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# Climate risk and private participation projects in infrastructure: Mitigating the impact of locational (dis)advantages

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ABSTRACT:

We investigate the impact of climate risk on the success versus failure of foreign direct investments in private participation infrastructure projects. We also consider the extent to which project-level characteristics mitigate such risks.

We study a sample from the World Bank covering 18,846 projects in 111 countries from 2004 to 2013. We apply logistic regressions to determine the impact of climate risk and mitigating project characteristics on project failure.

We find that higher levels of climate risk at the host country level are associated with higher risk of project failure. We also find that the disadvantage of higher climate risk is weakened by two project-level characteristics, namely, the inclusion of host government ownership in the project consortium and the size of the project.

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Our research contributes to the current debate about the impact of climate risks on international business ventures. We demonstrate that climate risk is a locational disadvantage for foreign direct investments in private participation infrastructure projects. We establish that the â€˜fittestâ€™ projects in locations characterized by higher climate risk tend to be those that involve host government participation in their ownership structure, as well as those of larger sizes.

# CLIMATE RISK AND PRIVATE PARTICIPATION PROJECTS IN INFRASTRUCTURE: MITIGATING THE IMPACT OF LOCATIONAL (DIS)ADVANTAGES


**Purpose**

We investigate the impact of climate risk on the success versus failure of foreign direct investments in private participation infrastructure projects. We also consider the extent to which project-level characteristics mitigate such risks.

**Design/methodology/approach**

We study a sample from the World Bank covering 18,846 projects in 111 countries from 2004 to 2013. We apply logistic regressions to determine the impact of climate risk and mitigating project characteristics on project failure.

**Findings**

We find that higher levels of climate risk at the host country level are associated with higher risk of project failure. We also find that the disadvantage of higher climate risk is weakened by two project-level characteristics, namely, the inclusion of host government ownership in the project consortium and the size of the project.

**Originality/value**

Our research contributes to the current debate about the impact of climate risks on international business ventures. We demonstrate that climate risk is a locational disadvantage for foreign direct investments in private participation infrastructure projects. We establish that the 'fittest' projects in locations characterized by higher climate risk tend to be those that involve host government participation in their ownership structure, as well as those of larger sizes.

**Keywords:** Climate Risk; Private Participation Infrastructure Projects; Major Disasters; Success versus Failure; Locational Disadvantages; Government Ownership; Project Size.

*"Climate risk is the most important systemic risk for the near future"*

*António Guterres UN Secretary-General´s speech (2019 World Economic Forum in Davos)*

## 1. Introduction

There is a growing sense that the macro-environment conditions, by which global competitiveness of a firm is established, are changing (Tian and Slocum, 2015). Increasing climate risk and the costly responses needed to address them are examples of the forces changing the global economic landscape (Dell *et al.,* 2014). These forces pose economic risks and new costs to countries and firms, respectively, through their negative impact on property and business operations (Wittneben and Kiyar, 2009). Extreme weather conditions (e.g. droughts and floods) decrease the value of assets (Mithani, 2017), disrupt supply chains, lead to suspension of operations, lost revenue, or even firm failure (Oetzel and Oh, 2014). Between 1997 and 2016, more than 524,000 people died and USD 3.16 trillion was lost worldwide as a result of an estimated 11,000 extreme weather events (Eckstein *et al.,* 2018).

At the same time, global integration continues to reduce the obstacles to cross-border economic activities posed by national boundaries which has led, among others, to an increase in cross-border infrastructure development (Doh and Ramamurti, 2003; Preece *et al.,* 2016). Thus, despite current trade tensions, some of the most ambitious cross-border infrastructure development projects (e.g., China's Belt and Road) are being undertaken, some even having the potential to alter the global economic order. Usually, cross-border infrastructure development is conducted through private participation infrastructure (PPI) projects in which private investors contribute equity to projects in international locations (Jiménez *et al.,* 2018). Although previously out of reach for many international investors, PPI projects have become commonplace, as governments increasingly rely on firms to provide capital, and take an equity stake in the development and operation of the project (Ramamurti and Doh, 2004; Jiang *et al.,* 2015). In spite of their popularity, these projects are physical asset-intensive, thus subject to the damaging effects of climate (Flyvbjerg *et al.,* 2009). Finally, PPIs are increasing in number in emerging economies (Ramamurti and Doh, 2004; Jiang *et al.,* 2015), where natural disasters tend to have some of the greatest consequences (Oetzel and Oh, 2014).

Within the set of known risks to international investment, climate risk, i.e. the higher likelihood that a country will suffer an extreme weather event, has not been extensively examined[1] (Kreft and Eckstein, 2014; Huang *et al.,* 2018). However, its potential negative repercussions can be substantial (Oetzel and Oh, 2014), making it necessary for firms to incorporate climate risk considerations when designing their strategies. Our contribution to this discussion is an empirical examination of climate risk as a critical success factor in private participation infrastructure (PPI) projects, which is a prerequisite to building global competitiveness for the firms involved.

Building on the eclectic (OLI) paradigm (Dunning, 1988, 2000; Cantwell and Narula, 2001) as the theoretical framework par excellence for investigating foreign direct investment (FDI), and drawing on previous recent literature on major disasters, we argue that climate risk represents a locational disadvantage for PPIs. We argue that this is because climate risk leads to increased operational complexity and higher financial expenditures, reducing the likelihood of investors to secure the financing of a project, while increasing its operating

[1] By climate risk in this paper we refer to relatively unpredictable meteorological, hydrological, and climatological events such as: tropical, local, and winter storms, hail, frost, tornados, river and flash floods, land movements, wild fires, and droughts (Kreft and Eckstein, 2014). Predictable environmental changes (e.g. air pollution), man-made, or technological disasters (e.g. oil spills, chemical explosions, biological infections) are beyond the scope of this paper (Oh and Oetzel, 2011; Oetzel and Oh, 2014).

costs (e.g. Huang *et al.,* 2018). However, despite natural disasters being largely outside the control of individuals or organizations (Oetzel and Oh, 2014), specific project-level characteristics such as host government ownership and project size can mitigate failure resulting from climate risk.

