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Climatic Factors as Determinants of International Migration: Redux

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Abstract

In this article, we revisit the issue of environmental change as a potential determinant of international migration, thereby providing an extension of our earlier paper. In contrast to Beine and Parsons (2015, *The Scandinavian Journal of Economics*, 117, 723–767) and in light of recent empirical contributions, we adopt an alternative identification strategy in which we only include fixed effects together with our measures of climatic change to quantify the net partial effect of climatic change on bilateral migration. Again drawing on panel data from 1960 to 2000, we further exploit the dyadic dimension of our data to highlight the importance of neighbouring countries and former colonial powers in determining the direction of climate-induced emigration. Our baseline results suggest that climatic shocks affect individuals' financial constraints more than their desire to move. Our key findings are that natural disasters tend to deter emigration but importantly spur emigration to neighbouring countries. For middle-income origins, natural disasters, while deterring migration, foster emigration to former colonial powers. (JEL codes: F22, J61)

Key words: international migration, environmental change, natural disasters

1. Introduction

The debate over the effects of climate change on migration continues to grow unabated. Developing country residents are most vulnerable to the first-order effects of climate change due to their reliance upon agriculture and a broader inability for many poorer households to smooth their consumption by accessing credit markets. Migration therefore represents an available coping, or indeed an adaptive, strategy through which households may react to changes in climatic conditions. Developed countries largely harbour fears of increased numbers of refugees from developing countries wishing to cross their borders. Despite dire predictions of 200 million 'environmental refugees' by 2050 (Myers 2002), the evidence base from which to assess the impacts of climate change on migration remains weak.[1] This is due to the statistical difficulties in distinguishing the myriad impacts through which climatic change may affect migration coupled with a paucity of available data.

This article is an extension to Beine and Parsons (2015), the first macroeconomic analysis of the effects of climate shocks on international migration in a global panel. In that paper we failed to discern a direct impact of climatic shocks (as measured by both natural disasters and slow-onset climatic change) on international migration having accounted for a range of other key drivers—economic, political, demographic, and social—that are commonly considered important determinants of migration. Rather we concluded that the effects of climatic shocks will likely be indirect, a supposition supported by additional regressions that showed that climatic change may affect wage differentials. We further provided evidence, in support of much of the available microeconomic literature that natural disasters led to increased internal migration as proxied by the rate of urbanization.

The existing academic literature remains inconclusive with regards the specific impact of climate change on migration. This is largely due to the high heterogeneity empirical approaches in tandem with contextual specificities. There are many dimensions of analysis along which studies exhibit differences. These dimensions concern the type and scope of migrations macro vs. micro analysis, international emigration of agents as opposed to internal mobility, etc. Some studies focus upon specific channels, while others propose reduced form analyses, abstracting from identifying specific channels. The literature relies upon various types of migration data. A specific difference is whether to use unilateral data, as opposed to dyadic data. Another important dimension is which types of climatic events are considered. Some studies focus on long-run changes in climatic conditions such as changes in rainfall and temperatures, while other papers concern natural disasters such as floods, hurricanes, and earthquakes. Last but not least, the specific formulations of measures of climatic conditions that differ across papers likely influence the results obtained.

In this article, we propose a specific analysis to study the impact of climatic shocks that takes into account the various approaches of the literature. After a selective coverage of the recent literature, we position our analysis and clarify the choices that we make. In particular, we document a net total effect of climatic change on international migration using bilateral data in the absence of other covariates. This lends credibility to our previous arguments developed in Beine and Parsons (2015) and clarifies why we failed to uncover a direct effect of climate change, while providing indirect evidence through the impact on wage differentials. We further draw upon the dyadic dimension of the data to provide new evidence of the effects of climate change, while further considering the income levels of origin countries.

Our baseline results show that on average, both short-run and long-run climatic change as measured by natural disasters and rainfall and temperature anomalies deter international emigration from middle-income countries but have no effect on emigration from poorer countries, the residents of which are likely to be more financially constrained. This result would suggest that the impact of climatic change affects individuals' financial constraints more than their desire to move. Interacting our climatic variables with a contiguity dummy variable, we further show that natural disasters indeed might deter emigration from all origin countries but importantly spur emigration to neighbouring countries. Conversely,

1 Millock (2015) provides an excellent review of the literature regarding both internal and international migration, related to slow-onset and sudden-onset environmental factors.

negative precipitation shocks constrain emigration to neighbouring countries from origins of both income levels. Our final result is that for middle-income origins, natural disasters that deter migration on aggregate foster emigration to former colonial powers. No evidence is found of this effect for poorer countries, which is not surprising, given that poor country residents would be unlikely to be able to cover the migration costs in the first place. Our results prove to be robust to alternative measures of natural disasters. Our study remains one of few which explicitly examines the long-run impact of climate change on international migration.

