Environment for Development

Discussion Paper Series December 2013 ■ EfD DP 13-17

The Effect of Hydro-meteorological Emergencies on Internal Migration

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Environment for Development

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September 2013

Abstract

We estimate the effect of hydro-meteorological emergencies on internal migration in Costa Rica between 1995 and 2000. Nationwide, we find that an increase of one emergency in a canton significantly increases average migration rates from that canton, after controlling for several social, economic, climatic and demographic factors in both the canton of origin and destination. Moreover, when we separately analyze landslides and floods, we find that both increase migration. However, we also find that emergencies with the most severe consequences, those with loss of lives, decrease migration. The severity of the consequences may explain the differences in the sign of the effect in previous research. We also find that emergencies will significantly increase population in metropolitan areas. Less severe emergencies significantly increase migration toward metropolitan areas. More severe emergencies significantly decrease migration toward non-metropolitan areas. This is especially important in developing countries, where cities face problems associated with overpopulation.

1 Introduction

An increasing body of evidence suggests that climatic systems are changing around the world (IPCC 2007 and IPCC 2012). There are also indications that, along with rising temperatures, the occurrence and intensity of extreme meteorological events may rise (UNDP 2012). As a consequence, policy makers and researchers have increasingly focused their attention on understanding how weather shocks will affect human well-being. One commonly used variable in economic models that reflects how climate and weather affect quality of life is migration (see, for instance, Cebula and Vedder, 1973; Graves, 1980; Cebula and Alexander 2006).

The relationship between extreme climatic events and migration has been studied extensively. Extreme hydro-meteorological events could increase migration flows. A household, for instance, might decide to send away one or more of its members to offset the effect of binding market imperfections and reduce idiosyncratic risks (Stark and Bloom, 1985; Stark, 1991; Massey et al., 1990; Massey et al, 1993; Waddington and Sabates-Wheeler, 2003). Migration could also serve as an adaptation strategy for entire populations in the face of varying climatic conditions (Petersen, 1958 and D'Andrea, et al., 2011). However, climatic shocks could also lead to reductions in migration flows (Tse, 2011). This, for instance, might be a consequence of the effects that extreme climatic events have on household wealth, increasing migration barriers.

To contribute to this debate, we analyze the effect of hydro-meteorological emergencies on internal migration in Costa Rica between 1995 and 2000. We run regressions on inter-cantonal migration gross rates. By focusing on gross rates, we are able to determine whether both sending and receiving flows between canton pairs can be affected by the occurrence of hydro-meteorological emergencies, information that would otherwise be ignored by using net rates. Also, by using rates, we can control for the "gravity effect" that population size has on migration flows both at origin and destination. Namely, we run regressions nationwide, but we also split the sample between those inside and outside the San Jose Metropolitan Area (also known as the Great Metropolitan Area), where Costa Rica's largest and most urbanized area lies.

We use generalized linear models (GLM), following Papke and Wooldridge (1996) for models where the dependent variable varies from 0 to 1. Our results show that an increase of one hydro-meteorological emergency in the canton of origin increases migration rates, on average, between 0.08 and 0.11 percentage points of the total population of the canton of origin, after controlling for socioeconomic and demographic variables of both origin and destination. These results are always significant and robust to different specifications. We also test ordinary least squares and find that the effects are even higher (0.34 increase in migration rate).

We further break down the data to test whether different types of emergencies affect migration similarly. We split emergencies by type, and analyze the separate effect of floods, landslides and other events to assess the effect of each component on migration. Our findings suggest that there are differentiated effects by type of event, although the sign of the effect is either positive or insignificant.

We also split emergencies by the consequences they had on populations. We analyze separately the effect of emergencies with loss of lives and other emergencies, which we define as less severe emergencies. We find that less severe emergencies, which were the most numerous, fostered emigration from affected areas. However, we also find that emergencies with loss of lives had a negative impact on migration. The severity of the consequences of the event may explain the different signs found in previous research.