We therefore aim to address the following research questions: (1) What is the impact of climate risk on the probability of success versus failure of PPIs? And (2) to what extent do government ownership and project size moderate this relationship? To answer our research questions, we analyzed a sample of 18,846 projects in 111 countries from 2004 to 2013.

Our paper contributes to the literature by examining new success factors for firms contributing to infrastructure projects, namely, the increasing risks posed by climate and factors that mitigate them. We thus contribute to, and extend research on location characteristics (e.g. Lien and Filatotchev, 2015; Ramamurti and Doh, 2004; Jiang *et al.,* 2015) by providing empirical evidence that unpredictable meteorological and climatological events impact whether projects succeed or fail. We also contribute to the literature on organizational responses to host country (climate) risk (Mithani, 2017; Huang *et al.,* 2018) by demonstrating the mitigating effects of two project-level characteristics. Consequently, our study also provides useful managerial implications for those companies aiming to weaken the potential adverse effects of high climate risk in the host country of the PPI.

## 2. Theory and Hypotheses

### *2.1 Applying FDI theory to the examination of PPI project success.*

The eclectic, or OLI, paradigm developed in response to the evolution of the international business landscape, originally for the purpose of providing an economic rationale for the existence and dominance of large multinationals (Dunning, 1988; Cantwell and Narula, 2001), but later adapted within international business scholarship to focus mainly on the location, performance, and survival of multinationals and their foreign subsidiaries, (Narula 2010). It aids analyses of FDI, by organising the factors involved into three groups. That is, as implied by its OLI acronym, advantages relating to the ownership, location, and internalisation of business transactions (Dunning, 2000; Narula, 2010). Our focus is on climate-risk as a location-specific characteristic reflecting significant changes in the macro-environment of international business, and PPI projects as a type of contract joint venture representing a newer ownership structure aimed at addressing the infrastructure needs faced by many countries around the world, many of which could not complete the projects without foreign participation.

FDI in PPI-projects however, exhibits some unique characteristics. First, available PPI project locations emerge in response to a range of pre-existing requests for proposal. Unlike FDI initiated by multinationals, investors do not, therefore, have a free hand in deciding where to invest. Instead, their decision is restricted to a smaller set of potential locations. In this respect, the characteristics of FDI locations in PPI-projects resemble natural-resource-seeking FDI, where the number of alternative locations is also limited (Cantwell *et al*., 2010). Unlike natural-resource-seeking and other types of investments, PPI projects are comparatively shorter-term investments; a characteristic which is comparable to international contract joint ventures (Beamish and Lupton, 2016). International locations confer both resources and risks to investors, which in turn have both direct and indirect implications for FDI project success (Hennart, 1991; Kim and Aguilera, 2016; Nachum *et al.,* 2008; Nielsen *et al.,* 2017).

Finally, other FDI project characteristics that are often of concern to foreign investors are the project *size* and *ownership structure* (Brouthers *et al.,* 2008; Tatoglou and Glaister, 2007; Zhang *et al.,* 2007). Both of these characteristics are especially pertinent to PPI-projects as once again, and somewhat differently from other FDI, investors may not have a free hand in the respective decisions.

## 2.2. Hypotheses development

Major hazards like terrorism and armed conflict have a negative impact on actual or expected FDI performance (Branzei and Abdelnour, 2010; Czinkota *et al.,* 2010; Oh and Oetzel, 2011, 2017; Oetzel and Oh, 2014; Witte *et al.,* 2017). First, major disasters increase stakeholder management costs (Pek *et al.,* 2018). Specifically, disasters can increase socio-psychological disruption and lead to chronic community stress (Gill and Picou, 1998) as well as social conflict and uncertainty (Picou *et al.,* 2004). Second, major disasters increase compliance costs aimed at addressing the causes of the disaster (Griffin *et al.,* 2016). These factors amplify uncertainty and complicate ex-ante contract negotiation and ex-post contract monitoring and enforcement, thus increasing the transaction costs incurred. Disasters can furthermore cause significant damage both to the property of the firm, and to the infrastructure network of the country (Pek *et al.,* 2018).

Climate disasters including droughts, extreme temperatures, and floods, are unpredictable meteorological and climatological events that have adverse impacts on local economies, firm property, and business operations (Mithani, 2017; Huang *et al.,* 2018). Researchers worldwide have documented the negative consequences, including economic losses, as well as casualties (Kreft and Eckstein, 2014). As a result, firms need to account for the likelihood and severity of extreme weather episodes so to enhance their chances of survival and avert decline. We argue that the added risk and uncertainty derived from climate risk increases transaction costs for PPIs. Even before a project is undertaken, higher climate risk will force investors to integrate disaster and recovery planning with development and financing stages. Thus, higher climate risk makes it necessary to invest additional resources in researching additional safeguards to enhance the survival of the facilities, acquiring insurance, and incorporating contingency and recovery plans to mitigate climate disasters (Huang *et al.,* 2018). As a result, the operational and financial complexity of the project will rise, making it more difficult for investors to source capital prior to building and operating the infrastructure.

