Climate risk, climate risk distance and foreign direct investment

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Abstract

Purpose – Climate risk greatly increases the risk exposure of global investments. Both the climate risks of home countries and host countries may affect international investment behaviors. The purpose of this paper is to explore the impact of climate risk and climate risk distance on foreign direct investment (FDI) inflows and outflows. Targeted proposals are provided to promote international economic and trade cooperation and the authors provide suggestions for the FDI strategies of multinational enterprises.

Design/methodology/approach – The authors define "climate risk distance" as the difference in climate risks between two countries. This paper uses both a theoretical model and a generalized least squares test to investigate the impact of climate risk distance on FDI from the perspectives of FDI inflows and outflows. In addition, the authors subdivide the samples according to the sign of climate risk distance and rank the FDI share from home country to host country into four groups according to the host country's climate risk index. Finally, the authors undertake empirical tests with outward foreign direct investment (OFDI) data to support the empirical results.

Findings – Investors from countries with low climate risks have the upper hand due to their competitive advantages, like their skills, trademarks and patent rights, which they can transfer abroad to offset the disadvantage of being non-native. This is generally defined as ownership advantage. The impact of climate risk distance on FDI depends on the sign of climate risk distance. Specifically, host countries with higher climate risks compared with the climate risk levels of home countries may experience insignificant reductions in FDI inflows. For investors from home countries with higher climate risks, they are less likely to invest in host countries with lower climate risks. The results for samples from emerging market economies are shown to be more significant.

Originality/value – This study advances the O (ownership advantage) part of the ownership, location and internationalization (OLI) paradigm by incorporating the climate risk distance between the home country and the host country into the influencing factors of FDI. Both the O part and the L (location advantage, the advantage that host countries offers to make internationalization worthwhile to undertake FDI) part of the OLI paradigm concerning climate risks are validated with FDI and OFDI data.

Keywords Climate risk, Climate risk distance, Foreign direct investment, Outward foreign direct investment

Paper type Research paper

1. Introduction

Economic globalization has led to international production becoming an "economic bridge" (Li and Vashchilko, 2010) between countries or regions in the world economic system. Foreign direct investment (FDI) is a key distribution channel of international production. The inflow and outflow of FDI seeks to promote optimal allocation of production factors such as labor, capital and technological progress around the world. In recent years, the scale and speed of

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international capital flows have shown a significant upward trend (Bhattacharya *et al.*, 1997), and links between international capital markets have strengthened. FDI is both profit seeking and wary of excessive risks. Significant market turmoil may cause international capital to seek a less risky environment. In addition, many, often complex factors, can also affect FDI flow.

Academia pays attention to the impact of institutional environmental differences on FDI inflows and outflows. Initially, many scholars used cultural distance instead of institutional environment differences to explore the impact of FDI on enterprises (Kogut and Singh, 1988; Shenkar, 2001). Some scholars argue that compared to cultural distance, institutional distance more accurately reflects key differences between national environments. Scholars explore the impact of various dimensions of institutional distance, including cultural differences, language differences, legal systems and macro and micro economic issues, in relation to FDI flow (Xu and Shenkar, 2002; Ionascu *et al.*, 2004; Estrin *et al.*, 2009). In sum, the impact of endogenous factors such as the institutional environment on FDI has been extensively analyzed. Yet, few scholars study the impact of exogenous factors such as climate risk on international capital flows.

Climate risk has always been a problem in relation to economic development faced by countries all over the world. In recent years, extreme weather and natural disasters, including torrential rains, floods, droughts, hurricanes and so on, have seriously threatened human life and health. The impact of climate change causes huge economic losses, and has attracted growing attention globally. According to a recent report from Germanwatch (Eckstein *et al.*, 2018), between 1998 and 2017 extreme weather led to more than 526,000 deaths and economic losses of more than $3.47tn, with a heavy global impact, especially in emerging market economies. In addition, climate change also causes both an indirect impact and a secondary economic risk. How to reduce the economic losses caused by climate disasters is an important issue for all countries as they seek to develop economically.

The degree of economic uncertainty caused by climate risks varies greatly from country to country. Not all multinational companies respond to climate risks in the same way. In addition to a direct impact on a host country's climate risk in relation to FDI, the scale of FDI may also vary depending on the home country's climate risks. According to ownership, location and internationalization (OLI) theory proposed by Dunning (1981), a company's international activities are determined by three factors: ownership (O) advantage location (L) advantage and internalization (I) advantage. Hypothetically, host countries with low climate risk reduce the uncertainty of capital return and lead to an "L" advantage, while enterprises in countries with high climate risk seek to develop an "O" advantage during a process of long-term risk adaptation. As a result, it appears that not all foreign investors are equally affected by a host country's climate risk. Specifically, companies located in high-climate-risk countries may not be excessively affected by high overseas climate risks. Based on the premise that the relative difference of climate risk between a home country and a host country may affect FDI, the authors establish both theoretical and empirical models to explore how climate risk distance affects FDI. Following that, the authors make relevant recommendations for the attention of both investors and governments.