Additionally, we analyze how the effects of hydro-meteorological emergencies might change when we focus on migration into the San Jose Metropolitan Area. We find that, within non-metropolitan areas, hydro-meteorological emergencies increase migration, especially to metropolitan cantons. Within metropolitan areas, these events also increase migration, especially to other metropolitan cantons. We also analyze these effects by severity by making the aforementioned partition of emergencies with loss of lives and less severe emergencies. We find that less severe emergencies significantly increase migration toward the San Jose Metropolitan Area. However, the most severe emergencies (those causing loss of lives) significantly decrease only migration toward non-metropolitan cantons. This set of results implies that emergencies, even if they are not directly affecting the San Jose Metropolitan Area, will significantly and positively affect population levels in that urban area. This issue is especially important in developing countries, where cities are already facing problems associated with overpopulation, such as congestion and housing deficits (UNFPA 2011; Lora 2010).

The remainder of this paper is organized as follows: Section 2 discusses literature on migration and its link to changing climatic conditions. Section 3 describes the model specification and dataset. Section 4 presents results and section 5 concludes.

2 Background

Central America is particularly prone to experiencing major weather events (ECLAC, 2011). Moreover, tropical cyclones forming in the Atlantic, which are the most recurrent type of major climatic event to hit the region, have been increasing steadily since 1970 (NOAA 2012). The number of major hurricanes has also been growing, at even faster rates, accounting for nearly 14% of all cyclones in the 2000-2009 decade, in contrast to the 10% they represented between 1970 and 1979 (NOAA 2012). Current forecasts by the IPCC predict an increase of 10% in the number of major meteorological events faced by the region in the next three decades (ECLAC, 2011).

In Costa Rica, 40 out of the 44 national emergencies that the Costa Rican National Emergencies Commission responded to between 1993 and 2009 were related to extreme weather episodes, striking rural areas the most. Most important, a large number of smaller weather-related occurrences repeatedly hit the country. Costa Rican authorities report that they responded to 23 national weather-related emergencies between 2000 and 2009, but nearly 5000 minor events during the same period.

Some climate change scenarios have suggested that by 2040 the country may have an intensification of seasons on the Pacific shore and in the Central Region (where 60% of the population live). The Atlantic and North regions, which are already subject to intense rainfall seasons, may also experience a sharp increase in rainfall levels in the wet season. Additionally, the country may face more droughts, water scarcity and floods as a result of climate change (UNDP 2012).

When facing climate shock risks and events, one alternative response or adaptation is migrating out of the affected area. Out-migration as a response to extreme hydro-meteorological events can be rationalized in two different ways. One is a household decision where one individual is sent off. Another is a group movement, where entire households and even communities migrate.

Neoclassic migration theory has stressed the importance of distance costs and economic expectations as the core factors driving migration decisions (Todaro M., 1970; Todaro and Harris, 1970; Sjaastad, 1962). However, the new economics of labor migration models emphasizes the role of migration as a risk reduction strategy, where households decide to send away one or more of their members to offset the effect of binding market imperfections and reduce idiosyncratic risks (Stark and Bloom, 1985; Stark, 1991; Massey et al., 1990; Massey et Al., 1993; Waddington and Sabates-Wheeler, 2003). For example, the lack of an insurance market instrument to offset the potential effects of extreme weather events increases the risks associated with rain-fed agriculture (Clarke and Grenham, 2011). If one or more household members migrate, households may then offset the idiosyncratic risks associated with extreme weather events and other location-specific characteristics, thereby reducing overall risk.

Other approches also analyze migration as an adaptation strategy for entire populations in the face of varying climatic conditions. Entire households and communities migrate in the face of unbearable conditions. Whole household migration as an adaptive response to varying climatic conditions at the local level is not new in human history (Petersen, 1958). For example, evidence from Greenland in the past 4500 years shows that abrupt temperature changes in the course of a few decades coincide in timing with the settlement and abandonment by local cultures (D'Andrea, et al., 2011).

Empirically, the first estimations of weather induced migration were looking for a methodological solution to overcome endogeneity problems in the migration literature (Munshi (2003) for Mexico; Chen (2009) for China; Pugatch and Yang (2010) for Mexico). These papers used rainfall variability as an instrumental variable for migrant flows in rural areas, which would in turn cause changes in an outcome variable of interest. Migration processes were thus conceived as a response to declining agricultural yields as a result of adverse weather conditions in the community of origin, which in turn reduced income and employment levels for rural households. This view considers migration as a second order outcome of weather shocks. Migration is therefore seen as an adaptive response to impaired living conditions due to weather shocks. Results from several large quantitative studies are consistent with this view, suggesting that weather shocks affect agricultural production, thus producing labor surpluses (shortages) at the origin, which would in turn promote (deter) migration flows (Feng et. al (2010) for Mexico; Feng et al. (2012) for the United States). Additionally, weather anomalies have been found to reduce post-shock consumption levels (a metric for increased vulnerability), resulting in a higher propensity to migrate (Vicarelli, 2011).