We therefore propose:

**H1:** The higher the climate risk in a host country, the less likely PPIs are to succeed.

Extending this discussion of the effects of climate risk on FDI performance, we argue that project characteristics confer advantages that can moderate this relationship. In particular state ownership, as in recent years state capitalism and mixed economies have been experiencing a renaissance (Bruton *et al.,* 2015; Musacchio *et al.,* 2015), notably in emerging economies (Musacchio and Lazarini, 2014). As a result of this trend, scholarly attention has focused on state ownership and its effects; e.g. in internationalization, mergers & acquisitions, culture (Inoue *et al.,* 2013; Cuervo-Cazurra *et al.,* 2014; Kalasin *et al.,* 2019). Although prior work has pointed out both positive and negative consequences of including government in the ownership of an investment (Lai and Warner, 2015), we posit that including host government ownership in a project can attenuate the impact of climate risk on the probability of PPI success (versus failure). While the inclusion of government can decrease the efficiency with which a project is planned, executed, and managed (Sun *et al.,* 2016). The benefit of having this stakeholder take ownership in the project with the resources of the state at its disposal seems apparent. Unexpected impediments to timely completion and budget adherence are typical in infrastructure projects, due to their somewhat idiosyncratic nature, and so having government resources (especially political) at the disposal of the project facilitates ongoing negotiations around expectations. Private investors can also accrue social capital from local government connections within the business ecosystem (Joo *et al.,* 2017). Not only can this lead to higher returns in the current project, but also in subsequent investments. Hence, it is advantageous for private investors to be involved in these projects for the longer-term benefits they are expected to confer in the host countries, and private investors can thus be more patient for returns from riskier investments (Lei *et al.,* 2017).

The inclusion of the government as an investor also increases the legitimacy of a project (Meyer *et al.,* 2014), which in turn facilitates creating estimates of the (financial) repercussions of climate events, and assistance in recuperating in their aftermath. Deryugina (2011), for example, shows that government aid attenuates losses from hurricanes, which facilitates the recovery of firms. As a result, firms experience no long-term effects on their earnings because host government ownership in a project can facilitate and accelerate access to public recovery programs.

We therefore propose:

**H2:** The negative effect of climate risk in a host country on PPIs is weaker when the project includes host government ownership.

Finally, we argue that the negative relationship between climate risk and the probability of PPI success (versus failure) is weaker in larger projects. Although larger organizations often entail bureaucratic rigidity and less flexible structures (Laforet, 2008), which increase managerial complexity and coordination costs (Nooteboom *et al.,* 2007) while hurting creativity and responsiveness to change (Damanpour and Wischnevsky, 2006). However, in the case of infrastructure projects, it is more likely that large projects are 'too big to fail' due to their perceived necessity for safety, efficiency, and overall economic development. A recent example is the replacement of the 13-foot high seawalls, destroyed by a massive *tsunami* in Japan, at a cost of 1.35 trillion yen (USD 12.7 billion) (Lim, 2018).

Larger projects consume more resources, in quantity and variety, (e.g. technology, human). These projects also tend to incorporate more organizational redundancy (Stan *et al.,* 2014) compared to smaller projects, whose lower levels of redundancy also limit the amount of host country knowledge they can absorb (Kumar, 2009). As a result, larger projects are better equipped to investigate more options for mitigating the effects of a natural disaster, build the facilities and other physical assets in a way that minimizes their exposure to climate effects, create backup facilities, and buy insurance (Huang *et al.,* 2018). Through actions such as lobbying, board interlocks with former politicians, and campaign contributions (Hillman and Wan, 2005), larger projects can obtain preferential treatment and information, both before and after natural disasters occur (Zhu and Chung, 2014).

Finally, participation in larger projects creates new business opportunities with positive additional side effects for private investors (Esty and Bell, 2018). When bidding on subsequent attractive contracts, investors may be more likely to succeed where there are expected benefits from their experience, preferential treatment from host country government and other partners, and reputational effects (Lei *et al.,* 2017). To obtain these reputational benefits, investors are likely to be more committed to projects despite increased climate risk. The experience obtained through successfully completing projects will reduce investors' ex-post contracting costs in future infrastructure projects, while the reputational effects from completing larger projects successfully will reduce ex-ante contracting costs.

We therefore propose:

**H3:** The negative effect of climate risk in a host country on PPIs is weaker in larger projects.

## 3. Method

*3.1 Sample*

Our sample is drawn from the World Bank's PPI dataset, a source commonly used in the literature (Jiang *et al.,* 2015, Jiménez *et al.,* 2018). It consists of 18,846 PPIs in 111 countries between 2004 and 2013 in which the main investor is a foreign firm, and for which data on climate risk are available.

<u>3.2. Variables</u>

*3.2.1. Dependent Variable*

The success of PPIs entails that a consortium of investors fulfils the legally binding agreement to invest funds, develop facilities, and provide the service. Projects, however, can fail when the investors or the government terminate the concession period prematurely. We measure project success (/failure) by using the status of a project as provided by the PPI dataset, in line with the literature (Jiang *et al.,* 2015). The PPI dataset reports the outcome of a project as "operational" when it provides services to the public, "merged" when the project merges with another, and "concluded" when the contract period has expired. We consider "operational", "merged", and "concluded" projects as successful and assign a value of 1. The PPI dataset reports a project as "cancelled" when the private sector investor(s) has exited, and "distressed" when the government or the investor(s) has either requested termination, or is in international arbitration.[2] We consider "cancelled" and "distressed" projects as failed.

