Does Climate Change Constitute a Financial Risk to Foreign Direct Investment? An Empirical Analysis on 200 Countries from 1970 to 2020

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ABSTRACT: In this paper, we study the role of climate change as a financial risk for foreign investors. Multinational enterprises seek to internationalize where financial risk is at the minimum level, including the climate change risk on profitability and productivity. Thereby, we conducted an empirical analysis of the effect of climate change on inward foreign direct investment (FDI) net inflows using data from 200 countries and times series from 1970 to 2020 and employing two categories of climate change indicators: Climatology and climate-related natural hazards. Using the estimation methods of fully modified ordinary least squares and robust weighted least squares, we concluded that the rise of climatology indicators (mean annual temperature and precipitations) negatively impacts inward FDI. Second, we conclude that most climate-related natural hazards (coastal/rural/urban floods, landslides, and cyclones) deter FDI while extreme heat and wildfires show no significant effect. In addition, the results show that the negative impact of climate change is more severe when the host economy depends on agricultural activities and there is no significant investment in research and development as compared with countries that depend on service and manufacturing activities and are more innovative and invest in technology infrastructure. Furthermore, we conclude that poorer host countries experience more severe effects of climate change on FDI than rich countries in terms of GDP per capita.

SIGNIFICANCE STATEMENT: The purpose of the paper is to investigate the effect of climate change on inflows of cross-border capital in 200 countries. In other words, we see if rising temperature and natural hazards related to climate change affect the decision of firms to invest in a given country. The results show that global warming and unstable meteorological indicators deter firms from investing abroad. Equally, natural hazards linked to climate change (coastal/rural/urban floods, landslides, and cyclones) constitute an investment risk. The finding suggests that the deterring effects of climate change are less severe when a given country depends less on agriculture and more on industrial sectors and when that country is more developed and technologically advanced.

KEYWORDS: Social science; Climate change; Regression analysis; Economic value

1. Introduction

The international economy is confronted frequently with multiple sources of technological, social, and environmental risks. These are either classic such as uncertainty in economic policy, geopolitical risks, commodity shocks, or many observed new risks observed recently, such as risks linked to climate change. Indeed, climate change refers to all the climatic variations that result in a warming or cooling of a given place, leading to extreme climatic damage, namely, sea level rise, droughts, floods, melting ice, cyclones, forest destabilization and fires, reduction of biodiversity (World Bank Group 2021; https://climateknowledgeportal.worldbank.org).

The United Nations Intergovernmental Panel on Climate Change (IPCC) published in August 2021 its new report containing new climate forecasts around the world. They forecasted an increase in the global average temperature by 1.5°C over the next 20 years, as well as the melting ice and rising sea levels by about 20 cm since 1900. On the other hand, scientists estimate that this increase could reach up to 1 m by 2100 and nearly 2 m by 2300 (IPCC 2021).

Today it not only represents one of the most significant threats to the environment and biodiversity, but climate change also has serious social, economic, and financial consequences. In addition, the effects of climate change on economies depend on their level of economic development, technological level, and sectoral structure related to the dominant activity such as industry, agriculture, or trade. Generally, the economic impact of climate change manifests itself in economic growth, wealth creation, productivity, and international trade. Equally, climate change harms territorial competitiveness and the performance of their attractiveness in terms of foreign direct investments (FDI; Wade and Jennings 2016; Auffhammer 2019; Kahn et al. 2019; Tol 2020).

Indeed, understanding the economic consequences of climate change becomes necessary not only for climate economists but also for professionals as investors involved in the modeling and forecasting of macroeconomic variables so they can reduce financial risks when investing in foreign markets.

Although climate change is one of the main factors affecting investor behavior, empirical studies focused on the impact on other economic variables while omitting the attractiveness of investments and FDI decision-making. According to our research, the only study analyzing the effect of changing climatology on FDI is the study of Barua et al. (2020) with panel data from 80 countries. They concluded that rising

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temperature and falling precipitation have a long-term negative impact on FDI. However, their results are heterogeneous because the temperature rise has a different effect on FDI inflows in the countries depending on their level of development. For natural disasters, many studies analyzed their impact on FDI location decisions (Noy and Vu 2010; Escaleras and Register 2011; Boustan et al. 2012; Doytch and Klein 2018; Doytch 2019; Oh et al. 2020; Neise et al. 2022). However, these studies have not distinguished natural disasters related to climate and meteorology from the geophysical ones, like earthquakes and volcanos. Despite that the work of Doytch (2019) has separated the natural disasters into different categories, including those that are related to climate change, the study has not focused on the effect of climate change on FDI and ignored the other indicators of climate change as climatology parameters (precipitations and temperature). In addition, the author used the frequency of natural disasters per year as an explanatory variable. Our study uses a more sophisticated indicator, which is the score of natural disaster hazards constructed by the Think Hazard organization, and its data are available on the Climate Change Knowledge Portal (CCKP). The author also used subpanels to compare the different effects of natural disasters on FDI between different geographies. Our paper uses moderating variables (GDP per capita, research and development, and the contribution of sectors to the GDP) to investigate the heterogeneity of the effect without the need to produce subpanels.

Therefore, our paper constitutes a novelty in the literature on FDI location factors by extensively analyzing the effect of climate change on inward FDI. In particular, our study differs from other studies by analyzing climate change in both aspects, the climatology indicators (temperature and precipitations) and natural disasters related to climate, in which previous papers worked only on one angle. Second, the data used in the empirical study are widely larger than other studies by working on 200 countries from 1970 to 2020. Third, previous papers have not used moderating variables to study the heterogeneity effect of climate change on FDI. In other words, climate change affects the inward FDI of host countries depending on their development level, sector's contribution to their GDP, and technological level. The previous studies only differentiated the effect by geographical location, which is less sophisticated than using moderating variables.

Thus, this paper aims to answer the following hypothesis: climate change constitutes a financial risk to foreign international investment. To investigate this hypothesis, we use an econometric model to analyze data of 200 countries over 51 years from 1970 to 2020. We divide the analysis into two axes, where each axis represents a substudy in itself, for two reasons: The first reason is strategic because there is no previous study on the effect of climate change using different measures and indicators. Therefore, we regrouped all the variables into two groups to facilitate the interpretation and the empirical analysis. The second reason is technical due to the incoherence of data: while climatology indicators are panel datasets, the data on natural disasters exist for one year as a cross-sectional dataset. Therefore, to avoid estimation errors, it is better to separate each group/axis in a different model for different estimations. These two groups of climate change variables are as follows:

1) The first axis will analyze the impact of two meteorological indicators, the average annual precipitation and temperature, using panel data from 200 countries over 51 years.
2) The second axis will analyze the impact of seven natural hazard indicators related to climate change (coastal floods, cyclones, extreme heat, landslides, river floods, urban floods, and wildfires) using cross-sectional data for 194 countries for 2010.

This paper is organized as follows: section 2 will present the literature review of the impact of climate change on FDI location choice. Section 3 will explain the research design to answer the research hypotheses. Section 4 will discuss the empirical results in detail.