Empirical research looking at the effects of floods on migration has significantly increased in the last years (see, for instance, Tse, 2011, Saldaa-Zorrilla and Sandberg, 2009, Gray and Mueller, 2012). However, the effects found in previous work have shown different signs and levels of significance. For instance, using an individual panel dataset to estimate the effect of floods on household migration decisions across provinces, districts and sub-districts in Indonesia, Tse (2011) finds that floods actually reduce the likelihood for households to move out at any geographical level. Additionally, Tse outlined the theoretic channels by which weather-related emergencies may both decrease emigration and increase immigration into affected areas. For instance, damaged infrastructure may result in an increased demand for workers, resulting in an increase in the marginal product of labor in the construction sector. The marginal product of labor can also be increased by the effects of extreme weather events on soil fertility. In particular, soil fertility can be enriched by alluvial deposits in floods (Tse, 2011). Additionally, extreme weather events can result in a greater mobilization of government, national, and international agencies in order to provide help and support. The increase in the marginal product of labor results in increased employment opportunities, and therefore generates a greater incentive to migrate into affected areas.

The existence of social networks and social ties may also result in an increase in immigration. Although social networks and family ties have been identified as a predominant mechanism for emigration from disadvantaged regions (see, for instance, Massey 1990), the existence of social ties in the face of extreme weather events can also generate flows into affected areas. This immigration can take place to participate in reconstruction tasks and to provide support to affected families. Also, property rights may be at risk of harm from post-shock isolation, resulting in a greater incentive for families to protect their landholdings (Tse, 2011).

Extreme weather events can change wealth levels, affecting the capacity of households to pay for migration-related costs. Wealth levels can change if extreme events damage or destroy assets such as housing or landholdings, or if extreme events induce a reduction of income. In this respect, a growing body of literature has analyzed whether the effects of extreme weather events on migration can change conditional on poverty levels. Although Tse outlines the mechanisms by which disasters can act as deterrents to migration, he does not find any of these mechanisms to be significant. In particular, he finds that disasters do not affect land holdings, housing, financial assets, farm business assets or non-farm business assets in Indonesia, ruling out some of the wealth channels through which floods may operate.

However, Saldaña-Zorrilla and Sandberg (2009), using a spatial model for Mexico's municipalities where weather events are the predominant source of natural disasters, find that regions more frequently affected by natural disasters show higher migration rates. They also find that marginalized regions, as defined by government agencies, are more prone to migration than non-marginalized regions in the event of natural disasters. They argue that a more educated population, present in non-marginalized municipalities, is better informed about emigration as a coping strategy. Moreover, Gray and Mueller (2012) find the effects of flooding were primarily non-significant, although when testing for non-linear effects they find within-district mobility increased for those whose sub-district was subject to moderate flooding, a result driven mainly by women and poor households.

However, Vicarelli (2011) finds that those who received government cash transfers or who lived in beneficiary regions (but who did not receive cash transfers themselves) were more likely to migrate out of affected areas, a result that suggests that the presence of safety nets may loosen financial constraints and favor migration. This result is consistent with Drabo and Mbayo (2011), who find that natural disasters foster international migration for those whose educational achievement is the highest.

3 Data

Migration information was collected from the 2000 census that includes Costa Rica's 81 cantons. We use inter-cantonal gross migration rates in the five year period between 1995 and 2000. Migration rates between the canton of origin and destination are calculated as the proportion of people living in the canton of destination in 2000 who lived in the canton of origin in 1995, relative to the canton of origin's total population in 1995. We then estimate the number of people living in the canton of origin in 1995 by summing up movers and non-movers. The share of migrants relative to the total population in 1995 is defined as the gross migration rate (see, for instance, Wadycki, 1974, and Fields, 1982). These flows represent a total of 6480 observations, 81 X 80 pair of cantons, thus excluding within-canton movers and non-movers.

