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## Climate Change and the Relocation of Population

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# Climate Change and the Relocation of Population\*

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## Abstract

Do natural disasters trigger intensified international migration? The aim of this paper is to assess the extent to which disasters initiate bilateral migration. To motivate the empirical strategy, I construct a stylized theoretical gravity model of migration that introduces disasters as random shocks. I present estimations that deploy a dataset of bilateral migration available for increments of 10 years from 1960-2010 for a large matrix of countries. Results suggest that disasters are on average positively associated with migration out of affected areas, but negatively for migration into affected countries. In addition, I show that results are primarily caused by disasters related to climate change. Migration to and from non-OECD and particularly middle income countries drive the patterns.

**Keywords:** Climate Change, Natural Disasters, International Migration, Gravity Model

**JEL-Classification:** F22, O15, Q54

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## I. Introduction

Why people migrate and have migrated in the past is no big secret. They move to improve their lives. Since recently though, globally falling transport costs lead to an unprecedented potential of migrants from developing countries (Hatton and Williamson, 2005). The impact of recent challenges, such as climate change and increasingly extreme natural disasters, on the future of mankind and the worldwide relocation of people is on these grounds one of the major potential problematic issues. In view of climate change, a pressing question to be answered is by how much do disasters trigger international migration?

According to the Intergovernmental Panel on Climate Change (IPCC), migration is an important adaptation strategy in the presence of natural disasters (see also McLeman and Smit, 2006; IPCC, 2012). However, knowledge remains limited on the factors at work involving disasters as a cause of international migration. Historically, the vast bulk of relocation of people caused by disasters has occurred within nations. In this context, previous research found an effect of disasters in particular on migration from rural to urban areas within national boundaries (Barrios et al., 2006). But lately it has become clear that global migration is again<sup>1</sup> on the rise due to the accelerating pace of globalization<sup>2</sup> but also due to intensified disaster frequency and scale.

The latest report by the IPCC (2012) and the Stern Review (Stern, 2006) particularly accentuate that climate change and associated disasters have become serious issues that are global in their consequences. As disasters occur more frequently and with greater magnitude, it will become increasingly impossible to sustain livelihoods in some regions (IPCC, 2012). As a consequence, people may migrate internationally (Tacoli, 2009; Barnett and Webber, 2010). Similarly,

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<sup>1</sup>Hatton and Williamson (2005) note that a first wave of voluntary mass migration took place in the 19th century and the beginning of the 20th century, while a second shift took place after World War II in the 20th century.

<sup>2</sup>The expansion of migration may be attributed to reductions in migration frictions, such as migration costs, migration policies or regional and global integration, which led to lower barriers to migration.

if by the end of this century extreme droughts double as estimated by Arnell (2004), more and more people will try to permanently relocate from already dry and poor areas, such as Sub-Saharan Africa, to fertile and rich regions, such as Europe. But industrialized countries get increasingly tough on migrants with even stricter immigration policies (Boeri and Brücker, 2005).

The fact that people may relocate permanently due to increasingly extreme disasters caused by a warming of the atmosphere<sup>3</sup> takes on particularly problematic features as poorer and developing countries will suffer the most, which already struggle to cope with disasters. As weather extremes turn more intense and frequent<sup>4</sup> a strategy is needed to globally manage migration and identify ways how to better deal with natural disasters.

The aim of this paper is to assess the extent to which natural disasters affect bilateral migration from a macro perspective. It relates to the literature on the determinants of migration<sup>5</sup>, to the more general empirical literature on bilateral migration<sup>6</sup>, and to the more specific subcategory on the relation between migration and natural disasters or climate change. Theoretical work on the role of disasters for migration is scarce. A theoretical study by Marchiori and Schumacher (2011) uses an overlapping generations model for two countries with endogenous climate change. Two of their key findings state that climate change increases migration and that even small changes in climate have significant effects on the number of migrants. Empirical research includes work by Naudé (2010) and Drabo and Mbaye (2011), who investigate the relation between disasters and international migration from Sub-Saharan Africa or developing countries, respectively. They find that disasters cause outmigration.

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<sup>3</sup>Researchers estimate a 2 to 3°C increase in temperature in the next 50 years, which leads to heavier or far less precipitation but also to more heat waves, while increasingly warm sea water leads to a rise in the sea level and stronger storms.

<sup>4</sup>Bailey and Wren-Lewis (2009) note that weather-related disasters doubled since the 1980s and Stern (2006) reports a three-fold increase since the 1960s.

<sup>5</sup>Important contributions have been made by Sjaastad (1962); Borjas (1987, 1989); Mincer (1978); Stark (1991).

<sup>6</sup>Studies include Lewer and Van den Berg (2008); Pedersen et al. (2008); Letouzé et al. (2009); Ortega and Peri (2009); Mayda (2010), to name only a few.

Using a gravity framework, Reuveny and Moore (2009) and Coniglio and Pesce (2011) analyze the role of source country climate anomalies on international migration to OECD countries. Their gravity results suggest that an increase in weather-related disasters in the source country increases migration. In a similar manner, Beine and Parsons (2012) examine the impact of climate-related variables and natural disasters in the source country on migration. Using a comprehensive dataset of migration for 1960 to 2000, they find no direct effect of climate anomalies or disasters striking the origin on bilateral migration.

A shortcoming of preceding studies is that they deploy only one-directional disasters or climate anomalies in the source country. They disregard the possibility that disasters in the destination may affect migration as well.<sup>7</sup> Following these considerations, Alexeev et al. (2011) estimate the impact of weather-related disasters in the origin and the destination on migration from 1986 to 2006. The authors find that an increase in weather-related events in the origin lead to higher outmigration and that an increase in disasters in the destination also trigger migration.<sup>8</sup> Hence, a range of promising approaches to identify the link between disasters or climate change and international migration exists. But, the underlying data used in seeking answers often has its drawbacks<sup>9</sup>, which makes it difficult to generalize results and policy implications.<sup>10</sup> This paper enhances and improves on previous approaches in three ways.

First, while previous gravity equations used in empirical applications of bi-

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<sup>7</sup>Beine and Parsons (2012), for instance, cannot control for climate anomalies in the destination as they include combined destination country and time fixed effects to control for multilateral resistance of the destination country.

<sup>8</sup>Note that their sample excludes South – South migration and that they use OECD outflows as inflows from OECD into non-OECD destinations. This might contain a large measurement error and bias their result. Even more crucial, they do not control for multilateral resistance.

<sup>9</sup>Empirical economists face a lack of observational data and definitional issues for migration and for disaster data. Historical climatic data are widely available but associated variables, such as soil moisture or maximum sustained wind speed, are poorly monitored or not observed with sufficient spacial resolution or temporal contiguity. Still, whether an extreme event results in a disaster is rather complex in nature and depends not only on the magnitude of the physical event but also on the degree of exposure and vulnerability to the anomaly.

<sup>10</sup>According to the Global Migrant Origin Database, migration to non-OECD countries accounts for 51% of international migration. Piguet et al. (2011) note that disasters are unlikely to affect migration in rich and politically stable economies.

lateral migration are known for their strong fit to the data, the estimated equations typically do not have a theoretical foundation. I motivate the empirical estimation by providing a stylized theoretical framework. I base the gravity model of migration on derivations by Anderson (2011) and extend it by introducing natural disasters as a further determinant that affects population movements. The migration gravity model depicts that bilateral migration depends on population stocks, on implicit migration frictions and on disaster events in the source and the destination country. Second, I empirically investigate the relation deploying a comprehensive dataset of a full matrix of countries of bilateral migration available in increments of 10 years from 1960 to 2010. I add to the literature by allowing disasters in the origin *and* the destination country to vary in impact and at the same time controlling for multilateral resistance (MR). Using explicit MR terms directly in the migration framework distinguishes this paper from previous approaches. It allows to control for disasters in the origin and in the destination country and for time-varying country characteristics, such as migration policies. MR terms are adapted to the setup from the derivations of Baier and Bergstrand (2009) using a Taylor series expansion. The results suggest that aggregated natural disasters are on average positively associated with migration out of affected areas, but negatively for migration into affected areas. By decomposing natural disasters into sub-categories, I show that diverse types of disasters have different implications on migration dynamics. Results suggest that the migration pattern stems particularly from hydrological and meteorological disasters. Third, I quantify migration flows asking what would happen to the size of population movements should global warming continue and weather-related disasters increase two- to three-fold.

The remainder of the paper is structured as follows. Section II. provides a simple theoretical gravity model of migration. Section III. provides details on the empirical strategy and the data. Section IV. describes aggregated results, findings on various types of disasters and a sensitivity analysis. Section V. quantifies results. The last section concludes.

## II. A Stylized Theoretical Framework

To provide a simple theoretical motivation for estimating bilateral migration in a gravity framework, I follow Anderson (2011). Consider a multi-country framework where  $i, j = 1, \dots, C$  denote countries, and  $h = 1, \dots, H$  denotes individuals. The migration decision is featured by the choice over a discrete number of alternative locations on a global scale. Each individual  $h$  has an idiosyncratic component of utility from migrating  $\xi_{ijh}$ , which is unobservable and independently distributed across individuals with an iid type-1 extreme value distribution. In addition, individuals face costs of migration, which are the same for all workers that migrate in a particular migration corridor,  $\kappa_{ij} = \kappa_{ji}$ . Migration costs constitute an iceberg cost factor  $\kappa_{ij} \geq 1$  and  $\kappa_{ii} = 1$ . Suppose  $w_j$  denotes the wage at location  $j$  and let  $w_{ij} = w_j / \kappa_{ij}$  be the net wage of a migrant from  $i$  in  $j$ . Individual  $h$  migrates if the utility for migrating to some destination  $j$  is larger than from staying at home,  $(w_j / \kappa_{ij}) \xi_{ijh} \geq w_i$ .

When a natural disaster strikes it damages and destroys both physical and human capital. By affecting host and/or origin communities, disasters reduce the productivity of labor and influence population movement, respectively. I thus formally introduce natural disasters as random shocks to the origin,  $D_i$ , and the destination,  $D_j$ , where  $D \in [0, 1]$ . The occurrence of disasters and the damage caused are assumed to be idiosyncratic across locations. Disasters may have two effects. First, they act as a direct shock to the aggregated population. The disaster-affected population in  $i$  and  $j$  is then given as  $D_i N_i$  and  $D_j N_j$ . Second, disasters also have a transitive effect on utility through wages as disasters suddenly shift demand and/or supply structures.

To evaluate migration, let us specify expected utility as a logarithmic CES function.<sup>11</sup> Given this, utility from migrating is log-linear in disaster-affected

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<sup>11</sup>Compare Feenstra, 2004, Appendix B, Example 3, where wage (the price of labor) is substituted for product prices.

wages relative to the costs of moving, such that

$$u_{ij} = (1 - \sigma) \ln w_j + (1 - \sigma) \ln D_j - (1 - \sigma) \ln \kappa_{ij} + \ln \xi_{ijh}, \quad (1)$$

where  $\sigma$  is the elasticity of substitution. Note that individual decisions can be aggregated up to a representative individual (McFadden, 1974), as migrants are assumed to be homogeneous except for the random term  $\ln \xi_{ijh}$  that is iid extreme value distributed. To retrieve a tractable gravity equation, I assume that the aggregated level of the discrete choice probability is equal to migration flows from source  $i$  to destination  $j$ . Aggregate bilateral migration is then given as

$$M_{ij} = P(u_{ij}) D_i N_i, \quad (2)$$

where the disaster-affected population in the source country takes a decision on migration and the probability  $P(u_{ij})$ <sup>12</sup> is given by

$$P(u_{ij}) = P(u_{ij} = \max_k u_{ik}) = \frac{e^{u_{ij}}}{\sum_k e^{u_{ik}}} \quad \text{for } ik \neq ij. \quad (3)$$

With logarithmic utility, the structure of the migration equation corresponds to the CES demand shares that support the trade gravity specification,<sup>13</sup>

$$M_{ij} = \frac{(w_j D_j / \kappa_{ij})^{\sigma-1}}{\sum_k (w_k D_k / \kappa_{ik})^{\sigma-1}} D_i N_i. \quad (4)$$

To derive a gravity equation, define  $\Gamma_i \equiv \sum_k (w_k D_k / \kappa_{ik})^{\sigma-1}$  and specify the aggregated labor market clearing condition as  $D_j N_j \equiv \sum_i M_{ij}$ . The clearing condition is then  $D_j N_j = w_j^{\sigma-1} D_j^{\sigma-1} \sum_i (\kappa_{ij}^{1-\sigma} / \Gamma_i) D_i N_i$ . In equilibrium, wages are

$$w_j^{\sigma-1} = \frac{N_j}{\Gamma_j N} \frac{D_j}{D_j^{\sigma-1}} \quad (5)$$

<sup>12</sup>For examples of bilateral migration discrete choice models that build on a multinomial logit function, see Beine et al. (2011), Grogger and Hanson (2011), Gibson and McKenzie (2011) or Beine and Parsons (2012).