2. Literature review of the effect of climate change on foreign direct investment

a. *General overview*

The literature recognized the impact of climate change on the economy depending on the sector and industry under study (Auffhammer 2019; Tol 2020). The different analyzes of this impact cover the field of economic growth, wealth creation, productivity, and business activities (Smith and Hitz 2003; Hallegatte et al. 2011; Groth and Brunsmeier 2016; Arnell et al. 2019). However, studies addressing the effect of climate change on domestic and foreign investment remain omitted despite being one of the factors affecting investment location decisions. In addition, it is plausible that the impact of climate change on FDI is more significant than on domestic investment because the foreign investor regularly faces a higher level of financial risks as stipulated by the hypothesis of liability of foreignness that can lead to loss of capital and investment in the host economy. In other words, the FDI faces many risks, including climate change and resulting natural disasters. The occurrence of risks related to climate change can cause damage to production sites and burden the host country's economy due to the destruction of infrastructure, logistics, and assets. Therefore, climate change tends to increase the occurrence and magnitude of natural disasters, rising temperatures, and drought (IPCC 2018). It constitutes a higher financial risk to foreign investors where natural disasters related to climate change put economies at risk, leading the multinational enterprises (MNEs) to consider the occurrence of natural disasters when making investment decisions and locating their FDI (Mani et al. 2003).

It turns out that the issue of climate change is increasingly relevant for the location of FDI because many sectors are more exposed to climate change, and the reorganization of the movement of FDI is linked to the climate in host countries. Therefore, one could say that the nature of the impact of climate change on investment depends on the sensitivity of each real sector and economic activity. However, climate change has not yet become a determinant/deterrent of FDI location decision literature (Neise et al. 2022).

For this, Moreno et al. (1996), in the second assessment report of the IPCC, classify sectors sensitive to climate change into three main categories:

1) economic activities directly sensitive to climate change, including infrastructure, real estate, construction, transport operation, and tourism,
2) economic activities with markets sensitive to climate change, including air conditioning equipment, adaptive building design, and construction, as well as transport infrastructure and services, and
3) economic activities based on inputs sensitive to climate change are industries that depend on the primary sector (agriculture and forestry), domestic and industrial biomass, and fossil/renewable energy.

b. *Hypotheses development*

1) The effect of climatology indicators changes on FDI

Climate change can negatively impact investment levels and discourage FDI such as drought and declining rainfall by deteriorating the productivity of several sectors like agriculture, agroindustry, and energy. Hence, production shocks resulting from climate change can reduce investments in agroindustry. In addition, the decrease in the level of precipitation and the availability of water can impact investments in hydropower. Indirectly, global warming and drought can negatively affect domestic and foreign investment through transmission channels such as the reduction of labor productivity and the volume of trade (Jones and Olken 2010; Niemelä et al. 2002). Also, Mercer (2015) argues that climate change may negatively impact return on investment (ROI) over the next 35 years for industries of fossil fuel, utilities, industrials, and consumer staples. And since FDI is determined primarily by ROI, climate change negatively impacts FDI through the return on investment channel. However, climate change can positively impact ROI in renewable energy, nuclear, and information and communication technology (ICT) activities, which deters FDI.

Ernst & Young (2016) proposed six reasons why climate change constitutes a financial investment risk and therefore deters FDI: 1) physical risks are the damage to infrastructure, land, buildings, and stocks or infrastructure; 2) secondary risks are the spillover effects of physical risk such as lower crop yields and resource shortages; 3) political risks: financial losses resulting from climate policies, such as carbon taxes, emission ceilings, or the withdrawal of subsidies; 4) liability risks are the financial liabilities, including insurance claims and legal damages, resulting from tort or negligence; 5) transitional risks are the financial losses resulting from disorderly or volatile adjustments in the value of assets; and 6) reputational risk: loss of trust and reputation due to actions incompatible with climate objectives.

However, the rising temperature can encourage investment in new activities and make particular regions favorable for the production of some goods as agriculture in relatively colder territories and prospecting for energy and mines in ice zones (Arctic). Furthermore, the rise in temperature changes the energy demand and could encourage investment in the energy sector.

The empirical studies have examined the impact of climate change on overall investment without distinguishing between domestic and foreign ones. For example, Dell et al. (2012) concluded that the decrease in rainfall impacts the overall investment negatively for rich countries, while the effect of the increase in temperature is insignificant. They argue that climate change may indirectly affect aggregate investment through the productivity of real sectors.

2) The effect of climate-related natural disasters on FDI

FDI is affected by the frequency of natural disasters. The negative impact of natural disasters manifested in the destruction of infrastructure, displacement of the local population, and decline in human capital resources. In addition, natural disasters cause bank liquidity shocks that discourage capital investment (Kato and Okubo 2018). However, in the long run, the impact becomes positive because natural disasters represent opportunities to be seized, such as the replacement and reconstruction of infrastructure and the updating of intangible capital (Noy and Vu 2010; Escaleras and Register 2011; Boustan et al. 2012; Doytch and Klein 2018; Doytch 2019; Oh et al. 2020; Neise et al. 2022).

Moreover, the theoretical basis of the economic analysis of natural disasters lies in the theory of growth by analyzing the short and long-term impact of these disasters on GDP. As already mentioned, natural disasters negatively impact FDI in the short term, but in the long term, GDP would rebound to a level exceeding the precatastrophic level. This hypothesis has its origin in the theory of endogenous growth under the hypothesis of “creative destruction.” In this context, reference is made to the “upgrading destruction” hypothesis where natural disasters destroy old assets with outdated technology and rebuild with new advanced practices and technology (Noy and Vu 2010; Doytch and Klein 2018). However, some characterize this hypothesis by arguing that growth converges to the precatastrophic level because the rise in marginal productivity is explained by a lack of capital available for the same amount of labor (Boustan et al. 2020). However, the impact of natural disasters depends on the country’s level of development.

Yang (2008) has studied the effect of hurricanes; as the most common and destructive types of natural disasters; on international financial flows including FDI. The author used meteorological data on storm paths and constructed a time-varying storm index from 1970 to 2002 of 87 countries. The empirical results show that FDI as a private flow is negatively affected by hurricane exposure and this effect appears greater in the richer half of the sample countries. The author explains the result by arguing that natural disasters may reflect the fall of rates of return on investment and increased risk perceptions on the part of international investors. Escaleras and Register (2011) worked on the effect of total events of natural disasters (earthquakes, floods, volcanos, landslides, windstorms) in a panel of 94 countries from 1984 to 2004 using the fixed effects model. They concluded that total damages in the prior 5–25 years affect negatively inward FDI. Kukułka (2014) studied the effect of natural disasters on inward FDI in southeastern Asian countries (Indonesia, Malaysia, Philippines, Thailand, and Vietnam) using times series from 1950 to 2013 and the ordinary least squares (OLS) estimation method. The results show a negative impact of the occurrence of natural disasters on inward FDI in Thailand and Malaysia and an insignificant impact on the remaining countries.