To construct the hydro-meteorological events variable, reported damages from Costa Rica's DesInventar Database (DesInventar) on storms, electric storms, flash floods, floods, rainfall, strong winds, and weather-related landslides between 1995 and 2000 are counted by canton. DesInventar compiles information on natural disasters grouped by type, geographic area of occurrence, reporting source, and reported damages in Costa Rica. We focus on the data given by the National Emergencies Commission

(CNE), which started reporting in 1995. Having the same data source across time provides more reliability. The year 1995 also marks the starting point of migration decisions in our dataset.

Methodologically, DesInventar counts a natural disaster as an event causing an effect on human lives or economic infrastructure, with no particular lower bound on the size of the damage caused. Additionally, it counts as one event the effect on a minimal geographic unit (namely, a neighborhood) so that a disaster that created extensive damage is counted as a number of events equal to the number of neighborhoods affected. Because our data is at the canton level, this serves as a unique opportunity to measure the frequency, type, impacts and extensiveness with which a particular canton has been subject to extreme weather events. Table 1 shows the types of emergencies we used in the analysis and how they were distributed over time and between non-metropolitan and metropolitan cantons[1]. In our sample, we focus on two subsets of emergencies. One splits emergencies by type, into floods, landslides, and other emergencies. The other splits emergencies by selecting those with loss of lives.

The DesInventar database records disasters for Costa Rica from 1969 to date. In order to be included in the database, an emergency has to be reported by one of the system's reporting sources. In this respect, DesInventar does not directly monitor the occurrence of emergencies, but rather relies on the reports of other sources that usually serve as monitors of emergencies, such as newspapers and national agencies for disaster attention. However, the reporting source may vary across different periods of time. In the case of Costa Rica, it was not until 1995 that the Costa Rican Agency for Risk Prevention and Emergency Attention (CNE) reported the occurrence and attention of disasters to the DesInventar database, while the source for previous years

[1]Metropolitan cantons are assigned by the Ministry of Economic Planning.

relied on newspaper reports. Because of this, reported events between 1990 and 1995 are not comparable to those reported between 1995 and 2000. Given this situation, we construct a variable that considers reported emergencies by canton between 1990 and 1995, using *La Nación* and *La República* as the sources of reported events. Both newspapers had at the time nationwide coverage and a focus on general news.

The rest of the explanatory variables are at the canton level and correspond to the base period 1995 (unless specified otherwise); they are grouped into nine categories (see Table 2): (i) health: child mortality rate; (ii) education: quality of classrooms and enrollment rates; (iii) economic: employment growth, measured as the rate of change in the number of employees contributing to social security; average residential power consumption, as a proxy for income; average industrial power consumption to account for industrial activity; and the 1984 marginalization index[2], which measures the access to basic services by canton; (iv) security: reported homicide rate; (v) amenities: reported number of businesses per capita in the leisure and hotel-and-restaurants sectors in the 1990 business census; (vi) political: abstention rate in the 1994 presidential elections; (vii) demographic variables: age composition, urban and rural population five years or older in 1984; (viii) location: two sets of dummy variables to account for region of origin and region of destination, a distance variable with distance between each canton's capital, and a third variable to indicate whether cantons are adjacent; and (ix) climatic: average monthly precipitation levels and annual mean temperatures were incorporated.

[2]We use 1984 as the only available information before 1995. We do this in order to focus on pre-event controls to avoid endogeneity problems.

4 Empirical Strategy

4.1 Specification

We use a gravity model to explain cross-canton gross migration rates as a function of population, distance and a set of push and pull factors that influence migration decisions. Push and pull factors reflect individuals rationally weighing up the costs and benefits of migrating. Individuals will migrate if and only if the benefits from migrating are higher than the monetary, psychological, information and opportunity costs of doing so. Migration rates are explained as an outcome of a set of push and pull factors that refer to location-specific characteristics that may affect migration decisions[3]. Those factors that reduce migration rates are pull factors, while those that induce people to migrate are push factors.

