Natural Disasters, Migration and Education: An Empirical Analysis in Developing Countries

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Abstract

This paper aims to assess the effect of natural disasters closely related to climate change on migration rates in developing countries, observing how this effect varies according to the level of education. We investigate this relationship by using panel data that measure international migration from developing countries to the main OECD destination countries. Estimations are made with a pair-country fixed effects estimator. The results show that natural disasters are positively associated with emigration rates. Furthermore, we show that natural disasters may exacerbate the brain drain in developing countries when they are at their most vulnerable and need greater support from skilled workers. We also find that the effect of natural disasters on migration varies depending on the geographical location of countries, as well as according to the type of disaster.

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1. INTRODUCTION

Many studies such as the Stern report (2007) and the Intergovernmental Panel on Climate Change (IPCC, 2007) have predicted an intensification of climate change and its consequences in the forthcoming years. Therefore, policy makers and academics have increasing concerns about the environment, which has thus occupied an important place in world governance. However, the partial failure of important meetings on the environmental issue shows that it is difficult for the states to agree on the strategy to adopt to reduce their impact on the environment. The interests and means of action differ according to each nation's level of development. Developed countries are responsible for an important part[2] of pollution and greenhouse gas emissions compared to developing countries, which are disproportionately affected owing to their economic vulnerability and lack of means due to poverty. Many developing countries are experiencing an increase in the frequency and costs of natural disasters, which are estimated on average at 5% of their GDP between 1997 and 2001 (IMF, 2003). They suffer a "double penalty" because less-developed countries may be trapped in a vicious circle, whereby their poverty makes them more vulnerable in the face of natural disasters, which in turn causes some issues in dealing with the consequences of these disasters. In this context, migration appears as one of the coping mechanisms for natural disasters.

History demonstrates that the natural environment is probably the oldest determinant of population displacement. For example, the climatic factor is seen as one of the main drivers of migration in the context of the ancient Chinese history (Huang and Su, 2009). Moreover, the climatic factor also influenced Polynesian migrations between 300 and 1400 (Bridgman,

[2] Rich countries will be responsible for 60-80% of gas emission by 2050 (Stern, 2007).

1983). The El Niño events between the 1970s and 1990s caused extended droughts in Ethiopia. They were followed by famine and political turmoil, which resulted in radical changes of government, secession and a massive program of population redistribution (Comenetz and Caviedes, 2002). More recently in 2004, the tsunami in Indonesia displaced 500,000 people, while Hurricane Katrina in 2005 had serious consequences in terms of human displacement for tens of thousands of migrants in 26 states of the USA. Moreover, it also contributed to increasing male migration from Honduras to Nicaragua (Smith, 2007).

According to the International Organization for Migration (IOM), in the next half century, 200 million people (equal to the current estimate of international migrants) could be permanent or temporary environmental migrants[3] within their countries or overseas. Therefore, the management of supplementary migratory flows from developing countries due to environmental events can be more complicated for developed countries. However, the alarming view concerning the consequences of environmental factors on migration is more and more put into perspective (Black, 2001; Piguet *et al.*, 2011). Views also differ on whether migration could be considered as an adaptation to risks associated with environmental shocks or failure. On the one hand, migration is viewed as an adaptive response (Black *et al.*, 2011), a mitigation and ex-post management strategy (Halliday, 2006) or even a solution to the failure of different survival strategies (Meze-Hausken, 2000; Smith, 2007). Furthermore, some operational organizations and academics point out the role that migration can play in helping home communities to adapt themselves; for instance, using the resources from migrant remittances (Barnett and Jones, 2002; IOM, 2007). On the other hand, some characterize migration as a failure, rather than as a form of adaptation. Oliver-Smith (2009) expresses the view that migration is a maladaptive response because it may trigger an

[3] We consider the term "environmental migrants", because it is larger and inclusive than environmental refugees. It takes into account the forced population displacement due to environmental reasons; with push factors largely more determinant then pull factors (For other definitions, see Appendix A available on the website of the journal).

increased risk for those who move, as well as possibly for areas towards which people migrate. Notwithstanding this, it is important to specify that the idea implying that environmental migrants could represent a “threat” for the receiving areas is very controversial (Piguet *et al.*, 2011).

The discussions and controversies related to the consequences of climate events on migration are likely due to the fact that the literature is relatively small regarding empirical evidence, apart from some case studies. Therefore, more research is needed and thus this paper aims to contribute to the literature by studying the relationship between natural disasters, mainly due to climate change, and migration in developing countries. Furthermore, for the first time in the literature, we investigate the effect of natural disasters on the selectivity of migrants regarding their level of education. The idea that environmental factors lead to more internal than international migration is becoming increasingly accepted (Piguet *et al.,* 2011). It is important to ascertain if this effect depends on the characteristics of migration such as the education level and, more specifically, if natural disasters can lead to brain drain, which is supposed to be a long-term migration. This issue is particularly crucial if we refer to the consequences of climate events in developing countries described above. It is thus important to know who migrates in terms of education when developing countries suffer from an environmental shock. Since we are interested in brain drain effects, we mainly focus on international migration from developing countries to developed countries.

To our knowledge, our paper is also the first seeking to form a consensus about the idea of migration as an adaptive response or failure strategy. Indeed, if one assumes the existence of a brain drain, namely that the most educated migrate, this can be seen as a failure strategy because it raises equity issues in the origin countries when they are at their most vulnerable. At the same time, it can be seen as positive and subsequently as an adaptive strategy from the perspective of remittances, for example. However, if we do not find any brain drain effect, this will support the argument of migration as an adaptive response, which would contribute to relativizing the negative consequences of climate events on migration. Our study also refers to natural disasters mainly determined by climate change, because even if they are sudden events, the frequency, magnitude or intensity of disasters are related to climate change, which is a longer process. Therefore, we use natural disasters closely associated with climate change as our variables of interest. They are composed of meteorological disasters considering the events caused by storms; hydrological disasters, using a variable that groups together the events caused by floods and other wet mass movements; as well as climatological disasters, which take into account disasters caused by drought, wildfire and extremely high temperatures. These data are provided by the Center for Research on the Epidemiology of Disaster (CRED). For the purpose of our analysis, namely exploring the relationship between natural disasters and migration, as well as between natural disasters and migration according to different levels of education, we use panel data from the World Bank Databases. This data set measures international migration to the six main OECD destination countries from 1975 to 2000. We conduct the analysis for low, medium and high education levels. We use a sample of 67 developing countries and run OLS estimations with pair-country and year fixed effects. We also take into account the geographical location of the countries and conduct a more detailed analysis of the effects of the aforementioned types of disasters on migration.

Our results can be summarized as follows: natural disasters are positively associated with migration rates. Beyond this result, the paper shows that natural disasters may exacerbate the brain drain in developing countries by involving the migration of highly skilled people. Our results are robust to various model specifications, estimators and measures of disasters. We also find some heterogeneity of the relationship between natural disasters and migration across regions. Moreover, the results show that effect of natural disaster on migration is mainly driven by hydrological disasters.

The remainder of the paper is organized as follows. The next section presents the existing literature on the relationship between environmental issue and migration, also drawing on the literature related to the selection of migrants and the brain drain issue. Section 3 presents the empirical design. Section 4 presents the results concerning the relationship between natural disasters and migration, as well as between natural disasters and migration, with a focus on the education level. Finally, concluding remarks and implications are provided in the last section.

2. LITERATURE REVIEW

This paper aims to study the relationship between natural disasters closely associated to climate change and migration, with a particular interest in migrants' level of education. Therefore, we firstly draw on literature on the relationship between climate change, natural disasters and migration, before subsequently reviewing the brain drain literature.

