would be sufficiently compensated for the additional risk associated with the host economy's climate risk. In essence, high levels of climate risk in a country are expected to result in a reduction in inward firm-level FDI. This poses a threat to economies vulnerable to climate change and, at the same time, are reliant on FDI to generate investment and activity within their economies. It is thus critical to gain a better understanding of the impact of climate risk on a firm's ability to attract FDI.

Climate risk has gained increased attention among investors in recent years, as many investors have sought to develop strategies to avoid or hedge against it (Andersson, Bolton, and Samama 2014). However, the empirical literature on the link between FDI and climate risk can best be described as mixed. For instance, some studies, including those by Shear, Ashraf, and Butt (2023) and Qing et al. (2024), find that climate risk negatively impacts

inward FDI, other studies like those by Barua, Colombage, and Valenzuela (2020) found mixed results while Gu and Hale's (2023) analysis of the impact of climate risk on FDI dynamics was inconclusive. These inconsistent results indicate that the relationship between climate risk and inward FDI requires further investigation. Therefore, this study seeks to expand the literature exploring the climate risk-FDI relationship by aiming to understand the impact of climate risk on the propensity of firms to attract FDI. In doing so, we seek to contribute to the limited but growing body of literature on climate risk and its impact on the probability of firms receiving FDI inflows.

We carry out our analysis using firms from Latin America and the Caribbean as our empirical example. Latin America and the Caribbean is an excellent case study for assessing the impacts of climate risk on inward FDI. The region, primarily occupied by developing economies, provides an interesting balance of service-based and commodity-based economies. While recent trends have suggested that global FDI has begun to trend downward (UNCTAD 2024), Latin America and the Caribbean have continued to benefit from these inflows, with the region accumulating USD 193 billion in FDI inflows in 2023 (UNCTAD 2024), about 2.7 percent of the region's GDP. The influx of these cross-border flows is primarily driven by the region's profit-making opportunities. Moreover, like many developing economies, FDI is one of the largest sources of foreign financing in Latin America and the Caribbean (UNCTAD 2024). The region thus depends on inward FDI to facilitate economic development (Kariuki, 2015). It is thus not surprising that several studies exist on the determinants of FDI in Latin America and the Caribbean. (Williams 2015; Rios-Morales and O'Donovan 2006; Fukumi and Nishijima 2010; Kolstad and Villanger 2007; Lall, Norman, and Featherstone 2003) However, these studies often focus on macroeconomic and institutional variables (De Groot and Pérez Ludeña 2014; Henry, Saadatmand, and Toma 2015; Shah and Qayyum 2015; Sookram et al. 2022). This study adds to the existing body of work on FDI in Latin America and the Caribbean in two ways. First, we focus on climate risk. As is well documented, the region also hosts a wide range of climatic conditions, including the Atlantic hurricane belt, which allows the study to gain insights from areas disproportionately affected by climate risk and its potential impact on inward FDI. Second, we opt to look at firm-level FDI. As mentioned earlier, most studies on Latin America and the Caribbean tend to be at the macro level.

The balance of the paper proceeds as follows: Section 2 provides a review of the related literature. Section 3 explores the methodology employed. This is followed by Section 4, which discusses the results, and Section 5, which provides the conclusion and discussion.

2. Literature review

he topic of climate risk has continued to grow in importance within the field of economics. The increasing global occurrences of natural disasters and extreme weather events have led numerous researchers to examine the

impact that climate risk poses on global economies and various economic factors. These researchers have demonstrated adverse economic outcomes related to climate risk and extreme weather events (Noy 2009; Dell, Jones, and Olken 2014). These studies suggest that climate change and the extreme climatic events associated with it create an environment that hinders or discourages investment.

This has also been observed at the firm level. Huang, Kerstein, and Wang (2018) utilised the Global Climate Risk Index published by Germanwatch to analyse the relationship between climate risk and financial performance. They demonstrated that higher levels of climate risk are associated with lower returns on assets, reduced cash flow from operations, and increased volatility. Other studies have demonstrated the impact of climate risk on investment pricing, including Zhang (2022), who showed the negative relationship between climate risk and global stock prices. Acharya et al. (2022) found similar results when analysing the effect of climate risk on municipal bonds. Hence, climate risk should be considered an investment and financial risk (Ait Soussane et al. 2022; Barua, Colombage, and Valenzuela 2020).