2. Literature review

2.1 Climate risk and company development

Climate risk seriously threatens human life and health, causes huge economic losses to society, and the effect of climate change attracts global attention. Huang *et al.* (2018) use the Climate Risk Index published by Germanwatch (Eckstein and Kreft, 2013) to explore the global impact of climate-related risks on financing choices of listed companies. They discovered that the losses caused by storms, floods, heat waves and so on cause both lower

and more unstable earnings which reduced cash flow. Lupton *et al.* (2021) examine the impact of climate risk on the success or failure of FDI in private participation infrastructure projects. They show that climate risk is a location disadvantage: the higher the climate risk of the host country, the greater the risk of investment failure. Kling *et al.* (2021) have constructed a new Climate Vulnerability Index and show that climate vulnerability limits financing channels, which directly or indirectly increases debt costs. In addition, enterprises in high climate risk countries may be subject to significant financial constraints.

The frequent occurrence of extreme weather has promoted enterprises to explore corresponding mitigation strategies. Kumarasiri and Gunasekarage (2017) conducted semistructured interviews with 39 executives of 18 large Australian listed companies directly involved in carbon emission management. From their interview data, it is clear that managers use management accounting technology as a risk management tool to mitigate risks related to climate change. Barbier and Burgess (2018) discuss how global enterprises, especially those in East Asia, seek to deal with climate risks via commitment, pricing mechanisms, scientific and technological innovation and other measures. Pinkse and Gasbarro (2019) investigate how enterprises in the oil and gas industry seek to improve cognitive ability to adapt to physical changes caused by climate risk. Finally, Daddi *et al.* (2020) have found that companies that are more sensitive to climate change are more likely to adopt mitigation and adaptation strategies.

2.2 Influencing factors of foreign direct investment

The existing literature on FDI is rich. The authors focus on various influencing factors which are grouped into two.

The first is that a country's or region's own institutional environment affects FDI inflows and outflows. Noorbakhsh *et al.* (2001) find that human capital is a significant determinant of FDI inflows, with its importance increasing over time. Emerging market economies can increase their attractiveness to FDI by improving local skills and enhancing human resource capabilities. Buthe and Milner (2008) suggest that emerging market economies that join the WTO and participate in Preferential Trade Agreements have more FDI inflows compared to other countries. International trade agreements provide foreign investors with a commitment mechanism on the return of their assets, thereby reducing the volatility of return rates. Luo *et al.* (2010) stress the importance of FDI promotion policies formulated by emerging market governments. Liu and Deseatnicov (2016) find that RMB appreciation has a negative impact on China's FDI inflows, while higher exchange rate volatility and expected depreciation encourage the country's FDI outflows.

The second aspect is the impact on FDI of differences in the institutional environment between a home country and a host country. Researchers have extensively examined differences in institutional environments. Multiple factors, including language distance, cultural distance, legal system and political environment are significant (Vidal-Suárez and López-Duarte, 2013). Some scholars focus on how a single factor in institutional environment differences affects the inflow and outflow of FDI. Eren and Jimenez (2015) examine the impact of corruption distance on the Turkey's inflow and outflow of FDI. Their empirical findings indicate that when the corruption distance between the home country and the host country is small, FDI flow is high. Conversely, countries whose corruption distance with Turkey is larger, find that FDI is diminished. O'Scawn (2018) studies the impact of cultural distance on China's FDI into 40 African countries. They indicate that cultural distance has a negative impact on China's FDI in the region. More generally, Li *et al.* (2021) suggest that cultural differences have a negative impact on the possibility and scale of Chinese FDI flowing into a host country. Nayak and Scheib (2020) discuss the relationship between cultural distance and FDI in Germany's service industry. In addition, some scholars have proposed that, compared

to a single factor, institutional distance can more accurately explain the differences between national environments (Xu and Shenkar, 2002; Phillips *et al.*, 2009). Recently, studies have begun to explore the effect of institutional distance and its various subfactors on FDI. For example, Cezar and Escobar (2015) show that institutional distance reduces both possibility and scale of FDI, while compared to emerging market economies, enterprises in developed economies are more likely to adapt to institutional distance. Mohsin *et al.* (2021) have found that institutional distance promotes China's FDI in countries along "One Belt One Road." Overall, cultural distance inhibits FDI, and its inhibitory effect of is significantly greater than the promotion of institutional distance.