The article is organized as follows. Section 2 sketches the recent literature and positions our article with respect to existing work. Section 3 discusses some empirical considerations, while Section 4 presents our data. Section 5 reports and discusses the results of our econometric investigation. Section 6 concludes.

2. Specific Literature Coverage and Contribution of the Paper

The literature on the connection between climate change and migration has developed at a pace over the past decade. Unsurprisingly, the heterogeneous approaches adopted have yielded quite, different findings. To clarify our contribution, it is important to detail recent studies in the field and to emphasize the various choices that those papers made. This section therefore provides a selective literature review of recent papers. Excellent overarching and comprehensive surveys are provided by Millock (2015) and Berlemann and Steinhardt (2017).

The potential effects of climatic change are myriad, such that causally identifying the impacts, both direct and indirect, proves difficult. Piguet et al. (2011) argue that because climate change impacts upon both an individual's desire and ability to migrate, it may in fact be impossible to determine whether environmental factors have a direct or indirect impact on migration. Climatic change may potentially directly force individuals to migrate, perhaps most obviously from small island states that are affected by rising sea levels. In a recent poll, some 70% of all households in Kiribati and Tuvalu stated that they would consider migrating because of the impact of climate change (Campbell and Warrick 2014), although Noy (2017) stresses that there have hardly been any concrete actions taken in terms of emigration from these islands. The focus of empirical studies in the economics literature however is not specifically on sea-level rises but rather on long-run changes in temperature and precipitation as well as natural disasters, which might be considered as more unexpected events.

Inference on the impact of climate change on international migration is hampered however, by the fact that climatic change may affect migration through many indirect channels. One important channel, already mentioned is the fact that climatic shocks tend to decrease income, leading to a widening of the expected income differential between the affected country and the rest of the world and thus to international emigration. This channel has received a lot of support in the literature.[2] The so-called wage differential channel or labour

2 See Marchiori et al. (2012). Mueller and Quisumbing (2011) find that the 1998 'flood of the century' in Bangladesh induced significant wage losses in affected areas. Mueller and Osgood (2009) conduct a similar analysis in the case of droughts that took place in Brazil. Gröger and Zylberberg (2015) finds that households affected by a drop of income triggered by typhoon-induced floods in Vietnam tend to migrate internally from rural to urban areas.

market channel nevertheless prevails in the absence of financial constraints at origin and assumes that affected individuals can afford to pay for the migration costs associated with international emigration. This assumption has been questioned in the migration literature and evidence suggests that individuals from poor countries are financially constrained.[3] If financial constraints exist, climatic shocks can be expected to hamper rather than to spur emigration to other countries, especially from low-income countries.

A third potential channel is the effect through institutions. Institutions have been considered as push factors of international migration.[4] Climate and natural disasters have been found to affect the quality and the evolution of institutions in many countries. Climatic conditions have for example been emphasized as predetermined determinants of institutions (Acemoglu et al. 2001 and Acemoglu and Robinson 2012).

A final channel is that of civil conflict, since climatic change is found to increase the likelihood of conflict (Dell et al. 2014). Many commentators, for example, have blamed the ongoing Syrian conflict on climate change. Climate change affects incomes, thus spurring conflict which in turn results in migration. While it is not that clear climate change is associated indirectly with the so-called refugee crisis, evidence in favour of this channel has been provided in the case of Sudan (Maystadt et al. 2015) and Somalia (Maystadt and Eckers 2014).

Given these ambiguities, Cai et al. (2016) and Cattaneo and Peri (2016) emphasize the importance of agriculture as a leading candidate for a mechanism through which climatic change influences international emigration. Falls in agricultural productivity as a result of adverse climatic conditions may result in financial constraints becoming ever more binding, especially in the poorest countries of the world, while spurring migration from more wealthy countries due to increased incentives from, for example, greater wage differentials (Beine and Parsons 2015). These effects could equally apply to internal as well as international migration. The paper of Marchiori et al. (2012), however, is the only paper that explicitly links the two. These authors explain how climate change may punish the agricultural sector and encourage urbanization. This may in turn encourage international migration due to both changes in wage differentials and increased welfare costs (such as increased incidence of illness and disease). A priori, we would expect that these effects would be largely borne by residents of rural areas in developing countries that are more dependent upon agriculture for their livelihoods. In the presence of migration costs, it also seems intuitive that any international emigrants would likely move to neighbouring countries. It therefore proves particularly important to include countries of the global south in any estimation as origins and destinations.