These empirical studies demonstrate the adverse impacts of climate risk on the broader economy and the challenges it creates for firms at a more micro-level. These adverse effects may be intensified for foreign investments as these investments tend to be riskier than domestic investments (Ait Soussane et al. 2022). Therefore, it's reasonable to suggest that climate risk may also negatively impact the probability of firms to receive inward FDI. Hence, we seek to deepen our understanding of climate risk as it relates to the probability of firms to attract FDI. To achieve this, we build on the theoretical work presented by Dunning's (1977;1979) eclectic theory of FDI, also known as the OLI paradigm. The theory suggests that FDI flows from MNCs are broadly explained by ownership advantages, location advantages, and internalisations. The location advantages specifically indicate that firms tend to seek out locations that are less risky (Faeth 2009). This would suggest that locations with higher levels of climate risk would have a lower propensity for inward FDI or receive lower levels of FDI inflows.

There is a small, albeit growing body of work seeking to explain the relationship between climate risk and FDI inflows both on a macro and micro level. However, as alluded to in the introduction, a clear consensus has not been established. For instance, at the macro-level, Barua, Colombage, and Valenzuela's (2020) assessed the impact of climate change (proxied by temperature and precipitation changes) on aggregate FDI. They found that temperature increases reduce FDI inflows to developing economies in the long run but increase inflows to developed economies. Chen et al. (2022) examined the impact of climate risk on net FDI inflows and also found that climate risk has an adverse effect on FDI inflows to developing economies. These results differ from the study conducted by Shear, Ashraf, and Butt (2023), where they found that FDI inflows are sensitive to climate risk in their assessment of the impact of climate vulnerability on FDI inflows. They found that this sensitivity only exists in high and middle-income economies and pointed out that MNCs investing in low-income economies are more focused on market size as the main driver of FDI flows.

Gu and Hale (2023) take a more comprehensive approach to the FDI-climate risk relationship through their investigation of both physical and transition climate risk at multiple levels of FDI. They sought to determine whether climate risks influence FDI dynamics to assess if MNCs factor these risks into their decision-making processes. The paper did not find a significant or consistent impact of physical climate risk on FDI inflows but suggested these impacts are likely to be more significant in the future. Finally, in their study analysing the effect of physical and transition climate risk on firm-level FDI inflows in China, Qing et al. (2024) found that climate risk negatively impacts firm-level inward FDI. Taken together, these studies have suggested that climate risk tends to adversely impact inward FDI, albeit to varying extents and with a level of nuance and raises questions as to whether the impact of climate risk may be more specific to the country or regions under study. This relationship thus requires further investigation in order to gain a better understanding of the impacts of climate risk on inward FDI.

In this study, we seek to contribute to the literature by assessing how climate risk impacts a firm's propensity to attract FDI in Latin America and the Caribbean. The existing climate risk-FDI research, including those referenced earlier in this section, makes valuable and insightful contributions to the literature. However, considering the growing acknowledgement of climate risk as part of the decision-making process of firms and the absence of a clear consensus on the impact of climate risk on FDI, the subject area requires further investigation. In addition, the literature has not established whether climate risk impacts the likelihood of firms to receive inward FDI. Assessing the probability that firms attract inward FDI under the influence of climate risk adds a novel perspective to the literature. Therefore, this paper hopes to add to the growing literature on climate risk and provide valuable insight into the relationship between climate risk and inward FDI.

3. Methodology

3.1 Data

Firm Level Data

The study employs both firm-level and country-level data. The firm-level data are from the World Bank Enterprise Survey (WBES). The WBES is a survey that focuses on individual firms within a representative sample of the private sector of an economy. So far, the WBES has been conducted in 159 countries, involving more than 219,000 interviews. This survey addresses various topics concerning the business environment, such as financial access, corruption, infrastructure, competition, and performance metrics. Our research focuses on firms in Latin America and the Caribbean, and we further refined the database by removing missing responses and erroneous codifications. As a result, our final dataset consisted of 20,382 firms spanning 30 countries from 2006 to 2018, as shown in Table 1.