<sup>13</sup>See Feenstra (2004) Appendix B for derivations of demand systems for discrete choice models.



with total world population  $N \equiv \sum_i N_i \equiv \sum_j N_j$  and  $\Gamma_j = \sum_i \frac{\kappa_{ij}^{1-\sigma} D_i N_i}{\Gamma_i}$ . Substituting for the equilibrium wage in equation (4) using equation (5) yields the tractable gravity specification of migration

$$M_{ij} = \frac{N_i N_j}{N} \left( \frac{\kappa_{ij}}{\tilde{\Gamma}_i \tilde{\Gamma}_j} \right)^{1-\sigma} D_i D_j, \quad (6)$$

with the outward migration friction price index of  $\tilde{\Gamma}_i^{1-\sigma} = \left[ \sum_j \frac{N_j D_j}{N} \left( \frac{\kappa_{ij}}{\tilde{\Gamma}_j} \right)^{1-\sigma} \right]$  and the inward migration friction price index of  $\tilde{\Gamma}_j^{1-\sigma} = \left[ \sum_i \frac{N_i D_i}{N} \left( \frac{\kappa_{ij}}{\tilde{\Gamma}_i} \right)^{1-\sigma} \right]$ . The first term denotes bilateral migration in a world without frictions, where migrants are found in equal shares relative to the population in all destinations. The second term denotes the impact of frictions in a world that entails costs to migration. The larger bilateral migration costs  $\kappa_{ij}$ , the lower are migration flows. Albeit, in a world in which migrants choose from a set of alternative destinations, migration also depends on multilateral resistance, which captures world-wide bilateral migration costs. The third term indicates that random shocks in the origin and in the destination country affect migration. As in the traditional gravity model, price indexes are computable once migration frictions  $\kappa_{ij}$  are constructed econometrically.<sup>14</sup>

### III. Empirical Strategy and Data

#### A. Empirical Strategy

To test that natural disasters exert a significant effect on bilateral migration patterns, this section outlines a fully fledged gravity model on a panel of bilateral migration, where equation (6) provides the starting point. In the following, I ask two things: (i) how does the number of disasters in the origin ( $D_{i,t}$ ) and

<sup>14</sup>To model unobservable migration frictions, I follow the literature and use a function of observables  $\kappa_{ij} = b_{ij} d_{ij}^p$ , where  $b_{ij}$  is a border dummy and  $d_{ij}^p$  is the bilateral distance between origin and destination.

the number of disasters in the destination ( $D_{j,t}$ ) affect bilateral migration flows ( $M_{ij,t}$ ); (ii) and, do various kinds of disasters related to geophysical, climatological, meteorological, or hydrological events affect bilateral migration differently? I embed the questions in an augmented log-linear specification of the gravity equation<sup>15</sup>

$$\begin{aligned} \ln M_{ij,t} = & \alpha_1 \ln(N_{i,t}N_{j,t}) + \alpha_2 D_{i,t} + \alpha_3 D_{j,t} + \alpha_4 \mathbf{X}_{ij,t} + \alpha_5 MR_{ij,t} \quad (7) \\ & + \nu_{ij} + \nu_t + \varepsilon_{ij,t}, \end{aligned}$$

where  $N_{i,t}N_{j,t}$  is the product of the total population of  $i$  and  $j$ ,  $D_{i,t}$  ( $D_{j,t}$ ) is the total number of natural disaster events in the origin (destination) in a given decade, and the vector  $\mathbf{X}_{ij,t} = [\ln(y_{j,t}/y_{i,t}); \ln(\text{POP Density}_{i,t} \times \text{POP Density}_{j,t}); \text{Polity}_{i,t}; \text{Polity}_{j,t}; \text{Civil War}_{i,t}; \text{Civil War}_{j,t}; \ln(\text{Migration Stock}_{ij,t-1} + 1)]$ . The variable  $y_{j,t}/y_{i,t}$  is the ratio of destination to origin per capita GDP and proxies wage differences. The vector also contains the product of population densities, Polity indexes, and count variables of civil wars that took place in the source or the destination country within the last 10 years of observation, respectively. To control for network effects, I include the migration stock that corresponds to the previous period.<sup>16</sup>  $\nu_t$  collects year dummies and controls for shocks common to all countries. I control for country-pair specific heterogeneity by including a complete collection of country-pair dummies,  $\nu_{ij}$ , that account for all time-invariant bilateral determinants of trade, such as distance, adjacency, or historical ties. The country-pair effects nest country dummies specific to each origin or destination country, respectively, and capture time-invariant country characteristics, initial migration stocks and the time-invariant component of multilateral remoteness. However, over a long period of time, multilateral resis-

<sup>15</sup>The augmented model includes controls which have been proven important in the empirical migration gravity literature, pair fixed effects and explicit multilateral resistance terms, which capture all bilateral migration frictions.

<sup>16</sup>The literature on networks identifies migrant networks to promote bilateral migration flows, trade and capital flows (Rauch and Trindade, 2002; Munshi, 2003; Kugler and Rapoport, 2007; Docquier and Lodigiani, 2010). In particular, Beine et al. (2011) find that migrant networks significantly increase migration flows to OECD countries.

tance (MR) does change. I approximate MR terms ( $MR_{ij,t}$ ) based on distance ( $MRDIST_{ij,t}$ ) and adjacency ( $MRADJ_{ij,t}$ ) following an approach by Baier and Bergstrand (2009). I derive MR indexes from a Taylor series expansion of the gravity equation.<sup>17</sup> This innovative econometric approach makes possible to control for the direct effects of disasters in the source and the destination country and to control at the same time for time-varying country characteristics, such as migration policies, which are absorbed in the MR terms, in a migration framework.  $\varepsilon_{ij}$  is an additive error term. The variance-covariance matrix is estimated using a heteroskedasticity-robust estimator that allows for clusters at the country-pair level.

Regarding the impact of disasters on migration, the presumption is that  $\alpha_2$  has a positive sign, such that disasters in the origin induce migration out of affected countries (i.e., due to higher utility elsewhere), while I expect  $\alpha_3$  to have a positive or a negative sign, indicating that disasters in a potential destination increase migration (i.e., due to increased demand for labor) or reduce migration (i.e., due to lower utility from migrating there).

## B. Data Sources

Migration data combine two datasets. The Global Migrant Origin Database (Version 4, 2007) provided by the World Bank reports bilateral migration stocks in a 10-year interval matrix for 1960-2000 for 226 countries based primarily on the foreign-born concept. The dataset combines census and population register records to construct decennial matrices corresponding to the last five completed census rounds. Data for 2010 are also provided by the World Bank. The dataset updates data by Ratha and Shaw (2007) by incorporating the latest migration data as described in the Migration and Remittances Factbook 2011. The

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<sup>17</sup>MR terms are calculated as  

$$MRDIST_{ij,t} = \left[ \left( \sum_{k=1}^C \theta_{k,t} \ln \text{Dist}_{ik} \right) + \left( \sum_{m=1}^C \theta_{m,t} \ln \text{Dist}_{mj} \right) - \left( \sum_{k=1}^C \sum_{m=1}^C \theta_{k,t} \theta_{m,t} \ln \text{Dist}_{km} \right) \right],$$

$$MRADJ_{ij,t} = \left[ \left( \sum_{k=1}^C \theta_{k,t} \text{Adj}_{ik} \right) + \left( \sum_{m=1}^C \theta_{m,t} \text{Adj}_{mj} \right) - \left( \sum_{k=1}^C \sum_{m=1}^C \theta_{k,t} \theta_{m,t} \text{Adj}_{km} \right) \right].$$
 $\theta$  denotes a states' share of population over 'total' world population,  $N_{k,t}/N$  and  $N_{m,t}/N$ .

2010 dataset uses the foreign-born concept and similar sources and methods as the 1960-2000 data. The migration datasets exclude refugees, so that the data capture long-term migration only. To test the model, I proxy migration flows by taking the difference between the reported migration stocks of contiguous data, similarly to Beine and Parsons (2012). In some cases migration stocks shrink over the observed time period due to several reasons, i.e. return migration, migration to a third country or death. This leads to negative values. As no information on these cases exist, I first take only non-negative migration flows as the dependent variable. In a robustness check, I assume that negative values constitute return migration and recalculate migration flows by summing the absolute value of the negative flow from destination to origin and initial positive migration flows from the origin and the destination.

Data on total population, population density, nominal GDP in US dollars and GDP per capita come from the World Bank's World Development Indicators (WDI). The Polity Index stems from the Polity IV Project (2010) and is rescaled from 0 to 20, with 0 being the most autocratic state and 20 being the most democratic state. Information on civil wars are taken from the Correlates of War Project, in particular from the Intra-State War Data (v4.1). I work with the total number of civil wars within the last 10 years of the reported migration observation. Geographic linkages — land area, distance, and common border — are taken from CEPII's Geographic and Bilateral Distance Database (2005).

Disaster data stem from the Emergency Events Database (EM-DAT) maintained by the Center for Research on the Epidemiology of Disasters (CRED). It should be clear from the outset that there exist doubts on the accuracy of data on natural disasters, mainly because often the main source of the data are national governments, which have an incentive in inflating the measured effects. But, using data from a single source should provide information on the relative size of disasters as biases should be systemic. The data should therefore be appropriate for the hypothesis I examine here. Further, estimated coefficients are biased downward if observed disaster effects are actually biased upward.

My approach is two-fold: the first defines large-scale disasters as events that (i) caused 1,000 or more injured or dead; (ii) affected 100,000 or more persons; or (iii) caused a monetary damage of 1 billion or more US dollars. To make damages comparable over time, I convert dollar values into constant 2000 US dollar values using the US GDP deflator from WDI. For robustness reasons, I use a lower threshold (large and medium-sized disasters) defined as (i) 500 or more dead or injured, or (ii) 50,000 or more persons affected; or (iii) a monetary damage of 500 million US dollars or more. Both classifications follow the convention of MunichRe (2006).

As migration stocks are reported in increments of 10 years and corresponding flows capture migration over 10 year intervals, I work with the number of disasters summed up over a given interval. The decadal dataset covers a total of 3,543 large natural disasters between 1960 and 2010. To be able to observe the particular impact of specific types of disasters, I distinguish disasters into sub-groups. Geophysical disasters group earthquakes, tsunamis, volcanic eruptions and landslides. Extreme temperature events, droughts and wildfires are classified as climatological events. Hydrological disasters cover floods and meteorological events group storms of any kind.<sup>18</sup> In total, I observe 239 geophysical and 3,304 climate-related disasters that are large in scale. Thereof, 525 are climatological, 1,529 are meteorological and 1,250 are hydrological events. The sample consists of 160 origin and 157 destination countries.<sup>19</sup> Table 7 in the Appendix reports summary statistics.

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<sup>18</sup>A last category not considered in the estimations are biological disasters, such as epidemics and insect infestations, which are assumed to have a minor impact on bilateral migration and are thus disregarded in the paper.

<sup>19</sup>The sample is unbalanced as controls or migration data are missing for some countries.