2.1. Environmental issue and migration

There is little evidence concerning the relationship between climate events and migration, with existing literature being very mixed. A branch of studies use the urbanization rate to proxy internal migration and find that climate events positively affect internal migration in developing countries (Barrios *et al*., 2006; Marchiori *et al*., 2012; Beine and Parsons, 2012). For instance, Barrios *et al*. (2006) show that a decrease of 1% in rainfall increases the urbanization rate in sub-Saharan Africa by 0.45%. In the case of international migration, Munshi (2003) finds that a decrease in rainfall increases emigration from Mexico to the USA. Marchiori and Schumacher (2011) show theoretically that minor impacts of climate change have major impacts on the number of migrants. Reuveny and Moore (2009) argue that environmental decline plays a significant role in out-migration, with their results suggesting that a 1% increase in disaster produces an increase in migration between 0.011 and 0.014 percent. Finally, Marchiori *et al*. (2012) find that rainfall and temperatures anomalies led to the international migration of 5 million people between 1960 and 2000, which corresponds to 0.3 per thousand individuals each year.

Another trend of the literature suggests that natural disasters have no direct impact on international migration, yet a possible indirect effect through the wage differentials, for example (Beine and Parsons, 2012). Naude (2010) also found the absence of a direct relation between natural disasters and migration, showing that natural disasters only affect emigration in sub-Saharan Africa by increasing the risk of conflicts related to the scarcity of resources and by having a negative impact on the GDP. Based upon a descriptive analysis, Findlay (1994) finds no effect of drought on migration in Mali at an aggregate level. However, she finds some changes related to the destinations, with more internal than international migration. Drought also affects the composition of migrants, given that more women and children migrate. Finally, it also changes the duration of migration, with a higher rate of circular rather than permanent migration, above all for poorer families.

Other studies argue that natural disasters have a negative effect on migration. For instance, Halliday (2006) finds that one standard deviation increase in damage due to earthquake lowers the probability of migrating from El Salvador to the USA by 37.11%. The main explanation is that this disaster reduces savings and access to credits, which limits the available funds for migration.

In any case, the effect of environmental events is heterogeneous according to different factors such as countries' level of vulnerability (Stern, 2007; IPCC, 2012), the nature of disasters (see for instance Perch-Nielsen *et al*., 2008), the short- or long-term perspectives (Shah, 2010), as well as the socio-demographic variables such as age or gender (Hunter and David, 2011; Gray and Mueller, 2012).

2.2 Selection of migrants and brain drain issue in developing countries

Our paper also addresses the issue of the selection of migrants in the case of natural disasters. The skill selectivity of immigrants depends on many factors such as wages, migration policies, as well as cultural factors and geographical distance (Belot and Hatton, 2012). There are different views about the selection of migrants from developing countries. According to Borjas (1987), migrants are negatively selected in poor countries because less skilled immigrants have a higher propensity to migrate, while there are also higher returns to migration in these countries. Another trend in the literature finds that there is a positive or intermediate selection of migrants from developing countries (Chiquiar and Hanson, 2005, Orrenius and Zavodny, 2005). Mckenzie and Rapoport (2010) form a consensus of these two visions and argue that the type of selection depends on the size of the network. If it is small, the high migration costs can only be afforded by the most educated people. However, when the network becomes larger, this will reduce the migration costs, thus inducing a negative selection of immigrants. In any case, when it is mainly the high skilled people who migrate from developing countries, this is called brain drain.

The brain drain literature has undergone significant development since the 1960s.[4] The causes and above all the consequences of brain drain have been explored by different studies and continue to spark much interest from researchers. According to Docquier and Marfouk (2006), high skill migration from developing countries to the OECD countries has greatly increased since the 1990s. Indeed, this type of migration has doubled, whereas it increased by 30% for low skilled immigrants. This brain drain phenomenon is caused by both push and pulls factors. These determinants can be the economic conditions or the size of the countries, the geographic proximity, the human capital level in the origin countries, or the immigration polices (Docquier *et al*., 2007; Mayda, 2010). In terms of the consequences of brain drain, the

[4] See Docquier and Rapoport (2012) for a complete literature review about brain drain.

evidence is much more mixed. Early studies argue that brain drain does not imply losses in the origin countries because skilled migration is viewed as a public good (Grubel and Scott, 1966) and due to the perspective of remittances. However, there is no consensus in the literature that remittances compensate the negative consequences of brain drain. Some studies argue that it is not the case because high skilled migrants tend to remit less (Faini, 2007; Niimi, Ozden and Schiff, 2010), whereas other results suggest mixed evidence (Bollard *et al*., 2011). Further studies point to the negative consequences of brain drain such as inequality due to the technological gap that brain drain creates between developed and developing countries (Bhagwati and Hamada, 1974). More recently, a growing part of the literature finds that brain drain can have a net positive effect and can be profitable to the origin countries. This trend of the literature argues that since there are high expectations about the returns of migration, high skilled migration is a driver of human capital formation and leads to more investment in education in the origin countries (Beine *et al.*, 2001; Easterly and Nyarko, 2009; Batista *et al*., 2012). However, even if there is a net positive gain, the effect is heterogeneous across countries (Beine *et al.*, 2008) and can be different in a specific negative context in the origin countries. For instance, Bhargava and Docquier (2008) find that a high prevalence of HIV leads to more brain drain in the health sector. Therefore, the aim of the empirical part is to contribute to the literature about natural disasters and migration, the selection of migrants and the brain drain issue by analyzing who migrates abroad regarding education when developing countries have to deal with negative shocks such as natural disasters.

3. EMPIRICAL DESIGN

This section is devoted to developing the empirical framework. However, before presenting the data, the two main specifications showing the different relationships between natural disasters and migration are discussed.

3.1. Methodology

Firstly, the effect of natural disasters on migration rates is estimated using the following bilateral specification:

$$mig_{i,j,t} = \alpha_1 disaster_{i,t} + \alpha_{ki} X_{k,i,t} + \alpha_{kj} X_{k,j,t} + \mu_{ij} + \kappa_t + \varepsilon_{i,j,t} \quad (1)$$

Where $mig_{i,j,t}$ and $disaster_{i,t}$ are the migration from the country i to the country j at the period t and natural disaster variable for the country i at the period t, respective. $X_{k,i,t}$ is the vector of control variables of the source country and $X_{k,j,t}$ that of the destination country, as generally used in migration estimations. We use country OLS fixed effects, whereby μ_{ij} represents the bilateral country-pair fixed effects that control for the unobservable characteristics between the origin and receiving countries. As previously mentioned, migration and above all high skilled migration has increased during the period studied. The figures of the trends of natural disasters show that migration stocks present an upward continuous trend for each region, except Europe and central Asia, which report a decrease prior to 1990 and an increase thereafter. The number of natural disasters also displays increasing trends for all regions.[5] Moreover, "regular" natural disasters are likely to happen in each country. Therefore, to avoid our results being driven by these elements, we control for year fixed effects using the variable κ_t . Finally, the unexplained residual is captured by $\varepsilon_{i,t}$.

Secondly, the analysis is specified by taking into account migration rates according to the education levels. We are interested in this point because we assume that natural disasters may affect the migration of people who are more educated or more skilled. This is because they often reflect those who get a job and a salary and thus have the means to go abroad, be safe and provide insurance for their family back in the affected country. With respect to policy implications, natural disasters can induce a brain drain, whose effects will be more serious in this context, within which countries require vast support for rebuilding and have a

[5] See the figures showing the trends of natural disasters and stocks of migrants of low and lower middle income countries in Appendix B available on the website of the journal.

special need for skilled workers. We assume that this effect is higher for the most highly educated. Therefore, we have a similar specification as in equation (1), except that the dependent variable $migeduc^{e}_{i,j,t}$ is the migration rate associated with each educational level e (e= low, medium and high educational levels). The model is given in Equation (2):

$$migeduc^{e}_{i,j,t} = \alpha^{e}_{1} disaster_{i,t} + \alpha^{e}_{ki} X_{k,i,t} + \alpha^{e}_{kj_{kj}} X_{k,j,t} + \mu_{ij} + \kappa_{t} + \varepsilon^{e}_{i,j,t} \qquad (2)$$

3.2. Data

This paper aims to assess the effect of natural disasters mainly determined by climate change on global migration rates, as well as according to the level of education. This relationship is investigated by using bilateral panel data with pair-country as the unit of observations, based upon 67 developing countries. As dependent variables, we use the bilateral Panel Data on International Migration of Schiff and Sjöblom (2008) (World Bank Databases)[6], which measures international migration from 1975 to 2000 concerning the six main destination countries: Australia, Canada, France, Germany, the United Kingdom and the United States. They measure emigration rates through the stocks of migrants from sending countries to these countries for three educational levels, namely low, medium and high, divided by the stock of adults (older than 25) corresponding to the same educational level in the country of origin, plus the stock of migrants of sending countries. In order to have the migration rate as a flow variable, we use the difference between two periods divided by the population of the country of origin plus the migrant stock. We multiply this rate by 1,000 and thus consider the migration rate for each 1,000 inhabitants. The data set uses the same methodology as Defoort (2008). We prefer this database to that produced by Docquier and Marfouk (2006); the latter uses the same measure, albeit for all OECD countries in 1990 and 2000, whereas the data that we are using has a larger temporal dimension and thus more observations.