Anuchitworawong and Thampanishvong (2015) analyzed inward FDI in Thailand from 1971 to 2012 using a system of simultaneous equations. They found that the degree of severity of natural disasters negatively affects inward FDI in Thailand. Doytch (2019) analyzed the effect of different natural disasters on FDI in manufacturing and service sectors using panel data of 69 countries from 1980 to 2011. The author finds that manufacturing FDI is negatively affected in the short run and positively in the long run for all types of natural disasters. However, the author stated that the effect in the service sector is unclear by finding that meteorological disasters do not affect FDI and climate, hydrological disasters have long-lasting negative effects and geophysical disasters have a positive impact on FDI in the long run.

3. Research design and method

a. Sample description and data sources

The empirical analysis is based on panel data of 200 countries[1] during the period 1970–2020. The selection of the sample is due to the significance of inward foreign direct investment according to the United Nations Conference on Trade and Development (UNCTAD) database. Therefore, those absent from the panel are because the data on inward FDI is nonsignificant to consider or not provided by the local authorities. In addition, the absence of data on the independent variables is a sufficient reason to exclude a country from the panel.

Data on inward foreign direct investment as the dependent variable are provided by UNCTAD (https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96740), which collects statistics on international capital for the balance of payments. On the other hand, the data on climate change indicators, as explanatory variables, are taken for the database of the World Bank. Particularly, the data on climatology indicators (mean annual temperature and mean annual precipitation) are collected from the database provided by CCKP (https://climateknowledgeportal.worldbank.org/download-data), a division of the World Bank that provides data on historical and projected climate, its vulnerabilities, and impacts. Data on climate-related natural hazard indicators are collected from the Think Hazard organization and are available on the CCKP database. For the moderating variables, the data on all variables related to gross domestic product and research and development are taken from the database of the World Bank (https://data.worldbank.org/indicator/).

b. Research hypotheses

Inspired by the literature review and aims to investigate the role of climate change as a financial risk to foreign investors, which affects the behavior of foreign investors when it comes to the location decision of their FDI, we formulate the central research hypothesis as follows: to what extent does climate change affect inward FDI?

To investigate this research hypothesis, we aim to confirm subhypotheses that are drawn from the literature review and formulated by the equations and research hypotheses described above:

- H1: More changes in climatology indicators, the more the climate change constitutes a financial risk to foreign investors. In other words, the changes in climatology indicators negatively impact inward FDI. In particular, a higher mean annual temperature and precipitation deters inward FDI.
- H2: More climate-related natural hazard indicators are higher, and more climate change constitutes a financial risk to foreign investors. In other words, a lower score of climate-related natural hazards (coastal flood, cyclone, extreme heat, landslide, river flood, urban flood, wildfire) impacts negatively inward FDI.

To investigate the two research hypotheses, we conduct an empirical analysis using an econometric model as presented below.

c. Variables description

1) The endogenous variable: FDI

According to the research hypothesis, we aim to identify the effect of climate change on the location decision of foreign capital. Therefore, FDI is the practical proxy variable usually employed by empirical researchers when answering this kind

[1] Afghanistan, Albania, Algeria, Angola, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, the British Virgin Islands, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Cayman Islands, the Central African Republic, Chad, Chile, China, China (Macao Special Administrative Region), Colombia, Comoros, Republic of the Congo, Democratic Republic of the Congo, Cook Islands, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, Czechia, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, French Polynesia, Gabon, The Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, South Korea, North Korea, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Moldova, Mongolia, Montenegro, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Sudan, Spain, Sri Lanka, State of Palestine, Sudan, Suriname, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tonga Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Turks and Caicos Islands, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Zambia, and Zimbabwe.

of research hypothesis related to internationalization and capital movement. Generally, the FDI is defined, according to the International Monetary Fund, as the portion held in the capital of a company that must be greater than 10% to distinguish it from the portfolio investment. In addition to direct equity investments, direct investments also include advances in associates' current accounts and private loans contracted by foreign plants with their parent companies, as well as reinvested profits. In particular, the variable used for the empirical analysis is the net flow of inward foreign direct investment.

2) The explanatory variables: Climate change

(i) Climatology indicators

The mean annual temperature is the average temperature of the maxima and minima for the warmest and coldest months. The glossary of CCKP defines the temperature as the expected temperature in degrees, valid for the indicated hour. Global temperature is an average of air temperature recordings from weather stations on land and sea and some satellite measurements. Extreme temperature events (maxima and minima) may have short-term durations of a few days with temperature increases of over 5°C above the normal temperatures.

The mean annual precipitation is calculated by summing the rainfall for a given year. The snowfall is considered an assumed water equivalent of the rainfall by using a specific gravity of 0.1 for freshly fallen snow. This means 25.4 cm of freshly fallen snow is assumed to be equal to 2.54 cm of rain. The glossary of CCKP defines precipitation as "water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth" (World Bank Group 2021, p. 7).

(ii) The climate-related natural hazard indicator

Climate-related natural hazard indicators provide a general view of the natural disasters for a given country that should be considered when investing abroad. The score ranges from 1 to 4: 1 for high hazard, 2 for medium hazard, 3 for low hazard, and 4 for very low hazard. The glossary of CCKP defines some of the natural hazards as follows: floods, including coastal, river, and urban ones, are the "overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged (World Bank Group 2021, p. 6)." The cyclone is defined as a "rapid-onset event that takes place in days or weeks (in contrast to slow-onset climate changes that occur over long periods) (World Bank Group 2021, p. 8)." Extreme heat is three or more days of above-average temperatures, generally defined as passing a certain threshold (e.g., above the 85th percentile for average daily temperature in a year).

3) The moderating variables

The first type of moderating variable is GDP per capita, which is used to moderate the effect of climate change on capital mobility in the sense that is usually employed by empirical analysis as a proxy for the level of development and market strength and economic resilience to exogenous shocks. Furthermore, GDP per capita is a gross domestic product, measured by current U.S. dollars, divided by midyear population. The World Bank defines GDP as "the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources" (Glossary of the World Bank; https://databank.worldbank.org/metadataglossary/africa-development-indicators/series/NY.GDP.MKTP.PP.KD#:~:text=GDP%20is%20the%20sum%20of,the%20value%20of%20the%20products).

The second type of moderating variable is the contribution by a specific sector to the value-added (percent of GDP). The present analysis uses three main sectors: industry, agriculture, and commerce. The underlying hypothesis is that the effect of climate change on FDI attractiveness depends on which sector is more dominant in the economy. For this matter, we use the part of the industry sector in GDP that includes subsectors of mining, manufacturing, construction, electricity, water, and gas; the part of the agriculture sector in GDP that includes subsectors of forestry, hunting, and fishing, as well as cultivation of crops and livestock production; and the part of the commerce sector in GDP that is the sum of merchandise exports and imports.