In summary, the impact of endogenous factors such as the institutional environment on FDI has been extensively analyzed. However, few scholars have studied the impact of exogenous factors, such as climate risk, on FDI. To fill gaps in the literature on international capital flows, this paper uses both a theoretical model and empirical tests to investigate the impact of climate risk distance on FDI from the perspectives of international direct investment inflows and outflows. In addition, the paper subdivides the samples between those with greater climate risk in the home country and those with greater climate risk in the host country. This classification is used to explore the impact of climate risk distance on FDI inflows in various national situations. The authors also rank the FDI share from home country to host country into four groups – from high to low quartile – according to the host country's Climate Risk Index. Then, based on the subdivided samples, the authors analyze how the climate risk distance affects FDI of various home countries. The authors also undertake empirical tests with outward foreign direct investment (OFDI) data to support the empirical results. The climate risks faced by countries all over the world have obvious heterogeneous characteristics, and this paper seeks to clarify the mechanisms of the influence of climate risk distance on the inflow and outflow of FDI. The paper also proposes targeted suggestions for promoting international economic and trade cooperation to achieve healthy development among countries. Finally, the authors offer advice for international investors and governments in relation to the topic of the paper.

3. Theoretical model and hypothesis development

3.1 Theoretical model

First, suppose that there is international capital i from country A, and its scale is fixed at 1. An investor must make a decision P whether or not to invest in country B. P = 1 indicates investing in B, and P = 0 indicates not investing in B:

$$P = \begin{cases} 1 & U(r_i) > U(\bar{r}) \\ 0 & U(r_i) \leq U(\bar{r}) \end{cases} \tag{1}$$

U represents utility. $\bar{r}$ is a constant, measuring the return to investors when they do not invest in B, and U (r_i) represents the expected utility of investors when they do invest in B. Obviously, investors choose to invest in country B only when $U(r_i) > U(\bar{r})$, and not to invest in country B when $U(r_i) \leq U(\bar{r})$. The authors further divide the investor's risk return into three parts based on the CAPM model:

$$r_i - r_f = \beta\left(E(r_m) - r_f\right) + cl_i + \varepsilon_i \tag{2}$$

$\beta(E(r_m) - r_f)$ represents a return related to market risk premium. cl_i is the change in investment return caused by climate disasters. e is the unpredictable income or loss caused in the host

country by other unexpected conditions. The authors define the climate risk distance between A and B as D, and D is equal to the average climate disaster loss of the host country (cr_B) minus the average climate disaster loss of the home country (cr_A), where cr_A is known.

Dunning (1981) shows that FDI is determined by the three basic factors of O-advantage, L-advantage and I-advantage. O-advantages include the company's technical advantages and organizational management capabilities, while investors in high climate risk countries adopt risk-resistant technical means, hardware equipment and organization charters to increase long-term risks adaptation (Barbier and Burgess, 2018; Gasbarro and Pinkse, 2016; Pinkse and Gasbarro, 2019; Pinkse and Kolk, 2010; Weinhofer and Busch, 2013). The purpose is that they can then better identify climate risk (Todaro *et al.*, 2021), while gaining increased ability to deal with climate risk and so improve their O-advantage. Overall, this forms an advantage in competition with host country enterprises.

On the other hand, climate risk affects the rate of return on investment (Busch *et al.*, 2012; Huynh *et al.*, 2020). Low climate risk is an important factor for the host country to attract investment. By investing in countries with lower climate risks, companies can reduce the uncertainty of income, which can form an L-advantage. Therefore, the authors assume that cr_B reduces cl_i and increases variance of cl_i. If cl_i follows a normal distribution, then $cl_i \sim N(-cr_B + f(D), -cr_B\sigma^2)$, where σ^2 is a constant and f(D) is part of the O-advantage effect.

This paper uses a utility function with a constant absolute risk aversion coefficient of α:

$$U = \left(1 - \frac{1}{\alpha}\right)e^{-\alpha(1+r_i)} \tag{3}$$

To allow for cr_B that makes U the largest factor, the authors take the derivative of U to cr_B to get the optimal value of cr_B. This problem is equivalent to Max $U' = \left(1 - \frac{1}{\alpha}\right)e^{-\alpha(1+cl_i)}$ where $E[U'(cr_B)] = \left(1 - \frac{1}{\alpha}\right)e^{-\alpha\left(-cr_B + f(D) + \alpha^2\sigma^2 D/2\right)}$. The authors take the derivative of $E[U'(cr_B)]$ to cr_B:

$$\frac{\partial\left(E\left[U'(cr_B)\right]\right)}{\partial(cr_B)} = (-\alpha)E\left[U'(cr_B)\right]\left[f_{cr_B}(cr_B - cr_A) - \left(1 - \frac{\alpha^2\sigma^2}{2}\right)\right] \tag{4}$$