Dependent variable

Our response variable is based on the WBES survey item that asks firms about their foreign ownership. Specifically, the item asks firms to report the percentage of their firm that is owned by private foreign individuals, companies or organisations. As per the OECD guidelines, the threshold for FDI that establishes a controlling interest is a minimum 10% ownership stake. Hence, our FDI variable is defined as follows:

$$FDI = \begin{cases} 0 \text{ if foreign owernship} < 10\% \\ 1 \text{ if foreign owernship} \geq 10\% \end{cases}$$

As such, we are modelling a firm's propensity to attract FDI.

Main independent variable: Climate Change Risk

We utilize country data from the Global Climate Risk Index published by Germanwatch as an approximation of climate risk. The index analyses the extent to which a country has been impacted by weather-related loss events such as storms, floods, heatwaves, etc. These events are assessed in the context of the associated number of casualties, casualties per 100,000 inhabitants, sum of losses in USD in purchasing power parity and losses per unit of GDP to generate these scores (Kreft and Eckstein 2014). Lower index scores indicate higher levels of climate risk. Annual scores are provided for a point two years prior to the release of the report. This study utilizes data from the 2008 to 2020 editions of the report. This index has been widely employed in climate change and climate risk literature (Huang, Kerstein, and Wang 2018; Wu, Fan, and Soo 2024; Xing and Wang 2022).

Apart from climate change risk, there are several determinants of firm-level FDI. As such, this study includes popular firm-level and country-level determinants of FDI, which are discussed in the following subsections.

Firm-Level Control variables

Our specification includes popular firm-specific determinants of FDI. Specifically, our study controls for the impact of productivity growth, firm age, export intensity, international certification, technology use, firm size, access to finance, tax obstacles and sector. We provide the definitions of the firm-level control variables in Table 2.

Country-Level Control variables

A country's macroeconomic environment can also impact a firm's attractiveness to foreign investors. In this study, we country for four country-level variables: inflation (measured as the percentage change in the GDP deflator), real GDP per capita (expressed in natural logarithms l), infrastructure (proxied by fixed broadband

subscriptions per 100 people obtained from the World Bank Database) and financial development (proxied by the financial development index obtained from the IMF)

3.2 Statistical method

Although the enterprise surveys collected information on firms, each survey was conducted independently in every country represented. Firms may be described as "nested" in their country of residence, and so, firms within the same country are more likely to be similar than those in different countries. This warrants a two-level multilevel model which allows us to simultaneously investigate the nature of between-country variability (macro-level effects) and within-country variability (firm-level effects). These models break down the random error term in accordance with the hierarchical structure of the data. As alluded to previously, the dependent variable is binary. As such, we employ a multilevel logit model, which we specify as

$$\begin{aligned} FDI &= \alpha_0 + \beta X_{ij} + \gamma Y_j + \delta_t + v_j + \epsilon_{ij} \\ &= (\alpha_0 + v_j) + \beta X_{ij} + \gamma Y_j + \epsilon_{ij} \end{aligned}$$

where FDI_{ij} indicates whether the level of foreign ownership of firm i in country j meets the FDI threshold. X_{ij} is a vector that contains the firm-level predictors, Y_j contains the country-level variables and δ_t is a set of time fixed effects. The two error components v_j, and ϵ_{ij} are the second and first-level residuals, respectively, each of which are assumed to have a zero mean and constant variance Moreover, $E\left[v_j \middle| X_{ij}, Y_j\right) = 0$ and $E\left[\epsilon_{ij} \middle| v_j, X_{ijk}, Y_j\right) = 0$. Finally, α_0, β and γ are the "fixed" parameters to be estimated and v_j is the random intercept at the country level.

4. Results

Descriptive statistics

Table 3 presents some descriptive statistics for all variables included in the study. For the qualitative variables, we provide information on the frequency and percentage of observations in each category and estimates of the mean and standard deviation for the quantitative variables.