*3.2.2. Independent Variable*

We measure climate risk using data from Germanwatch (Kreft and Eckstein, 2014) on the total losses from climate events, in millions USD adjusted to purchasing power parity (PPP). This variable is based on the worldwide data collection and analysis provided by Munich Re's NatCatSERVICE; the world's leading reinsurance company. Data from Germanwatch datasource has been frequently employed in the literature as a measure of the severity of climate risk a country faces (Burnell, 2012; Rivera and Wamsler, 2014; Garschagen and Romero-Lankao, 2015; Huang *et al.*, 2018).

*3.2.3. Moderators*

In Hypotheses 2 and 3, we propose that several project-level features can play a moderating role in the relationship between the climate risk in a host country and the success of PPIs in that host country. First, we test the effect of host government ownership. We code this variable 1 when the ownership of the project includes the host government as an investor,

[2] According to the data source, the private sector might have exited in one of the following ways: (1) selling or transferring its economic interest back to the government before fulfilling the contract terms; (2) removing all management and personnel from the concern; or (3) ceasing operation, service provision, or construction for 15 percent or more of the license or concession period, following the revocation of the license or repudiation of the contract.

and 0 otherwise. Finally, we test the effect of project size, for which we use the total value of investments subject to a logarithmic transformation.

*3.2.3. Control variables*

We include in the model a range of project and country level control variables employed by several prior studies of PPIs (Jiang *et al.,* 2015; Jiménez *et al.,* 2018; 2019). At the project level, the controls include the age of the project, the delay between the project closure and the project commitment, whether the project is greenfield or brownfield, if it is publicly traded, and whether it includes only foreign investors or also at least one investor from the host country. In addition, we control for the sector of the project.

At the country level, we control for the GDP, GDP growth, unemployment rate, and level of political stability (POLCONV index). Lastly, we also include dummies to account for any unobservable characteristics of the geographic region where the project takes place.

<u>3.3. Analytical Method</u>

Given the binary nature of our dependent variable and the cross-sectional nature of the data in the PPI dataset, we rely on binary logistic models as our estimation technique. We mean-centre all the variables included in interactions (Aiken and West, 1991).

**4. Results**

We report the descriptive statistics of the variables in Table 1 and the correlation coefficients in Table 2. All variance inflation factors (VIFs) are below the limit of 10 recommended by Neter et al. (1985). The mean VIF of the model is 2.76. Besides, the relatively low correlations between predictors suggest that multicollinearity is not an issue.

We present the results obtained from the logit regressions hierarchically in Table 3. Model 1 includes the climate risk index and the control variables. Then, in Models 2–4 we include the interaction terms alternatively; so to test our moderating hypotheses.

The results of the control variables in Model 1 show that several project- and country-level variables have a positive relationship with the likelihood of project success. Similarly, projects in the energy and telecom sectors are more likely to succeed; whereas projects in water sewerage are more likely to fail. Projects are also more likely to succeed when they are located in host countries with a higher GDP and lower unemployment rates. Projects that are older, have a longer delay (meaning more time to prepare the investment since the concession), publicly traded, brownfield, and include a local investor in the consortium are more likely to succeed compared to their counterparts. Interestingly, larger projects are more likely to fail. While we argued earlier that larger projects are better shielded from the negative effects of climate risk (for which we provide empirical support next), this result shows that despite being more protected from this particular risk, larger projects are less likely to succeed than smaller ones. Larger projects tend to be subject to disadvantages such as higher managerial complexity and coordination costs (Nooteboom *et al.,* 2007), bureaucratic rigidity and a less flexible structure (Laforet, 2008), greater organizational inertia (Zhou and Li, 2010) and lower creativity and responsiveness to changes (Damanpour and Wischnevsky, 2006). All of these can contribute to higher failure rates. Similarly, projects including host government ownership are also less likely to succeed. We argued previously that including the host government as an investor helps mitigate the effects of climate risk (for which we also provide empirical support next). Nonetheless, this result also points to potential disadvantages related to host government ownership, such as conflicts of interest and interference resulting from a political agenda (Sun *et al.,* 2016).

The coefficient of climate risk in Model 1 is negative and significant ( $\beta$ = -7.60e-05, $p < 0.001$), indicating that climate risk levels are statistically associated with a greater likelihood of project failure. This result is consistent across all subsequent models, supporting Hypothesis 1. However, given the binary nature of our dependent variable, and since our model is non-linear, the marginal effect does not equal the coefficient obtained in the model but varies with the value of all model variables (Wiersema and Bowen, 2009). To be able to assess the size of this effect, we need to estimate the average marginal effects. The results show that when climate risk increases by one standard deviation, the likelihood of PPI success decreases by 1.323% ($p < 0.01$) and ranges between 1.440% and 1.368% in the models including the interaction[3].

In Model 2 we find that the coefficient of the interaction between climate risk and host government ownership is positive ( $\beta$ = 0.000120, $p < 0.001$). Hypothesis 2 is therefore supported. We supplement this coefficient analysis with graphical analysis (Ai and Norton, 2003). Figure 2 depicts the average marginal effects of government ownership at various levels of climate risk. Projects without host government ownership in comparison to those with host government ownership have a relatively steeper slope in the graph suggesting that while higher levels of climate risk in a host country have an overall negative effect on project success, this effect is mitigated when the project includes host government ownership. For instance, when climate risk is at the lowest level of the sample, projects including host government ownership have a 91.95% probability of success; whereas projects without host government ownership have a 95.74% probability of success. However, at the highest level of climate risk, the probability of success drops to 53.36% for projects without host

[3] Results available from the authors upon request.

government ownership; whereas it increases to 97.43% for projects with host government ownership.