[6]http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:21866422~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html

For the climate change indicators representing the variables of interest, we use the Centre for Research on the Epidemiology of Disaster (CRED) data (2010), which give information from 1900 to 2010. We use a dummy variable taking a value of 1 if the country experienced natural disasters in the five year period. We only keep natural disasters that were likely to be caused by climate change. Thus, we focus on meteorological disasters (storms), hydrological disasters (floods and other wet mass movements) and climatological disasters (drought, wildfire and extremely high temperatures).

We control for the additional explanatory variables that can influence migration (see Table 1 for the summary statistics)[7]. These variables are considered as push or pull factors of migration. Therefore, we control for the GDP of the source countries, as well as that of the destination countries, measuring their development level. This also allows measuring the economic conjuncture of the countries. In fact, this variable provides information about some economic indicators such as the unemployment rate or the fiscal deficit. Moreover, climate factors affect GDP (Dell *et al*., 2009), which in turn can influence migration. Nonetheless, given that panel data are used in this study, the changes over time capture variation in the GDP and subsequently give an idea about the evolution of the economic performance. We also consider the dynamics of the population in terms of migration. The demographic pressure is measured through variables such as the population density, the total population of source and destination countries, which is another indicator of the country's size. Following previous studies such as Barrios *et al*. (2006), Marchiori *et al*. (2012) and Beine and Parsons (2012), we control for the internal migration by including the urbanization rate in our estimation. This is also useful to capture the migration of the poorest population and the low skilled people who are more likely to migrate internally than internationally. We control for the availability of arable land, which captures the economic opportunities of a country,

[7] For the definition and sources of variables, see Appendix C available on the website of the journal.

primarily in developing countries, where agriculture is the main activity. We include in our estimations the quality of the institutional situation in the country through political rights and civil war variables, which lead to the widespread displacement of population. Finally, we capture average rainfall and temperature variables to control for normal climatic conditions.[8]

4. RESULTS

4.1. Natural disasters and migration rate

We conduct analysis for low and lower middle income countries (See list of developing countries below). Table 2 shows the results of the effect of natural disasters on the overall migration rate. All regressions include pair-country fixed effects and period dummies. Column 1 of Table 2 shows the plain correlation between the natural disaster dummy and the migration rate without any control variable. Natural disaster is significant at a 10% level and has a positive sign. In Column 2 of Table 2, we introduce the most exogeneous control variables, namely the logarithm of the average rainfall and temperature, the percentage of arable land and the variable measuring the quality of a country's institutions. While none of these variables is significant, the effect of natural disasters on the migration rate remains significant and positive. Nonetheless, the magnitude of the coefficient significantly increases, from 0.560 to 0.705, indicating that weather variables, arable land and institutions' quality contribute to explaining the relationship between natural disaster and migration. In Column 3, we control for the occurrence of a civil war over the period studied, the size of the population of origin and destination, the urban population and the population density in the origin country. The positive effect of natural disaster persists and it becomes significant at a level of 5%. In Column 4 of Table 2, we add as controls the lagged of the log GDP in the origin and the destination countries, because these variables are supposed to be more exogeneous than

[8] We thank one of the referees for this suggestion.

the log of the current GDP.[9] The results are very similar to the previous one. Finally, the results also remain robust to the inclusion of the log GDP in the origin and the destination countries in Column 5 of Table 2.

Similar results have been obtained in the literature with different indicators of natural disasters and migration variables. Using the logarithm of the total number of people affected by weather-related natural disasters in the origin country as variable of interest and the logarithm of the number of people who migrated from the country of origin as dependent variable, Reuveny and Moore (2009) found that natural disasters cause international migration with an elasticity ranging from 0.011 to 0.014. However, Beine and Parsons (2012) find little or no support for any relationship between short- and long-run climatic factors on international migration. They recognize that their results do not necessarily imply that climate factors have no effect on migration. They also highlight that environmental events influence international migration through other channels such as wage differentials. Similarly, Naudé (2010) found that the total number of natural disasters mainly affects international net migration through conflict and job opportunities.

4.2. **The effect of natural disasters on migration according to the education level.**

The effect of natural disasters on the migration of high educated people is presented in Table 3. We conduct the same analysis as those in Table 2, albeit only for the high educated people. The simple correlation between the natural disaster dummy and the emigration rate of high educated people is positive but not significant. Once we control for the most exogeneous variables (Column 2 of Table 3), namely the occurrence of the civil war and the population variables (Column 3 of Table 3) as well as the lagged GDP in the origin and the destination countries (Column 4 of Table 3), the coefficient becomes positive and significant at a 5% level. The magnitude of the coefficient shows that over a five-year period, 5.917 per 1,000

[9] Following the referee's suggestion, we also estimate our main model specification by allowing country-specific time trend. Although the associated fall in degrees of freedom decreases the efficiency of the point estimates, the results are largely similar. Results are available upon request.

inhabitants with a high education level each year leave a country that experienced natural disasters. The results are also robust when we control for the current GDP (Column 5 of Table 3). Tables 4 and 5 show the results of same estimates as in Table 2, but for the low and medium educated people, respectively. The sign of the natural disaster dummy variable remains positive in all estimates, except in Column 1 of Table 5, where it is negative. However the coefficient is not significant in any of these estimates. Overall, our results suggest that only individuals with a high level of education migrate when a natural disaster occurs.

In Table 2, the magnitude of the coefficient indicates that over a five-year period, between 0.56 and 0.814 per 1,000 inhabitants each year leave a country that experienced natural disasters for the overall population. Comparing the magnitude of the coefficients of natural disaster in Column 4 to that of the population of origin, it appears that a 1% increase in the population of origin will reduce the migration rate by about 0.08 per 1,000 inhabitants over a five-year period. The population of destination will increase the migration rate by similar level. If we refer to the coefficients of the GDP, our results show that a 1% increase in the GDP of destination increases the overall migration rate by 0.055 per 1,000 inhabitants. However, when the high educated population is considered in Table 3, the coefficient of natural disasters is multiplied by more than eight, while those of the population of origin and destination are not statistically significant. A 1% rise in the GDP of origin reduces the migration rate by 0.069 per 1,000 inhabitants, while a 1% rise in the GDP of destination increases the migration rate by 0.28 per 1,000 inhabitants. While we do not find any effect of civil war on the overall migration rate, our results show that the occurrence of a civil war increases migration rate of those high educated by between 3.7 and 4.3 per 1,000 inhabitants. Therefore, the effect of civil war on the high educated migration is slightly smaller than the effect of natural disaster.

Why should natural disasters increase the migration of high educated people, and not the migration of low or medium educated people? Our result can be explained by the cost of migration and the liquidity constraints faced by the less wealthy people, given that skilled people are less likely to be unemployed and thus can more easily support migration costs. For instance, (Halliday, 2006) makes the link between natural disasters, wealth and migration, suggesting that even if earthquakes slow migration independently of the level of wealth, liquidity constraints remain an important factor because wealthier households have a higher probability of migration. If we refer to our analysis, this supports the assumption that the most educated people, who are supposedly also wealthier, would migrate more easily than those less educated. However, there is the counter-argument that less educated people are more vulnerable to the consequences of natural disasters and thus might use migration as a coping mechanism. We assume that even if less educated people migrate, they would migrate internally or to those countries closest to them (see for instance Beine and Parsons, 2012), and not necessarily toward the main OECD receiving countries. In our estimates, we control for the share of the urban population, which is a proxy of this internal migration, whereby the result of the natural disaster dummy for low and medium educated people remains non-significant. Moreover, we assume that, due to their skills, high educated people can more easily obtain legitimate documents to enter host countries. Therefore, it is likely that migration policies could generally be more tolerant to skilled workers and migrants are integrated more easily in the job market of the receiving countries if they are qualified. This seems particularly true in the case of negative shocks such as natural disasters. Accordingly, natural disasters due to climate change may heighten the brain drain phenomenon in developing countries just when they need the most skilled and qualified people to deal with the damage caused. However, at the same time, our results suggest a consensus between the views that migration is a failure or an adaptive strategy. Since the most skilled people leave when the developing countries have to deal with negative climate shocks, this can be interpreted as a failure strategy. Nevertheless, if those people send remittances, it can mitigate the losses due to the brain drain, which can be only assimilated to an adaptive strategy if the effect of remittances truly compensates the costs of brain drain.