No consensus has been reached in the literature with regards the effects of climatic change on migration. This is due to a set of differences in the way scholars address the issue. In particular, major differences in geographical foci, in the specific research questions being posed, in the type of migration data analysed, the types of migration studied, in the econometric methods being relied upon, and last but not least in the alternative formulations of climatic variables.

Country-specific or migration corridor-specific studies are strongly context-dependent. Findley (1994) for example finds that drought in Mali reduces migration, while Gray (2009)

3 Mayda (2010) finds for instance evidence of a quadratic relationship between income and emigration which is consistent with the presence of financial constraints.

4 See Ariu et al. (2016) for instance.

finds in Ecuador that internal and international migration both decreased with increasing precipitation. In contrast, Ruiz (2015) finds that floods and to a lesser extent droughts in Mexico triggers interstate mobility. Gröger and Zylberberg (2015) provide similar evidence for Vietnam in the case of typhoon-induced floods. Dallmann and Millock (2017) found similar results in the case of intra-regional migration in India triggered by variations in rainfall. Munshi (2003) finds a statistically significant and positive relationship between emigration from rural Mexico to the USA and low rainfall at origin, while Kniveton et al. (2008) find that greater amounts of rainfall can lead to increased numbers of Mexican emigrants from one particular city to the USA. This lack of consensus also extends to the impact of natural disasters.[5] Cross-country panel studies, which are arguably more externally valid, those that examine long-run climatic change, for example, Backhaus et al. (2015), Coniglio and Pesce (2015), Cai et al. (2016), and Marchiori et al (2012), generally conclude that a positive link exists between rising temperatures, shortages in precipitation, and international emigration. So too generally does the macroeconomic literature find a positive link between natural disasters and international migration (Naudé 2008; Reuveny and Moore 2009; Drabo and Mbaye 2011, 2015).

Only two studies, namely, Beine and Parsons (2015) and Cattaneo and Peri (2016), make an explicit distinction between expected (long-run climatic change) and unexpected factors, in the form of natural disasters. Both these studies examine the long-run effects of climatic change on migration using differenced census data at 10-year intervals, while also importantly including countries of the global south as both origins and destinations. Both studies find that natural disasters spur internal migration but have no effect on international migration. Interestingly they reach different conclusions with regards the impacts of long-term climatic change on international migration. Beine and Parsons (2015) do not find any direct impact of long-run climate change having accounted for a raft of other covariates. These authors instead argue for the existence of an indirect impact through wage differentials which is consistent with the microeconomic literature. Cattaneo and Peri (2016) employ a unilateral analysis in which they only include batteries of fixed effects in addition to their measures of climatic change. They find that increasing temperatures reduces emigration from poor countries but increases emigration from medium-income countries.

In this extension of Beine and Parsons (2015), we quantify the net partial effect of climatic factors on bilateral migration patterns. We define the net partial effect as the aggregate sum of all channels of influence of climatic factors on international migration. Furthermore, we draw upon more fully the dyadic dimension of the data. This enables us to capture potentially different migration responses of financially constrained agents to climatic shocks. In particular, we expect that if emigration is operating as a coping strategy, agents will tend to choose destinations associated with lower migration costs.

5 Halliday (2006) finds that earthquakes have a negative effect on international migration flows, while Paul (2005), Gray and Mueller (2012), and Bohra-Mishra et al. (2014) find, respectively, that tornados, floods, and natural disasters generally had no significant impact on internal migration. Gröschl and Steinwachs (2017) find mixed results of natural disasters on bilateral long-term migration. They find no robust evidence of the natural hazards as push factors in low-income countries. They find however that natural disasters can act as push and pull factors in middle-income countries when timing is correctly accounted for.

3. Empirical Considerations

In our previous paper (Beine and Parsons 2015) we estimated a pseudo-gravity model, which derives from a random utility model in a similar vein to Dallmann and Millock (2016) and Coniglio and Pesce (2015). This approach has been widely applied outside of the environment and migration literature; see for example Grogger and Hanson (2011) and Beine et al (2011). According to this approach, homogenous agents maximize their utility by deciding whether to remain at home or migrate abroad to potentially all destinations globally. In weighing up the possibilities, agents consider the income they would receive by remaining or leaving against the migration costs incurred from travelling to a specific destination, which increase for example with distance but are hypothesized to decrease with migrant networks.

In our previous paper we modelled climatic change as a non-pecuniary cost (or indeed benefit) at origin along with measures of political and demographic factors. In essence therefore, our approach attempted to find a direct effect of climatic change on international migration above and beyond a range of other leading potential drivers. We failed to find any direct effect using this approach. Instead we argued that environmental change manifest indirectly, and we demonstrated one such indirect channel using our data, since environmental change may affect labour market incentives by affecting wage differentials.