Model 3 shows a positive and significant coefficient for the interaction between climate risk and larger projects ( $\beta = 9.81e\text{-}06$, $p < 0.001$). Hypothesis 3 is therefore supported. Figure 3 depicts the marginal average effects of project size at various levels of climate risk. Smaller projects in comparison to larger projects suggests have a relatively steeper slope in the graph suggesting that while higher levels of climate risk in the host country have an overall negative effect on the likelihood of a project's success, this effect is less pronounced when the project is larger. For instance, when climate risk is at the lowest level of the sample, smaller projects have a 95.22% probability of success; whereas larger projects have a 93.87% probability of success. However, at the highest level of climate risk, the probability of success drops to 51.54% for smaller projects and only to 83.25% for larger projects.

We also checked that the results do not show any significant change when the variables in the interactions are not mean-centred (Haans *et al.,* 2016). Moreover, we tested the results when employing a logarithmic transformation of the climate risk variable. The results were again in line with those presented in our main models.[4]

## 5. Discussion

Our research shows that climate risk can have a critical impact on the outcome of investment in PPI. Yet, despite some recent advances on the study of major disasters (Oh and Oetzel, 2011, 2017; Pek *et al.,* 2018), the literature on climate risk is still under-developed

[4] Results of all robustness tests are available from the authors upon request.

(Oetzel and Oh, 2014; Huang *et al.,* 2018). To fill this apparent gap in the literature, we studied the relationship between climate risk and the probability of PPIs success versus failure. The negative relationship we found can be explained by the fact that climate risk, conceptualized as unpredictable meteorological and climatological events, increases uncertainty and transaction costs for a PPI project, irrespective of extreme weather events actually occurring. As the operational complexity and financial requirements of a project rise, it is more difficult for investors to secure the financing of the project after they get permission to build and operate the infrastructure. Moreover, once the project is ongoing, the operating costs are also higher (Huang *et al.,* 2018).

Our findings extend the theorizing on the locational (dis)advantages of FDI in PPI projects, by suggesting to what extent a locational disadvantage like climate risk could be mitigated by certain project characteristics (namely, size and government ownership). Prior research has mainly focused on institutional antecedents to location preference of multinationals (Kim and Aguilera, 2016; Nielsen *et al.,* 2017). Our study thus contributes a novel perspective on a very different kind of risk to the typical political hazards and other liabilities of foreignness faced by foreign investors. Furthermore, we relate this to realized performance outcomes, namely the success or failure of a PPI project, rather than the extensively studied issue of location attractiveness. Given the idiosyncratic nature of PPI as a type of FDI, the impact of climate risk could therefore be considered a signal of the particular locational (dis)advantages to foreign investors (Dunning, 1988; Cantwell, 2009).

Complementary to this, we contribute to the literature on MNE investment strategy aimed at mitigating risks (Lien and Filatochev, 2015). In particular, the use of international contract joint ventures as an increasingly popular mechanism to address infrastructure challenges around the world. To date, the discussion on internalization advantages afforded by international joint ventures has focused predominantly on the choice between wholly owned subsidiaries and joint ventures of varying ratios of foreign to domestic ownership (e.g. Hennart, 1991; Majocchi *et al.,* 2013). The viable alternative of comparatively shorter-term international contract joint ventures has been under-studied in this discussion (Beamish & Lupton, 2016) and so our study will hopefully inspire jumping off points for authors studying their role in the evolving landscape of multinational business. We found that projects involving host government ownership, attenuate the negative effects of climate risk on the probability of PPI project success versus failure. This could be explained by a preferential treatment of the project by the government; e.g. in terms of providing information about the forecast of the occurrence of natural disasters and the extent of repercussions, as well as any planned recovery actions if disasters actually occur (Ridge *et al.,* 2017). Likewise, preferential treatment may be granted to investors in government-owned projects; fostering the determination of such investors to see the project to its successful conclusion. Government ownership can also make it easier for the project to obtain financial aid if necessary (Deryugina, 2011). Furthermore, the extent to which the participation of MNEs in high climate risk PPI project locations leads to a higher probability of winning similar contracts should be studied, as this is a logical determinant of the type of capacity development that may be necessary to build global leadership in a changing environment (Tian and Slocum, 2015).

We also obtained empirical evidence that the effects of climate risk on the probability of success versus failure in PPIs are attenuated in larger projects, as these may have a greater amount and variety of resources and slack at their disposal (Stan *et al.,* 2014). Investors can leverage these additional resources to select a site which is less susceptible to the impact of climate, protect physical assets, and buy insurance against natural hazards (Huang *et al.,* 2018), or implement political strategies to obtain government support (Zhu and Chung, 2014). Large projects can lead to positive reputational effects, which in turn lead to higher risk tolerance and greater determination to achieve success on the part of private investors. Similar to projects including host government ownership, this can lead investors to consider the additive advantages of experiential learning and gains from preferential treatment in subsequent projects, when evaluating the overall PPI benefits.

Finally, this study contributes to the literature on PPI investments (Ramamurti and Doh, 2004; Jiang *et al.,* 2015). We explain that the negative effect of unpredictable meteorological and climatological events is due to the increased burdens that investors can encounter during the planning, development, and financing stages; and potential recovery later on. Thus, climate risk can jeopardize the success of projects not only by the direct effect of physical damages on an already operational project, but also by preventing the conditions required by the investors to implement the project. Finally, our study adds to the risk–performance literature on major disasters (Oh and Oetzel, 2011, 2017; Pek *et al.,* 2018), and climate risk in particular (Mithani, 2017; Huang *et al.,* 2018). We offer a finer-grained analysis of this relationship in PPIs, and demonstrate the extent to which alternative consortium compositions can reduce project failure.