4.3. **Robustness checks: GMM System estimates of the relationship between natural disasters and migration**

In order to test the robustness of our results, following Naude (2010), we use the GMM system estimator (Blundel and Bond, 1998) to estimate the relationship between the natural disaster dummy on the overall migration rate (Columns 1 and 2 of Table 6) and the migration rate of the high educated people (Columns 3 and 4 of Table 6). We also use the two-step estimator which performs better than the one step estimator, according to the literature (Windmeijer, 2005). The Hansen test of overidentification restrictions (p=0.377 for Columns 1 and 2 and p=0.875 for Columns 3 and 4 of Table 6) and the Arellano-Bond test for second order autocorrelation (p=0.772 for Columns 1 and 2 and p=0.315 for Columns 3 and 4 of Table 6) do not allow rejecting the hypothesis concerning the validity of the lagged variables in level and in difference as instruments, nor the hypothesis of no second order autocorrelation. The results regarding the natural disaster dummy are significant for both the overall migration rate and the migration rate of high educated people. However, while the magnitude of the coefficient associated with the natural disaster dummy is close to that found in Table 3 for high educated people, the size of the coefficient associated with the natural disaster in the estimates regarding the overall migration rate is slightly smaller. Therefore, a more conservative approach would consider that over a five-year period, 0.437 per 1,000 inhabitants each year leave a country that experienced natural disasters.

4.4. **The effect of natural disasters migration rate according to the geographical location**

It has been shown in the literature that there is significant heterogeneity across regions in terms of the brain drain phenomenon (Docquier, Lowell and Marfouk, 2009). Moreover, even if natural disasters affect all countries, it is interesting to test whether people's behavior regarding migration depends on the country's geographical location. Table 7 presents the results for the overall population regardless the level of education, while Table 8 details the results for the high educated population. The variable of interest is the natural disaster dummy and some interaction terms between the natural disaster variable and geographical dummies. [10] Although we do not find any significant effect for the East Asia and Pacific (EAP) (Column 2 of Table 7) and Middle East and North Africa (MENA) (Column 5 of Table 7) regions, our results show that there is a negative relationship between the interaction term between natural disaster dummy and the variable sub-Saharan Africa (SSA) (Column 1 of Table 7), Europe and Central Asia (ECA) (Column 3 of Table 7) and South Asia (SA) (Column 6 of Table 7) and the migration variable. These findings mean that people from these three regions will migrate less due to the occurrence of natural disasters compared to people from other regions. The effect is positive for Latin America and Caribbean (LAC) (Column 4 of Table 7), where we observe an increasing migration rate due to natural disasters, compared to other regions.

For the high educated population, the results in Table 8 show that there is no difference between regions in the relation linking natural disasters to migration, with the exception of for SSA (Column 1 of Table 8). For this region, we find a significant and negative relationship between the interaction term between natural disaster dummy and the variable SSA and the migration rate of high educated people. This finding means that high educated people from SSA will migrate less due to the occurrence of natural disasters, compared to people from the other regions.

[10] We do not run the estimations for each sub-region dummy because of their low sample size.

4.5. **Natural disasters and migration according to the type of disasters**

In Tables 9 and 10, we use the sub-components of natural disasters as variables of interest and conduct our analysis for the overall migration rate and the migration rate of the high educated people, respectively. The variables of interest are the hydrological disaster dummy (Columns 1 and 2 of Tables 9 and 10), the climatological disaster dummy (Columns 3 and 4 of Tables 9 and 10) and the meteorological disaster dummy (Columns 5 and 6 of Tables 9 and 10), respectively. In Table 9, we show the results of the effect of the disaggregated variables on the overall migration rate. We find that the hydrological disaster dummy has a significant and positive effect on migration in the estimates with and without controls. The climatological disaster dummy is positively correlated with the migration rate. Once we add the control variables to the estimates, the positive effect remains, although the parameter of interest is not precisely estimated. The meteorological disaster dummy has a negative sign, but the coefficients are not statistically significant in any of the estimates. Our result suggest that for flood and mass movement included in hydrological events, people have less possibilities to stay and thus have to migrate. Put differently, other alternatives to deal with the environmental shocks are less available for hydrological disasters compared to other types of events. In Table 10, the significant and positive relationship between the hydrological disaster dummy and the migration rate is also confirmed for the highly educated people (Column 2 of Table 10). The climatological and meteorological components of natural disasters are positive but not significant. To summarize, our findings suggest that the impacts of natural disasters on the migration rate of the overall population and for high educated people are mainly driven by hydrological disasters.

5. CONCLUDING REMARKS AND IMPLICATIONS

This paper assesses the relationship between natural disasters closely related to climate change and migration by examining migration rates and levels of education. Results from a fixed effects estimator show that natural disasters have a significant and positive effect on migration rates. We also find that the effect differs according to educational levels, with natural disasters only having an effect on the migration of people with a high level of education. We find some differences in the migration behavior across regions, while a more detailed analysis also shows that the impacts of natural disaster on migration are mainly driven by the hydrological disasters. Our results are robust to various model specifications, estimators and measures of disasters.

Overall, our study highlights the fact that the relationship between environmental issue and migration is among the main challenges of the twenty-first century for all countries in general, and particularly for developing countries. The poorest countries have to cope with the economic consequences of climate change and natural disasters, which weaken states and reduce their ability to provide opportunities and services to help people to become less vulnerable, above all if those people already live in marginalized areas. As well as their poverty, developing countries are in a disadvantageous situation due to their rapid population growth, massive urbanization and geographical environment, which make them more vulnerable and less able to adapt to climate change (Stern, 2007). Indeed, low adaptive capacity increases vulnerability, social and economic costs, which affect these areas' human capital and development levels, constituting transmission channels for migration. Therefore, the migration of high educated people in this context may exaggerate or on the contrary attenuate the negative consequences of environmental shocks.

One of the important implications of our study is that the migration of high skilled people due to natural disasters can be interpreted as both a failure strategy and an adaptive response to migration in this context. It is a failure strategy because when developing countries are facing such events, they need all their financial and human resources to deal with the consequences. Therefore, developing countries may face equity issues due to the brain drain effect and the loss of qualifications and skills, just when they are at their most vulnerable. On the other hand, it can be interpreted as an adaptive response if these migrants send remittances that cover the costs of the brain drain. Therefore, this paper opens some avenues for future research to ascertain how remittances can compensate the negative consequences of the migration of high skilled workers in a context of environmental shocks.

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LIST OF DEVELOPING COUNTRIES:

Afghanistan, Albania, Armenia, Burundi, Benin, Bangladesh, Belize, Bolivia, Central African Republic, China, Côte d'Ivoire, Cameroon, Congo Republic, Ecuador, Egypt Arab Republic, Ghana, The Gambia, Guatemala, Guyana, Honduras, Haiti, Indonesia, India, Iran Islamic Republic, Iraq, Jordan, Kenya, Kyrgyzstan, Cambodia, Lao PDR, Liberia, Sri Lanka, Lesotho, Morocco, Maldives, Mali, Myanmar, Mongolia, Mozambique, Mauritania, Malawi, Niger, Nicaragua, Nepal, Pakistan, Philippines, Papua New Guinea, Paraguay, Rwanda, Sudan, Senegal, Sierra Leone, El Salvador, Swaziland, Syria, Togo, Thailand, Tajikistan, Tonga, United Republic of Tunisia, Tanzania, Uganda, Ukraine, Viet Nam, Yemen, Zambia, Zimbabwe.