The third type of moderating variable is the R&D expenditure part in GDP. Research and development (R&D) could play a role in moderating the effect of climate change on FDI because R&D indicates the level of innovation and scientific progress of a given country. R&D expenditure includes both capital and current expenditures in the four main sectors: business enterprise, government, higher education, and private nonprofit. R&D covers basic research, applied research, and experimental development.

4) Control variables

Our data on inward FDI are mixed and do not distinguish between vertical from horizontal foreign direct investment, which leads us to use the knowledge-capital model (KCM) introduced by Carr et al. (2001). That conceptual model aims to identify the type of FDI by computing other location factors of FDI: market size, trade tariffs, and factor endowment. In other words, location factors explain the type of FDI and its motivation, whether horizontal or vertical. According to the knowledge-capital model, horizontal FDI is affected positively by large market size and high tariffs. The vertical FDI is affected negatively by high tariffs and positively impacted by input endowment.

Inspired by the theoretical model of KCM, we include the variables as follows: Market size measured by current GDP is a proxy for market size. For factor endowment, we use the revealed comparative advantage (RCA), which is based on the Ricardian trade model to indicate the competitiveness of a country that has on other countries. The revealed comparative advantage is the exports share of a product j with the total exports of a given country divided by the exports share of the product in the total exports of a zone reference. And finally, we use the weighted average tariffs effectively applied (TAR). In addition, we add the rule of law index as a proxy for institutional quality that reflects "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." This index is ranged between −2.5 for weak rule of law and 2.5 for strong rule of law.

d. Empirical model

To identify the effect of climate change on foreign investors behavior, we formulate the general hypothesis as a linear model to measure the marginal impact of climate change indicators on inward FDI as below:

$$\text{FDI} = \alpha + \beta\text{Climate\_Change} + \sum\beta_k(X) + \varepsilon.$$

The dependent variable is the foreign direct investment regressed by the main explanatory variables related to climate change. In addition, we use moderating variables to control the effect of climate change on foreign investment behavior. Last, we add other control variables inspired by the knowledge-capital model. The following equations capture the particular hypotheses depending on subresearch hypothesis.

1) The impact of climatology change on foreign investment

The following two models, Eqs. (3.1) and (3.2), respectively, are the formulation of the first research hypothesis (H1) by representing the effect of changing of climatology on inward FDI along with the presence of the five moderating variables and four control variables:

$$\begin{aligned}\text{FDI}_{it} = \alpha_i &+ \beta_1\text{MAT}_{it} + \beta_2(\text{MAT}\times\text{GDPA})_{it} + \beta_3(\text{MAT}\times\text{GDPI})_{it} + \beta_4(\text{MAT}\times\text{GDPC})_{it} + \beta_5(\text{MAT}\times\text{GDP})_{it}\\ &+ \beta_6(\text{MAT}\times\text{RD})_{it} + \beta_7\text{Market}_{it} + \beta_8\text{RCA}_{it} + \beta_9\text{TAR}_{it} + \beta_{10}\text{IQ}_{it} + \varepsilon_{it} \quad \text{and} \qquad (3.1)\end{aligned}$$

$$\begin{aligned}\text{FDI}_{it} = \alpha_i &+ \beta_1\text{MAP}_{it} + \beta_2(\text{MAP}\times\text{GDPA})_{it} + \beta_3(\text{MAP}\times\text{GDPI})_{it} + \beta_4(\text{MAP}\times\text{GDPC})_{it} + \beta_5(\text{MAP}\times\text{GDP})_{it}\\ &+ \beta_6(\text{MAP}\times\text{RD})_{it} + \beta_7\text{Market}_{it} + \beta_8\text{RCA}_{it} + \beta_9\text{TAR}_{it} + \beta_{10}\text{IQ}_{it} + \varepsilon_{it}. \qquad (3.2)\end{aligned}$$

FDI denotes the net flow of inward FDI in millions of current USD in the country i in year t, MAT denotes the mean annual temperature measured by the Celsius metric in the country i in year t, MAP denotes the mean annual precipitation measured by the millimeter metric in the country in year t, GDPA is the part of agriculture in the GDP of country i in year t, GDPI is the part of the industry in the GDP of country i in year t, GDPC is the part of commerce and trade in the GDP of country i in year t, GDP denotes the GDP per capita in current USD of country i in year t, RD indicates the part of the expenditure of research and development in GDP of country i in year t, RCA_i indicates the revealed comparative advantage of country i in year t, Market_i denotes the gross domestic product in current USD by millions in host country i in year y, Tar_i indicates the weighted average tariffs effectively applied on imports of country i in year t, IQ_{it} denotes the rule of law index of country i in year t, α denotes the specific fixed effect of each country to control for the omitted factors relatively stable over time, and ε is the normally distributed error term.

2) The impact of climate-related natural hazards on foreign investment

The following seven models—Eqs. (3.3), (3.4), (3.5), (3.6), (3.7), (3.8), and (3.9)—are the formulation of the second research hypothesis (H2) by representing the effect of a climate-related natural hazard on inward FDI along with the presence of the five moderating variables and four control variables:

$$\begin{aligned}\text{FDI}_i = \alpha_i &+ \beta_1\text{CF}_i + \beta_2(\text{CF}\times\text{GDPA})_i + \beta_3(\text{CF}\times\text{GDPI})_i\\ &+ \beta_4(\text{CF}\times\text{GDPC})_i + \beta_5(\text{CF}\times\text{GDP})_i\\ &+ \beta_6(\text{CF}\times\text{RD})_i + \beta_7\text{Market}_i + \beta_8\text{RCA}_i\\ &+ \beta_9\text{TAR}_i + \beta_{10}\text{IQ}_i + \varepsilon_i, \qquad (3.3)\end{aligned}$$

$$\begin{aligned}\text{FDI}_i = \alpha_i &+ \beta_1\text{CY}_i + \beta_2(\text{CY}\times\text{GDPA})_i\\ &+ \beta_3(\text{CY}\times\text{GDPI})_{it} + \beta_4(\text{CY}\times\text{GDPC})_i\\ &+ \beta_5(\text{CY}\times\text{GDPC})_i + \beta_6(\text{CY}\times\text{RD})_i\\ &+ \beta_7\text{Market}_i + \beta_8\text{RCA}_i + \beta_9\text{TAR}_i + \beta_{10}\text{IQ}_i + \varepsilon_i, \qquad (3.4)\end{aligned}$$

$$\begin{aligned}\text{FDI}_i = \alpha_i &+ \beta_1\text{EH}_i + \beta_2(\text{EH}\times\text{GDPA})_i\\ &+ \beta_3(\text{EH}\times\text{GDPI})_i + \beta_4(\text{EH}\times\text{GDPC})_i\\ &+ \beta_5(\text{EH}\times\text{GDP})_i + \beta_6(\text{EH}\times\text{RD})_i\\ &+ \beta_7\text{Market}_i + \beta_8\text{RCA}_i + \beta_9\text{TAR}_i + \beta_{10}\text{IQ}_i + \varepsilon_i, \qquad (3.5)\end{aligned}$$