This equation reveals the influence of cr_B on both O-advantage and L-advantage. If cr_B* maximizes $E[U'(cr_B)]$, then $f_{cr_B}\left(cr_B^* - cr_A\right) - \left(1 - \frac{\alpha^2\sigma^2}{2}\right) = 0$. If $cr_B > cr_B^*$, then O-advantage is surpassed by L-advantage. If $cr_B < cr_B^*$, then L-advantage is overtaken by O-advantage. Both situations lead to the reduction of U' and U. The utility of capital i invested in host country B first increases as the climate risk distance D grows. After reaching the critical value $cr_B^* - cr_A$, the utility of capital i invested in host country B decreases as the climate risk distance D diminishes.

This paper also examines how the host country's climate risk affects investment decisions. According to Figure 1, investors have no motivation to invest abroad when $U(\bar{r}) > U(r_j)_{Max}$. When $U(\bar{r}) < U(r_j)_{Max}$, investors have motivation to transfer assets overseas and invest in the country that makes $cr_B = cr_B^*$ to obtain the greatest return.

3.2 Hypothesis development

Based on the results of our theoretical model analysis, the authors believe that the impact of the host country's climate risk on investors depends on the climate risk of that country.

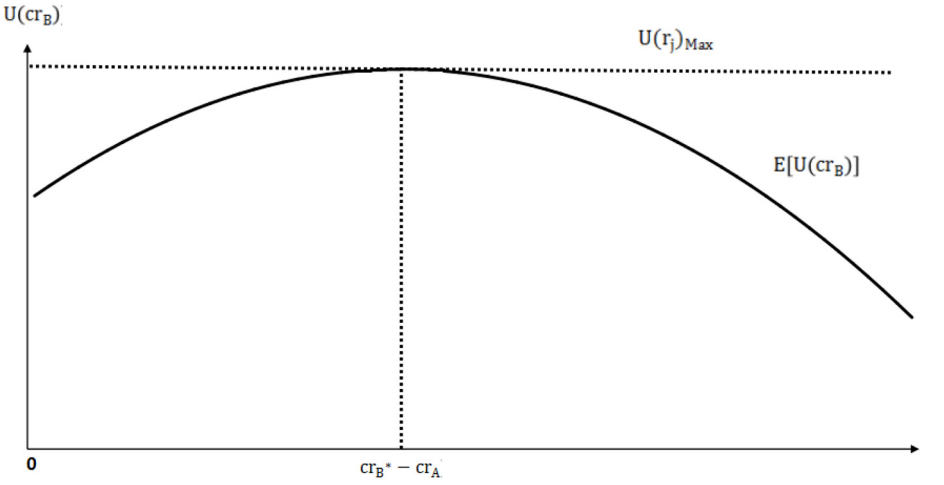

Figure 1.
Host country climate risk and utility of making investment

Specifically, if the climate risk of the home country is less than that of the host country, then the climate risk of the home country may have a great impact on investors' decision-making because investors' future returns face greater uncertainty. When the climate risk of the home country is relatively higher, its climate risk may not have a significant impact on investors. But overall, the host country's lower climate risk can be regarded as their L-advantage. After excluding the influence of other factors, investors should position their overseas investments in places with lower climate risks, so as to reduce the costs caused by risks and uncertainties. As a result, the authors propose *H1*:

H1. The climate risk of the host country is negatively correlated with inward FDI.

However, the various experiences of investors will generally determine their ability to deal with emergencies. Investors from countries with high climate risks may gain a competitive advantage through insurance, a comprehensive company management system, a stable industrial chain, a lower asset-liability ratio or more cash. Their experience may encourage other companies in the market, as their experience in their home country improves their location-bound O-advantage. As a result, they may also be more inclined to invest in countries where climate risk is relatively high. This leads to *H2a* and *H2b*:

H2a. If the climate risk distance between the home country and the host country is positive, then its impact on FDI is negative.

H2b. If the climate risk distance between the home country and the host country is negative, then its impact on FDI is positive.