Table 1: Summary Statistics

Variables	Mean	SD	Min	Max	Observations
Migration rate	1.349	7.077	-6.492	130.799	1,946
Migration high educated	13.217	41.987	-240.801	506.332	1,946
Migration low educated	1.25	11.326	-94.347	293.694	1,946
Migration medium educated	2.763	23.227	-494.443	518.343	1,946
Natural Disaster Dummy	0.782	0.413	0	1	1,946
Hydrological Disaster Dummy	0.634	0.482	0	1	1,946
Meteorological Disaster Dummy	0.331	0.471	0	1	1,946
Climatological Disaster Dummy	0.478	0.500	0	1	1,946
Log Rainfall	8.345	0.460	5.884	9.635	1,916
Log Temperature	5.476	0.662	0.095	5.848	1,916
Arable land percentage	14.443	13.034	0.192	72.124	1,922
Institutions quality	5.147	1.686	1	7	1,878
Civil War	0.271	0.445	0	1	1,946
Log Population Origin	15.952	1.68	11.442	20.939	1,946
Log Population Destination	17.83	0.859	16.48	19.435	1,946
Urban Population	32.61	16.087	3.891	79.231	1,946
Population Density	91.27	137.418	1.035	958.607	1,946
Log GDP origin	8.341	1.742	3.687	13.831	1,894
Log GDP Destination	13.663	1.037	11.812	15.98	1,946

Table 2: Natural disasters and migration rate

	Dependent Variable: Overall migration rate				
	(1)	(2)	(3)	(4)	(5)
Natural Disaster Dummy	0.560*	0.705*	0.820**	0.787**	0.814**
	(0.334)	(0.369)	(0.402)	(0.385)	(0.401)
Log Rainfall		0.257	0.165	0.241	0.109
		(0.239)	(0.203)	(0.205)	(0.199)
Log Temperature		-0.352	-0.678	-0.848	-0.947*
		(0.275)	(0.492)	(0.550)	(0.531)
Arable Land Percentage		-0.074	0.030	0.031	0.059
		(0.064)	(0.053)	(0.057)	(0.059)
Institutions Quality		-0.033	-0.034	-0.020	-0.026
		(0.072)	(0.069)	(0.068)	(0.067)
Civil War			0.131	0.102	0.080
			(0.321)	(0.325)	(0.321)
Log Population Origin			-8.188*	-7.993*	-8.477*
			(4.577)	(4.552)	(4.636)
Log Population Dest.			6.574**	8.018**	11.957***
			(2.861)	(3.172)	(4.538)
Urban Population			-0.027	-0.025	-0.026
			(0.070)	(0.069)	(0.070)
Population Density			-0.000	0.002	0.001
			(0.003)	(0.003)	(0.003)
Log GDP Origin (lag)				-0.580*	
				(0.328)	
Log GDP Dest. (lag)				1.310**	
				(0.636)	
Log GDP Origin					-0.468
					(0.297)
Log GDP Dest.					5.511***
					(1.870)
Constant	1.219***	1.088	18.968	-25.618	-145.641**
	(0.279)	(3.534)	(48.010)	(43.489)	(6.207)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes
N	402	396	396	396	396
Number of pair countries	1,946	1,848	1,848	1,830	1,824
R square within	0.019	0.020	0.049	0.053	0.067

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Natural disasters and migration of high educated people

	Dependent Variable: Migration rate of high educated people				
	(1)	(2)	(3)	(4)	(5)
Natural Disaster Dummy	2.210	4.845**	5.067**	5.917**	4.218*
	(2.454)	(2.401)	(2.360)	(2.316)	(2.381)
Log Rainfall		1.749	0.530	0.221	0.582
		(1.825)	(1.853)	(1.763)	(1.895)
Log Temperature		0.415	1.028	0.740	-2.834
		(1.358)	(2.609)	(2.482)	(2.276)
Arable Land Percentage		-0.133	-0.173	0.414	-0.280
		(0.651)	(0.551)	(0.415)	(0.567)
Institutions Quality		-0.515	-0.587	-0.405	-0.560
		(0.361)	(0.367)	(0.371)	(0.365)
Civil War			4.357***	4.322***	3.728***
			(1.514)	(1.503)	(1.378)
Log Population Origin			-0.800	1.861	-0.822
			(25.818)	(26.620)	(25.763)
Log Population Dest.			-29.901	-26.365	-5.758
			(26.696)	(27.685)	(27.743)
Urban Population			0.492	0.467	0.465
			(0.315)	(0.310)	(0.317)
Population Density			0.012	0.054*	0.036*
			(0.015)	(0.029)	(0.021)
Log GDP Origin (lag)				-3.136	
				(1.911)	
Log GDP Dest. (lag)				-2.663	
				(5.840)	
Log GDP Origin					-6.854**
					(2.758)
Log GDP Dest.					28.404***
					(7.395)
Constant	12.567***	-4.665	528.734*	473.822	-224.707
	(1.882)	(21.001)	(280.785)	(320.731)	(335.382)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes
N	1,946	1,848	1,848	1,830	1,824
Number of pair countries	402	396	396	396	396
R square within	0.007	0.013	0.019	0.024	0.035

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Natural disasters and migration of low educated people

	Dependent Variable: Migration rate of low educated people				
	(1)	(2)	(3)	(4)	(5)
Natural Disaster Dummy	0.514	1.024	1.038	0.997	1.003
	(1.000)	(1.054)	(1.036)	(1.061)	(1.029)
Log Rainfall		-2.055	-1.892	-1.799	-1.946
		(1.956)	(1.970)	(1.969)	(1.960)
Log Temperature		-0.335	-0.385	-0.632	-0.682
		(0.468)	(0.509)	(0.520)	(0.493)
Arable Land Percentage		-0.009	0.100	0.111	0.126
		(0.304)	(0.341)	(0.364)	(0.380)
Institutions Quality		-0.239	-0.270	-0.253	-0.271
		(0.206)	(0.207)	(0.207)	(0.211)
Civil War			0.884	0.838	0.830
			(1.135)	(1.138)	(1.157)
Log Population Origin			-2.783	-2.591	-3.070
			(3.447)	(3.510)	(3.638)
Log Population Dest.			16.538***	18.226***	21.028*
			(6.275)	(6.194)	(10.957)
Urban Population			-0.192*	-0.188	-0.186*
			(0.113)	(0.114)	(0.112)
Population Density			0.009	0.012*	0.012*
			(0.006)	(0.007)	(0.007)
Log GDP Origin (lag)				-0.824*	
				(0.445)	
Log GDP Dest. (lag)				1.506*	
				(0.892)	
Log GDP Origin					-0.562
					(0.518)
Log GDP Dest.					4.327
					(4.896)
Constant	2.351*	21.894	-229.185*	-271.384**	-360.197
	(1.216)	(20.430)	(124.386)	(117.781)	275.045
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes
N	1,946	1,848	1,848	1,830	1,824
Number of pair countries	402	396	396	396	396
R square within	0.015	0.014	0.020	0.021	0.022

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Natural disasters and migration of medium educated people

	Dependent Variable: Migration rate of medium educated people				
	(1)	(2)	(3)	(4)	(5)
Natural Disaster Dummy	-0.588	1.126	1.289	1.341	1.299
	(1.493)	(0.846)	(0.888)	(0.907)	(0.889)
Log Rainfall		-0.270	-0.483	-0.581	-0.538
		(0.985)	(1.031)	(1.041)	(1.038)
Log Temperature		-0.544	-0.945	-0.849	-1.065
		(0.506)	(0.670)	(0.668)	(0.704)
Arable Land Percentage		-0.096	0.022	0.042	0.032
		(0.122)	(0.113)	(0.119)	(0.117)
Institutions Quality		0.311	0.307	0.309	0.315
		(0.208)	(0.205)	(0.207)	(0.203)
Civil War			0.561	0.572	0.531
			(0.583)	(0.592)	(0.565)
Log Population Origin			-10.305**	-10.531**	-10.643**
			(4.518)	(4.624)	(4.420)
Log Population Dest.			11.345***	11.401***	30.323***
			(4.066)	(4.022)	(8.562)
Urban Population			0.005	0.007	0.001
			(0.078)	(0.078)	(0.076)
Population Density			-0.002	0.000	-0.001
			(0.003)	(0.004)	(0.004)
Log GDP Origin (lag)				0.179	
				(0.404)	
Log GDP Dest. (lag)				-0.089	
				(1.138)	
Log GDP Origin					-0.154
					(0.439)
Log GDP Dest.					19.108***
					(4.978)
Constant	1.474	4.905	-25.781	-30.035	-628.929***
	(1.030)	(11.008)	(56.499)	(67.341)	(170.664)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes
N	1,946	1,848	1,848	1,830	1,824
Number of pair countries	402	396	396	396	396
R square within	0.003	0.002	0.034	0.034	0.067