### 5.1. Managerial Relevance

Despite natural disasters being considered largely uncontrollable "acts of God" (Oetzel and Oh, 2014), we propose two project characteristics in PPIs that can help managers buffer the investment from the impact of climate risk. This can be helpful when managers are considering whether to invest in locations characterized by both a high level of climate risk and high market attractiveness. Specifically, firms planning to become investors in PPI projects located in countries characterized by high levels of climate risk, should prioritize partnering with the host government and conduct larger-scale projects, in order to partially mitigate the adverse effects of climate risk. An important practical implication for policy-makers is that governments needing private investors in infrastructure can signal commitment to the projects and increase attractiveness for investors. Similarly, governments might attract larger investments by bundling multiple projects.

5.2. Limitations and Avenues for Future Research

We acknowledge that our paper is subject to several limitations, which open interesting avenues for future research. First, we analyse the impact of our variables on PPI project success. However, these could also affect additional FDI aspects such as profitability and reinvestment. Similarly, future research can build upon these ideas by considering the strategies of firms in other kinds of FDI (e.g. in manufacturing). Second, in this paper we focus on climate risk, conceptualized as unpredictable meteorological and climatological events. However, the literature on major risks has identified other potential sources of uncertainty for investors, such as technological disasters, terrorism, and war (Branzei and Abdelnour, 2010; Czinkota *et al.,* 2010; Oh and Oetzel, 2011, 2017; Oetzel and Oh, 2014; Pek *et al.,* 2018). Future studies can analyse how these types of risks affect PPIs. Third, we are unable to distinguish between the effects of different types of natural disasters (e.g. the specific effect of droughts, extreme temperatures, floods). Fourth, due to data availability restrictions, we measured host government ownership with a dummy variable. Studying the effects of different percentages of host government ownership constitutes a promising next step to enlarge our research. Finally, data availability in the PPI dataset also prevented us from conducting a panel data analysis, but it would be very interesting to check if our cross-sectional estimates hold in longitudinal studies.

Despite the aforementioned limitations, we believe our paper contributes a nuanced understanding of climate risk as a locational (dis)advantage for FDI, while also signposting some fruitful directions for private investors and governments to prepare in order to better address this particular type of external source of risk. Yet, more effort is needed to understand how major disasters affect FDI and PPI projects, and thus, we cannot but encourage other scholars to continue this line of investigation so to deepen our knowledge in this area.

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**Figure 1. Conceptual Framework**

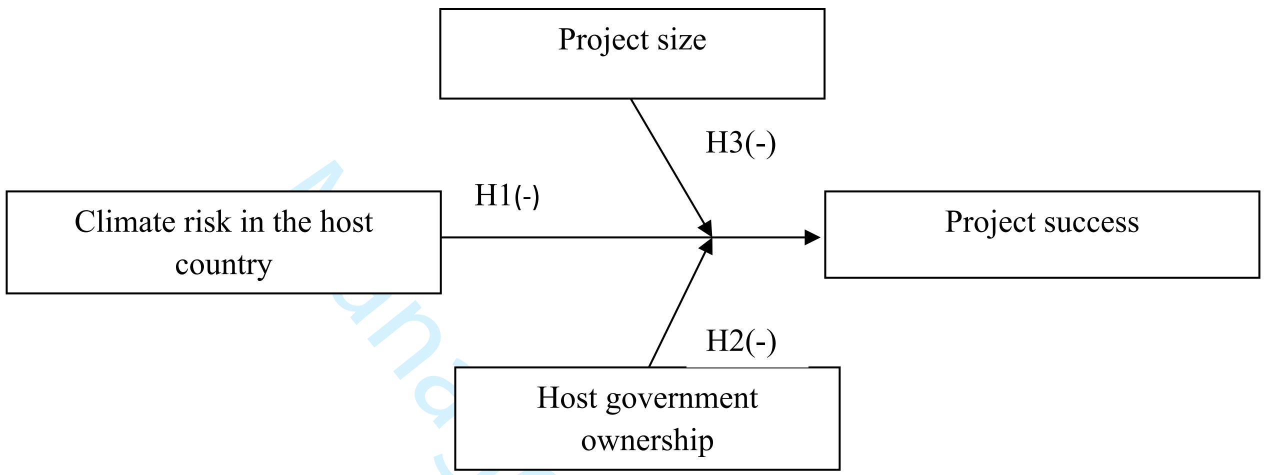

**Table 1. Descriptive statistics**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Successful | 18,846 | 0.935 | 0.246 | 0 | 1 |
| East Asia | 18,846 | 0.081 | 0.273 | 0 | 1 |
| Central Europe | 18,846 | 0.050 | 0.219 | 0 | 1 |
| Middle East and North Africa | 18,846 | 0.292 | 0.454 | 0 | 1 |
| South Asia | 18,846 | 0.360 | 0.480 | 0 | 1 |
| Sub-Saharan Africa | 18,846 | 0.123 | 0.328 | 0 | 1 |
| Latin America | 18,846 | .0945 | .2925 | 0 | 1 |
| Energy | 18,846 | 0.217 | 0.412 | 0 | 1 |
| Telecom | 18,846 | 0.721 | 0.448 | 0 | 1 |
| Transport | 18,846 | .0326 | .1776 | 0 | 1 |
| Water sewerage | 18,846 | 0.028 | 0.166 | 0 | 1 |
| Total investment | 18,846 | 3.080 | 2.59 | -0.693 | 13.97 |
| Age | 18,846 | 4.298 | 2.419 | 1 | 10 |
| Delay | 18,846 | 7.432 | 6.134 | 0 | 23 |
| Publicly traded | 18,846 | 0.107 | 0.309 | 0 | 1 |
| Greenfield | 18,846 | 0.819 | 0.384 | 0 | 1 |
| Host government ownership | 18,846 | 0.274 | 0.446 | 0 | 1 |
| Host country POLCONV | 18,846 | 0.240 | 0.241 | 0 | 0.837 |
| GDP | 18,846 | 10.87 | 1.041 | 0 | 12.93 |
| GDP growth | 18,846 | 5.887 | 5.100 | -33.1 | 34.5 |
| Unemployment | 18,846 | 4.852 | 6.555 | 0 | 37.6 |
| Local investor | 18,846 | 0.101 | 0.302 | 0 | 1 |
| Climate risk | 18,846 | 2026.78 | 9059.61 | 0 | 75474.21 |