Many firms (40 per cent) can be categorised as small (less than 20 employees). On average, firms in the sample operated for 26 years and exported about 9 per cent of their sales. Many firms faced difficulties with financing (72 per cent) and tax rates (84 per cent), and though only a portion of the firms held an internationally recognised quality certification (22 per cent), most had their own website (59 per cent). Turning to the variable of interest, less than 12 per cent of firms in the sample attracted FDI (defined as having more than 10 per cent foreign

ownership). Among those firms meeting the FDI threshold, about 27% indicated foreign ownership between 10 and 50 per cent.

However, Figure 1 shows significant variation in the share of firms with FDI across countries. In this sample, firms in Guyana, Dominica, and The Bahamas had the largest portions of firms with foreign ownership of 10 per cent or more. Specifically, roughly 20 per cent (Costa Rica) to 27 per cent (Guyana) of firms in these countries met the FDI threshold. Differences in individual firm characteristics are unlikely to be the sole cause of these observed differences in a firm's ability to attract FDI in LAC. There are likely to be context effects. In this study, we test whether differences in climate risk across countries explain some of the observed differences. As a preliminary step to the analysis, we look at the bivariate relationship between the share of firms that meet the FDI threshold and the average climate risk by country. The scatter plot (Figure 2) hints that the proportion of firms with FDI is higher in countries with greater climate risk.

Multilevel analysis

The bivariate analysis suggests a positive relationship between firm-level FDI and climate risk. However, for this analysis, the individual-level firm data were aggregated at the country level, which could give rise to the ecological fallacy. Moreover, there are several variables outside of climate risk that affect a firm's ability to attract FDI. As such, we proceed to estimate the multilevel logit model.

First, we investigate whether a multilevel model is warranted, that is, whether the multilevel logit regression provides a better fit than the standard logit model. The likelihood ratio (LR) test suggests that our multi-level model offers a significantly better first to the data than the single-level model ($\chi^2 = 56.9; p < 0.001$). We can, therefore, conclude that firms in our sample do not act as independent observations, lending further credence to our use of a multi-level model.

Table 4 presents the results from the multilevel logit model. The coefficients of logit models are not easy to interpret, as documented by Greene (2020) and Cameron and Trivedi (2022). Although the coefficients can indicate the sign and statistical significance of the predictors, their interpretation is not straightforward. For ease of interpretation, we calculated the average marginal effects (AMEs). For categorical variables, the AMEs show the average percentage point differences in probability between the reference category of a variable and the other categories of that variable. For continuous variables, the AMEs represent the average percentage point change in probability when the independent variables change by one unit.

We begin with our variables of interest- climate risk. We find no evidence to suggest that climate risk influences a firm's propensity to attract FDI in LAC. Rather, the results from the multilevel logistic model suggest that a firm's ability to attract FDI in LAC is more likely to be affected by firm characteristics and two of our macro-level variables. At the firm level, our results suggest that the probability that a firm attracts FDI is positively correlated with the firm's productivity, its export intensity, having an international quality certification, its technology use and

its size but negatively correlated with its age and financing obstacles. Meanwhile, at the country level, the propensity for firm-level FDI declines with financial development in LAC and inflation.

5. Discussion and conclusion

Climate change is having an increasing impact on the global economy. Long-term changes in climate patterns and extreme weather events have resulted in negative economic outcomes both at a macro and micro-economic level. These events have resulted in an increased focus on and consideration of climate risk in economic literature and the decision-making of firms. As a result, we sought to gain a greater understanding of how climate risk impacts the propensity of firms to receive inward FDI. We also intended to add to a growing but underdeveloped body of literature analysing the relationship between climate risk and FDI.

Utilising the Global Climate Risk Index as a proxy for climate risk, we employed a multilevel logit model to analyse whether climate risk influences a firm's propensity to attract FDI in LAC. We find no evidence to suggest that climate risk impacts a firm's propensity to attract FDI in the region. The ability of firms to encourage FDI inflows was more likely dependent on its fundamentals rather than climate risk. This may suggest that MNCs have historically not considered climate risk as a significant factor when deciding to invest in firms within LAC.

One of the major limitations of this study is that the data used was collected between 2006 and 2018. The focus on climate risk has intensified since 2018 as the world witnessed an increase in unprecedented climatic events. It begs the question of whether the relationship between climate risk is likely to change if one uses post-2018 data.