## IV. Natural Disasters and International Migration

### A. Benchmark Results

This section presents results on the impact of large-scale aggregated disaster variables on migration patterns, as well as of disaggregated disaster type variables. The presumption is that disasters related to climate change (i.e., extreme temperature events, droughts, wildfires, floods, and storms) play a substantial role with respect to their impact on international migration, while the effect of geophysical disasters (i.e., earthquakes, volcanic eruptions, tsunamis, and landslides) is less sound. This can be motivated by the nature of these events. While geophysical disasters are known to occur repeatedly in specific regions due to the geological character of the earth, their frequency of occurrence is rather stable over time. Yet, people might deliberately choose to live in these regions due to the particular richness of soil and willingly take their chances. They might even adapt to geophysical disasters in regions that are known to be susceptible to geophysical events, or migrate within the boundary of nations rather than to migrate internationally. In contrast, disasters related to climate change occur with a higher frequency and magnitude in recent decades and also strike regions that are not traditionally affected by catastrophic events. As disasters related to climate change often strike more randomly, people might be more prepared to move internationally if disastrous weather events destroy their livelihoods. While these considerations may also apply to disasters hitting potential destination countries, one could also think of a different scenario where disastrous events increase the demand for labor to promote reconstruction. This may lead to positive (or non-negative) international migration movements toward destination regions hit by a disaster.

Table 1 reports benchmark results for aggregated disasters and for different types of disasters in the origin and the destination country. All regressions include country-pair fixed effects, year dummies and MR measures. Further, all regressions include several controls derived from the migration literature. Col-

**TABLE 1**  
Migration and Large Natural Disasters, 1960-2010

Dependent Variable: ln bilateral migration flows from $i$ in $j$						
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $^i_t, D_t^i$	0.001*** (0.00)					
Disaster $^j_t, D_t^j$	-0.001** (0.00)					
Geophysical Disaster $^i_t$		0.013** (0.01)				-0.002 (0.01)
Geophysical Disaster $^j_t$		0.024*** (0.00)				0.058*** (0.01)
Climatic Disaster $^i_t$			0.006 (0.01)			-0.007 (0.01)
Climatic Disaster $^j_t$			0.009* (0.00)			0.006 (0.01)
Meteorological Disaster $^i_t$				0.003** (0.00)		0.002* (0.00)
Meteorological Disaster $^j_t$				-0.002** (0.00)		-0.004*** (0.00)
Hydrological Disaster $^i_t$					0.002*** (0.00)	0.002*** (0.00)
Hydrological Disaster $^j_t$					-0.009*** (0.00)	-0.015*** (0.00)
<b>Controls</b>						
ln ( $y_t^j / y_t^i$ )	0.263*** (0.02)	0.255*** (0.02)	0.254*** (0.02)	0.260*** (0.02)	0.263*** (0.02)	0.257*** (0.02)
ln ( $POP_t^i \times POP_t^j$ )	-5.090*** (0.86)	-5.115*** (0.86)	-5.086*** (0.86)	-5.093*** (0.86)	-5.101*** (0.86)	-5.000*** (0.86)
ln ( $POP\ Density_t^i \times POP\ Density_t^j$ )	4.877*** (0.86)	4.898*** (0.86)	4.888*** (0.86)	4.880*** (0.86)	4.883*** (0.86)	4.764*** (0.86)
Polity Index $^i_t$	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)
Polity Index $^j_t$	-0.004 (0.00)	-0.004 (0.00)	-0.004 (0.00)	-0.004 (0.00)	-0.003 (0.00)	-0.003 (0.00)
Civil War $^i_t$	0.000 (0.00)	-0.001 (0.00)	-0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.001 (0.00)
Civil War $^j_t$	-0.009 (0.01)	-0.009 (0.01)	-0.008 (0.01)	-0.009* (0.01)	-0.007 (0.01)	-0.009* (0.01)
ln Migration Stock $^{ij}_{t-1}$	0.088*** (0.01)	0.088*** (0.01)	0.088*** (0.01)	0.088*** (0.01)	0.086*** (0.01)	0.087*** (0.01)
$R^2$ within	0.235	0.235	0.235	0.235	0.236	0.239
Observations	35,479	35,479	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

umn (1) reports results on the total number of disasters within a 10-year time span. Column (2) depicts results on geophysical disaster events, column (3) on climatic disasters, column (4) on meteorological disasters, column (5) on hydrological disasters, and column (6) reports findings on the five types of disasters simultaneously.

In line with Lewer and Van den Berg (2008), the ratio of the two countries' GDP per capita levels, a proxy for relative wage differences, increases bilateral migration. Contrasting their cross-sectional results, migrants move less to countries more similar with respect to their population size. Countries more similar with respect to population density experience higher migration flows than those more different in population density. The political structure of the source and the destination country signals no direct effect on international migration. Civil wars in the origin have no significant impact on outmigration, while one more year of militarized conflict in a destination country reduces bilateral migration towards this country by about 1%. Network effects, captured by the inclusion of the lagged bilateral migration stock, signal a positive and significant effect. This is in line with expectations and in accordance to research on migration networks (Docquier and Lodigiani, 2010; Beine et al., 2011). In particular, Table 1 reports that migration networks explain 9% of the variability of migration flows, controlling for country pair and time fixed effects. Coefficients on controls remain in line across different specifications.

Table 1 column (1) depicts that disasters in the source country have a significant and positive impact on bilateral migration flows out of the region, while disasters in the destination reduce migration flows toward this country. I find that an additional natural disaster event in the origin increases outmigration by 0.1% ( $\exp(0.001) - 1 \approx 0.001$ ), while an additional event in the destination reduces bilateral migration by 0.1% ( $\exp(-0.001) - 1 \approx -0.001$ ). Results on disasters in the origin country are in line with expectations and with the literature (Drabo and Mbaye, 2011; Coniglio and Pesce, 2011; Reuveny and Moore, 2009). The results confirm the presumption that the decision to migrate is also



affected by disasters occurring in potential destination countries.

Column (2) reports that one additional geophysical event that hits the source country pushes outmigration by 1.3%, while geophysical disasters in the destination increase bilateral migration, possibly due to increased labor demand as reconstruction is labor intensive. Column (3) depicts that climatic disasters in the origin have no impact on international migration. Climatic disasters in the destination have a slightly significant positive effect, which vanishes in column (6) when the overall effect is taken into account. Meteorological events push migrants out of affected areas and attract less migrants if they occur in a destination country, as shown in column (4). The same is true for hydrological disasters. Column (5) depicts that if one more hydrological disaster hits the source country, outmigration increases by 0.2%. An additional hydrological disaster in the destination decreases bilateral migration flows by about one percent. Column (6) looks at the impact of the different disaster types simultaneously. Findings suggest that geophysical disasters in the destination increase bilateral migration, while meteorological (storms) and hydrological (flooding) disasters spur outmigration in the source country and reduce migration toward the destination.

The results are broadly in line with findings on origin country effects in the literature. Reuveny and Moore (2009) and Alexeev et al. (2011) find a positive impact of weather-related disasters in the origin on outmigration, and Drabo and Mbaye (2011) find that climatological, meteorological and hydrological disasters increase outmigration. Similarly, Coniglio and Pesce (2011) find that temperature and precipitation anomalies, which are highly related to climate-related events, increase migration.

### *B. Conditional Results*

Earlier research has shown that the effect of a disaster is crucially conditioned on the size of a country. Naturally, countries large in surface area leave more room to move within their boundaries if hit by a natural disaster. And, in large

countries, usually a smaller fraction of the country is affected by a disaster, whereas disasters often destroy large parts in small countries and thus more often force parts of the population to move internationally. For this reason, the presumption is that country size plays a crucial role for the effect of natural disasters on international migration. I thus condition the disaster frequency variable on the source and destination country's surface area, respectively. I expect that if a disaster strikes a source country which is large in size, the migration enhancing impact of the disaster is less strong. While, if the destination country is large in terms of its geographical size and hit by a disaster, the impact of a natural disaster on bilateral migration toward the country is less negative.

Results are reported in Table 2. Again, column (1) reports results for the aggregated disaster variable. As expected, natural disasters in the source country increase outmigration, while disaster events in the destination reduce bilateral migration flows. The larger the source country if hit by a disaster the less international migration takes place, while the larger the destination that is hit by a disaster, the less strong the migration preventing mechanism of the disaster. Evaluated at the mean surface area, one more disaster in the source country triggers 0.3% more outmigration, while one more disaster in a medium-sized destination country leads to 0.2% less migration. Column (2) indicates that geophysical disasters have a significant and positive impact on international migration, but less so in larger countries. In a similar manner, climatic disasters in the source and destination signal more migration in column (3). A medium-sized source country that is affected by one more climatic disaster experiences an increase in migration of 1.6%. An additional meteorological disaster in the origin leads to increased international migration of about 1% as shown in column (4). An additional severe storm in a medium-sized destination reduces migration by 0.5%. The pattern is again strongest for hydrological disaster events, where an additional disaster in a medium-sized source country leads to 1% more outmigration and in a medium-sized destination leads to 2.7% less bilateral migration (compare column (5)). Patterns remain qualita-

**TABLE 2**  
Migration and Large Natural Disasters, 1960-2010 (conditional)

Dependent Variable: ln bilateral migration flows from $i$ in $j$	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $^i_t$ , $D_t^i$	0.028*** (0.01)					
Disaster $^j_t$ , $D_t^j$	-0.014*** (0.01)					
Geophysical Disaster $^i_t$		0.184* (0.10)				-0.003 (0.10)
Geophysical Disaster $^j_t$		0.608*** (0.11)				0.721*** (0.11)
Climatic Disaster $^i_t$			0.078* (0.05)			0.141*** (0.05)
Climatic Disaster $^j_t$			0.222*** (0.04)			0.192*** (0.04)
Meteorological Disaster $^i_t$				0.022** (0.01)		0.035*** (0.01)
Meteorological Disaster $^j_t$				-0.017*** (0.01)		-0.010 (0.01)
Hydrological Disaster $^i_t$					0.060*** (0.02)	0.054*** (0.02)
Hydrological Disaster $^j_t$					-0.089*** (0.01)	-0.057*** (0.02)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.002*** (0.00)					
$D_t^j \times \ln \text{Area}_t^j$	0.001** (0.00)					
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		-0.011* (0.01)				0.002 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.037*** (0.01)				-0.043*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic			-0.005 (0.00)			-0.009*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic			-0.014*** (0.00)			-0.013*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological				-0.001** (0.00)		-0.002*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological				0.001** (0.00)		0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological					-0.004*** (0.00)	-0.003*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological					0.005*** (0.00)	0.003** (0.00)
<b>Controls</b>						
$\ln(y_t^j/y_t^i)$	0.259*** (0.02)	0.255*** (0.02)	0.251*** (0.02)	0.255*** (0.02)	0.260*** (0.02)	0.252*** (0.02)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	-5.120*** (0.86)	-4.907*** (0.85)	-5.021*** (0.86)	-5.115*** (0.86)	-5.095*** (0.86)	-4.704*** (0.84)
$\ln(\text{POP Density}_t^i \times \text{POP Density}_t^j)$	4.925*** (0.86)	4.697*** (0.85)	4.854*** (0.86)	4.904*** (0.86)	4.917*** (0.86)	4.538*** (0.84)
Polity Index $^i_t$	-0.003 (0.00)	-0.002 (0.00)	-0.002 (0.00)	-0.003 (0.00)	-0.002 (0.00)	-0.003 (0.00)
Polity Index $^j_t$	-0.003 (0.00)	-0.004 (0.00)	-0.004 (0.00)	-0.003 (0.00)	-0.002 (0.00)	-0.002 (0.00)
Civil War $^i_t$	0.003 (0.00)	-0.001 (0.00)	-0.000 (0.00)	0.002 (0.00)	0.001 (0.00)	0.002 (0.00)
Civil War $^j_t$	-0.010* (0.01)	-0.008 (0.01)	-0.007 (0.01)	-0.010* (0.01)	-0.007 (0.01)	-0.008 (0.01)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.086*** (0.01)	0.089*** (0.01)	0.090*** (0.01)	0.088*** (0.01)	0.084*** (0.01)	0.087*** (0.01)
$R^2$ within	0.237	0.237	0.236	0.236	0.237	0.243
Observations	35,479	35,479	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

tively similar if the different types of disasters are controlled for simultaneously in column (6). Geophysical and climatic disasters in the destination increase migration, climatic and meteorological disasters in the source country promote migration, and hydrological disasters push migration in the origin and limit migration to disaster struck destinations.