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Robustness check: GMM System estimates of the relationship between natural disasters and migration

	Dependent Variable: Overall migration rate		Dependent Variable: Migration rate of high educated people	
	Coef.	Standard error	Coef.	Standard error
	(1)	(2)	(3)	(4)
Overall migration rate (lag)	0.947***	(0.130)	0.720***	(0.107)
Natural Disaster Dummy (lag)	0.437*	(0.261)	6.858*	(3.989)
Log Rainfall	-0.042	(0.266)	-2.414	(2.199)
Log Temperature	0.050	(0.183)	0.802	(1.457)
Arable Land Percentage	0.014	(0.027)	0.035	(0.193)
Institutions Quality	0.026	(0.068)	-0.427	(0.508)
Civil War (lag)	-0.245	(0.444)	-6.973	(4.510)
Log Population Origin (lag)	-0.337	(0.506)	0.808	(4.654)
Log Population Dest. (lag)	0.617	(1.326)	38.339***	(14.344)
Urban Population (lag)	-0.000	(0.018)	-0.106	(0.168)
Population Density (lag)	-0.000	(0.001)	0.001	(0.013)
Log GDP Origin (lag)	0.006	(0.263)	-2.416	(2.694)
Log GDP Dest. (lag)	-1.302	(1.449)	-49.224***	(17.279)
Constant	12.226	(10.964)	37.003	(91.236)
Time Dummies	Yes		Yes	
N	1,460		1,460	
Number of pair countries	380		380	
Number of instruments	25		25	
	chi2(9) = 9.68		chi2(9) = 4.51	
Hansen test of overid. restrictions	Prob > chi2= 0.377		Prob > chi2 = 0.875	
Arellano-Bond test for second-order autocorrelation	z = -0.29 Pr > z = 0.772		z = 1.00 Pr > z = 0.315	

Table 7: Natural disasters and migration according to the geographical level

	Dependent Variable: Overall migration rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Natural Disaster Dummy	1.504*	0.878**	0.846**	0.192*	0.764*	0.835**
	(0.766)	(0.421)	(0.414)	(0.099)	(0.418)	(0.409)
(Natural Disaster)x(SSA)	-1.402*					
	(0.769)					
(Natural Disaster)x(EAP)		-0.732				
		(0.534)				
(Natural Disaster)x(ECA)			-2.456*			
			(1.439)			
(Natural Disaster)x(LAC)				5.417*		
				(3.031)		
(Natural Disaster)x(MENA)					0.131	
					(0.351)	
(Natural Disaster)x(SA)						-0.833*
						(0.468)
Log Rainfall	0.291	0.238	0.222	0.065	0.245	0.220
	(0.208)	(0.206)	(0.204)	(0.188)	(0.205)	(0.204)
Log Temperature	-1.060*	-0.669	-0.882	-0.642	-0.846	-0.865
	(0.642)	(0.553)	(0.566)	(0.466)	(0.552)	(0.556)
Arable Land Percentage	0.019	0.043	0.028	0.003	0.033	0.031
	(0.054)	(0.059)	(0.056)	(0.050)	(0.056)	(0.056)
Institutions Quality	-0.032	-0.016	-0.022	-0.017	-0.021	-0.021
	(0.070)	(0.068)	(0.068)	(0.067)	(0.068)	(0.068)
Civil War	0.056	0.120	0.088	0.000	0.101	0.093
	(0.328)	(0.330)	(0.327)	(0.320)	(0.325)	(0.325)
Log Population Origin	-7.799*	-7.954*	-8.225*	-5.568	-8.042*	-8.012*
	(4.449)	(4.545)	(4.670)	3.567	(4.534)	(4.559)
Log Population Dest.	8.018**	8.018**	8.018**	8.018**	8.018**	8.018**
	(3.156)	(3.173)	(3.171)	(3.111)	(3.173)	(3.171)
Urban Population	-0.027	-0.022	-0.026	-0.030	-0.024	-0.025
	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)
Population Density	0.001	0.002	0.002	0.000	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log GDP Origin (lag)	-0.549*	-0.570*	-0.623*	-0.617*	-0.578*	-0.590*
	(0.320)	(0.327)	(0.342)	(0.334)	(0.329)	(0.331)
Log GDP Dest. (lag)	1.310**	1.310**	1.310**	1.310**	1.310**	1.310**
	(0.642)	(0.637)	(0.640)	(0.629)	(0.636)	(0.633)
Constant	-27.934	-27.487	-21.244	-62.706	-24.930	-24.927
	(43.518)	(43.521)	(45.155)	(41.830)	(43.364)	(43.705)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1,830	1,830	1,830	1,830	1,830	1,830
Number of pair countries	396	396	396	396	396	396
R square within	0.077	0.074	0.073	0.088	0.074	0.073

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Natural disasters, migration and education according to the geographical level

	Dependent Variable: migration rate of high educated people					
	(1)	(2)	(3)	(4)	(5)	(6)
Natural Disaster Dummy	10.374**	4.076***	5.983**	4.438**	6.750**	5.662**
	(4.155)	(1.515)	(2.377)	(2.205)	(2.756)	(2.385)
(Natural Disaster)x(SSA)	-8.710**					
	(3.950)					
(Natural Disaster)x(EAP)		14.670				
		(12.562)				
(Natural Disaster)x(ECA)			-2.719			
			(6.148)	13.465		
(Natural Disaster)x(LAC)				(9.955)		
(Natural Disaster)x(MENA)					-4.887	
					(3.262)	
(Natural Disaster)x(SA)						4.362
						(4.963)
Log Rainfall	0.532	0.288	0.199	-0.217	0.071	0.330
	(1.753)	(1.763)	(1.772)	(1.795)	(1.762)	(1.779)
Log Temperature	-0.577	-2.856	0.703	1.253	0.633	0.829
	(2.536)	(3.735)	(2.543)	(2.476)	(2.446)	(2.496)
Arable Land Percentage	0.341	0.186	0.411	0.344	0.362	0.416
	(0.410)	(0.391)	(0.415)	(0.421)	(0.408)	(0.415)
Institutions Quality	-0.479	-0.497	-0.407	-0.398	-0.385	-0.402
	(0.383)	(0.394)	(0.372)	(0.371)	(0.369)	(0.372)
Civil War	4.039***	3.958***	4.307***	4.069***	4.345***	4.367***
	(1.456)	(1.412)	(1.515)	(1.492)	(1.512)	(1.501)
Log Population Origin	3.071	1.073	1.605	7.890	3.677	1.958
	(26.540)	(26.421)	(27.082)	(27.516)	(27.360)	(26.634)
Log Population Dest.	-26.365	-26.365	-26.365	-26.365	-26.365	-26.365
	(27.657)	(27.653)	(27.699)	(27.578)	(27.653)	(27.695)
Urban Population	0.452	0.419	0.465	0.454	0.458	0.468
	(0.310)	(0.305)	(0.312)	(0.308)	(0.306)	(0.310)
Population Density	0.050*	0.051*	0.054*	0.051*	0.053*	0.053*
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Log GDP Origin (lag)	-2.943	-3.331*	-3.183*	-3.227*	-3.200*	-3.085
	(1.897)	(1.907)	(1.893)	(1.934)	(1.930)	(1.925)
Log GDP Dest. (lag)	-2.663	-2.663	-2.663	-2.663	-26.365	-2.663
	(5.819)	(5.768)	(5.842)	(5.851)	(27.653)	(5.842)
Constant	459.433	511.297	478.664	381.620	448.157	470.204
	(319.623)	(332.058)	(323.541)	(304.921)	(316.409)	(321.548)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1,830	1,830	1,830	1,830	1,830	1,830
Number of countries	396	396	396	396	396	396
R square within	0.028	0.029	0.024	0.028	0.025	0.024