## Table 2. Correlation matrix and VIFs

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1, Successful | 1 | | | | | | | | | | | | | | | | | | | | | - |
| 2. East Asia | -0.23* | 1 | | | | | | | | | | | | | | | | | | | | 2.48 |
| 3. Central Europe | -0.01 | -0.06* | 1 | | | | | | | | | | | | | | | | | | | 1.53 |
| 4. Middle East | 0.03* | -0.19* | -0.14* | 1 | | | | | | | | | | | | | | | | | | 4.11 |
| 5. South Asia | 0.06* | -0.22* | -0.17* | -0.48* | 1 | | | | | | | | | | | | | | | | | 4.79 |
| 6. Sub-Saharan Africa | 0.06* | -0.11* | -0.06* | -0.24* | -0.28* | 1 | | | | | | | | | | | | | | | | 2.76 |
| 7. Energy | -0.12* | 0.37* | 0.09* | 0.09* | -0.35* | -0.15* | 1 | | | | | | | | | | | | | | | 7.09 |
| 8. Telecom | 0.39* | -0.38* | -0.07* | -0.13* | 0.36* | 0.18* | -0.84* | 1 | | | | | | | | | | | | | | 8.51 |
| 9. Water sewerage | -0.39* | 0.08* | -0.01* | 0.15* | -0.12* | -0.06* | -0.09* | -0.27* | 1 | | | | | | | | | | | | | 2.01 |
| 10. Total investment | -0.14* | 0.08* | 0.06* | 0.23* | -0.45* | 0.14* | 0.27* | -0.32* | 0.04* | 1 | | | | | | | | | | | | 1.77 |
| 11. Age | -0.05* | 0.00 | 0.06* | -0.02* | 0.04* | -0.17* | -0.20* | 0.11* | 0.10* | 0.08* | 1 | | | | | | | | | | | 1.78 |
| 12. Delay | 0.29* | -0.27* | -0.01* | -0.33* | 0.38* | 0.01* | -0.29* | 0.42* | -0.19* | -0.23* | -0.30* | 1 | | | | | | | | | | 2.38 |
| 13. Publicly traded | 0.08* | -0.08* | 0.09* | -0.19* | 0.29* | -0.12* | -0.10* | 0.13* | -0.05* | -0.00 | -0.02* | 0.39* | 1 | | | | | | | | | 2.45 |
| 14. Greenfield | -0.08* | -0.03* | -0.15* | 0.19* | -0.05* | 0.09* | -0.08* | 0.15* | -0.08* | 0.05* | 0.00 | -0.22* | -0.60* | 1 | | | | | | | | 2.2 |
| 15. Host government ownership | -0.02* | -0.07* | 0.03* | -0.23* | 0.21* | -0.04* | -0.07* | 0.01* | 0.13* | -0.04* | 0.10* | 0.22* | 0.44* | -0.45* | 1 | | | | | | | 1.55 |
| 16. Host POLCONV | -0.12* | 0.09* | 0.29* | -0.24* | -0.24* | 0.19* | 0.23* | -0.28* | 0.11* | 0.16* | -0.08* | 0.04* | 0.07* | -0.24* | 0.01* | 1 | | | | | | 1.86 |
| 17. GDP | -0.09* | 0.13* | 0.01 | 0.02* | -0.15* | -0.06* | 0.24* | -0.28* | 0.08* | 0.20* | -0.28* | 0.10* | 0.12* | -0.14* | 0.00 | 0.24* | 1 | | | | | 1.63 |
| 18. GDP growth | 0.02* | -0.03* | -0.05* | 0.08* | 0.06* | -0.05* | 0.15* | -0.11* | -0.03* | -0.01* | -0.11* | -0.15* | -0.19* | 0.16* | -0.07* | -0.22* | 0.29* | 1 | | | | 1.57 |
| 19. Unemployment | -0.05* | -0.04* | 0.15* | 0.29* | -0.38* | -0.05* | -0.06* | -0.00 | 0.13* | 0.38* | 0.36* | -0.16* | -0.12* | 0.03* | 0.00 | 0.03* | -0.10* | -0.26* | 1 | | | 1.86 |
| 20. Local investor | -0.12* | 0.38* | 0.01 | -0.21* | -0.02* | 0.01 | 0.18* | -0.15* | -0.04* | 0.02* | 0.08* | -0.15* | -0.08* | 0.01 | -0.17* | 0.29* | 0.04* | -0.08* | -0.09* | 1 | | 1.5 |
| 21. Climate risk | -0.43* | 0.44* | -0.04* | -0.14* | -0.01 | -0.08* | 0.19* | -0.18* | 0.03* | -0.04* | -0.09* | -0.03* | 0.02* | -0.01 | -0.03* | 0.07* | 0.14* | 0.02* | -0.11* | 0.30* | 1 | 1.35 |