Cattaneo and Peri (2016) remain more parsimonious, however and, following Dell et al (2012), only implement fixed effects in their estimation in addition to their measures of climatic change. The strategy of these authors therefore is to capture the total net effect of climatic change, regardless of the underlying mechanism as opposed to what might instead be termed the partial effect as we examined in our previous paper.[6] In contrast to our previous work, Cattaneo and Peri (2016) aggregate their bilateral observations across destinations. A particular advantage of such a choice is that the environmental variables and the international migration that is hypothesized to be affected by climatic change are observed in the same dimension, that is origin-time. In this extension article, we again draw upon bilateral data, but this time we follow Cattaneo and Peri (2016) in only including fixed effects in an attempt to estimate the net partial effect of climatic change on international migration.

The use of bilateral data as opposed to unilateral data yields several advantages. First, by considering three sources of variations (origin, destination, and time), it is possible to include a set of rich fixed effects. In particular, it allows to include destination–time fixed effects that allow to capture unobserved factors such as immigration policies at destination.[7] These policies are likely to be important hurdles to overcome for migrants coming from developing countries. Secondly, the use of dyadic data allows to look at specific patterns of emigration. This can be done by looking at some interaction terms capturing specific migration corridors associated with lower migration costs. This is likely important in the cases of financially constrained agents when considering emigration as a potential coping strategy. Last but not least, the use of dyadic data greatly expands the number of observations in the data.[8]

6 One additional argument in favour of this parsimonious specification is that the failure to find some direct effect might be due to over-controlling for the effects of climate change.

7 This corresponds to the α_{jt} in Equation (1) below.

8 Depending on the specification and the sample of countries, the number of observations is multiplied by between 50 and 150.

The equation we estimate is therefore:

$$Ln\left(\frac{N_{ijt}}{N_{iit}}\right) = \beta_1 lnP_{it} + \beta_2 lnT_{it} + \beta_3 lnD_{it} + \alpha_{jt} + \mu_i + \epsilon_{ijt}. \quad (1)$$

Where N_{ijt}=the number of migrants that have moved from origin i to destination j at time t, and N_{iit} captures natives that choose not to move such that $Ln\left(\frac{N_{ijt}}{N_{iit}}\right)$ is the log of the bilateral migration rate. P_{it} captures changes in precipitation at origin, and T_{it} refers to our measures of variation in temperature. Both P_{it} and T_{it} can be considered as long-term climatic shocks and as such might be thought of as largely expected. D_{it} rather captures our measure of natural disasters, which can be considered as largely unexpected. α_{jt} refers to a set of fixed effects in the destination–time dimension, while μ_i is a set of origin dummies. Equation 1 is estimated using the Poisson-pseudo maximum likelihood estimator. This allows for zeroes in the dependent variable whilst also crucially results in unbiased estimates should any of the covariates of Equation (1) be correlated with higher moments of the error term, which is often the case in log-linear models (see Santos Silva and Tenreyro 2006).

4. Data

As opposed to some recent studies that examine the effects of climatic change on annual flows of migrants (Coniglio and Pesce 2015 and Cai et al. 2016), we rather follow Beine and Parsons (2015) and Cattaneo and Peri (2016) and use decadal flows by averaging migrant stocks as recorded in census data (from Özden et al. 2011), from 1960 to 2000.[9] We therefore examine the long-run consequences of climatic change on international migration as opposed to any shorter-term movements. Our approach means we can include countries of the global South as both origins and destinations, which is important since financial constraints are more likely binding in relatively poorer nations such that any international migratory response to climatic factors is more likely to be regional—most likely to neighbouring countries.[10] In contrast to Beine and Parsons (2015), however, we exclude Organisation for Economic Co-operation and Development nations as origin countries as do Cattaneo and Peri (2016). We also follow these authors in delineating between poor countries and middle-income countries with the former being those countries in the bottom 25% of income per capita (Purchasing Power Parity) in the year 1990, while middle-income countries are defined as the remainder.

9 More frequent data capture shorter-term variability such that establishing correlations is easier. Such data are noisier however (Millock 2015) and may not be as accurate (Cattaneo and Peri 2016). Using decadal mobility flows allows to capture any potential effect of gradual changes in climatic conditions. Also, these data allow to capture South-South migration flows that represent, as our results show, an important part of the reaction of migrants to climatic shocks. The computation of decadal flows from stocks is nevertheless not without issues. For instance, it cannot capture return migration from natives. However, Beine and Parsons (2015) propose some robustness check using alternative definitions to address partially the problem.

10 Negative bilateral migration rates arise in cases when bilateral migrant stocks decreased over time. These observations are dropped from the analysis.