4. Empirical strategy

4.1 The model

Climate disasters have shown an increasing trend in recent years, seriously increasing the risk exposure of various assets. As a result, the study of global samples is very important. To comprehensively analyze the impact of climate risk on FDI, the authors use the climate risk indicators of both the host and home countries in our empirical research. This paper

first investigates how a host country's climate risk affects its country's attractiveness for FDI. The authors construct the following model (a):

$$FDI_{ijt} = \alpha_i + \beta_1 CRB_{jt} + \beta_2 D_{jt} + \beta_3 X_{jt} + \mu_{ijt} + \varepsilon_{ijt} \quad (a)$$

where the dependent variable is FDI_{ijt}, the FDI flow from a home country i to host country j at time t. The independent variables are CRB_{jt} and D_{jt}. X_{ijt} denotes control variables. μ is the between-entity error, and ε is the within-entity error.

According to the positive or negative impact of the climate risk distance, the full sample is divided into two subsamples for empirical analysis. In doing so, the authors can observe the impact of the positive and negative of climate risk distance on FDI. In addition, many emerging market economies are facing significant impacts from climate disasters. The geographical location of these countries can result in relatively frequent occurrence of natural disasters. Besides, such countries may not have sufficient capacity to deal with climate disasters. Therefore, the samples of emerging market economies are included separately in the study. The authors use random effect logistic regression to control the correlation between different samples.

4.2 Variables and measurements

The global sample the authors used includes 183 countries and territories. The time span is from 2006 to 2012, and the total number of observations is 14,586. The authors use the bilateral FDI data of UNCTAD as the dependent variable. These data include FDI data reported by both the host and home countries. To unify data sources, this paper uses the host country's FDI inflow sources to reflect its attraction to international capital. Included in these observations amount to 7,215 covering FDI data in relation to home country capital in countries with higher climate risk, and 7,371 relating to FDI data of home country capital to countries with lower climate risk.

The independent variables are the host country's Climate Risk Index and distance. Because there are many types of climate disasters globally, it seems too simplistic to consider only the impact of one climate disaster. In addition, economic losses do not include the huge impact of natural disasters on human capital. To comprehensively consider various factors, including measuring climate risk, this paper uses the Climate Risk Index published by Germanwatch covering 2006–2012. The index combines four indicators: deaths caused by extreme weather per year (DT), deaths per 100,000 residents (DP), economic losses calculated by purchasing power parity (AL) and the loss per unit of GDP (LP). The lower the Climate Risk Index, the more a country has suffered a severe impact from sudden climate disasters. To make a higher index represent a higher risk, the authors take the opposite number of the index as cr_B.

The authors use the climate risk of the host country to subtract the climate risk of the home country to get the climate risk distance. Therefore, a positive climate risk distance indicates that FDI is from a higher climate risk country to a lower climate risk country, and a negative climate risk distance indicates that FDI is from a lower climate risk country to a higher climate risk country. According to the climate risk distance, the samples are divided into those with greater climate risk in home country and those with greater climate risk in the host country. Adopting this method, the authors observe both the impact of climate risk on investors' ability to counter climate risks and of climate risk on FDI decision-making.

There are many studies covering factors influencing FDI decision-making, including the institutional environment and the degree of economic development. This paper integrates these findings into our research to observe the combined effects of both these variables and

climate risk on FDI. This paper also adopts various characteristics of the home country as control variables. The authors use the natural logarithm of the host country's gross domestic product (GDP), the Human Development Index and the Economic Freedom Index. GDP data comes from the IMF. The Human Development Index, calculated by the United Nations, measures *inter alia* per capita GDP, education level and population life expectancy. The Economic Freedom Index is an index constructed by Heritage Foundation in 2012, which measures the degree of freedom of a country's fiscal, trade and monetary policies. Table 1 shows the description of each variable. The authors also use additional variables to represent the institutional differences between two countries, such as administrative distance, geographic distance and whether the residents belong to a common race. Administrative distance uses a comprehensive index constructed by Berry *et al.* (2010) that includes colonial background and various differences, of: language, religion and law. Geographical distance and common ethnicity data come from CEPII. Finally, to prevent significant multicollinearity between variables, the authors used the DW test. The test results reject the hypothesis of multicollinearity at the 1% level.

5. Results

5.1 FDI and climate risk: full sample

Model (a) draws on Godinez and Liu (2015) who uses random effects generalized least squares regression to control the correlation between data. The regression results are shown in Table 2. First, the authors do not add climate risk-related variables for regression, and the regression result is regression 1. Then, to explore the impact of climate risk on FDI, the authors compare the regression results with the regression results of regression 2 with climate risk. The regression coefficient of the development climate risk distance rejects the null hypothesis at a robust level of 1%. This shows that the higher the host country's climate risk, the lower FDI it will attract. FDI takes climate risk factors into consideration in terms of location selection. This supports *H1*.