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Natural disasters and migration according to the type of disasters

	Dependent Variable: Overall migration rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Hydrological Disaster Dummy	0.599**	0.910**				
	(0.294)	(0.428)				
Climatological Disaster dummy			0.415*	0.385		
			(0.241)	(0.240)		
Meteorological Disaster dummy					-0.454	-0.148
					(0.386)	(0.250)
Log Rainfall		0.309		0.484*		0.497*
		(0.215)		(0.256)		(0.260)
Log Temperature		-0.769		-0.902		-0.697
		(0.525)		(0.578)		(0.558)
Arable Land Percentage		-0.010		0.043		0.027
		(0.051)		(0.060)		(0.056)
Institutions Quality		-0.014		-0.010		-0.015
		(0.067)		(0.067)		(0.068)
Civil War		0.046		0.107		0.081
		(0.325)		(0.327)		(0.333)
Log Population Origin		-8.179*		-7.673*		-7.501*
		(4.597)		(4.446)		(4.429)
Log Population Dest.		8.018**		8.018**		8.018**
		(3.171)		(3.184)		(3.190)
Urban Population		-0.029		-0.029		-0.031
		(0.070)		(0.070)		(0.072)
Population Density		0.002		0.001		0.001
		(0.004)		(0.003)		(0.003)
Log GDP Origin (lag)		-0.634*		-0.640*		-0.678*
		(0.340)		(0.340)		(0.356)
Log GDP Dest. (lag)		1.310**		1.310**		1.310**
		(0.643)		(0.632)		(0.633)
Constant	1.254***	-22.532	1.481***	-31.654	1.815***	-34.792
	(0.198)	(44.853)	(0.121)	(42.091)	(0.198)	(41.604)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1,946	1,830	1,946	1,830	1,946	1,830
Number of pair countries	402	396	402	396	402	396
R square within	0.02	0.056	0.019	0.05	0.018	0.047

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Natural disasters, migration and education according to the type of disasters

	Dependent Variable: Migration rate of high educated people					
	(1)	(2)	(3)	(4)	(5)	(6)
Hydrological Disaster Dummy	3.066	5.145**				
	(2.012)	(2.019)				
Climatological Disaster dummy			0.514	0.701		
			(1.084)	(1.126)		
Meteorological Disaster dummy					1.757	0.953
					(1.664)	(1.281)
Log Rainfall		1.025		1.950		1.723
		(1.771)		(1.845)		(1.805)
Log Temperature		1.322		1.055		0.776
		(2.510)		(2.588)		(2.495)
Arable Land Percentage		0.173		0.415		0.391
		(0.432)		(0.428)		(0.416)
Institutions Quality		-0.360		-0.357		-0.367
		(0.363)		(0.363)		(0.363)
Civil War		3.936***		4.109***		3.909***
		(1.447)		(1.433)		(1.426)
Log Population Origin		1.581		4.790		4.429
		(27.066)		(26.910)		(26.743)
Log Population Dest.		-26.365		-26.365		-26.365
		(27.730)		(27.808)		(27.812)
Urban Population		0.429		0.418		0.407
		(0.307)		(0.309)		(0.309)
Population Density		0.054*		0.051*		0.051*
		(0.029)		(0.029)		(0.029)
Log GDP Origin (lag)		-3.629*		-3.818*		-3.909**
		(1.942)		(1.964)		(1.988)
Log GDP Dest. (lag)		-2.663		-2.663		-2.663
		(5.883)		(5.889)		(5.890)
Constant	12.239***	477.829	14.059***	421.758	13.630***	432.355
	(1.330)	(322.137)	(1.067)	(312.255)	(1.036)	(313.787)
Pair-country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1946	1830	1946	1830	1946	1830
Number of pair countries	402	396	402	396	402	396
R square within	0.008	0.023	0.006	0.017	0.006	0.017

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Online Appendix

Appendix A: Definitions

A.1 Intergovernmental Panel on Climate Change (IPCC, 2007)) definition

“*Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods”.*

A.2 Definitions of environmental migrants/ refugees

El Hinnawi (1985): Environmental migrants are *“people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption that jeopardized their existence or seriously affected the quality of their life”.*

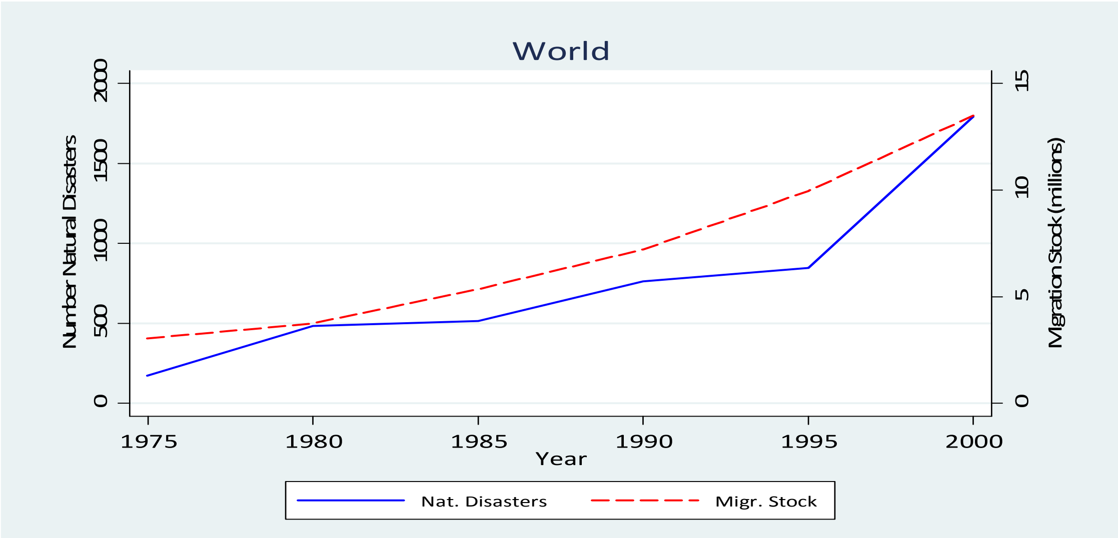
Bates (2002) criticizes the definition and classification of environmental migration of El-Hinnawi in the UNEP 1985 report. For Bates, this definition does not provide generic criteria distinguishing environmental refugees from other types of migrants and does not specify differences between types of environmental refugees. It makes no distinction between refugees who flee volcanic eruptions and those who gradually leave their homes as soil quality declines. For Bates, “a working definition of environmental refugees includes *people who migrate from their usual residence due to changes in their ambient non-human environment”*. This definition remains necessarily vague in order to incorporate the two most important features of environmental refugees: the transformation of the environment to one less suitable for human occupation and the acknowledgment that this causes migration. The author establishes a classification of environmental refugees according to the causes of migration. One distinguishes between three categories of human migration due to environmental change: (i) Environmental refugees due to disasters caused by natural or technological events. Those people are short-term refugees in geographically limited areas. Natural disasters, which include hurricanes, floods, tornadoes, earthquakes or events that made a place inhabitable temporarily or permanently are considered, alongside technological disasters resulting from human choices, as unintentional migration. (ii) Environmental refugees due to expropriation of the environment are people who leave their habitat permanently to allow land use. The expropriation of the environment can be due on one hand to economic development such as the construction of hydroelectric dams or roads and, on the other hand, to warfare and the destruction of the environment, strategically displacing the population during war incorporating, for instance, land mines. (iii) Environmental refugees due to the deterioration of the environment: the migration of these people is caused by the anthropogenic degradation of their environment: one talks about environmental migrants. The effect of environmental degradation ripples through the local economy context to affect migration. While disasters and expropriation refugees do not possess any real means to control environmental change, environmental migrants can decide the strategies to cope with environmental change.