Short-run environmental factors are captured by our natural disasters variable, which includes droughts, earthquakes, extreme temperatures, floods, storms, volcanic eruptions, epidemics, insect infestations, and miscellaneous occurrences (i.e. technological accidents of a non-industrial or transport nature).[11] These data are obtained from the International Disaster Database, which is compiled by the Centre for Research on the Epidemiology of Disasters. This variable is simply calculated as the total number of natural disasters in a given decade.

To capture long-run environmental factors, we use precipitation and temperature data obtained from the TS3.0 data set, created under the auspices of the QUEST-GSI project and obtained from the Climatic Research Unit of the University of East Anglia. The original observations correspond to high-resolution grids and are collected on a monthly basis. Area weights are used to aggregate the data to the country level. Annual observations are then calculated as the average of monthly observations and decennial observations as the means across years. While the impact of these variables has been found to vary across localities, uncertainty also remains with regards the most appropriate way of formulating these variables for use in our empirical model. Measuring precipitation and temperature in absolute levels might not be appropriate because this formulation fails to adequately capture migratory responses to changes from standard climatic conditions. Rather, these would capture whether migration is more prevalent from rainier or warmer countries.

Instead, we calculate two separate measures, termed deviations and—drawing upon the wide body of climate literature (Nicholson 1986) and following Marchiori et al. (2012)—anomalies. Deviations (in both temperature and precipitation) are calculated as the differences of countries' decadal averages from their long-run averages. Following Marchiori et al. (2012), we take the long run to refer to the period 1901–2000, and anomalies are calculated as the deviations of countries' decadal averages (in temperature and precipitation) from their long-run average, divided by the corresponding long-run standard deviation, formally defined as:

$$Clim_{it} = \frac{Clim_{level,it} - \mu_i^{LR}(Clim_{level})}{\sigma_i^{LR}(Clim_{level})}.$$

Here, $Clim_{level,it}$ denotes the level of rainfall or temperature of country i in decade t, $\mu_i^{LR}(Clim_{level})$ denotes the long-run mean average rainfall or temperature of country i, and similarly μ_i^{LR} denotes the long-run standard deviation of rainfall or temperature of country i. Marchiori et al. (2012) argue that the use of anomalies eliminates scale effects as well as correcting for the fact that climatic variations in more arid regions are typically greater when compared to the mean. Moreover, because the long-run mean average can be assumed to capture typical weather conditions in a particular country, 'anomalies thus describe how far the weather conditions depart from this normal in a given year [...] capturing deviations in the weather from the norm' (Marchiori et al. 2012, p. 18). In contrast

11 As an alternative approach, only climate-related natural disasters could be considered. Nevertheless, even the evidence that some disasters such as earthquakes do (or do not lead) to displacement is informative, since they generate the same type of consequences for affected people. In that perspective, our article gives a positive assessment of the displacement effect of natural disasters. A second step could be to start from that evidence to be more specific about the long-term consequences of climate change by type. This is obviously beyond the scope of the current article.

Table 1. Baseline results. Dependent variable: bilateral migration rate

Variable	(1) Poor countries	(2) Middle-income	(3) Poor countries	(4) Middle-income
	Climatic deviations		Climatic anomalies	
Natural disasters	−0.238(0.179)	−0.187(0.120)	−0.218(0.179)	−0.236*(0.126)
Excess temperature	−0.021(0.103)	−0.504***(0.082)	−0.001(0.119)	−0.725***(0.133)
Shortage precipitation	0.017(0.089)	0.316***(0.075)	0.054(0.103)	−0.132*(0.068)
Origin FE	Yes	Yes	Yes	Yes
Destination–year FE	Yes	Yes	Yes	Yes
Number observations	22,362	113,767	22,362	113,767
R^2	0.200	0.973	0.201	0.980

Notes: Time period: 1960–2000. Poisson ML estimates. Estimated specification: equation (1).
FE, Fixed Effects; ML, Maximum Likelihood.
*, ** and *** denote significance at 10, 5 and 1% levels.

to Beine and Parsons (2015), however, we only examine positive temperature and negative precipitation deviations and anomalies, since these deviations are usually seen as the typical negative developments associated with long-run climate change.

5. Results

5.1. Benchmark results

Our baseline results are presented in Table 1. Columns (1) and (2) detail our results concerning deviations, while Columns (3) and (4) rather include our (preferred) measure of anomalies. Columns (1) and (3) refer to poor countries, while Columns (2) and (4) instead focus upon middle-income countries. In the absence of additional controls and in line with the results of Beine and Parsons (2015), we find no effect of any of our climate variables on international migration from poor countries in our sample. This is most likely because residents of these countries are severely financially constrained and so they are unable to move even if they wish to. In contrast to the findings of our previous paper, however, we do find a direct total effect of temperature on bilateral emigration from middle income countries. A 10% increase in the occurrence of positive temperature anomalies is predicted to decrease bilateral migration by just over 7%. In other words, in the absence of our additional controls, we do uncover a total impact of climatic change on international migration, albeit a negative one. Turning to precipitation, our results illustrate how crucial it is to adopt the correct measure of climatic change, since our measure of negative precipitation deviations is positively correlated with international emigration, while our measure of negative precipitation anomalies is weakly negatively correlated. In other words, our results show that if one does not control for the long-run volatility of climatic conditions to correct for the fact that more arid regions have more volatile climates, it is easy to obtain a result with an opposite sign.