To study separately the impact of positive climate risk distance and negative climate risk distance on FDI, the climate risk distance is divided into the home country high-risk group and the host country high-risk group in regression 3 and 4, respectively. The regression results indicate that when the home country risk is high, then the coefficient of climate risk distance does not reject the null hypothesis at the significance level of 10%, indicating that it has no impact on the size of FDI. The possible reason is that the risk dispersion effect of climate risk distance (L-advantage) and the comparative advantage effect (O-advantage) cancel each other out. When the host country's risk is higher, it is shown at a significance level of 5% that a higher climate risk distance increases the size of FDI. *H2a* is verified. If the climate risk distance between the home country and the host country is positive, then the impact of climate risk distance on FDI is negative.

5.2 FDI and climate risk: emerging market economies sample

Because emerging market economies have poor infrastructure and are more vulnerable to climate extremes than advanced economies (Eckstein *et al.*, 2018), the authors believe that a study of the impact of climate risk on the sample of developing countries is warranted. This paper excludes the sample of developed economies as host countries. Compared with developed economies, emerging market economies are generally less able to withstand climate risks. As a result, FDI inflows from these countries face greater uncertainty. In other words, risks may have a greater impact on FDI flows to emerging market economies. Using the same regression steps as described above, the authors find that the empirical results further verify the hypothesis. The regression results are shown in Table 3. The authors

Table 1.
Model (a) variables, measurements and sources

Variable types	Variable	Measure	Source
Independent variable	FDI	FDI from home country A to host country B	UNCTAD
Dependent variables	CR_B	Climate Risk Index of host country B	Germanwatch
	D	Climate Risk Distance, Climate Risk Index of host country B minus Climate Risk Index of home country A	Germanwatch
	D1 (Climate Risk Index of host country B is lower)	Climate Risk Distance (Climate Risk Index of host country B is lower)	Germanwatch
	D2 (Climate Risk Index of host country B is higher)	Climate Risk Distance (Climate Risk Index of host country B is higher)	Germanwatch
Control variables	GDP	Natural logarithm of host country B's GDP	IMF
	ADIST	A comprehensive index of whether the two countries formerly had colonial relations, the proportion of people who speak the same language and have the same religion, and whether they share a legal system. The larger the index, the greater the distance	Berry *et al.* (2010)
	GDIST	Geographical distance between the political centers of the two countries (km)	CEPII
	COME	Whether the ethnic origins of the two countries are the same (it is 1 if they are same, otherwise it is 0)	CEPII
	HDI	An index that comprehensively measures GDP per capita, education and life expectancy per capita. From low to high (0–100)	United Nations
	EFI	An index reflecting the degree of freedom of a country's fiscal, trade and monetary policies. Not free to free (0–100)	Heritage Foundation

Table 2.
Model (a) results: full sample

Variables	(1) FDI	(2) FDI	(3) FDI	(4) FDI
CR_B		−35.850***	−24.435*	−50.431***
D		−23.355***		
D1 (Climate risk of home country is higher)			14.452	
D2 (Climate risk of host country is higher)				−28.821**
GDP	2,558.842***	2,471.742***	2,110.729***	2,860.417***
ADIST	−37.345***	−36.311***	−32.177***	−39.020***
GDIST	−0.512***	−0.542***	−0.390***	−0.721***
COME	3,465.293***	3,312.801***	6,097.711***	−138.919
HDI	−8,968.910***	−7,661.985***	−2,835.167	−13,566.836***
EFI	341.535***	339.673***	226.851***	487.067**
Constant	−71,607.641***	−67,778.709***	−57,288.799***	−80,264.010***
Wald test (χ^2)	1,427.41	1,446.82	757.46	753.90
Observations	14,586	14,586	7,371	7,215

Notes: *Significance of 10%; **significance of 5%; ***significance of 1%

Table 3. Model (a) results: emerging market economies sample

Variables	(5) FDI	(6) FDI	(7) FDI	(8) FDI
CR_B		−13.664**	−14.758*	−12.082
D		−23.140***		
D (Climate risk of home country is higher)			25.445***	
D (Climate risk of host country is higher)				−19.321*
GDP	1,666.792***	1,748.886***	1,884.837***	1,665.881***
ADIST	−8.723**	−7.379**	−11.452***	−3.080
GDIST	−0.156***	−0.175***	−0.291***	−0.0648
COME	2,064.902***	1,947.602***	2,494.443***	3,836.729***
HDI	−1,356.279	−1,956.686	−4,585.017	24.764
EFI	179.064**	181.673***	218.027***	153.555***
Constant	−48,439.650***	−49,290.248***	−51,647.739***	−48,284.907***
Wald test (χ^2)	613.29	638.51	434.56	277.93
Observations	9,168	9,168	4,714	4,454

Notes: *Significance of 10%; **significance of 5%; ***significance of 1%

observe that the regression coefficients of (6) and (8) CR_B and D are both significantly negative, and the coefficient of D in (7) is significantly positive at the 1% level, which validates our *H1*. It shows that emerging market economies have invested a lot of assets abroad due to their high climate risks.