* $p<0.05$

**Table 3. Logit regression result**

| VARIABLES | (1) Base | (2) Government ownership | (3) Project Size |
|---|---|---|---|
| East Asia | 0.832*** | 0.749*** | 0.785*** |
| | (0.213) | (0.213) | (0.214) |
| Central Europe | -1.271*** | -1.283*** | -1.237*** |
| | (0.237) | (0.235) | (0.236) |
| Middle East and North Africa | 2.447*** | 2.586*** | 2.552*** |
| | (0.210) | (0.212) | (0.211) |
| South Asia | -0.978*** | -0.869*** | -0.998*** |
| | (0.208) | (0.210) | (0.209) |
| Sub-Saharan Africa | -0.436* | -0.389* | -0.378 |
| | (0.237) | (0.237) | (0.237) |
| Energy | 2.785*** | 2.882*** | 2.753*** |
| | (0.183) | (0.183) | (0.182) |
| Telecom | 6.187*** | 6.211*** | 6.101*** |
| | (0.259) | (0.260) | (0.261) |
| Water sewerage | -1.718*** | -1.585*** | -1.869*** |
| | (0.230) | (0.226) | (0.231) |
| Total investment | -0.0732** | -0.0860*** | -0.101*** |
| | (0.0316) | (0.0315) | (0.0316) |
| Age | 0.279*** | 0.284*** | 0.281*** |
| | (0.0291) | (0.0293) | (0.0291) |
| Delay | 0.211*** | 0.224*** | 0.204*** |
| | (0.0240) | (0.0244) | (0.0240) |
| Publicly Traded | 2.539*** | 2.000*** | 2.210*** |
| | (0.854) | (0.760) | (0.793) |
| Greenfield | -3.618*** | -3.481*** | -3.543*** |
| | (0.197) | (0.196) | (0.196) |
| Host government ownership | -1.274*** | -1.253*** | -1.236*** |
| | (0.148) | (0.150) | (0.148) |
| Host country POLCONV | -0.470 | -0.129 | -0.488 |
| | (0.308) | (0.315) | (0.309) |
| GDP | 0.341*** | 0.297*** | 0.352*** |
| | (0.0533) | (0.0546) | (0.0538) |
| GDP growth | 0.0189 | 0.0232 | 0.0148 |
| | (0.0147) | (0.0150) | (0.0148) |
| Unemployment | -0.0701*** | -0.0682*** | -0.0719*** |
| | (0.0114) | (0.0113) | (0.0113) |
| Local investor | 0.457** | 0.661*** | 0.551*** |
| | (0.187) | (0.193) | (0.188) |
| Climate risk | -7.60e-05*** | -8.45e-05*** | -7.95e-05*** |
| | (4.36e-06) | (5.16e-06) | (4.61e-06) |
| Climate risk*Host government ownership | | 0.000120*** | |
| | | (1.79e-05) | |
| Climate risk*Total investment | | | 9.81e-06*** |
| | | | (1.87e-06) |
| Constant | -2.228*** | -2.111*** | -2.227*** |
| | (0.609) | (0.623) | (0.611) |
| Log likelihood | -1380.04*** | -1352.60*** | --1369.39*** |
| Pseudo R2 | 69.48 | 70.09 | 69.72 |
| Observations | 18,846 | 18,846 | 18,846 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Figure 2. Average marginal effects of government ownership at various levels of climate risk**

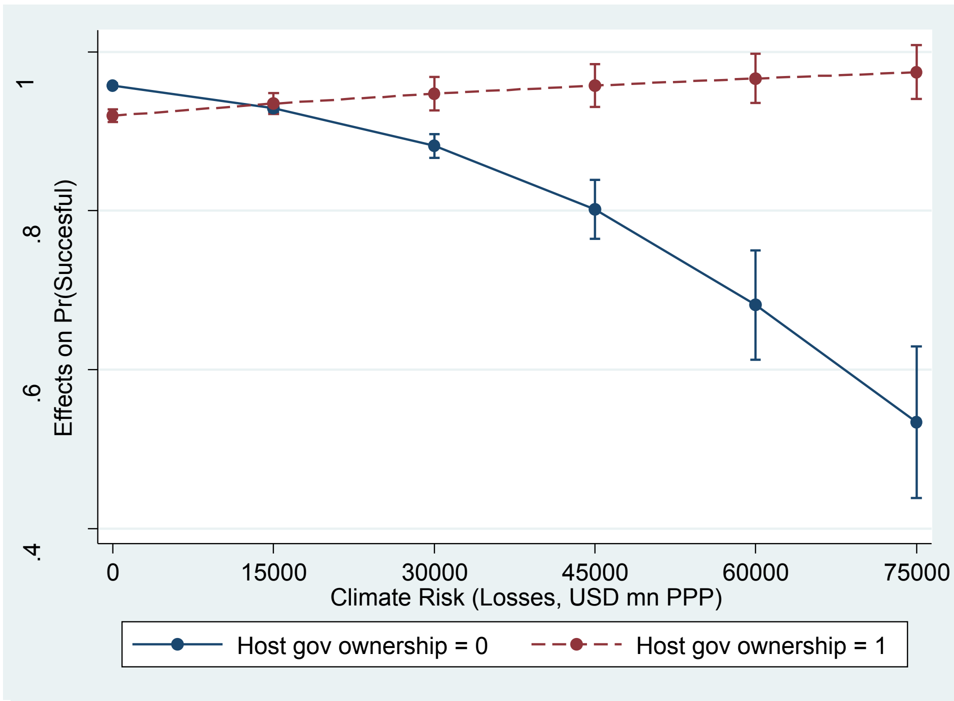


**Figure 3. Average marginal effects of project size at various levels of climate risk**