These results illustrate three key aspects that emerge from the literature. First, the effect of climate change is likely to depend upon the classification of origin country, for example their level of economic development. Secondly, some results might go in the opposite direction to the one usually expected, that is that climatic shocks can hamper rather than trigger international emigration. Finally, the measurement of these shocks, especially for long-run climatic changes matter for the results.

5.2. Specific patterns of emigration

A priori it is reasonable to assume both that poorer countries will be most affected by climate change and since financial constraints in poorer countries will be more binding that any movement from these countries will likely be over shorter distances. In general, financially constrained agents will choose the destinations associated with the lowest migration costs, such as those at short distance or with special links with the origin country.

To investigate this idea, we estimate the same regression but in addition, drawing upon the dyadic nature of our data, also include interactions of a dummy capturing specific characteristics between origins and destinations with our measures of climatic change. The extended specification takes the following form:

$$Ln\left(\frac{N_{ijt}}{N_{iit}}\right) = \beta_1 lnP_{it} + \beta_2 C_{ij} lnP_{it} + \beta_3 lnT_{it} + \beta_4 C_{ij} lnT_{it} + \beta_5 lnD_{it} + \beta_6 C_{ij} lnD_{it} + \alpha_{jt} + \mu_i + \epsilon_{ijt}, \tag{2}$$

where C_{ij} captures the dyadic characteristic between the origin and the destination. We consider two types of bilateral characteristics. The first captures whether the two countries are contiguous or not, that is share a common border. The second captures historical colonial links.

The results involving the contiguity dummy are presented in Table 2. The most significant finding when we include the interaction terms, in contrast to the results in Table 1 and those in the previous literature, is that natural disasters are found on average to decrease emigration from both poor and middle-income countries but importantly found to significantly increase emigration to neighbouring countries. Concentrating on the results when we estimate anomalies in Columns 3 and 4, our results for temperature show that emigration is more or less equally constraining to neighbouring countries when compared to the average. Our results on precipitation further show for both sets of countries that while on average negative precipitation anomalies have no effect on international migration, they constrain migration to neighbouring countries.

Finally, we again draw upon the dyadic dimension of the data to examine whether colonial links, which the empirical literature has consistently shown to be an important determinant of global migration patterns, are influential in determining international movements in light of climatic change. These makes sense since colonial powers maintain strong links with their ex-colonies and indeed typically provide aid and other forms of emergency assistance, especially following natural disasters. Furthermore, colonial links initially triggered significant movements of workers and people from the colonies and the metropolis. They are often one of the main sources of large diasporas (Beine et al. 2011).[12] Again focusing upon our results for anomalies in which we have most confidence, our regressions highlight another key result. Existing literature typically shows no evidence in favour of natural disasters

12 Other initial shocks building important diasporas are bilateral agreements such as the guest worker programs that prevailed after the end of the Second World War. See Beine et al. (2011) on that.

Table 2. Specific emigration patterns: contiguity. Dependent variable: bilateral migration rate

Variable	Poor countries	Middle-income	Poor countries	Middle-income
	Climatic deviations		Climatic anomalies	
Natural disasters	−0.677***	−0.247*	−0.695***	−0.314**
	(0.155)	(0.123)	(0.169)	(0.131)
Disasters*contiguity	1.177***	0.984	1.270***	1.095***
	(0.132)	(0.163)	(0.120)	(0.182)
Excess temperature	0.098	−0.446***	0.183	−0.668***
	(0.086)	(0.091)	(0.136)	(0.149)
Temperature*contiguity	−0.299	−0.967***	−0.317	−0.816***
	(0.204)	(0.125)	(0.335)	(0.134)
Precipitation shortage	−0.156**	0.286***	0.173	−0.049
	(0.072)	(0.077)	(0.130)	(0.070)
Precipitation*contiguity	0.559***	0.689**	−0.820***	−0.941***
	(0.175)	(0.335)	(0.266)	(0.136)
Origin FE	Yes	Yes	Yes	Yes
Destination-year FE	Yes	Yes	Yes	Yes
Number observations	22,362	113,767	22,362	113,767
Pseudo-R^2	0.374	0.977	0.394	0.970