In short, our analysis demonstrates that when investing overseas, foreign investors are affected not only by the climate risk of the host country, but also by the "climate risk distance." To study this problem, the authors put forward two hypotheses. Our first hypothesis suggests that, in general, the climate risk of the host country leads to a decrease in FDI inflows. Our second hypothesis is divided into two parts: the first proposes that the positive climate risk distance is negatively correlated with FDI inflows, and the second suggests that the negative climate risk distance is positively correlated with FDI inflows.

Our results support these two hypotheses. When the climate risk distance is positive, it hinders FDI. When the climate risk distance is negative, it does not significantly decrease FDI. This is consistent with our analysis results based on OLI theory. This paper further tests this conclusion by studying the relationship between climate risk and OFDI below.

6. Further discussion: OFDI and climate risk

6.1 The model and variables

To examine how climate risk in home countries affects OFDI, and to provide support for the results of model (a), model (b) was constructed. All countries are divided into four groups, 1, 2, 3, and 4 according to the quartile of climate risk from low to high. Then the proportions of OFDI from home country A to each group of host countries was calculated year by year. The authors employed them as dependent variables. The independent variables referred to the Climate Risk Index of the home country, and controlled the inflation rate, gross national product, Human Development Index, foreign trade scale, unemployment rate and economic freedom index. The description of each variable is shown in Table 4. Through such processing and regression, the authors can find out whether countries correspond to each other. This research adopts the panel data ordinary least square regression method to control the annual and national fixed effects to eliminate influence of individual differences:

$$OFDI_{ijt} = \alpha_i + \beta_1 CRB_{it} + \beta_3 X_{it} + \mu_{ijt} + \varepsilon_{ijt} \quad (b)$$

6.2 The regression of OFDI on climate risk: full sample results

Table 5 shows the full sample regression results. The empirical research results show that climate risk of home countries significantly affects the proportion of FDI inflows to the host countries of Group 1 and Group 2. The regression result (9) shows that every time the home country's climate risk increases by 1, the home country's OFDI to the host country in the group decreases by 0.218%; while the regression result (10) shows that every time climate risk of home country increases by 1, the home country's OFDI to the host country of group 2 increases by 0.184%. Investors from home countries with different climate risks choose to invest in different groups of countries. For investors from countries with a higher climate risk, they are less likely to invest in group 1 and more likely to invest in group 2. This result proves the impact of climate risk distance on FDI from another perspective. Under the combined effect of the climate risk of home country and climate risk distance between home and host countries, OFDI presents the characteristic of being concentrated in a certain range.

Variable types	Variable	Measure	Source
Dependent variables	OFDI1	Percentage of OFDI flowing into countries with the lowest climate risk (Climate Risk Index in the 0%–25% quantile)	UNCTAD
	OFDI2	Percentage of OFDI flowing into countries with low climate risk (Climate Risk Index in the 25%–50% quantile)	UNCTAD
	OFDI3	Percentage of OFDI flowing into countries with high climate risk (Climate Risk Index in the 50%–75% quantile)	UNCTAD
	OFDI4	Percentage of OFDI flowing into countries with the highest climate risk (Climate Risk Index in the 75%–100% quantile)	UNCTAD
Independent variables	CR_A	Home Country Climate Risk Index	Germanwatch
Control variables	CPI	Consumer Price Index	IMF
	GDP	Natural logarithm of host country B's GDP	IMF
	HDI	An index that comprehensively measures GDP per capita, education, and life expectancy per capita. From low to high (0–100)	United Nations
	TRADE	Total foreign trade/GDP	IMF
	U	Unemployment rate	IMF
	EFI	An index reflecting the degree of freedom of a country's fiscal, trade, and monetary policies. Not free to free (0–100)	Heritage Foundation

Table 4.
Model (b) variables

Variables	(9) OFDI1	(10) OFDI2	(11) OFDI3	(12) OFDI4
CR_A	−0.00218**	0.00184***	0.000432	−8.82e-05
CPI	0.00221	0.00314	−0.00681**	0.00146
GDP	0.00902	0.769**	−0.0849	−0.693
HDI	4.575	−4.599**	0.638	−0.613
TRADE	−0.235	−0.0144	0.321***	−0.0718
U	0.0127	0.00812	0.00555	−0.0264***
EFI	−0.00692	0.000940	0.00528	0.000701
Constant	−1.533	−13.77**	0.901	15.41
Years	Yes	Yes	Yes	Yes
Countries	Yes	Yes	Yes	Yes
R-squared	0.314	0.443	0.350	0.292
N	493	493	493	493