Our results so far are preliminary and serve as a first step in analysing the relationship between climate risk and inward firm-level FDI. Future iterations of this study will also seek to explore whether the relationship between FDI and climate risk depends on the nature of the firm (for instance, the firm size, financing obstacles or whether the firm is involved in extractive activities). This will facilitate a greater understanding of firm decision-making relating to climate risk and FDI.

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Appendix

Table 1

Country	Number of firms
Antigua and Barbuda	124
Argentina	2,161
Bahamas	98
Barbados	105
Belize	145
Bolivia	733
Brazil	945
Chile	1,471
Colombia	2,362
Costa Rica	285
Dominica	135
Dominican Republic	414
Ecuador	997
El Salvador	1,205
Grenada	117
Guatemala	765
Guyana	111
Honduras	398
Jamaica	208
Mexico	2,125
Nicaragua	876
Panama	435
Paraguay	499
Peru	2,026
Saint Kitts and Nevis	101
Saint Vincent and the Grenadines	109
Suriname	300
Trinidad and Tobago	282
Uruguay	721
Venezuela	129

Table 2: Definition of firm-level variables

Variable	Definition
Productivity growth	Measured as the percentage change in sales per worker over the last two years
Firm size	A 3-category variable capturing whether the firm is small (less than 20 employees), medium-sized (20 to 99 employees) or large (over 99 employees). Small firms serve as the reference category
Firm age	The number of years that the firm has been in operation
Export intensity	The percentage of sales the firm exports (exports to sales ratio)
International certification	A binary indicator that takes on a value of 1 if the firm has international certification and 0 otherwise
Technology use	A binary indicator that takes on a value 1 if the firm has its own webpage, 0 otherwise
Financing obstacles	A binary indicator that takes on a value 1 if the firm indicated there were obstacles obtaining finance, 0 otherwise
Tax obstacles	A binary indicator that takes on a value 1 if the firm indicated tax rates were an obstacle 0 otherwise
Sector	A binary indicator that takes on a value 1 if the firm operates in the manufacturing sector, 0 for services

Table 3: Descriptive Statistics

	Frequency (%)	Mean [std. dev]
Firm level variables		
FDI		
More than 10% foreign ownership	2,295 (11.26)	n.a.
Less than 10% foreign ownership	18,087 (88.74)	n.a.
Firm size		
Small (base)	8,159 (40.03)	n.a.
Medium	7,440 (36.50)	n.a.
Large	4,783 (23.47)	n.a.
Firm age (in years)	n.a.	25.69 (19.43)
Export intensity	n.a.	9.34 (22.89)
International certification		
Yes (base)	4,396 (21.57)	n.a.
No	15,986 (78.43)	n.a.
Technological use		
Yes (base)	14,762 (72.43)	n.a.
No	5,620 (27.57)	n.a.
Faced financing obstacles		
Yes (base)	45,000 (50.62)	n.a.
No	43,899 (49.38)	n.a.
Tax rate obstacles		
Yes (base)	17,040 (83.60)	n.a.
No	3,342 (16.40)	n.a.
Sector		
Manufacturing	21,278 (57.24)	n.a.
Services	15,898 (42.76)	n.a.
Country-level variables		
Climate risk	n.a.	65.53 (27.39)
Real GDP per capita (logged)	n.a.	8,296.16 (5,584.06)
Inflation	n.a.	6.80 (8.51)
Financial development	n.a.	0.27 (0.11)
Infrastructure	n.a.	7.31 (6.18)
Time Fixed Effects		
2006 (base)	6,386 (31.33)	n.a.
2009	945 (4.64)	n.a.
2010	8,712 (42.74)	n.a.
2016	1,149 (5.64)	n.a.
2017	3,042 (14.92)	n.a.
2018	148 (0.73)	n.a.