### *C. Heterogeneity across Country Groups*

According to Piguet et al. (2011) it is rather unlikely that disasters affect migration in rich and politically stable economies. To take a closer look, I first split the sample into OECD and non-OECD economies. Second, I distinguish rich, middle, and poor countries.

Table 3 Panel A reports the results when splitting the sample into OECD and non-OECD economies. As one might have presumed, previous findings are predominantly driven by non-OECD countries (compare columns (A1), (A3) and (A5)). While estimates on non-OECD countries mirror previous findings, results for OECD countries are mainly insignificant. Solely in columns (A4), (A6) and (A8), coefficients suggest that more international migration takes place if the destination is an OECD economy, despite the fact that it is hit by a disaster. To conclude from this, natural disasters affect international migration mainly to and from non-OECD economies, while migration from OECD countries is not affected at all and migrants toward OECD economies pay no attention to disasters happening there. They might even be attracted to OECD economies for labor intensive reconstruction purposes. Full results for Panel A are reported in Table 8, Appendix.

In a next step, I distinguish rich, middle, and poor countries in Panel B. To determine the sets of low, middle and high income countries, I follow the World Bank classification. As suspected, the population in low income source countries does, on average, not have the resources that allow them to migrate internationally when faced with a crisis.<sup>20</sup> For this reason, estimates capture no

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<sup>20</sup>Resources include financial resources but also access to networks that facilitate relocation.

**TABLE 3**  
Summary: Development Status, 1960-2010 (conditional)

Dependent Variable: ln bilateral migration flows from  $i$  to  $j$

PANEL A: OECD versus non-OECD									
Origin	non-OECD	OECD	all	all	non-OECD	non-OECD	OECD	OECD	
Destination	all	all	non-OECD	OECD	non-OECD	OECD	non-OECD	OECD	
	(A1)	(A2)	(A3)	(A4)	(A5)	(A6)	(A7)	(A8)	
Disaster $_i^i$ , $D_i^i$	0.032*** (0.01)	0.008 (0.05)	0.033*** (0.01)	0.010 (0.01)	0.036*** (0.01)	0.013 (0.01)	0.013 (0.07)	0.052 (0.08)	
Disaster $_i^j$ , $D_i^j$	-0.012** (0.01)	-0.013 (0.01)	-0.022*** (0.01)	0.411*** (0.04)	-0.024*** (0.01)	0.390*** (0.04)	-0.025** (0.01)	0.414*** (0.08)	
<b>Interactions</b>									
$D_i^i \times \ln \text{Area}_i^i$	-0.002*** (0.00)	-0.001 (0.00)	-0.002*** (0.00)	-0.000 (0.00)	-0.002*** (0.00)	-0.001 (0.00)	-0.001 (0.00)	-0.004 (0.01)	
$D_i^j \times \ln \text{Area}_i^j$	0.001* (0.00)	0.001 (0.00)	0.001*** (0.00)	-0.026*** (0.00)	0.002*** (0.00)	-0.025*** (0.00)	0.002** (0.00)	-0.027*** (0.01)	
$R^2$ within	0.262	0.174	0.165	0.359	0.172	0.387	0.179	0.275	
Observations	28,683	6,796	24,791	10,688	19,579	9,104	5,212	1,584	
PANEL B: Income Groups									
Origin	low	low	low	middle	middle	middle	high	high	high
Destination	low	middle	high	low	middle	high	low	middle	high
	(B1)	(B2)	(B3)	(B4)	(B5)	(B6)	(B7)	(B8)	(B9)
Disaster $_i^i$ , $D_i^i$	0.021 (0.19)	0.133 (0.15)	-0.073 (0.11)	-0.009 (0.01)	0.025** (0.01)	0.024** (0.01)	-0.014 (0.14)	-0.142* (0.08)	-0.047 (0.08)
Disaster $_i^j$ , $D_i^j$	-0.273 (0.21)	-0.019 (0.01)	0.455*** (0.09)	-0.341** (0.15)	-0.017** (0.01)	0.270*** (0.05)	-1.185*** (0.28)	-0.023** (0.01)	0.352*** (0.07)
<b>Interactions</b>									
$D_i^i \times \ln \text{Area}_i^i$	-0.003 (0.02)	-0.010 (0.01)	0.007 (0.01)	0.000 (0.00)	-0.001* (0.00)	-0.001** (0.00)	0.001 (0.01)	0.009* (0.01)	0.003 (0.00)
$D_i^j \times \ln \text{Area}_i^j$	0.021 (0.02)	0.001 (0.00)	-0.028*** (0.01)	0.027** (0.01)	0.001*** (0.00)	-0.017*** (0.00)	0.099*** (0.02)	0.002** (0.00)	-0.023*** (0.00)
$R^2$ within	0.200	0.171	0.398	0.214	0.190	0.371	0.128	0.199	0.235
Observations	1,749	2,871	3,273	2,690	7,345	7,484	1,778	4,457	3,832

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Controls, constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule. Income group classification is according to the World Bank convention. Full results for Panel A are reported in Table 8 and for Panel B in Table 9 in the Appendix.

effect in columns (B1), (B2) or (B3) for source country disasters. But, if the destination is high income and migrants come from low income economies, they are not kept from migrating there by disasters happening in the high income destination (compare column (B3)). Further, a low income destination struck by an additional disaster is even less attractive to migrants from middle (compare col-

umn (B4)) or high income economies (compare column (B7)), while the disaster in the source does not matter if the destination is low income. Again, middle income countries mirror the story outlined in previous sections. On average, they have the means to move internationally if necessary (compare columns (B5) and (B6)), but attract themselves less migrants as potential disaster-struck destinations (compare columns (B5) and (B8)). Once more, column (B6) depicts that migrants from middle income economies pay no attention to disasters happening in high income destinations, but migrate there anyways. Further, results indicate that people in high income source countries do not relocate due to a disaster (compare columns (B7) to (B9)), but high income destination countries attract migrants even if a natural disaster occurs (compare columns (B3), (B6), and (B9)). This leads to the conclusion that high income countries are able to better cope with disasters or are better prepared. The pattern seen in previous estimations that disasters are on average associated with migration out of affected areas, but negatively for migration into affected countries is mainly driven by middle income countries. Full results for Panel B are reported in Table 9.<sup>21</sup>

The reason that people in middle income economies are more likely to relocate internationally in case of a disaster than people in high income countries might relate to the fact that property and life in high income economies are more often insured against damage or loss than in middle or low income countries. Hence, the insurance penetration<sup>22</sup> is, on average, much higher in rich economies than in middle or low income countries (compare Figure 2 in the Appendix). People in high income countries see, on average, no need to migrate internationally, as they are more often compensated by their insurance for damage and loss due to disasters than those in middle and low income countries who often lack insurance.

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<sup>21</sup>Similar results are obtained when not conditioning on surface area.

<sup>22</sup>The insurance penetration (life and non-life) is measured as life insurance premium volume as a share of GDP or non-life insurance premium volume as a share of GDP, respectively.

#### *D. Robustness Checks*

In the robustness checks, I address five concerns. First, results could depend on the applied definition of 'large-scale' disasters. I conduct robustness checks pertaining to this choice. Second, two datasets are matched to obtain data for 1960 to 2010. In a robustness check, I only use the 'original' dataset from 1960-2000 to see whether the choice of data matters. Third, the baseline regression accounts only for positive migration flows. In an alternative approach, I assume that all negative values relate to return migration and recalculate migration flows accordingly. Fourth, if both the origin and the destination country are hit by a disaster, what happens to migration? To give an answer to this question, I introduce an interaction term that captures whether both countries in a pair were struck by a disaster. Finally, I turn to an important discussion on flow adjustment problems. In empirical investigations of migration patterns it is not clear whether migration flow or stock data should be used. Accordingly, I conduct a robustness test using migration stocks instead of flows.

**Disaster Decision Rule.** Table 4 summarizes results for the conditional specifications using medium-sized and large disasters, utilizing a lower threshold as specified in the data section. The lower threshold realizes an additional 1,327 natural disasters and thus increases the total number of disasters in the analysis by about 28%. As expected, results remain qualitatively similar compared to those under the 'large-scale' decision rule. Naturally, the effects turn out to be slightly smaller in magnitude as natural disasters of smaller scale are also considered. Still, natural disasters in the origin positively affect international migration flows, while destination country disasters negatively affect migration in column (1). Geophysical disasters in the origin have no significant effect, while those in the destination attract migrants, possibly due to increased labor demand after a disaster in columns (2) and (6). Climatic disasters push people out of their source country (see column (6)) and seem to attract migrants if striking a potential destination in columns (3) and (6). Meteorological disasters

in the origin increase outmigration (compare columns (4) and (6)). Again, hydrological disasters support the outlined pattern. In column (6), an additional hydrological disaster spurs bilateral outmigration by 1.5% for a medium-sized source country, while the migration abating effect of an additional hydrological disasters in a medium-sized destination is about 2.5%. Full results can be found in Table 10 in the Appendix.<sup>23</sup>

**Global Migrant Origin Database.** Table 5 columns (1) and (2) summarize conditionals results using only data from the Global Migrant Origin Database. As expected, results remain in line. Controls signal similar results as before. Nicely, the coefficient on the polity index of origins turns negative and significant for all specifications and positive for destinations. Hence, if an origin country is more democratic (achieves a higher polity index), less outmigration takes place, while more people migrate towards democratic destination countries. Estimates depict that disasters are on average positively associated with migration out of affected areas, but negatively for migration into affected countries. Column (2) depicts that the story is again mainly driven by hydrological disasters (flooding) in the 1960 to 2000 period. Full results are reported in Table 11 in the Appendix.

**Return Migration.** The benchmark specifications consider only positive migration and disregard any negative migration flows resulting from differentiating migration stocks. In an alternative but rather extreme approach, I now include all negative values as return migration – as no information on negative flows exists – and recalculate migration flows by summing up the absolute value of the negative flow from destination to origin and initial positive flows from source to destination country.<sup>24</sup> Table 5 columns (3) and (4) report conditional

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<sup>23</sup>As expected, if I use all natural disasters reported in the database, including small, medium and large disasters, I find no significant effect of disasters on migration. To conclude from this, a disaster has to be large and thus severe enough to trigger international migration. Small disaster which are much more frequent than medium or large disasters do not affect migration across borders. This could also be the reason why Beine and Parsons (2012) find no significant effect.

<sup>24</sup>Note that this approach most likely overstates real return flows, as the migration stock may as well shrink with some migrants dying and others moving on to a third country. But it will give



**TABLE 4**  
**Summary: Migration and Medium Natural Disasters, 1960-2010 (conditional)**

Dependent Variable: ln bilateral migration flows from $i$ in $j$						
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $_t^i$ , $D_t^i$	0.020*** (0.00)					
Disaster $_t^j$ , $D_t^j$	-0.006* (0.00)					
Geophysical Disaster $_t^i$		0.097 (0.07)				-0.087 (0.07)
Geophysical Disaster $_t^j$		0.386*** (0.07)				0.466*** (0.07)
Climatic Disaster $_t^i$			0.056 (0.04)			0.083* (0.05)
Climatic Disaster $_t^j$			0.192*** (0.04)			0.172*** (0.04)
Meteorological Disaster $_t^i$				0.016** (0.01)		0.019** (0.01)
Meteorological Disaster $_t^j$				-0.006 (0.00)		-0.003 (0.01)
Hydrological Disaster $_t^i$					0.059*** (0.01)	0.065*** (0.02)
Hydrological Disaster $_t^j$					-0.078*** (0.01)	-0.075*** (0.02)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.001*** (0.00)					
$D_t^j \times \ln \text{Area}_t^j$	0.000 (0.00)					
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		-0.006 (0.00)				0.007 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.023*** (0.00)				-0.028*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , climatic			-0.003 (0.00)			-0.005* (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic			-0.013*** (0.00)			-0.011*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological				-0.001** (0.00)		-0.001** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological				0.000 (0.00)		0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological					-0.004*** (0.00)	-0.004*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological					0.005*** (0.00)	0.004*** (0.00)
$R^2$ within	0.237	0.237	0.235	0.235	0.238	0.243
Observations	35,479	35,479	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Controls, constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of medium-sized and large disasters according to the decision rule. Full results are reported in Table 10 in the Appendix.