Notes: Time period: 1960–2000. Poisson ML estimates. Estimated specification: Equation (2). C_{ij} is a dummy variable capturing whether origin and destination share a common border.
*, ** and *** denote significance at 10, 5 and 1% levels.

fostering international migration. Our results in Table 3 however show for both poor and middle-income origins, once colonial dummy interactions are included, that on average natural disasters deter migration, especially from poorer countries that are more financially constrained, but spur migration to former colonial powers. Our results on temperature confirm our results in Table 1. We find no additional effect for poor countries when we include the colony*precipitation variable, but this interaction is significant for middle-income countries, although the coefficient on this variable is smaller than the equivalent contiguity variable. In other words, negative precipitation anomalies deter longer distance migrations as when compared to migration to neighbouring countries, the costs of which are no doubt cheaper.

5.3. Robustness check: alternative data on natural disasters

The use of the EM-DAT database to capture the occurrence of natural disasters stems from its large coverage in terms of time and space. For the purpose of our analysis that emphasizes the role of climatic shocks as potential push factors in developing countries, this is an important advantage. The EM-DAT data have been nevertheless subject to different criticisms. One of the criticisms is that the EM-DAT data do not include relatively small disasters, which has led to the developments of alternative data set such as the Ifo Game data set.[13]

13 On the other hand, there might be some concerns that in the early years of the data set, the data of natural disasters from the EM-DAT data set are subject to some measurement errors. Some authors have argued in favour of selecting the natural disasters on the basis of some measures of their magnitude, either in terms of number of people affected or dead, or in terms of material

Table 3. Specific emigration patterns: colonial links. Dependent variable: bilateral migration rate

Variable	Poor countries	Middle-income	Poor countries	Middle-income
	Climatic deviations		Climatic anomalies	
Natural disasters	−0.255	−0.235**	−0.241	−0.317**
	(0.180)	(0.118)	(0.179)	(0.126)
Disasters*colony	0.533***	0.845***	0.661***	0.948***
	(0.222)	(0.208)	(0.152)	(0.155)
Excess temperature	−0.012	−0.467***	0.001	−0.691***
	(0.106)	(0.084)	(0.122)	(0.135)
Temperature*colony	−0.363**	−0.592***	−0.221	−0.534***
	(0.183)	(0.115)	(0.191)	(0.128)
Precipitation shortage	0.005	0.303***	0.074	−0.062
	(0.089)	(0.075)	(0.107)	(0.070)
Precipitation*colony	0.318	0.060	−0.347	−0.471***
	(0.243)	(0.292)	(0.213)	(0.143)
Origin FE	Yes	Yes	Yes	Yes
Destination–year FE	Yes	Yes	Yes	Yes
Number observations	22,362	113,767	22,362	113,767
Pseudo R^2	0.205	0.981	0.202	0.974

Notes: Time period: 1960–2000. Poisson ML estimates. Estimated specification: Equation (2). C_{ij} is a dummy variable capturing whether origin and destination shared a colonial link after 1945.
*, ** and *** denote significance at 10, 5 and 1% levels.

To address this concern, we conduct some robustness checks and use the data on natural disasters of the Ifo Game database (Felbermayr and Gröschl 2015). It should emphasized that the Ifo Game data also rely on the EM-DAT database but provide a less comprehensive coverage of the natural disasters. The data basically start in 1979, which means that we can use it for the impact on emigration between 1980 and 2000. The geographical coverage is significantly lower, too. While the EM-DAT data provide measures of the natural disasters for 217 countries, the Ifo Game captures natural disasters only for 92 countries in the 80s and 105 countries in the 90s.[14]

For the sake of assessing the robustness of our results, we re-estimate Equation (2) using two different measures of natural disasters. The first one involves the total number of disasters, while the second one captures only disasters that are considered as large.[15] Table 4 provides the results using the anomalies for the measures of the long-run shocks in terms of temperature and rainfall (the results using deviations instead of anomalies yield the same conclusion and are available upon request).

damages. Unfortunately, such information in terms of magnitude is reliable after 1990, which would limit the scope of our investigation.

14 Still, looking at the correlation between the EM-DAT data and the Ifo Game data for the overlapping sample, we find that our measure of natural disasters is highly correlated with the measures of the Ifo Game. The correlation with the total disasters amounts to 0.78, while the one with the large disasters is equal to 0.69.

15 Disasters are considered large if they killed more than 1000 people or affected more than 100,000 people or caused damages over USD 1 billion.