According to this, our econometric model takes the following form:

$$m_{ij} = \lambda_{IJ} + \beta_1 HE_i + \beta_2 d_{ij} + \beta_3 adj_{ij} + \sum_{k=1}^{K} \alpha_k X_{ik} + \sum_{l=1}^{L} \delta_l (Z_{jl} - Z_{il}) + u_{ij},$$

where m_{ij} is the migration rate from location i to location j, λ_{IJ} reflects the fixed migration flow between region I where canton i is located and region J where canton j is located, HE_i is the number of hydro-meteorological events in location i, d_{ij} is the distance from canton i's capital to canton j's capital, and adj_{ij} takes the value of 1 if cantons i and j are adjacent and 0 otherwise. We additionally control for K characteristics of location i, X_{ik}, and for the differences of L characteristics between j and i, $Z_{jl} - Z_{il}$.

Given that m_{ij} is a proportion that can only take values between 0 and 1, we use

[3] For a broader discussion of migration models, see Massey et al. (1993) and Massey and Espinoza (1997).

a generalized linear model (GLM) following Papke and Wooldridge (1996). The generalized linear model addresses the bounded nature of our dependent variable. However, we also run OLS for our core model in order to compare the results between GLM and a linear specification. Note that the coefficients associated with Papke and Wooldridge 1996's GLM are not marginal effects. Marginal effects of a hydro-meteorological event on migration must be calculated conditioned on some value of the vector of explanatory variables. In this paper, we report marginal effects for GLM models that were calculated at the sample's mean for each independent variable.

4.2 Identification

In order to estimate unbiased effects of hydro-meteorological emergencies on internal migration, the correlation between the error, u_{ij}, and the presence of emergencies, HE_i, should be zero. This condition could be violated if there are unobservable factors that are simultaneously correlated with the presence of emergencies and migration. For instance, it might be the case that emergencies might be correlated with historical average temperature and precipitation levels and therefore with agricultural productivity, which might also affect migration flows. If this is the case, the estimated effects of emergencies might be biased upward. To address this issue, in our regression, we control for population, historical average temperature, and precipitation levels, among other variables.

Certainly, it is highly unlikely that migration would affect the likelihood of a hydro-meteorological event. However, migration could affect what is considered an emergency. For instance, a flood that would have clearly been an emergency in highly populated areas might not have been considered as such in less populated areas. This could potentially affect the independent variable. However, if this is the case, one would expect that migration might lead to a reduced number of emergencies reported. This might bias the coefficients against our hypothesis.

Additionally, given that migration is measured in the same period as emergencies, it could be the case that most of the migration in a canton in the period took place before the floods. If pre-flooding migration flows are similar to those places that are less affected, then one should not expect any source of bias. If migration flows are larger in those cantons that are affected by hydro-meteorological emergencies, the estimates will be biased only if these migration flows were caused by unobservable factors that are not considered in the regression. However, within the regression, we control for several social, economic, climatic and demographic factors of the cantons in origin and destination.

5 Results

In Table 3, we show regressions testing the effect of emergencies on nationwide gross migration percentages. Overall, we find that an increment of one hydro-meteorological emergency increases nationwide gross migration. GLM estimates shown in columns 1 to 3 differ from one another in the use of regional fixed effects. Column 1 shows a model with regional fixed effects by origin but not by destination. Column 2 presents a model with fixed effects by region of destination but not by region of origin, while the model in column 3 presents regional fixed effects by both origin and destination. The marginal effect of emergencies on migration is similar across these models. These results suggest that different specifications of regional fixed effects do not significantly affect the estimates.

In Column 4 in Table 3, we show the results of an ordinary least squares (OLS) regression using regional fixed effects by both origin and destination. We find that this model also yields positive and significant effects, consistent with the results from the GLM model. However, the coefficient is significantly higher. Our main conclusions will be based on the GLM because it takes into account that our dependent variable is bounded in the closed interval [0,1]. The boundedness of the dependent variable might be what explains the large magnitude of the effect in OLS model. However, it is important to show that qualitatively OLS and GLM yield similar results.