REFERENCES:

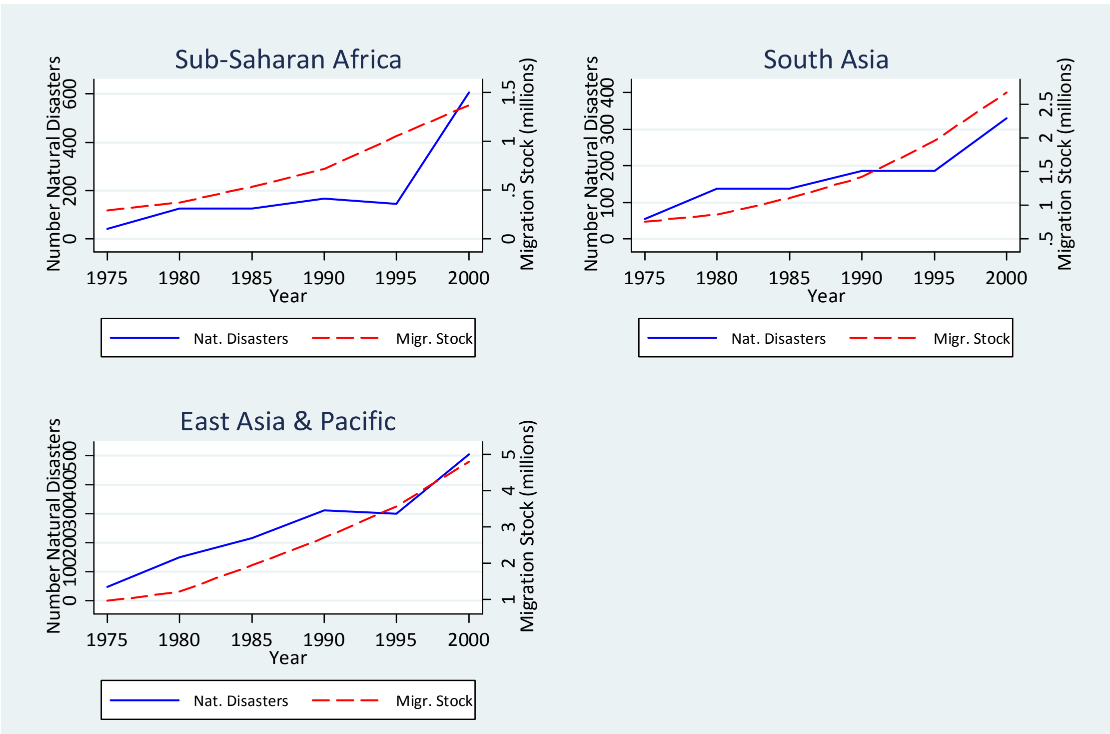
El-Hinnawi, E. (1985), "Environmental Refugees", United Nations Environment Programme, Nairobi, Kenya.

Bates, D. (2002), "Environmental Refugees? Classifying Human Migrations Caused by Environmental Change", *Population and Environment* **23**(5), 465-477.

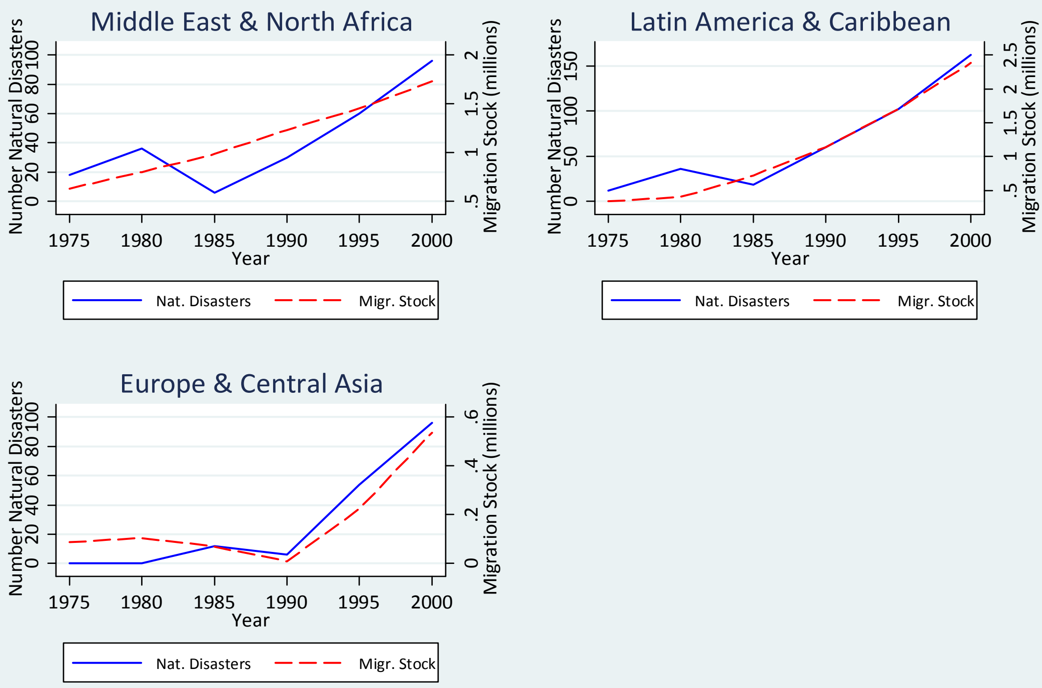
Appendix B: Trends of Natural Disasters and stocks of Migrants of low and lower middle income countries



Source: Authors' construction based on data from CRED, and Schiff and Sjöblom (2008)



Source: Authors' construction based on data from CRED, and Schiff and Sjöblom (2008)



Source: Authors' construction based on data from CRED, and Schiff and Sjöblom (2008)

Appendix C: Variables definition and sources

Variables	Definition	Source
-Low educational migration rate -Medium educational migration rate -High educational migration rate	Stocks of migrants from sending countries to the 6 key receiving countries in the OECD (Australia, Canada, France, Germany, UK, USA) by educational level, divided by the stock of adults (+25) corresponding to the same educational level, in the country of origin + The stock of migrants of sending countries.	M. Schiff and M.C Sjoblom (World Bank Databases)
Migration rate	Total of low, medium and high educational levels	M. Schiff and M.C Sjoblom (World Bank Databases)
Migrant stock lag	Lagged migrant stocks	M. Schiff and M.C Sjoblom (World Bank Databases)
Natural disasters	Dummy variable taking the value 1 if the country experienced natural disasters in the five year period. These disasters are meteorological disasters (storms); hydrological disasters (floods and other wet mass movements; and drought, wildfire) and climatological disasters (extremely high temperatures).	CRED 2010
GDP origin	Gross Domestic Product at the origin country	Online World Bank WDI
GDP destination	Gross Domestic Product at the destination country	Online World bank WDI
Population origin	Total population in the country of origin	Online World Bank WDI
Population destination	Total population in the country of destination	Online World Bank WDI
Population density	Number of inhabitants per km²	Online World Bank WDI
Urban population	Urbanization rate in the origin country	Online World Bank WDI
Arable area percentage	Arable area as percentage of total land area	Online World Bank WDI
Institutions quality	Political Rights are measured on a one-to-seven scale, with one representing the highest degree of Freedom and seven the lowest.	Freedom House
Civil war	Dummy variable taking the value 1 for a minimum of 25 battle-related deaths per year and 0 otherwise.	UCDP/PRIO Armed Conflict Dataset
Rainfall	Average rainfall per year	Mitchell T., Carter T., Jones P., Hulme M. and New M. (2003)
Temperature	Average temperature per year	Mitchell T., Carter T., Jones P., Hulme M. and New M. (2003)

REFERENCES:

Freedom House dataset: http://www.freedomhouse.org

Mitchell, T., T. Carter, P. Jones, M. Hulme, and M. New (2003), “A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901–2000) and 16 scenarios (2001–2100)”. Tyndall Working Paper 55, Tyndall Centre for Climate Change Research, Norwich, UK.

UCDP/PRIO Armed Conflict Dataset: http://www.prio.org/Data/Armed-Conflict/

World Development Indicators, Worldbank online databases: [Available at] http://data.worldbank.org/data-catalog/world-development-indicators.