$$\begin{aligned}\text{FDI}_i = \alpha_i &+ \beta_1\text{LS}_i + \beta_2(\text{LS}\times\text{GDPA})_i + \beta_3(\text{LS}\times\text{GDPI})_i\\ &+ \beta_4(\text{LS}\times\text{GDPC})_i + \beta 5(\text{LS}\times\text{GDP})_i\\ &+ \beta_6(\text{LS}\times\text{RD})_i + \beta_7\text{Market}_i + \beta_8\text{RCA}_i\\ &+ \beta_9\text{TAR}_i + \beta_{10}\text{IQ}_i + \varepsilon_i, \qquad (3.6)\end{aligned}$$

$$\begin{aligned}\mathrm{FDI}_i = \alpha_i &+ \beta_1\mathrm{RF}_i + \beta_2(\mathrm{RF}\times\mathrm{GDPA})_i + \beta_3(\mathrm{RF}\times\mathrm{GDPI})_i \\ &+ \beta_4(\mathrm{RF}\times\mathrm{GDPC})_i + \beta_5(\mathrm{RF}\times\mathrm{GDP})_i \\ &+ \beta_6(\mathrm{RF}\times\mathrm{RD})_i + \beta_7\mathrm{Market}_i + \beta_8\mathrm{RCA}_i \\ &+ \beta_9\mathrm{TAR}_i + \beta_{10}\mathrm{IQ}_i + \varepsilon_i, \qquad (3.7)\end{aligned}$$

$$\begin{aligned}\mathrm{FDI}_i = \alpha_i &+ \beta_1\mathrm{UF}_i + \beta_2(\mathrm{UF}\times\mathrm{GDPA})_i + \beta_3(\mathrm{UF}\times\mathrm{GDPI})_i \\ &+ \beta_4(\mathrm{UF}\times\mathrm{GDPC})_i + \beta_5(\mathrm{UF}\times\mathrm{GDP})_i \\ &+ \beta_6(\mathrm{UF}\times\mathrm{RD})_i + \beta_7\mathrm{Market}_i + \beta_8\mathrm{RCA}_i \\ &+ \beta_9\mathrm{TAR}_i + \beta_{10}\mathrm{IQ}_i + \varepsilon_i, \quad \text{and} \qquad (3.8)\end{aligned}$$

$$\begin{aligned}\mathrm{FDI}_i = \alpha_i &+ \beta_1\mathrm{WF}_i + \beta_2(\mathrm{WF}\times\mathrm{GDPA})_i \\ &+ \beta_3(\mathrm{WF}\times\mathrm{GDPI})_i + \beta_4(\mathrm{WF}\times\mathrm{GDPC})_i \\ &+ \beta_5(\mathrm{WF}\times\mathrm{GDP})_i + \beta_6(\mathrm{WF}\times\mathrm{RD})_i + \beta_7\mathrm{Market}_i \\ &+ \beta_8\mathrm{RCA}_i + \beta_9\mathrm{TAR}_i + \beta_{10}\mathrm{IQ}_i + \varepsilon_i. \qquad (3.9)\end{aligned}$$

FDI denotes the net flow of inward FDI in millions of current USD in country i, CF denotes the score of hazardous costal flood in country i, CY denotes the score of hazardous cyclone in country i, EH denotes the score of hazardous extreme heat in country i, LS denotes the score of hazardous landslide in country i, RF denotes the score of hazardous river flood in country i, UF denotes the score of hazardous urban flood in country i, WF denotes the score of hazardous wildfire in country i, GDPA is the part of agriculture in the GDP of country i, GDPI is the part of industry in the GDP of country i, GDPC is the part of commerce and trade in the GDP of country i, GDP denotes the GDP per capita in current USD of country i, RD indicates the part of expenditure of research and development in GDP in country I, RCA_i indicates the revealed comparative advantage of country i in year t, Market_i denotes the gross domestic product in current USD by millions in host country i in year y, Tar_i indicates the weighted average tariffs effectively applied on imports of country I in year t, IQ_{it} denotes the rule of law index of country i in year t, α denotes the specific fixed effect of each country to control for the omitted factors relatively stable over time, and ε is the normally distributed error term.

e. Estimation method

This paper works on panel data where $N = 200$ country and $T = 51$ (from 1970 to 2020). Hence, we choose the estimation method of fully modified ordinary least squares (FMOLS) proposed by Pedroni (2001). These estimators have the advantage of producing unbiased estimators even with endogenous regressors and of allowing the coefficients to differ between countries. The chosen panel method is the: the "grouped mean" estimation. According to Pedroni (2001), an advantage of the grouped-mean estimator over the "pooled" estimator is that the t statistic for this estimator allows for a more flexible alternative hypothesis. Indeed, grouped-mean estimators are based on panel interdimensions, whereas pooled estimators are based on panel intradimensions.

However, for the second group of equations, the data are cross sectional because of the presence of data for 2010 only. In addition, because of the lack of data, the number of countries is reduced to 194 countries. We chose the robust least squares (RLS) estimation method for the second group of models because OLS estimators are much less robust under the existence of observations outside the norm for our regression model. Thus, the outliers would not accurately reflect the underlying statistical relationship between the dependent and explanatory variables. In other words, outliers tend to pull the least squares fit too far in their direction by receiving much more weight than they deserve, which causes heteroscedasticity and normality problems. Thus, the estimators of robust least squares reduce the influence of these outliers to provide better data by downweighting the outliers, which makes their residuals larger and easier to identify. In particular, we use the M estimation technique elaborated by Huber (1973) that addresses dependent variables, that is, FDI's outliers, where there are large residuals because its values differ noticeably from the regression model norm. Consequently, robust weighted least squares (RWLS) provide an alternative to other least squares estimation methods by requiring less restrictive assumptions about normality and homoscedasticity using the Welsch function as the best of other weight functions (Yulita et al. 2018).

4. Results and discussion

The present section is presenting the empirical estimation of the models discussed in the previous section. The presentations of the empirical results follow the same structure explained previously where we conduct two separate analyses of the effect of climate change on inward FDI. Section 4a analyzes the effect of climatology variables on inward FDI by the difference between the mean annual temperature and the mean annual precipitations. Section 4b answers the research hypothesis on the effect of different natural disasters related to climate changes on FDI as cyclones, floods, and extreme heat.

a. The effect of climatology indicators changes on FDI

Table 1 represents the estimate of Eq. (3.1) with an included period number of 51 and included cross-sectional number of 183, which gives an unbalanced total panel number of 5529. For the moderating variable, we include the ones related to the sector's contribution to GDP.[2] Table 2 represents the estimate of Eq. (3.1) with an included period number of 24 and included cross-sectional number of 138, which gives an unbalanced total panel number of 1834. For the moderating variable, we include the ones related to GPD per capita and R&D.

[2] The model has been split into two equations because of data incompatibility considering that the data on RD begins from 1996 whereas the other control variables begin from 1970, which would produce a significant imbalance in panel.