As discussed, the source of data between 1990-1995 and 1995-2000 is different. The first period contains only newspaper reports, while the data for the period between 1995 and 2000 includes only emergencies reported by the Costa Rican disaster response agency. Because of this, we cannot directly test the effects or compare the marginal effects associated with emergencies in each period. However, we can use the emergencies between 1990 and 1995 as controls to assess whether past emergencies, and not current ones, might be the triggers of migration. In Column 5 in Table 4, we show the effect of emergencies on migration after controlling for emergencies reported between 1990 and 1995. The marginal effect for emergencies occurring between 1995 and 2000 is still positive and significant even after controlling for emergencies between 1990 and 1995, although the magnitude of the effect shows a slight reduction. We will base our conclusions on this model and choose this model to explore further the relationship between emergencies and migration. The marginal effect associated with emergencies in this model is interpreted as follows: an additional emergency in the canton of origin would increase emigration rates to another canton by 0.0010 percentage points of the total population in the canton of origin. Given that there are 80 cantons to which an individual could emigrate, an additional hydro-meteorological emergency causes an aggregate migratory effect of 0.08 percentage points of the total population in the canton of origin. On average, about 10.4 percent of a canton's population migrated during that period. This means that one emergency accounts for 0.77 percent of the total emigration movements in a given canton. These estimates reflect average effects. There might be cantons or sets of cantons where the impacts are significantly larger or smaller.

As can be seen in Table 1, most emergencies in the sample were reported between 1999 and 2000. However, it is likely that most permanent migration movements between 1995 and 2000 occurred before 1999. By excluding the emergency observations between 1999 and 2000, we may be able to exclude some temporary migration induced by emergencies, and we can also assess whether the large number of events occurring in the last year of the sample may be playing a large part in the sign and significance of the coefficient. In Column 6 in Table 4, we show a GLM model that includes emergencies only from 1995 to 1999 as the explanatory variable. We find, again, that emergencies have a positive and significant effect on migration and that the effect is similar in magnitude to the regression that includes emergencies in 2000.

Results shown in Table 3 are consistent with previous findings showing that disasters and emergencies can foster migration out of affected areas. Also, the marginal effects found are robust across different specifications. We next proceed to split our sample to analyze the effect of different types of emergencies on migration and to test whether the effects change in the San Jose Metropolitan Area and in non-metropolitan cantons.

5.1 By type of emergency

We further break down the data to test whether different types of emergencies affect migration similarly (see Table 4). We split emergencies by type, and separately analyze the effect of floods, landslides and the other events to assess the effect of each component on migration. More than 90 percent of our sample consists of emergencies triggered by floods or landslides. We find that all emergencies appear to have an enhancing effect on migration movements for the period 1995-2000. For the period between 1995 and 1999, none of the emergency types has a negative and significant effect on migration.

We also split emergencies by the consequences they had on populations (see Table 4). We separately analyze the effects of emergencies with loss of lives and less severe emergencies. We find that the effect of emergencies changes across different types of consequences. For the period between 1995 and 1999 and from 1995 to 2000, the effect of emergencies with loss of lives on migration was negative and significant, a result that suggests that the severity of the impact may impede people from migrating. The effect of less severe emergencies is positive.

5.2 Urbanization effects

In Table 5, we show models disaggregated by zone of origin and destination. We analyze how the effects of hydro-meteorological emergencies might change when we focus on non-metropolitan and metropolitan migration. We find that, within non-metropolitan areas, hydro-meteorological emergencies increase migration, especially to metropolitan areas. Within the San Jose Metropolitan Area, these events also increase migration, especially to other metropolitan areas. When we analyze these effects by severity, we find again that less severe emergencies significantly increase migration toward metropolitan areas. However, emergencies with loss of lives significantly decrease only migration toward non-metropolitan areas. This set of results implies that emergencies, even if they are not directly affecting metropolitan areas, will significantly and positively affect population levels.

6 Conclusions

We estimated the effect of hydro-meteorological emergencies on internal migration in Costa Rica between 1995 and 2000. We used generalized linear models (GLM) following Papke and Wooldridge (1996) for models where the dependent variable varies from 0 to 1. Our results showed that an increase of one hydro-meteorological emergency at the canton of origin increases migration rates, on average, between 0.08 and 0.11 percentage points of the canton of origin's total population, after controlling for socioeconomic and demographic variables at both origin and destination. These results are always significant and robust to different specifications.

We also analyzed separately the effect of floods, landslides and other events to assess the effect of each component on migration. Our findings suggested that there are differentiated effects by type of event, although the sign of the effect is either positive or insignificant when it is negative. We then separately analyzed the effect of emergencies with loss of lives and less severe emergencies. We find that less severe emergencies, which were the most numerous, fostered emigration from affected areas. However, we also find that emergencies with loss of lives had a negative impact on migration. The severity of the consequences of the event may explain the different signs found in previous research.