Table 4: Multilevel model results

	Average marginal effects	Standard errors
Firm level variables		
Firm size (ref: small)		
Medium	0.053***	0.006
Large	0.153***	0.011
Productivity growth	0.005**	0.002
Firm's age	-0.001***	0.000
Export intensity	0.001***	0.000
International certification	0.098***	0.008
Financing obstacles	-0.028***	0.006
Tax rate obstacles	-0.003	0.007
Sector (Manufacturing)	-0.032***	0.005
Technology use	0.043***	0.006
Country-level variables		
Climate risk	0.006	0.005
Real GDP per capita (logged)	-0.006	0.013
Inflation	-0.002**	0.001
Financial development	-0.041**	0.019
Infrastructure	0.008	0.005
Time fixed effects		
2009	-0.042	0.033
2010	-0.004	0.009
2016	0.003	0.017
2017	-0.031**	0.013
2018	-0.015	0.026
Country effects ($\sigma^2_{v_j}$)	0.115***	

Figure 1: Average firm-level FDI by country

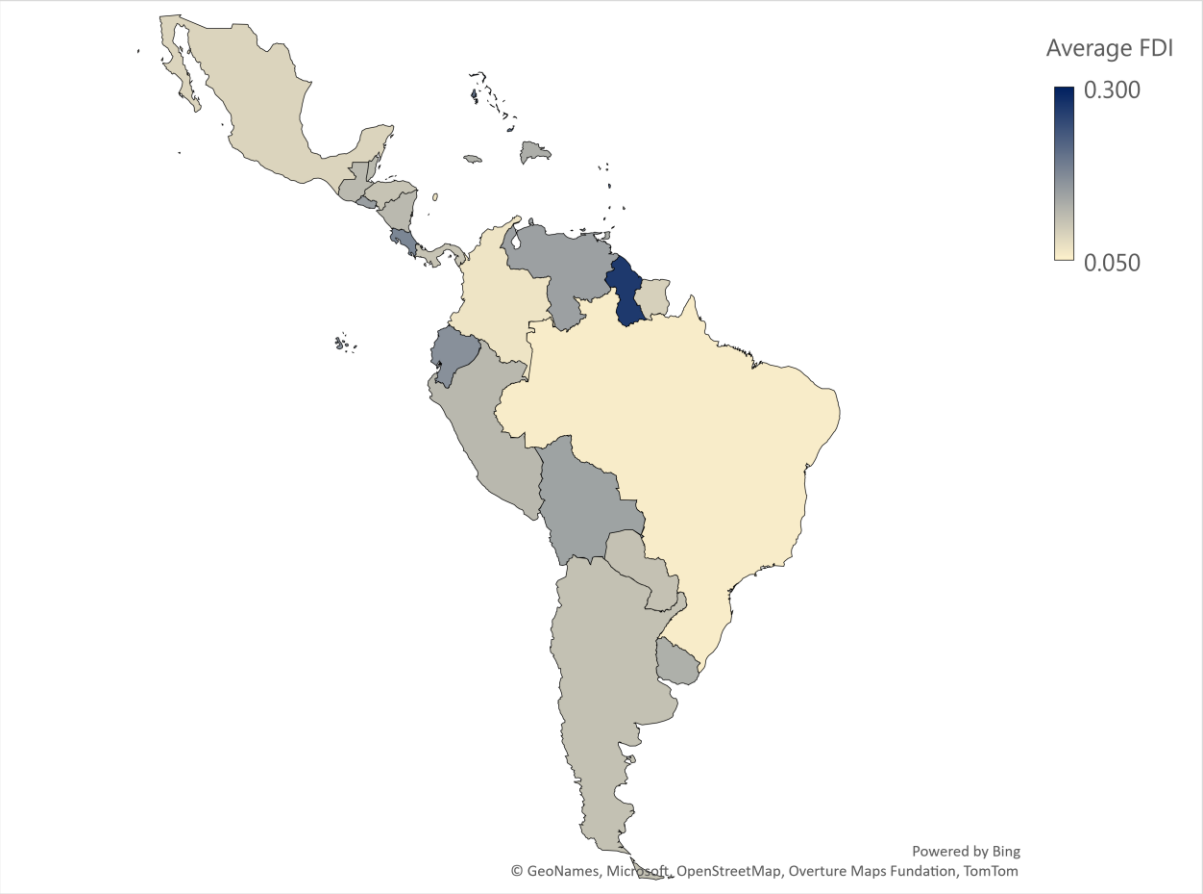

Figure 2 Bivariate relationship between Firm-level FDI and Climate Risk across countries