TABLE 1. Effect of mean annual temperature on FDI with moderating role of sector's contribution in GDP. On e, two, and three asterisks indicate significance levels at 10%, 5%, and 1%, respectively. The estimation method is FMOLS with no trend specification. The panel method is grouped. The selection of lag order is based on the vector autoregressive (VAR) specification method where the criterion likelihood ratio (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz criterion (SC), and Hannan Quinn (HQ) indicate the optimum lag order at 8, 9, and 10.

Variables	Coef	Std error	t statistic
MAT	−204.7291**	83.7144	−2.4455
MAT × GDPA	−3.3114***	2.3224	1.4258
MAT × GDPI	−1.2745*	0.7075	1.8018
MAT × GDPC	1.7465	3.6587	0.4773
Market	1.37×10^{-8}***	2.51×10^{-10}	54.5997
RCA	−2426.1690**	1130.3260	−2.1464
TAR	150.1565*	108.8787	1.3791
IQ	2760.8050***	687.3469	4.0166
MAT(−8)	−102.7679**	49.0808	−2.0938
MAT(−9)	195.4096***	51.8867	3.7660
MAT(−10)	123.0607**	50.3845	2.4424
Adjusted R^2		0.6687	

According to all estimates, the MAT affects negatively inward FDI at a significance level of 5%. This result is compatible with the literature in the sense that global warming deteriorates productivity and hinders economic growth (Wade and Jennings 2016; Hallegatte et al. 2017; Auffhammer 2019; Arnell et al. 2019; Tol 2020), hence the attractiveness of FDI. The present results confirm hypothesis H1.

Particularly, the data show that this negative impact is only valid for economies that tend to rely on agriculture and the industrial sector at a significance level between 1% and 5%, while those who depend on the service sector as commerce and trade are not affected that much. In other words, more important is the part of the agricultural and industrial sector in the value-added formation (GDP) of a country, more likely it suffers from the negative impact of rising mean annual temperature on its economy and therefore its attractiveness of FDI. The contribution of the service sector (commerce) in the GDP has no impact on FDI attractiveness. On the other hand, it shows that GDP per capita does not moderate the relationship between MAT and FDI that indicates that the level of development and wealth creation is not a factor in the equation. However, R&D plays a positive moderator that means that countries who invest more in research and innovation face fewer consequences of climate change.

In general, the rise of mean annual temperature constitutes a financial risk to foreign investors. The empirical results show that the MAT impacts negatively inward FDI, which means the rise of global temperature restrains productivity and troubles foreign investors' investment estimates. For moderating variables, we conclude that the contribution of the agricultural and industrial sector in the GDP is a negative moderator of the impact on FDI, which means that the more the economy depends on agriculture and industry the more the negative impact on FDI is severe (the agriculture is tenser than the industry). In addition, R&D is a positive moderator, which means the more the country invests in innovative technologies, the less is exposed to the negative impact of rising temperature on FDI. On the other hand, the contribution of commerce to GDP, as well as GDP per capita, has no moderating role.

TABLE 2. As in Table 1, but for the effect of mean annual temperature on FDI with moderating role of GDP per capita and R&D.

Variables	Coef	Std error	t statistic
MAT	−265.6808**	167.6444	−1.5847
MAT × GDP	0.0057	0.0051	1.1149
MAT × RD	121.7778*	143.9914	0.8457
Market	1.43×10^{-8}***	4.12×10^{-10}	34.654
RCA	−3274.7030	3127.839	−1.0469
TAR	334.7311*	289.6256	1.1557
IQ	1702.1780**	1822.1690	0.9341
MAT(−8)	49.4556	147.3400	0.3356
MAT(−9)	369.1858***	134.8802	2.7371
MAT(−10)	−68.9074	129.9212	−0.5303
Adjusted R^2		0.7820	

Table 3 represents the estimate of Eq. (3.2) with an included period number of 51 and included cross-sectional number of 183, which gives an unbalanced total panel number of 5529. For the moderating variable, we include the ones related to the sector's contribution to GDP. Table 4 represents the estimate of Eq. (3.2) with an included period number of 24 and included cross-sectional number of 138, which gives an unbalanced total panel number of 1834. For the moderating variable, we include the ones related to GPD per capita and R&D.

In general, the estimation results show that the MAP affects negatively inward FDI at a significance level of 5%. This result is compatible with the literature in the sense that the rising of mean precipitation in a country would not be adequate to its infrastructure and productive system, which also deteriorates its productivity and hence the mobility of FDI (Doytch 2019). The present results confirm hypothesis H1.

TABLE 3. As in Table 1, but for the effect of mean annual precipitation on FDI with moderating role of sector's contribution in GDP.

Variables	Coef	Std error	t statistic
MAP	−1.8546*	1.0653	−1.7408
MAP × GDPA	−0.0616*	0.0389	1.5850
MAP × GDPI	0.0095	0.0516	0.1850
MAP × GDPC	0.0086	0.0100	0.8585
Market	1.38×10^{-8}***	2.53×10^{-10}	54.485
RCA	−837.6715	1112.871	−0.7527
TAR	268.3752**	109.8945	2.4421
IQ	2615.0810***	661.2594	3.9546
MAP(−8)	−0.5508	0.4472	−1.2316
MAP(−9)	0.3694	0.4770	0.7744
MAP(−10)	1.5267***	0.5102	2.9920
Adjusted R^2		0.6957	

TABLE 4. As in Table 1, but for the effect of mean annual precipitation on FDI with moderating role of GDP per capita and R&D.

Variables	Coef	Std error	t statistic
MAP	-2.7620^{**}	2.417 913	−1.1423
MAP × GDP	0.0001^{**}	6.79×10^{-5}	2.1784
MAP × RD	1.6079^{*}	1.643 262	0.9785
Market	$1.43 \times 10^{-8****}$	3.96×10^{-10}	36.1950
RCA	−992.2190	2863.988	−0.3464
TAR	451.9769^{*}	302.2649	1.4953
IQ	512.6796^{*}	1997.9090	0.2566
MAP(−8)	−0.5637	1.4367	−0.3923
MAP(−9)	2.9077^{*}	1.5014	1.9366
MAP(−10)	−0.5873	1.4758	−0.3979
Adjusted R^2		0.7798	

TABLE 5. Similar to Table 1, but for the effect of coastal flood hazard score on FDI. The estimation method is RWLS with M estimation. The covariance type for the estimation is Huber type with Welsch function for the weight. The scale estimate used is Huber.