Finally, we analyzed how the effects of hydro-meteorological emergencies might change when we focus on non-metropolitan and metropolitan migration. We find that, within non-metropolitan areas, hydro-meteorological emergencies increase migration, especially to metropolitan areas. Within metropolitan areas, these events also increase migration, especially to other metropolitan areas. When we analyze these effects by severity, we find again that less severe emergencies significantly increase migration toward metropolitan areas. However, emergencies with loss of lives significantly decrease only migration toward non-metropolitan areas. We conclude that emergencies will lead to increases in metropolitan population areas. This issue is especially important in developing countries, where cities are already facing problems associated with overpopulation, such as congestion and housing deficits (UNFPA 2011; Lora 2010).

Future research should focus on the relationship between climate and hydro-meteorological emergencies. This will help us understand how climate change will affect migration via extreme events and emergencies. Additionally, it would be important to explore the effectiveness of migration as an adaptation strategy. That would test whether those who were exposed to emergencies and migrated ended up better off than those who were exposed to emergencies and did not migrate.

References

[1] Cebula, R., and Alexander, G., (2006) "'Determinants of Net Interstate Migration, 2000-2004"' Armstrong Atlantic State University - USA. Special Section on Migration - JRAP 36(2): 116-123. ? 2006

[2] Cebula, R., and Vedder, A. (1973) "'Note on Migration, Economic Opportunity, and the Quality of Life"' Journal of Regional Science Volume 13, Issue 2, pages 205-211

[3] Chen, Y. (2009). Network effects among rural-to-urban migrants in China. Oxford, UK: University of Oxford - Sociology Working Papers.

[4] Clarke, D., and Grenham, D. (2011). Microinsurance and climatic related disasters: challenges and options. United Kingdom: Government Office for Sci-

ence.

[5] CNE. (2008). Plan General de la Emergencia por Situaci?n Generada por la Sequ?a en Guatuso, Los Chiles, Upala y San Carlos. San Jose?, Costa Rica: Comisi?n Nacional de Prevenci?n de Riesgos y Atenci?n de Emergencias.

[6] CNE. Planes Generales de la Emergencia. Recuperado el 20 de March de 2012, de Comisi?n Nacional de Emergencias.

[7] D'Andrea, W. J., Huang, Y., Fritz, S. C., and Anderson, J. (2011). Abrupt Holocene climate change as an important factor for human migration in West Greenland. PNAS , 5.

[8] DesInventar Disaster Inventory System. (2009). DesInventar Methodological Guide. Version 8.1.9. DesInventar Online.

[9] Drabo, A., Mbaye, L. M. (2011). Climate Change, Natural Disasters and Migration: An Empirical Analysis in Developing Countries. Bonn: IZA Discussion Paper 5927.

[10] ECLAC; DANIDA; SICA; UKAID; CCAD. (2011). La Economic?a del Cambio Clima?tico en Centroame?rica. Ciudad de Me?xico: CEPAL - Naciones Unidas.

[11] Feng, S., Krueger, A. B., Oppenheimer, M. (2010). Linkages among climate change, crop yields and Mexico-US cross-border migration. Proceedings of the National Academy of Sciences of the United States of America.

[12] Feng, S., Oppenheimer, M., Schlenker, W. (2012). Climate change, crop yields, and internal migration in the United States. Cambridge, Massachusetts: NBER.

[13] Fields, G. S. (April de 1982). Place-to-Place Migration in Colombia. Economic Development and Cultural Change , p?g. 20.

[14] Graves, P. E. (1980). "Migration and climate". Journal of regional Science, 20(2), 227-237.

[15] Gray, C. L., Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. Proceedings of National Academy of Sciences .

[16] UNDP. (2012). Escenarios de cambio clima?tico regionalizados para Costa Rica. San Jose?.

[17] IPCC. (2007). Integovernmental Panel on Climate Change. Valencia, Spain.

[18] IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Special report of the Integovernmental Panel on Climate Change. Cambridge University Press

[19] Lora, E., (2010). "Beyond the Facts: Understanding Quality of Life"

[20] Massey, D. S. (1990). Social Structure, Household Strategies, and the Cumulative Causation of Migration. Population Index, Vol 56, No. 1 , 3-26.