Table 4. Robustness check: natural disasters based on Ifo Game data

Variables	Unconditional				Contiguity				Colonial links			
	Poor		Middle-income		Poor		Middle-income		Poor		Middle-income	
All natural disasters	−0.024	–	0.209	–	−0.683		0.084		−0.148		0.138	
	(0.411)		(0.223)		(0.573)		(0.204)		(0.437)		(0.225)	
Large disasters	–	−0.496	–	0.042		−1.136**		−0.199		−0.711		0.050
		(0.534)		(0.288)		(0.473)		(0.298)		(0.567)		(0.285)
Disasters*condition	–	–	–	–	1.492***	2.486***	1.093***	1.812***	1.918***	2.748***	0.929***	0.736***
					(0.227)	(0.388)	(0.103)	(0.218)	(0.227)	(0.435)	(0.128)	(0.193)
Temperature anomalies	0.346	0.177	0.113	0.140	0.149	−0.702	0.339***	0.444***	0.381	0.188	0.157(0.144)	0.209
	(0.309)	(0.294)	(0.139)	(0.137)	(0.228)	(0.631)	(0.123)	(0.131)	(0.316)	(0.298)		(0.146)
Temperature*condition	–	–	–	–	−0.407	−0.291	−0.868***	−1.154***	0.816	1.297	−0.574***	−0.930***
					(0.287)	(0.256)	(0.106)	(0.135)	(0.717)	(0.817)	(0.136)	(0.162)
Precipitation anomalies	−0.406*	−0.498*	0.083	0.114	−0.633**	−0.771**	−0.000	0.003	−0.428*	−0.566*	0.105(0.127)	0.143
	(0.229)	(0.266)	(0.121)	(0.121)	(0.239)	(0.299)	(0.127)	(0.133)	(0.248)	(0.293)		(0.122)
Precipitation*condition	–	–	–	–	−0.306	0.214	0.677***	0.972***	−0.455*	−0.134	−0.036	−0.241
					(0.360)	(0.256)	(0.160)	(0.186)	(0.253)	(0.299)	(0.128)	(0.151)
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Destination–year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number observations	2853	2853	4140	4140	2853	2853	4140	4140	2853	2853	4140	4140
Pseudo-R^2	0.306	0.318	0.215	0.216	0.384	0.439	0.565	0.528	0.310	0.321	0.381	0.331

Notes: Time period: 1960–2000. Poisson ML estimates. See Tables 1–3 for further explanations.
*, ** and *** denote significance at 10, 5 and 1% levels.

Table 4 confirms our main result. First, the unconditional impact of natural disasters (left panel) is not clear-cut. While in some regressions, the occurrence of natural disasters tends to deter emigration, especially in poor countries, the result is never significantly positive. There is no evidence of a positive unconditional effect. This might be due to the reduced sample associated to the use of the Ifo Game database. More importantly, natural disasters tend to foster emigration to specific destinations, ones that are contiguous to the affected country of origin and those sharing colonial links. This impact is found to be more important for poor countries, although it also holds for middle-income countries. Importantly, the results are qualitatively similar when we use only large disasters from the Ifo Game data set as opposed to all disasters. All in all, the use of the Ifo Game data of natural disasters confirms our previous results emphasizing the heterogeneity of the effects of natural disasters on emigration.

6. Conclusion

The literature on the connection between climate change and migration has recently developed along several dimensions at both the micro and macro levels. The literature has considered different concepts and measures of climate change, emphasizing a contrast between long-run climatic factors and unexpected short-run shocks like natural disasters. There is also a gradual recognition that the impact of climate change on migration is likely to depend on the characteristics of the affected country, in particular with respect to their level of income and the importance of the agricultural sector in the economy. As emphasized in the literature, due to prevailing financial constraints, agents from poorer countries are likely to move less rather than more in response to negative climatic developments.

Adopting a macro perspective, this article reflects many of the developments in the literature. We extend the analysis of Beine and Parsons (2015) who investigate the long-run response in terms of international migration flows over periods of 10 years to the occurrence of natural disasters and long-run climatic developments such as excess temperatures and shortages of rain with respect to their long-run averages. We make an explicit distinction between poor and middle-income origin countries and examine patterns of emigration in response to climatic shocks. In particular, we examine whether agents tend to emigrate to destinations associated to lower migration costs, in particular to countries that share colonial links or a common border.

We draw several important conclusions First, our results support the idea that the impacts of climate change on international migration depend upon the level of income at origin. For example, natural disasters tend to deter emigration rather than triggering it, in poor and middle-income countries. Secondly, the patterns of emigration likely play an important role. In poor countries, natural disasters reduce emigration on aggregate while spurring emigration to specific destinations associated with low migration costs such as contiguous countries or former colonizers. Thirdly, the way climatic shock variables are formulated proves crucial for a judicious assessment of their precise effects. For instance, scaling deviations with some measure of climatic volatility is important for the evaluation of impacts such as those associated with increasing temperatures and precipitation shortages.

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