Variable	Coef	Std error	Z statistic
C	3657.2840^{***}	510.3339	7.1664
CF	8578.4590^{***}	545.6483	15.721
CF × GDPA	56.4380^{***}	18.830	2.9971
CF × GDPI	-228.8181^{***}	21.293 62	−10.745
CF × GDPC	-99.4154^{***}	4.739 208	−20.977
CF × GDP	470.7925^{***}	43.291 11	10.875
CF × RD	865.0310^{***}	193.9740	4.4595
Adjusted Rw^2		0.1416	
Rn^2 statistic		683.3651^{***}	

The result above is confirmed with moderating variable: the data show that this negative impact is only valid for economies that tend to rely on the agriculture sector at a significance level of 1%, while those who depend on the industrial and service sector (commerce and trade) are not significant. In other words, more important is the part of the agricultural sector in the value-added formation (GDP) of a country, more likely it suffers from the negative impact of rising mean annual precipitation on its economy and therefore its attractiveness of FDI. While the contribution of the industrial and service sector (commerce) to the GDP has no impact on FDI attractiveness. Equally, it shows that GDP per capita does not moderate the relationship between MAP and FDI, which indicates that the level of development and wealth creation is not a factor in the equation. However, R&D plays a positive moderator, which means that countries who invest more in research and innovation face fewer consequences of changing in precipitations.

In general, the change of mean annual precipitation constitutes a financial risk to foreign investors. The empirical results show that the MAP impacts negatively inward FDI, which means the change of global level of precipitations restrains productivity and troubles foreign investors' investment estimates. For moderating variables, we conclude that the contribution of the agricultural sector in the GDP is a negative moderator of the impact on FDI, which means that the more the economy depends on agriculture the more negative impact on FDI is severe In addition, the R&D is a positive moderator, which means more the country invests in innovative technologies, the less is exposed to the negative impact of changing in precipitation level on FDI. On the other hand, the contribution of industry and commerce to GDP, as well as GDP per capita, have no moderating role.

In addition, the estimations of control variables show a positive effect of market size on inward FDI, which indicates the horizontal nature of the investments. According to the KCM, the horizontal FDI are seeking large market size and economic growth to increase the commercial profit of MNE. In addition, high tariffs affect inward FDI, which confirms the horizontal type under the premise that these types of investment are called "tariff-jumping FDI" where high tariffs encourage the MNE to bypass the border and create local subsidiaries. However, the RCA as proxy for factor endowment has inconclusive results, which is reasonable due to the fact that horizontal FDI do not consider factor endowment as vertical FDI. Last, institutional quality positively affects inward FDI, which is not surprising due to the large amount of literature supporting good governance as a strong determinant of FDI location choice.

We can now reach our first conclusion: The first hypothesis claims that changes in climatology indicators impact inward FDI negatively, which confirms the finding of Barua et al. (2020). In particular, climate change–related precipitations and temperature constitute a financial risk to foreign investors especially when the economy depends on agricultural activities, and there is no significant investment in research and development. Furthermore, we conclude that economic development (GDP per capita and the contribution of industry and service in the added value) has no role in moderating the negative effect of climate change on the economy and international investment.

b. *The effect of climate-related natural hazard indicators on FDI*

Table 5 represents the estimate of Eq. (3.3) with an included observation of 56 after adjustment. According to the estimates, the CF score impacts positively inward FDI at a significance level of 1%. This result is compatible with the literature in the sense that natural disasters related to climate change deteriorate productivity and hinder economic growth; hence, the attractiveness of FDI. In other words, a higher score of coastal flood means less risk of getting it. The present results confirm hypothesis H2, which means that coastal flood represents a financial risk of foreign investment. Particularly, the data show that this positive impact is enhanced for economies that tend to rely on the agriculture sector at a significance level of 1%. Equally, the higher the country's GDP per capita and R&D expenditure, the more the score of coastal flood attracts FDI.

On the other hand, the higher the contribution of the service and industrial sector in GPD, the less FDI the country receives. In other words, the more important is the part of the

TABLE 6. As in Table 5, but for the effect of cyclone hazard score on FDI.

Variable	Coef	Std error	Z statistic
C	10 033.3800***	386.5981	25.9529
CY	1121.5580***	367.5041	3.0518
CY × GDPA	−42.9735***	6.9567	−6.1772
CY × GDPI	−39.7976***	11.9389	−3.3334
CY × GDPC	−22.1693***	3.2659	−6.7880
CY × GDP	−105.2067***	22.9533	−4.5835
CY × RD	−995.0481***	150.3078	−6.6200
Adjusted Rw^2		0.1026	
Rn^2 statistic		281.0429***	

TABLE 8. As in Table 5, but for the effect of landslide hazard score on FDI.

Variable	Coef	Std error	Z statistic
C	3790.4060***	288.1814	13.1528
LS	4318.7710***	271.3952	15.9132
LS × GDPA	−82.9969***	8.4393	−9.8345
LS × GDPI	−41.9602***	11.3046	−3.7117
LS × GDPC	−32.0864***	2.3740	−13.5152
LS × GDP	249.7675***	19.9138	12.542 40
LS × RD	−311.8106***	103.1896	−3.0217
Adjusted Rw^2		0.0491	
Rn^2 statistic		444.6610***	

industrial and commercial sector in the value-added formation (GDP) of a country, the less likely that it suffers from the negative impact of the coastal flood on its economy and therefore its attractiveness of FDI.

Table 6 represents the estimate of Eq. (3.4) with an included observation of 36 after adjustment. According to the estimates, the CY score impacts positively inward FDI at a significance level of 1%. Even so, a cyclone is a rapid onset event, and it causes devastating damage to infrastructure, which deters foreign investment. In other words, a higher score of cyclone means less risk of getting it. The present results confirm hypothesis H2, which means that cyclone represents a financial risk for foreign investors. Particularly, the data show that all the moderating variables have negative signs at a significance level of 1%, which means this positive impact matters for economies that tend to be less rich and invest less in R&D.

Table 7 represents the estimate of Eq. (3.5) with an included observation of 77 after adjustment. According to the estimates, the EH score does not affect inward FDI. This result is explained by the fact that extreme heat is a rapid onset event that takes place only for a few days. Unlike cyclones, extreme heat is a well-managed risk, therefore, the score of extreme heat would not impact the location decision of foreign investors. The results infirm hypothesis H2 and conclude that extreme heat is not a financial risk for foreign investors. On the other hand, the data show that the score impacts positively when the country has higher GDP per capita and a technologically innovative structure.

Table 8 represents the estimate of Eq. (3.6) with an included observation of 78 after adjustment. According to the estimates, the LS score has a positive effect on the inward FDI significance level of 1%. The result is explained by the fact that landslides have a devastating effect on countries' infrastructure, therefore, the score of landslides would attract location foreign investors. The results confirm hypothesis H2 that the landslides represent a financial risk for foreign investors. Furthermore, the data show that GDP per capita enhances the positive effect, which means that a high level of development mitigates the risk of landslides.

Table 9 represents the estimate of Eq. (3.7) with an included observation of 76 after adjustment. According to the estimates, the RF score has a positive effect on the inward FDI significance level of 1%. The result is explained by the fact that rural floods have a devastating effect on countries' infrastructure, therefore, the score of rural would attract location foreign investors. The results confirm hypothesis H2 that rural represents a financial risk for foreign investors. Furthermore, the data show that GDP per capita and R&D expenditure enhance the positive effect, which means that a high level of development and technological capacities mitigate the risk of rural floods.