**TABLE 5**  
Summary: Robustness Checks

Dependent Variable: ln bilateral migration flows from $i$ in $j$ , including return migration						
	Time Span, 1960-2000		Return Migration		Combined Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $_t^i$ , $D_t^i$	0.040*** (0.01)		0.021*** (0.01)		0.029*** (0.01)	
Disaster $_t^j$ , $D_t^j$	-0.019** (0.01)		-0.006 (0.01)		-0.014*** (0.01)	
Geophysical Disaster $_t^i$		-0.096 (0.14)		0.149 (0.10)		0.019 (0.10)
Geophysical Disaster $_t^j$		0.063 (0.17)		0.640*** (0.13)		0.743*** (0.11)
Climatic Disaster $_t^i$		0.140** (0.07)		-0.022 (0.05)		0.161*** (0.05)
Climatic Disaster $_t^j$		0.048 (0.06)		0.151*** (0.05)		0.210*** (0.04)
Meteorological Disaster $_t^i$		0.056*** (0.02)		0.024** (0.01)		0.034*** (0.01)
Meteorological Disaster $_t^j$		0.012 (0.02)		-0.002 (0.01)		-0.010 (0.01)
Hydrological Disaster $_t^i$		0.040* (0.02)		0.078*** (0.02)		0.057*** (0.02)
Hydrological Disaster $_t^j$		-0.111*** (0.02)		-0.072** (0.03)		-0.054*** (0.02)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.002*** (0.00)		-0.001*** (0.00)		-0.002*** (0.00)	
$D_t^j \times \ln \text{Area}_t^j$	0.001** (0.00)		0.000 (0.00)		0.001** (0.00)	
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		0.008 (0.01)		-0.008 (0.01)		0.001 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.002 (0.01)		-0.039*** (0.01)		-0.044*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic		-0.010** (0.00)		0.003 (0.00)		-0.011*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic		-0.003 (0.00)		-0.010*** (0.00)		-0.014*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological		-0.004*** (0.00)		-0.002** (0.00)		-0.002*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological		-0.001 (0.00)		-0.000 (0.00)		0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological		-0.002 (0.00)		-0.005*** (0.00)		-0.004*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological		0.007*** (0.00)		0.005** (0.00)		0.003** (0.00)
$D_t^i \times D_t^j$					-0.058** (0.03)	-0.093*** (0.03)
$R^2$ within	0.249	0.252	0.195	0.199	0.237	0.243
Observations	30,606	30,606	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Controls, constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule. Full results for 1960-2000 results (columns (1) and (2)) are reported in Table 11, for return migration (columns (3) and (4)) in Table 12, and for the combined effects in Table 13 in the Appendix.

results for large disasters and the baseline sample.

Controls signal similar results as before. Nicely, the polity index of origins turns negative and significant. But, the destination coefficient on the polity index turns all negative as well, possibly due to considering return migration. Conditional results on disasters are slightly weaker with respect to significance but they still reaffirm previous results. In particular, hydrological disasters fully confirm earlier patterns. Source country flooding or storms increase outmigration, while hydrological events in the destination reduce migration. Hence, results remain largely in line with previous findings even when considering the extreme hypothesis on return migration.

**Combined Disaster Effects.** Do migration patterns change if both countries in a migration corridor are struck by disasters? To give an answer to this question, I introduce an interaction term that is one if both countries in a pair are hit by a disaster and zero otherwise. Conditional summary results are reported in columns (5) and (6) of Table 5. I find that patterns for individual disasters remain the same. The interaction term is negative and strongly significant, indicating that if the origin and the destination are both hit by natural disasters, less migration takes place between this pair. Full results are reported in Table 13, Appendix.

**Migration Stocks.** The empirical literature on migration faces important issues concerning data on bilateral migration. A large matrix of migration is only available in 10 year steps for migrant stocks, as it relies on census data. But, one could easily think that 10-year differences are hard to interpret as migration flows due to adjustment problems. Also, from a theoretical perspective it is not clear whether to use migration flow or stock data. Accordingly, I conduct a robustness test using migration stocks instead of calculated flows to see

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an indication whether the baseline results hold.

**TABLE 6**  
Migration Stocks and Large Natural Disasters, 1960-2010 (conditional)

Dependent Variable: ln bilateral migration stocks from $i$ in $j$				
Disaster Variable:	Lagged		5 year cumulated	
	(1)	(2)	(3)	(4)
Disaster $^i_t, D_t^i$	0.020 (0.02)		0.040*** (0.01)	
Disaster $^j_t, D_t^j$	-0.074*** (0.02)		-0.011* (0.01)	
Geophysical Disaster $^i_t$		-1.211*** (0.28)		-0.030 (0.08)
Geophysical Disaster $^j_t$		0.717** (0.32)		0.319*** (0.08)
Climatic Disaster $^i_t$		0.011 (0.12)		-0.015 (0.07)
Climatic Disaster $^j_t$		-0.086 (0.16)		-0.473*** (0.07)
Meteorological Disaster $^i_t$		0.140*** (0.04)		0.078*** (0.02)
Meteorological Disaster $^j_t$		-0.243*** (0.04)		-0.127*** (0.02)
Hydrological Disaster $^i_t$		0.048 (0.07)		0.038*** (0.01)
Hydrological Disaster $^j_t$		0.075 (0.08)		0.002 (0.01)
<b>Interactions</b>				
$D_t^i \times \ln \text{Area}_t^i$	-0.001 (0.00)		-0.002*** (0.00)	
$D_t^j \times \ln \text{Area}_t^j$	0.006*** (0.00)		0.001** (0.00)	
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		0.088*** (0.02)		0.002 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.045* (0.02)		-0.020*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic		0.000 (0.01)		0.004 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic		-0.002 (0.01)		0.031*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological		-0.011*** (0.00)		-0.005*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological		0.019*** (0.00)		0.008*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological		-0.001 (0.00)		-0.003*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological		-0.006 (0.00)		0.000 (0.00)
$R^2$ within	0.264	0.266	0.264	0.268
Observations	59,369	59,369	59,369	59,369

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Controls, constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule. Full results are reported in Table 14 in the Appendix.

whether results still hold.<sup>25</sup> Table 6 deploys migration stocks instead of flows using the conditional model as before. Results generally reaffirm previous findings. Using only one year lagged disasters in column (1), I find that disasters in the destination prevent migrants from going there. Using disasters cumulated over five years previous to measuring the migration stock in column (3) shows that disasters in the source country drive more people out of the country, while disasters prevent people from migrating to disaster prone destinations. It is mainly meteorological and partly hydrological disasters that drive this result. Looking at a dynamic model, which includes the lag of the dependent variable, I find very similar patterns as before.<sup>26</sup> The lag of the dependent variable, which captures network effects, is positive and significant as expected. Again, it seems to be mostly storms and partly flooding that drive the results. Full results for the simple model and on the dynamic model are reported in Table 14 and in Table 15 in the Appendix, respectively.

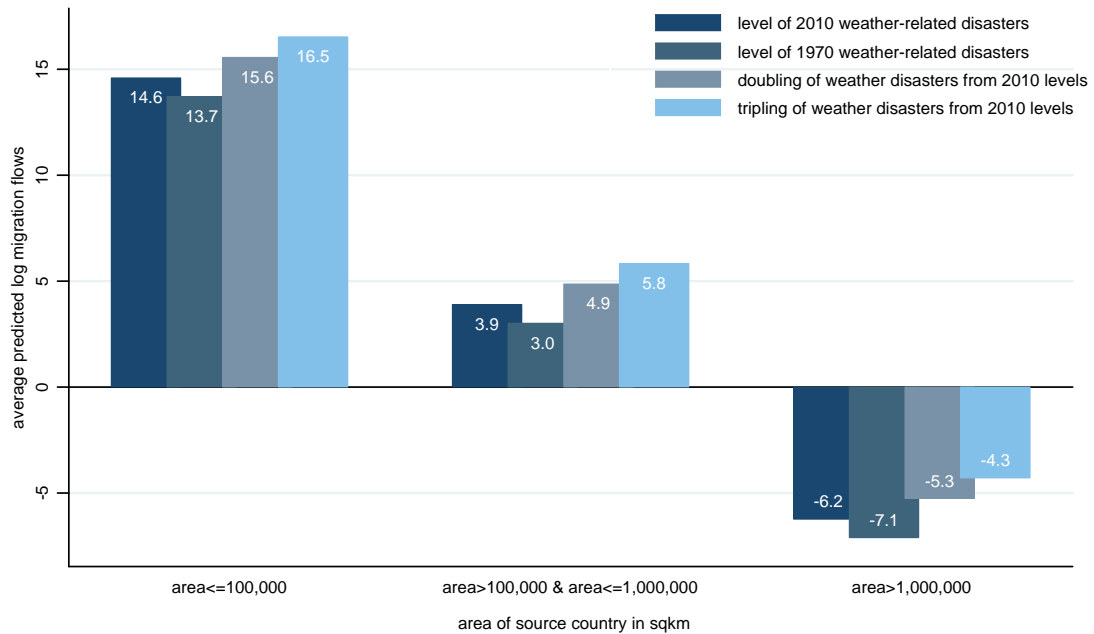
## V. Quantification from Climatic Scenarios

The 2012 report by the IPCC on climate change predicts a surge in extreme weather events in the foreseeable future. According to the IPCC, more extreme weather results in more natural disasters if climate change increases temperature and thereby increases natural risks, while the vulnerability of populations is at the same time not reduced. Following this, the IPCC report also points out that the increase in natural disasters creates prerequisites for population movements. While the previous results show that natural disasters induce migration from the origin country, the question of the size of these population movements remains unanswered. This section tries to give an answer to this.

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<sup>25</sup>There are also several drawbacks from using migration stock data, i.e. controlling for network effects might introduce a so called Nickell bias.

<sup>26</sup>When error terms are serially correlated, coefficient estimates of the dynamic equation suffer from the Nickell bias. The fact that the panel dataset is unbalanced and the inclusion of lagged variables reduces the time span covered limits possibilities considerably. I thus estimate a dynamic version only as a robustness check and coefficients should be treated with caution.



**FIGURE 1**  
Quantification of Migration Flows

Under the assumption that temperature increases by 2 to 3 degree Celsius in the next 50 years, weather-related disaster may increase two- to three-fold (see i.e. Bailey and Wren-Lewis, 2009 or Stern, 2006). Using the estimates from the preferred regression (6 in Table 2), I simulate the effect of changes in weather-related disaster variables (climatic, meteorological, and hydrological events) on predicted migration flows, holding everything else constant. The following counterfactuals are of particular interest: what happens to the size of population movements should weather-related disasters double or triple due to climate change? Alternatively, what happens if disaster levels come down to where they were at the start of the current globalization phase?

Figure 1 depicts results. What immediately strikes is that large source countries with an area size of more than one million square kilometers (sqkm) do not experience international migration due to weather-related disasters. This

confirms earlier conjectures that if countries strike in a large country, people move within rather than internationally. For this reason, it is not surprising to see very small migration numbers if any at all for large countries.