Notes: **Significance of 5%; ***significance of 1%

Table 5.
Model (b) results: full sample

6.3 The regression of OFDI on climate risk: emerging market economies sample results

To test whether OFDI from emerging market economies is also affected by climate risk, the authors conduct the procedure of 6.1 on samples of such countries. The regression results are shown in Table 6. The empirical results show that the climate risk of home countries

Variables	(13) OFDI1	(14) OFDI2	(15) OFDI3	(16) OFDI4
CR_A	−0.00245*	0.000179	−0.000312	0.000355
CPI	0.000932	−0.00420	0.00236	−0.000942
GDP	−0.00164	−0.0359***	−0.0443***	−0.0790***
HDI	−0.271	−0.517**	−0.0961	−0.0265
TRADE	−0.108	−0.0870	0.0684	−0.156
U	0.00108	0.00214	−0.00300	0.000339
EFI	−0.00238	−0.00213	0.000819	−0.00637
Constant	−1.509	−1.414**	1.340*	2.582
Years	Yes	Yes	Yes	Yes
Countries	Yes	Yes	Yes	Yes
R-squared	0.3327	0.2780	0.2201	0.2813
N	310	310	310	310

Notes: *Significance of 10%; **significance of 5%; ***significance of 1%

Table 6.
Model (b) results: emerging market economies sample

significantly affects the proportion of FDI inflows to the host country of Group 1. The regression result (13) shows that every time the climate risk of the home country increases by 1, the FDI of the home country into the host country of group 1 is reduced by 0.245%. Combined with the results in 6.2, this further supports *H1* and *H2a* and *H2b*. Climate risk and climate risk distance do have an impact on capital flows in emerging market economies.

7. Conclusions

Climate risk increases the risk exposure of global investments. A growing body of research has shown that both home and host country factors influence the investment decisions of multinational investors. Therefore, the authors explore the impact of climate risk and climate risk distance on FDI, so as to provide investment advice for multinational investors.

In this study, the authors analyzed how the host country's climate risk affects FDI, that is, whether it is higher or lower than the home country's climate risk. This paper makes this distinction to examine whether investors from each group of countries react differently to the host country's climate risks. The authors also include the "climate risk distance" concept to assess how the difference in climate risk between the host and the home country affects FDI. Our research results show that when the climate risk of the home country is lower than that of the host country, the climate risk distance has a negative impact on FDI. Companies from high-climate risk countries are not affected by the climate risk distance when investing in the host country.

Based on the OLI theory, investors from countries with lower climate risks have the upper hand due to the unique advantages of their ownership. However, investors located in higher climate risk countries gain advantage by conducting their business in challenging locations. Specifically, the authors believe that companies located in countries with high climate risks have internalized knowledge of how to deal with climate risks. This O-advantage helps such companies reduce the costs associated with dealing with climate risks in foreign countries. So the authors advanced the O part of the OLI paradigm by incorporating the climate risk distance between the home country and the host country into the influencing factors of FDI.

Second, this paper incorporated FDI, OFDI and climate risk into the regression model of fixed effects and random effects. Empirical evidence was provided to supplement the

evidence that when the company invests overseas, investors from countries with high climate risks are not affected by this concern. As a result, the authors enrich research on the relationship between climate risk and FDI. In addition, the authors believe that research in this field can be further refined going forward. This is because different industries have varying abilities to deal with climate risks, and so research on different industries may well lead to differing conclusions.

This paper contributes to the growing literature on FDI and climate risk. The impact of climate risk on economic activity is becoming more serious but few studies have addressed the topic. The authors expound the different impact mechanisms of national climate risk and climate risk distance on FDI based on the OLI theory. Besides, this paper provides empirical evidence to complement the studies. New researches can focus on the impact of different extreme climate types on FDI in different industries, so as to obtain more specific research conclusions.

Our work has a value both for investors and governments. For the former, when choosing FDI locations, they should not only consider the degree of climate risk in the target country, but also consider their own company's advantages in relation to climate risk prevention and resistance. From a government's point of view, it is necessary, first, to establish robust international cooperation to prevent the continuous deterioration of the climate. Second, it is necessary to establish a good prevention and confrontation mechanism so as to reduce the impact of extreme weather on a country and so increase its attractiveness for foreign investment. Especially for the emerging market economics with high climate risks, it is necessary to face this problem because FDI is an important driving force for their development. The authors suggest policy makers to provide foreign capital with ways to adapt to the climate, such as government–enterprise cooperation, company cooperation and providing consulting services.

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Further reading

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