Table 10 represents the estimate of Eq. (3.8) with an included observation of 76 after adjustment. According to the estimates, the UF score has a positive effect on the inward FDI significance level of 1%. The result is explained by the fact that rural floods have a devastating effect on countries' infrastructure, therefore, the score of urban would attract location foreign investors. The results confirm hypothesis H2 that urban represents a financial risk for foreign investors. Furthermore, the data show that GDP per capita and R&D expenditure enhance the positive effect, which means that a

TABLE 7. As in Table 5, but for the effect of extreme heat hazard score on FDI.

Variable	Coef	Std error	Z statistic
C	7899.2840***	432.4177	18.2677
EH	−335.7792	326.4139	−1.0286
EH × GDPA	−23.5966**	9.6275	−2.4509
EH × GDPI	−95.6841***	11.3716	−8.4142
EH × GDPC	−5.3496**	2.3866	−2.2414
EH × GDP	189.8575***	27.2283	6.9727
EH × RD	435.7014***	84.3463	5.1656
Adjusted Rw^2		0.0330	
Rn^2 statistic		202.9118***	

TABLE 9. As in Table 5, but for the effect of rural flood hazard score on FDI.

Variable	Coef	Std error	Z statistic
C	9543.6280***	476.4885	20.0290
RF	1073.9710**	490.8048	2.1881
RF × GDPA	−68.8654***	15.1781	−4.5371
RF × GDPI	−193.1247***	24.4598	−7.8955
RF × GDPC	−25.7669***	4.5294	−5.6888
RF × GDP	62.4833	50.7455	1.2313
RF × RD	155.5424	169.3416	0.9185
Adjusted Rw^2		0.0340	
Rn^2 statistic		204.9114***	

TABLE 10. As in Table 5, but for the effect of urban flood score on FDI.

Variable	Coef	Std error	Z statistic
C	8728.8270***	435.2870	20.0530
UF	2730.6670***	456.8638	5.9769
UF × GDPA	−121.5418***	13.1798	−9.2217
UF × GDPI	−167.2122***	20.8061	−8.0366
UF × GDPC	−37.3386***	4.0686	−9.1771
UF × GDP	129.9834***	40.2592	3.2286
UF × RD	239.0364**	118.3437	2.0198
Adjusted Rw^2		0.0446	
Rn^2 statistic		265.6986***	

TABLE 11. As in Table 5, but for the effect of wildfire score on FDI.

Variable	Coef	Std error	Z statistic
C	9448.8770***	390.5104	24.19 622
WF	−764.5433**	338.8088	−2.2565
WF × GDPA	−107.3944***	15.4682	−6.9428
WF × GDPI	−64.5302***	18.3421	−3.5181
WF × GDPC	−7.8703**	3.7326	−2.1084
WF × GDP	−52.2538*	30.4394	−1.7166
WF × RD	−20.8305	129.5137	−0.1608
Adjusted Rw^2		0.0202	
Rn^2 statistic		146.0541***	

high level of development and technological capacities mitigate the risk of urban flood.

Table 11 represents the estimate of Eq. (3.9) with an included observation of 78 after adjustment. According to the estimates, the WF score affects negatively the inward FDI significance level of 1%, which informs hypothesis H2 that wildfire represents a financial risk for foreign investors.

We can now reach our second conclusion: the second hypothesis claims that scores of climate-related natural hazards affect inward FDI positively. In other words, a higher risk of climate-related natural hazards impacts FDI location decisions negatively, which confirms the work of Noy and Vu (2010), Escaleras and Register (2011), Boustan et al. (2012), Doytch and Klein (2018), Doytch (2019), Oh et al. (2020), and Neise et al. (2022). Thus, climate change–related natural hazard constitutes a financial risk to foreign investors. These findings are significant for floods (rural, urban, and coastal) and landslides. However, the data show no significant effect of extreme heat and wildfires on FDI location decisions. Furthermore, we conclude that economic development (GDP per capita and R&D expenditure) plays a positive moderator. It means a rich and more innovative country could handle natural hazards with less severe damage than could a poor and less innovative country.

5. Conclusions

Investing abroad is a decision that considers numerous variables in the perspective of making sure as much as it takes that this decision shall be profitable for the investor. Among others, climate change occupies an important place in decision-making when it comes to starting a business abroad or investing in an existing foreign structure, as the shifts in weather patterns, changes in temperature, and risks of desertification are likely to drive the investor to reconsider investing in a certain region.

Hence, for a multinational corporation whose strategy is to establish a lasting interest in a foreign company—in the framework of foreign direct investment—the climate change effects on the decision of investing overseas vary depending on the sectors and their sensitivity to climate change, which the existing literature has classified into two main categories.

For economic activities that are directly exposed to climate change, the effects on investment are whether positive—such as a region with high temperatures promoting FDI in the energy sector—or negative—such as the desertification phenomenon that discourages FDI. Also, in the cases of economic activities with markets sensitive to climate change as well as activities based on inputs sensitive to the latter, effects are apprehended indirectly through transmission channels. Climate change can be considered as a financial investment risk for an MNE, in terms of physical and secondary risks, political risks, liability risks, etc., exposing the investing company to eventual high losses.

On the empirical level, our study tries to investigate the role of climate change as a financial risk to foreign investors and how does it affect foreign investors' behavior, which the literature has not treated and remained focused on overall investment. Thus, to conduct our empirical analysis, we used data of 200 countries during the period 1970–2020, as the endogenous variable is inward foreign direct investment; the explanatory variables are climatology indicators (mean annual temperature and precipitation) and climate-related natural hazard indicators; and other moderating variables.

Hence, following the main research hypothesis, the general hypothesis, and the subsequent hypotheses, we concluded first that climate change–related to precipitations and temperature constitute a financial risk to foreign investors especially when the economy is more agricultural and there is no significant investment in R&D, then we found that a higher risk of climate-related natural hazard impact negatively the location decision of international investment.

Climate change as a financial risk for the foreign investor would be helpful for public officials in charge of public policies related to the territorial attractiveness of FDI. By considering this factor as a determinant of the location choice of MNE, the host country has to implement measures to reduce the risk of climate change and its implication on the local economy, productivity, and stability. Furthermore, public officials need to consider more investment in research and development so the country can achieve a sufficient level of technological capacities and innovation to absorb negative chocs from climate change.

However, some limits restrained our work. For instance, the lack of well-constructed data on climate change is a major research hypothesis for empirical analysis to deduct more detailed results. In addition, sectoral data on inward FDI are not available on a large scale, which deprives the empirical work of heavy analysis. Furthermore, the literature review did not give us some form of "knowledge-capital model" to identify the type of FDI, whether it is horizontal or vertical, and its motivation, whether it is market seeking, resource seeking, efficiency seeking, or cost seeking. Hence, the development of the present study will be at a case-study level so we can consider the sectoral differences, the type of FDI, and its motivation.

Data availability statement. Datasets analyzed during the current study are available at the UNCTAD (https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96740), Climate Knowledge Portal (https://climateknowledgeportal.worldbank.org/download-data), and World Bank (https://data.worldbank.org/indicator/).

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