The baseline average prediction of the log of migration flows is weather-related disaster set at 2010 levels is 14.6 for source countries of 100,000 sqkm or smaller, which corresponds to an average migration flow of 2,1 millions. The second bar depicts the effect of bringing weather-related disasters back to their 1970 level, holding all other variables constant. The average migrant flow would decrease to 891,000 (13.7). For the third bar, I simulate the case where weather-related disasters double with respect to 2010 levels, migration flows would on average increase to 7,3 million (the fourth bar). Under the assumption of an even more dramatic scenario, where weather-related events increase three-fold compared to 2010 levels, climate events induce on average even more migration. This is shown in the fifth bar, which depicts about 14,6 million migrants from source countries of 100,000 sqkm or smaller in size if weather-related disasters triple. The picture is far less dramatic for source countries with a surface area between 100,000 and one million sqkms, the effects are qualitatively similar but quantitatively much smaller. The finding that the impact of weather-related disasters on the migration flows decreases with surface area is consistent with my previous results. For this reason, I conclude that forty years of climate change have substantially increased population relocation and will considerably increase migration in the future, particularly from smaller countries, if the exposure and vulnerability of these populations to climate change and concomitant increased disasters cannot be reduced.

## **VI. Concluding Remarks**

This paper provides an answer to the pressing question on the impact of climate change and associated natural disasters on international migration. To motivate the empirical strategy, I construct a stylized gravity framework of bilateral

migration introducing disasters as random shocks. To test the implications empirically, I deploy a matrix of international migration available for increments of 10 years from 1960 to 2010. The fixed-effects gravity estimations are augmented by the use of explicit MR terms to control for unobservable time-varying country variables, such as migration policies. Results suggest that aggregated disasters in the origin increase outmigration, on average, while disasters in the destination decrease international migration. Results hold when conditioned on geographic country size. As suspected, findings are dominated by weather-related events, particularly by severe flooding. The effect of geophysical disasters is less sound. The latter are known to occur repeatedly in specific regions, which are often characterized by particularly rich and fertile soil. Hence, people might willingly take their chances and adapt to the disaster risk in regions susceptible to geophysical events. Contrasting this, events related to climate have occurred with a higher frequency and magnitude in recent decades and have also struck regions not traditionally affected. As a result, weather-related events may lead to international migration. By decomposing the sample, I show that results are particularly driven by migration to and from developing (middle income) countries. Overall, results are robust to the definition of disasters, when considering 'return' migration, or if migrant stocks are used instead of flows.

Presented results yield supportive evidence that migration serves as an adaptation strategy to climate change. This is particularly true for middle income countries where large parts of the population are not insured against damage or loss, but may have the resources to afford to move internationally. Moreover, counterfactual scenarios show that outmigration induced by climate change will increase rapidly, particularly from small countries, if no action is taken against climate change or to reduce the exposure and vulnerability of populations in small and developing countries to severe disaster risks.



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## Appendix

**TABLE 7**  
Summary Statistics and Data Sources

Variable	Obs.	Mean	St. Dev.	Data Source
$\ln$ migration flow $_{t}^{ij}$	35,479	3.932	2.943	Migration DRC (2007) & World Bank (2010)
$\ln$ return migration flow $_{t}^{ij}$	35,479	4.222	2.978	Migration DRC (2007) & World Bank (2010)
Large Disaster $_{t}^{i}$	35,479	6.186	32.616	EM-DAT (2011)
Large Disaster $_{t}^{j}$	35,479	4.868	21.205	EM-DAT (2011)
Large geophysical Disaster $_{t}^{i}$	35,479	0.435	2.840	EM-DAT (2011)
Large geophysical Disaster $_{t}^{j}$	35,479	0.323	2.063	EM-DAT (2011)
Large climatic Disaster $_{t}^{i}$	35,479	0.782	2.284	EM-DAT (2011)
Large climatic Disaster $_{t}^{j}$	35,479	0.656	1.753	EM-DAT (2011)
Large meteorological Disaster $_{t}^{i}$	35,479	2.323	14.854	EM-DAT (2011)
Large meteorological Disaster $_{t}^{j}$	35,479	2.320	14.424	EM-DAT (2011)
Large hydrological Disaster $_{t}^{i}$	35,479	2.645	17.702	EM-DAT (2011)
Large hydrological Disaster $_{t}^{j}$	35,479	1.570	6.687	EM-DAT (2011)
Major Disaster $_{t}^{i}$	35,479	8.495	40.946	EM-DAT (2011)
Major Disaster $_{t}^{j}$	35,479	6.962	27.575	EM-DAT (2011)
Major geophysical Disaster $_{t}^{i}$	35,479	0.669	4.146	EM-DAT (2011)
Major geophysical Disaster $_{t}^{j}$	35,479	0.511	2.741	EM-DAT (2011)
Major climatic	35,479	0.918	2.428	EM-DAT (2011)
Major climatic	35,479	0.820	1.949	EM-DAT (2011)
Major meteorological Disaster $_{t}^{i}$	35,479	3.384	20.057	EM-DAT (2011)
Major meteorological Disaster $_{t}^{j}$	35,479	3.457	19.640	EM-DAT (2011)
Major hydrological Disaster $_{t}^{i}$	35,479	3.524	21.201	EM-DAT (2011)
Major hydrological Disaster $_{t}^{j}$	35,479	2.174	8.093	EM-DAT (2011)
$\ln$ Area $_{t}^{i}$	35,479	12.490	1.855	CEPII (2005)
$\ln$ Area $_{t}^{j}$	35,479	12.378	1.860	CEPII (2005)
$\ln$ (POP $_{t}^{i} \times$ POP $_{t}^{j}$ )	35,479	32.464	2.122	WDI (2011)
$\ln$ ( $y_{t}^{j}/y_{t}^{i}$ )	35,479	0.440	2.189	WDI (2011)
$\ln$ (POP Density $_{t}^{i} \times$ POP Density $_{t}^{j}$ )	35,479	7.660	2.040	WDI (2011)
Polity Index $_{t}^{i}$	35,479	11.367	7.383	Polity IV Project (2010)
Polity Index $_{t}^{j}$	35,479	12.836	7.476	Polity IV Project (2010)
Civil War $_{t}^{i}$	35,479	0.403	1.699	Intra-State War Data (v4.0)
Civil War $_{t}^{j}$	35,479	0.277	1.390	Intra-State War Data (v4.0)
$\ln$ migration stock $_{t-1}^{ij}$	35,479	3.813	3.076	Migration DRC (2007) & World Bank (2010)
$\ln$ migration stock $_{t}^{ij}$	59,369	4.472	3.038	Migration DRC (2007) & World Bank (2010)
MRDist $_{t}^{ij}$	35,479	9.468	0.581	own calculation
MRAdj $_{t}^{ij}$	35,479	-0.068	0.101	own calculation

**TABLE 8**  
 Migration and Large Natural Disasters, OECD versus NonOECD, 1960-2010  
 (conditional)

Dependent Variable: ln bilateral migration flows from  $i$  to  $j$

Origin	non-OECD	OECD	all	all	non-OECD	non-OECD	OECD	OECD
Destination	all	all	non-OECD	OECD	non-OECD	OECD	non-OECD	OECD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Disaster $_t^i$ , $D_t^i$	0.032*** (0.01)	0.008 (0.05)	0.033*** (0.01)	0.010 (0.01)	0.036*** (0.01)	0.013 (0.01)	0.013 (0.07)	0.052 (0.08)
Disaster $_t^j$ , $D_t^j$	-0.012** (0.01)	-0.013 (0.01)	-0.022*** (0.01)	0.411*** (0.04)	-0.024*** (0.01)	0.390*** (0.04)	-0.025** (0.01)	0.414*** (0.08)
<b>Interactions</b>								
$D_t^i \times \ln \text{Area}_t^i$	-0.002*** (0.00)	-0.001 (0.00)	-0.002*** (0.00)	-0.000 (0.00)	-0.002*** (0.00)	-0.001 (0.00)	-0.001 (0.00)	-0.004 (0.01)
$D_t^j \times \ln \text{Area}_t^j$	0.001* (0.00)	0.001 (0.00)	0.001*** (0.00)	-0.026*** (0.00)	0.002*** (0.00)	-0.025*** (0.00)	0.002** (0.00)	-0.027*** (0.01)
<b>Controls</b>								
$\ln(y_t^j/y_t^i)$	0.203*** (0.02)	0.453*** (0.05)	0.169*** (0.02)	0.311*** (0.04)	0.129*** (0.02)	0.272*** (0.04)	0.398*** (0.05)	0.855*** (0.14)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	-4.050*** (0.95)	-9.297*** (2.14)	-6.023*** (0.98)	-3.380* (1.92)	-4.959*** (1.14)	-2.773 (1.92)	-8.548*** (2.10)	-133.958*** (36.18)
$\ln(\text{POP Dens}_t^i \times \text{POP Dens}_t^j)$	3.802*** (0.95)	9.000*** (2.14)	5.869*** (0.99)	4.037** (1.92)	4.887*** (1.13)	3.143 (1.92)	7.850*** (2.11)	136.008*** (36.17)
Polity Index $_t^i$	-0.008*** (0.00)	-0.014** (0.01)	-0.006** (0.00)	0.005 (0.00)	-0.007** (0.00)	-0.000 (0.00)	-0.001 (0.01)	-0.028** (0.01)
Polity Index $_t^j$	-0.003 (0.00)	0.003 (0.01)	0.002 (0.00)	0.011** (0.01)	0.009*** (0.00)	-0.001 (0.01)	-0.021*** (0.01)	0.059*** (0.01)
Civil War $_t^i$	0.005 (0.00)	-0.059 (0.05)	0.000 (0.01)	0.010 (0.01)	0.002 (0.01)	0.010 (0.01)	-0.004 (0.06)	-0.100 (0.10)
Civil War $_t^j$	-0.023*** (0.01)	0.038*** (0.01)	-0.013** (0.01)	0.418*** (0.11)	-0.027*** (0.01)	0.447*** (0.12)	0.034*** (0.01)	0.323** (0.16)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.081*** (0.01)	0.041* (0.02)	0.067*** (0.01)	0.084*** (0.01)	0.071*** (0.02)	0.073*** (0.02)	0.031 (0.03)	-0.026 (0.04)
$R^2$ within	0.262	0.174	0.165	0.359	0.172	0.387	0.179	0.275
Observations	28,683	6,796	24,791	10,688	19,579	9,104	5,212	1,584

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

**TABLE 9**  
**Migration and Large Natural Disasters by Income Group, 1960-2010**  
**(conditional)**

Dependent Variable: ln bilateral migration flows from  $i$  to  $j$

Origin	low	low	low	middle	middle	middle	high	high	high
Destination	low	middle	high	low	middle	high	low	middle	high
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Disaster $^i_t$ , $D_t^i$	0.021 (0.19)	0.133 (0.15)	-0.073 (0.11)	-0.009 (0.01)	0.025** (0.01)	0.024** (0.01)	-0.014 (0.14)	-0.142* (0.08)	-0.047 (0.08)
Disaster $^j_t$ , $D_t^j$	-0.273 (0.21)	-0.019 (0.01)	0.455*** (0.09)	-0.341** (0.15)	-0.017** (0.01)	0.270*** (0.05)	-1.185*** (0.28)	-0.023** (0.01)	0.352*** (0.07)
<b>Interactions</b>									
$D_t^i \times \ln \text{Area}_i^i$	-0.003 (0.02)	-0.010 (0.01)	0.007 (0.01)	0.000 (0.00)	-0.001* (0.00)	-0.001** (0.00)	0.001 (0.01)	0.009* (0.01)	0.003 (0.00)
$D_t^j \times \ln \text{Area}_i^j$	0.021 (0.02)	0.001 (0.00)	-0.028*** (0.01)	0.027** (0.01)	0.001*** (0.00)	-0.017*** (0.00)	0.099*** (0.02)	0.002** (0.00)	-0.023*** (0.00)
<b>Controls</b>									
$\ln(y_t^j/y_t^i)$	0.170 (0.11)	0.268*** (0.06)	0.068 (0.07)	-0.059 (0.07)	0.214*** (0.04)	0.264*** (0.04)	0.091 (0.08)	0.326*** (0.06)	0.214*** (0.06)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	1.292 (2.95)	-1.854 (3.16)	-4.078 (3.13)	3.428 (4.83)	-9.036*** (1.80)	-4.678** (2.12)	9.220*** (2.93)	-9.568*** (2.14)	-17.535*** (6.07)
$\ln(\text{POP Dens}_t^i \times \text{POP Dens}_t^j)$	-1.707 (2.86)	2.058 (3.14)	3.826 (3.12)	-3.357 (4.78)	8.630*** (1.80)	4.758** (2.11)	-9.198*** (2.92)	8.728*** (2.14)	18.003*** (6.07)
Polity Index $^i_t$	-0.014 (0.01)	-0.008 (0.01)	-0.004 (0.01)	-0.007 (0.01)	-0.001 (0.00)	-0.003 (0.00)	0.006 (0.01)	-0.005 (0.01)	0.003 (0.01)
Polity Index $^j_t$	-0.001 (0.01)	0.023** (0.01)	-0.092*** (0.01)	0.009 (0.01)	0.025*** (0.01)	-0.024*** (0.01)	0.005 (0.01)	0.013* (0.01)	0.014* (0.01)
Civil War $^i_t$	-0.004 (0.02)	-0.001 (0.02)	0.028* (0.02)	-0.003 (0.01)	0.002 (0.01)	0.004 (0.01)	-0.005 (0.11)	-0.004 (0.07)	-0.140* (0.07)
Civil War $^j_t$	-0.004 (0.03)	-0.065*** (0.01)	0.531*** (0.15)	-0.052** (0.02)	-0.018** (0.01)	0.311* (0.17)	-0.006 (0.02)	0.035*** (0.01)	0.596*** (0.17)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.077 (0.05)	0.117** (0.05)	0.078** (0.03)	0.074 (0.05)	0.067** (0.03)	0.030* (0.02)	0.138*** (0.05)	0.016 (0.03)	0.023 (0.03)
$R^2$ within	0.200	0.171	0.398	0.214	0.190	0.371	0.128	0.199	0.235
Observations	1,749	2,871	3,273	2,690	7,345	7,484	1,778	4,457	3,832

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule. Income group classification is according to the World Bank convention.

**TABLE 10**  
Migration and Medium Natural Disasters, 1960-2010 (conditional)

Dependent Variable: ln bilateral migration flows from $i$ in $j$						
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $_t^i$ , $D_t^i$	0.020*** (0.00)					
Disaster $_t^j$ , $D_t^j$	-0.006* (0.00)					
Geophysical Disaster $_t^i$		0.097 (0.07)				-0.087 (0.07)
Geophysical Disaster $_t^j$		0.386*** (0.07)				0.466*** (0.07)
Climatic Disaster $_t^i$			0.056 (0.04)			0.083* (0.05)
Climatic Disaster $_t^j$			0.192*** (0.04)			0.172*** (0.04)
Meteorological Disaster $_t^i$				0.016** (0.01)		0.019** (0.01)
Meteorological Disaster $_t^j$				-0.006 (0.00)		-0.003 (0.01)
Hydrological Disaster $_t^i$					0.059*** (0.01)	0.065*** (0.02)
Hydrological Disaster $_t^j$					-0.078*** (0.01)	-0.075*** (0.02)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.001*** (0.00)					
$D_t^j \times \ln \text{Area}_t^j$	0.000 (0.00)					
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		-0.006 (0.00)				0.007 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.023*** (0.00)				-0.028*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , climatic			-0.003 (0.00)			-0.005* (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic			-0.013*** (0.00)			-0.011*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological				-0.001** (0.00)		-0.001** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological				0.000 (0.00)		0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological					-0.004*** (0.00)	-0.004*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological					0.005*** (0.00)	0.004*** (0.00)
<b>Controls</b>						
$\ln(y_t^j/y_t^i)$	0.260*** (0.02)	0.256*** (0.02)	0.252*** (0.02)	0.255*** (0.02)	0.259*** (0.02)	0.255*** (0.02)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	-5.103*** (0.86)	-4.965*** (0.85)	-5.060*** (0.86)	-5.112*** (0.86)	-5.112*** (0.86)	-4.839*** (0.85)
$\ln(\text{POP Density}_t^i \times \text{POP Density}_t^j)$	4.907*** (0.86)	4.768*** (0.85)	4.892*** (0.86)	4.904*** (0.86)	4.948*** (0.86)	4.694*** (0.85)
Polity Index $_t^i$	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)	-0.003 (0.00)	-0.002 (0.00)	-0.003 (0.00)
Polity Index $_t^j$	-0.003 (0.00)	-0.004* (0.00)	-0.004 (0.00)	-0.003 (0.00)	-0.002 (0.00)	-0.002 (0.00)
Civil War $_t^i$	0.002 (0.00)	-0.001 (0.00)	-0.000 (0.00)	0.001 (0.00)	0.001 (0.00)	0.001 (0.00)
Civil War $_t^j$	-0.009* (0.01)	-0.009* (0.01)	-0.007 (0.01)	-0.009* (0.01)	-0.007 (0.01)	-0.008 (0.01)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.086*** (0.01)	0.086*** (0.01)	0.091*** (0.01)	0.088*** (0.01)	0.083*** (0.01)	0.083*** (0.01)
$R^2$ within	0.237	0.237	0.235	0.235	0.238	0.243
Observations	35,479	35,479	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of medium-sized disasters according to the decision rule.

**TABLE 11**  
Migration and Large Natural Disasters, 1960-2000 (conditional)

Dependent Variable: ln bilateral migration flows from $i$ in $j$	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $^i_t, D_t^i$	0.040*** (0.01)					
Disaster $^j_t, D_t^j$	-0.019** (0.01)					
Geophysical Disaster $^i_t$		0.242* (0.13)				-0.096 (0.14)
Geophysical Disaster $^j_t$		0.039 (0.16)				0.063 (0.17)
Climatic Disaster $^i_t$			0.147** (0.06)			0.140** (0.07)
Climatic Disaster $^j_t$			0.051 (0.06)			0.048 (0.06)
Meteorological Disaster $^i_t$				0.039*** (0.01)		0.056*** (0.02)
Meteorological Disaster $^j_t$				-0.007 (0.01)		0.012 (0.02)
Hydrological Disaster $^i_t$					0.061*** (0.02)	0.040* (0.02)
Hydrological Disaster $^j_t$					-0.116*** (0.01)	-0.111*** (0.02)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.002*** (0.00)					
$D_t^j \times \ln \text{Area}_t^j$	0.001** (0.00)					
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		-0.015* (0.01)				0.008 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.002 (0.01)				-0.002 (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic			-0.010** (0.00)			-0.010** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic			-0.003 (0.00)			-0.003 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological				-0.002*** (0.00)		-0.004*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological				0.000 (0.00)		-0.001 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological					-0.004** (0.00)	-0.002 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological					0.007*** (0.00)	0.007*** (0.00)
<b>Controls</b>						
$\ln (y_t^j / y_t^i)$	0.313*** (0.02)	0.312*** (0.02)	0.307*** (0.02)	0.311*** (0.02)	0.315*** (0.02)	0.310*** (0.02)
$\ln (\text{POP}_t^i \times \text{POP}_t^j)$	-3.224*** (0.80)	-3.286*** (0.80)	-3.180*** (0.80)	-3.270*** (0.80)	-3.192*** (0.80)	-3.238*** (0.80)
$\ln (\text{POP Density}_t^i \times \text{POP Density}_t^j)$	2.798*** (0.80)	2.849*** (0.80)	2.747*** (0.80)	2.828*** (0.80)	2.757*** (0.80)	2.794*** (0.80)
Polity Index $^i_t$	-0.005** (0.00)	-0.004* (0.00)	-0.004** (0.00)	-0.005** (0.00)	-0.004** (0.00)	-0.006** (0.00)
Polity Index $^j_t$	0.007*** (0.00)	0.006*** (0.00)	0.006*** (0.00)	0.006*** (0.00)	0.008*** (0.00)	0.008*** (0.00)
Civil War $^i_t$	0.003 (0.00)	0.002 (0.00)	0.003 (0.00)	0.004 (0.00)	0.000 (0.00)	0.000 (0.00)
Civil War $^j_t$	-0.016*** (0.01)	-0.017*** (0.01)	-0.016*** (0.01)	-0.016*** (0.01)	-0.014*** (0.01)	-0.013*** (0.01)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.013 (0.01)	0.018 (0.01)	0.017 (0.01)	0.016 (0.01)	0.010 (0.01)	0.010 (0.01)
$R^2$ within	0.249	0.247	0.247	0.248	0.250	0.252
Observations	30,606	30,606	30,606	30,606	30,606	30,606

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.



**TABLE 12**  
Return Migration and Large Natural Disasters, 1960-2000 (conditional)

Dependent Variable: ln bilateral migration flows from $i$ in $j$ , including return migration						
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster $^i_t, D_t^i$	0.021*** (0.01)					
Disaster $^j_t, D_t^j$	-0.006 (0.01)					
Geophysical Disaster $^i_t$		0.273*** (0.10)				0.149 (0.10)
Geophysical Disaster $^j_t$		0.552*** (0.12)				0.640*** (0.13)
Climatic Disaster $^i_t$			-0.009 (0.05)			-0.022 (0.05)
Climatic Disaster $^j_t$			0.191*** (0.05)			0.151*** (0.05)
Meteorological Disaster $^i_t$				0.014 (0.01)		0.024** (0.01)
Meteorological Disaster $^j_t$				-0.005 (0.01)		-0.002 (0.01)
Hydrological Disaster $^i_t$					0.058*** (0.02)	0.078*** (0.02)
Hydrological Disaster $^j_t$					-0.065*** (0.02)	-0.072** (0.03)
<b>Interactions</b>						
$D_t^i \times \ln \text{Area}_t^i$	-0.001*** (0.00)					
$D_t^j \times \ln \text{Area}_t^j$	0.000 (0.00)					
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		-0.016*** (0.01)				-0.008 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.035*** (0.01)				-0.039*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic			0.001 (0.00)			0.003 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic			-0.013*** (0.00)			-0.010*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological				-0.001 (0.00)		-0.002** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological				0.000 (0.00)		-0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological					-0.004*** (0.00)	-0.005*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological					0.004** (0.00)	0.005** (0.00)
<b>Controls</b>						
$\ln(y_t^j/y_t^i)$	0.248*** (0.02)	0.247*** (0.02)	0.244*** (0.02)	0.245*** (0.02)	0.247*** (0.02)	0.245*** (0.02)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	-4.877*** (0.89)	-4.687*** (0.88)	-4.787*** (0.89)	-4.865*** (0.89)	-4.865*** (0.89)	-4.465*** (0.88)
$\ln(\text{POP Density}_t^i \times \text{POP Density}_t^j)$	4.946*** (0.89)	4.749*** (0.88)	4.866*** (0.89)	4.925*** (0.88)	4.957*** (0.89)	4.576*** (0.88)
Polity Index $^i_t$	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)
Polity Index $^j_t$	-0.009*** (0.00)	-0.009*** (0.00)	-0.009*** (0.00)	-0.009*** (0.00)	-0.008*** (0.00)	-0.008*** (0.00)
Civil War $^i_t$	0.015*** (0.01)	0.012** (0.01)	0.013** (0.01)	0.014*** (0.01)	0.014*** (0.01)	0.014*** (0.01)
Civil War $^j_t$	-0.015** (0.01)	-0.014** (0.01)	-0.014** (0.01)	-0.016** (0.01)	-0.013** (0.01)	-0.015** (0.01)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.084*** (0.01)	0.086*** (0.01)	0.087*** (0.01)	0.085*** (0.01)	0.082*** (0.01)	0.084*** (0.01)
$R^2$ within	0.195	0.196	0.195	0.195	0.196	0.199
Observations	35,479	35,479	35,479	35,479	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

**TABLE 13**  
Migration and Combined Disaster Effects, 1960-2010 (conditional)

Dependent Variable: ln bilateral migration flows from $i$ in $j$		
	(1)	(2)
Disaster $_t^i, D_t^i$	0.029*** (0.01)	
Disaster $_t^j, D_t^j$	-0.014*** (0.01)	
Geophysical Disaster $_t^i$		0.019 (0.10)
Geophysical Disaster $_t^j$		0.743*** (0.11)
Climatic Disaster $_t^i$		0.161*** (0.05)
Climatic Disaster $_t^j$		0.210*** (0.04)
Meteorological Disaster $_t^i$		0.034*** (0.01)
Meteorological Disaster $_t^j$		-0.010 (0.01)
Hydrological Disaster $_t^i$		0.057*** (0.02)
Hydrological Disaster $_t^j$		-0.054*** (0.02)
<b>Interactions</b>		
$D_t^i \times \ln \text{Area}_t^i$	-0.002*** (0.00)	
$D_t^j \times \ln \text{Area}_t^j$	0.001** (0.00)	
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		0.001 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.044*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic		-0.011*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic		-0.014*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological		-0.002*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological		0.000 (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological		-0.004*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological		0.003** (0.00)
$D_t^i \times D_t^j$	-0.058** (0.03)	-0.093*** (0.03)
<b>Controls</b>		
$\ln (y_t^j / y_t^i)$	0.259*** (0.02)	0.251*** (0.02)
$\ln (\text{POP}_t^i \times \text{POP}_t^j)$	-5.105*** (0.86)	-4.645*** (0.85)
$\ln (\text{POP Density}_t^i \times \text{POP Density}_t^j)$	4.905*** (0.86)	4.480*** (0.85)
Polity Index $_t^i$	-0.003 (0.00)	-0.003 (0.00)
Polity Index $_t^j$	-0.003 (0.00)	-0.002 (0.00)
Civil War $_t^i$	0.003 (0.00)	0.002 (0.00)
Civil War $_t^j$	-0.010* (0.01)	-0.009 (0.01)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.086*** (0.01)	0.087*** (0.01)
$R^2$ within	0.237	0.243
Observations	35,479	35,479

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

**TABLE 14**  
Migration Stocks and Large Natural Disasters, 1960-2010 (conditional)

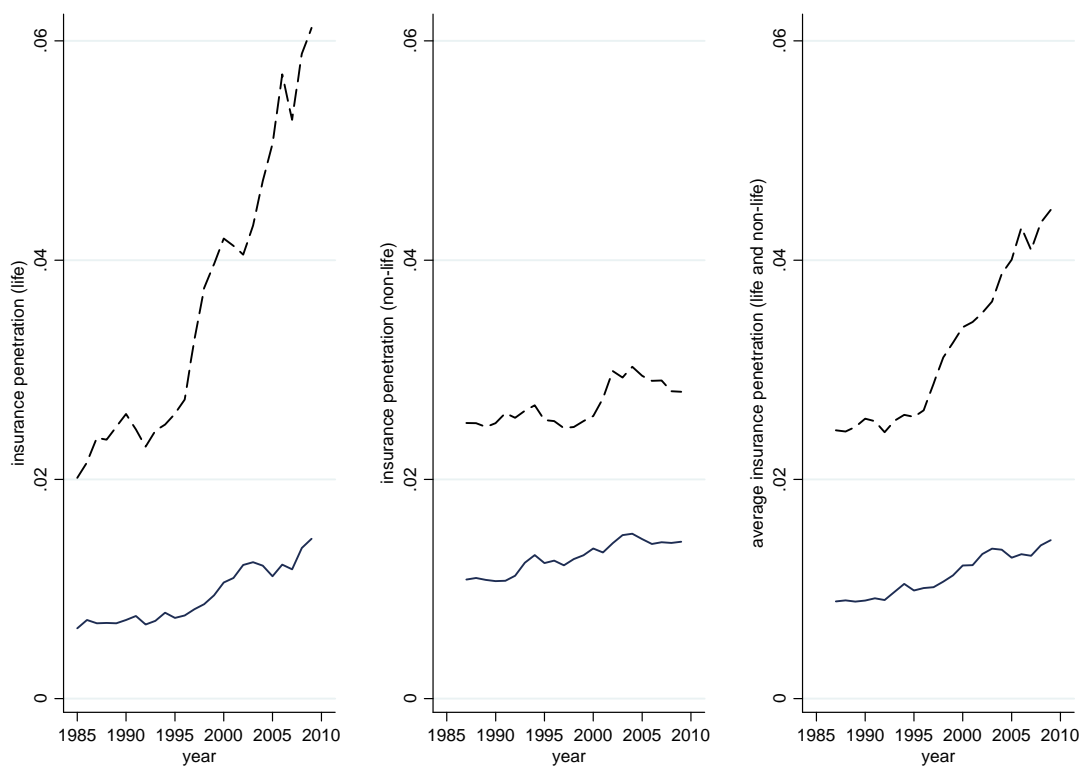
Dependent Variable: ln bilateral migration stocks from $i$ in $j$				
Disaster Variable:	Lagged		5 year cumulated	
	(1)	(2)	(3)	(4)
Disaster $_t^i, D_t^i$	0.020 (0.02)		0.040*** (0.01)	
Disaster $_t^j, D_t^j$	-0.074*** (0.02)		-0.011* (0.01)	
Geophysical Disaster $_t^i$		-1.211*** (0.28)		-0.030 (0.08)
Geophysical Disaster $_t^j$		0.717** (0.32)		0.319*** (0.08)
Climatic Disaster $_t^i$		0.011 (0.12)		-0.015 (0.07)
Climatic Disaster $_t^j$		-0.086 (0.16)		-0.473*** (0.07)
Meteorological Disaster $_t^i$		0.140*** (0.04)		0.078*** (0.02)
Meteorological Disaster $_t^j$		-0.243*** (0.04)		-0.127*** (0.02)
Hydrological Disaster $_t^i$		0.048 (0.07)		0.038*** (0.01)
Hydrological Disaster $_t^j$		0.075 (0.08)		0.002 (0.01)
<b>Interactions</b>				
$D_t^i \times \ln \text{Area}_t^i$	-0.001 (0.00)		-0.002*** (0.00)	
$D_t^j \times \ln \text{Area}_t^j$	0.006*** (0.00)		0.001** (0.00)	
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		0.088*** (0.02)		0.002 (0.01)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.045* (0.02)		-0.020*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic		0.000 (0.01)		0.004 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic		-0.002 (0.01)		0.031*** (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological		-0.011*** (0.00)		-0.005*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological		0.019*** (0.00)		0.008*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological		-0.001 (0.00)		-0.003*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological		-0.006 (0.00)		0.000 (0.00)
<b>Controls</b>				
$\ln(y_t^j/y_t^i)$	0.286*** (0.01)	0.285*** (0.01)	0.285*** (0.01)	0.281*** (0.01)
$\ln(\text{POP}_t^i \times \text{POP}_t^j)$	-1.611*** (0.55)	-1.575*** (0.56)	-1.617*** (0.55)	-1.675*** (0.55)
$\ln(\text{POP Density}_t^i \times \text{POP Density}_t^j)$	1.928*** (0.55)	1.906*** (0.56)	1.948*** (0.55)	1.988*** (0.55)
Polity Index $_t^i$	-0.003* (0.00)	-0.003** (0.00)	-0.003** (0.00)	-0.003** (0.00)
Polity Index $_t^j$	-0.009*** (0.00)	-0.009*** (0.00)	-0.009*** (0.00)	-0.008*** (0.00)
Civil War $_t^i$	-0.002 (0.00)	-0.001 (0.00)	-0.001 (0.00)	-0.003 (0.00)
Civil War $_t^j$	0.003 (0.00)	0.002 (0.00)	0.003 (0.00)	0.004 (0.00)
$R^2$ within	0.264	0.266	0.264	0.268
Observations	59,369	59,369	59,369	59,369

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.

**TABLE 15**  
 Dynamic Model: Migration Stocks and Large Natural Disasters, 1960-2010  
 (conditional)

Dependent Variable: ln bilateral migration stocks from $i$ in $j$				
Disaster Variable:	Lagged		5 year cumulated	
	(1)	(2)	(3)	(4)
Disaster $_t^i, D_t^i$	0.011 (0.02)		0.030*** (0.01)	
Disaster $_t^j, D_t^j$	-0.107*** (0.02)		-0.021*** (0.01)	
Geophysical Disaster $_t^i$		-1.088*** (0.25)		-0.022 (0.07)
Geophysical Disaster $_t^j$		0.494 (0.35)		0.175** (0.08)
Climatic Disaster $_t^i$		0.044 (0.11)		0.084 (0.06)
Climatic Disaster $_t^j$		0.368** (0.15)		-0.407*** (0.07)
Meteorological Disaster $_t^i$		0.079** (0.04)		0.036* (0.02)
Meteorological Disaster $_t^j$		-0.311*** (0.03)		-0.088*** (0.02)
Hydrological Disaster $_t^i$		-0.015 (0.06)		0.034*** (0.01)
Hydrological Disaster $_t^j$		0.159** (0.07)		-0.002 (0.01)
<b>Interactions</b>				
$D_t^i \times \ln \text{Area}_t^i$	-0.000 (0.00)		-0.002*** (0.00)	
$D_t^j \times \ln \text{Area}_t^j$	0.008*** (0.00)		0.002*** (0.00)	
$D_t^i \times \ln \text{Area}_t^i$ , geophysical		0.079*** (0.02)		0.002 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , geophysical		-0.030 (0.02)		-0.010* (0.01)
$D_t^i \times \ln \text{Area}_t^i$ , climatic		-0.003 (0.01)		-0.005 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , climatic		-0.037*** (0.01)		0.028*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , meteorological		-0.006** (0.00)		-0.002 (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , meteorological		0.024*** (0.00)		0.006*** (0.00)
$D_t^i \times \ln \text{Area}_t^i$ , hydrological		0.002 (0.00)		-0.002*** (0.00)
$D_t^j \times \ln \text{Area}_t^j$ , hydrological		-0.010** (0.00)		0.000 (0.00)
<b>Controls</b>				
$\ln (y_t^i / y_t^j)$	0.230*** (0.01)	0.231*** (0.01)	0.231*** (0.01)	0.227*** (0.01)
$\ln (\text{POP}_t^i \times \text{POP}_t^j)$	-2.994*** (0.53)	-2.960*** (0.54)	-2.996*** (0.53)	-3.041*** (0.53)
$\ln (\text{POP Density}_t^i \times \text{POP Density}_t^j)$	3.268*** (0.53)	3.253*** (0.54)	3.283*** (0.53)	3.319*** (0.53)
Polity Index $_t^i$	0.001 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Polity Index $_t^j$	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)
Civil War $_t^i$	-0.001 (0.00)	0.000 (0.00)	0.000 (0.00)	-0.000 (0.00)
Civil War $_t^j$	0.001 (0.00)	-0.000 (0.00)	0.001 (0.00)	0.002 (0.00)
$\ln \text{Migration Stock}_{t-1}^{ij}$	0.219*** (0.01)	0.220*** (0.01)	0.219*** (0.01)	0.216*** (0.01)
$R^2$ within	0.291	0.294	0.292	0.294
Observations	53,317	53,317	53,317	53,317

Note: \*\*\*, \*\*, \* denote significance at the 1%, 5%, and 10% level, respectively. Constant, country pair and time fixed effects, and MR terms included in all regressions but not reported. Country pair clustered robust standard errors reported in parenthesis. Disasters are the number of large-scale disasters according to the decision rule.



Note: The figure uses data from the World Bank Database on Financial Institutions for 1987 to 2009. The dotted line indicates the average insurance penetration for high income countries, while the solid line is for middle and low income countries. Insurance penetration is measured as life insurance premium volume as a share of GDP or nonlife insurance premium volume as a share of GDP, respectively.

**FIGURE 2**  
Insurance Penetration by Income Level (1987-2009)