[21] Massey, D. S., Arango, J., Hugo, G., Kouaci, A., Pellegrino, A., Taylor, E. J. (1993). Theories of International Migration: A Review and Appraisal. Population and Development Review, Vol. 19, No. 3 , 431-466.

[22] Munshi, K. (2003). Networks in the modern economy: Mexican migrants in the U.S. labor market. The Quarterly Journal of Economics , 549-599.

[23] National Oceanic and Atmospheric Administration. (01 de January de 2012). North Atlantic Hurricane Database (HURDAT). Recuperado el 10 de July de 2012, de NOAA

[24] Papke, L.E., Wooldridge,, J. 1996 "Econometric Methods for Fractional Response Variables with an Application to 401 (K) Plan Participation Rates." Journal of Applied Econometrics 11 (6)

[25] Petersen, W. (1958). A General Typology of Migration. American Sociological Review, 23 , p?gs. 256-266.

[26] Pugatch, T., Yang, D. (2010). The Impact of Mexican Immigration on U.S. Natives: Evidence from Migrant Flows Driven by Rainfall Shocks. University of Michigan.

[27] Salda?a-Zorrilla, S., Sandberg, K. (2009). Impact of climate related disasters on human migration in Mexico: a spatial model. Climate Change 96 , 97-118.

[28] Sjaastad, L. A. (1962). The costs and returns of human migration. Journal of Political Economy 70S , 80-93.

[29] Stark, O. (1991). The Migration of Labor. Cambridge: Basil Blackwell.

[30] Stark, O., Bloom, D. E. (1985). The New Economics of Labor Migration. American Economic Review 75 , 173-178.

[31] Todaro, M. (1970). A Model of Labor Migration and Urban Unemployment in Less Developed Countries. American Economic Review 59 , 138-148.

[32] Todaro, M., Harris, J. (1970). Migration, Unemployment and Development: A Two Sector Analysis. American Economic Review 60 , 126-142.

[33] Tse, C.-W. (2011). Do natural disasters really lead to more migration? Evidence from Indonesia. Boston, Massachusetts.

[34] UNFPA. (2011). State of World Population. People and possibilities in a world of 7 billion. United Nations Population Fund (UNFPA).

[35] Vicarelli, M. (2011). Exogenous Income Shocks and Consumption Smoothing Strategies Among Rural Households in Mexico. Center for International Development, Harvard Kennedy School.

[36] Waddington, H., Sabates-Wheeler, R. (2003). How Does Poverty Affect Migration Choice? A Review of Literature. Sussex: Institute of Development Studies.

[37] Wadycki, W. J. (May de 1974). Alternative Opportunities and Interstate Migration: Some Additional Results. The Review of Economics and Statistics, p?g. 4.

Table 1. Hydro-meteorological emergencies 1995-2000[a]

	1995-1996		1996-1997		1997-1998		1998-1999		1999-2000	
	SJM	No SJM	SJM	No SJM	SJM	No SJM	SJM	No SJM	SJM	No SJM
Total emergencies	11	69	4	104	14	16	65	109	298	200
By type										
Landslides	3	2	2	36	3	1	20	26	106	53
Floods	8	66	2	67	7	15	43	82	170	141
Gales	0	0	0	1	2	0	2	0	8	3
Flash floods	0	1	0	0	2	0	0	1	2	2
Rain	0	0	0	0	0	0	0	0	12	1
By impact										
Emergencies with deaths	0	4	1	13	1	0	0	1	0	1
Emer. with damaged houses	6	6	0	48	10	11	52	61	240	131
Other emergencies	5	59	3	43	3	5	13	47	58	68

a. From July 1995 to June 2000
Damaged houses exclude those emergencies also having loss of lives

Table 2 Descriptive Statistics

Variables	All Average	All Stand. error	SJM Average	No SJM Average	Period	Source
Dependent variable						
Gross migration (%) a	0.13	0.00	0.13	0.13	1995-2000	INEC
Variable of Interest						
Hydro-meteorological emergencies	10.98	0.13	12.65	9.96	1995-2000	CNE
Emergencies with loss of lives	0.26	0.01	0.06	0.38	1995-2000	CNE
Less severe emergencies	10.73	0.13	12.58	9.58	1995-2000	CNE
Floods	7.42	0.09	7.42	7.42	1995-2000	CNE
Landslides	3.11	0.06	4.32	2.36	1995-2000	CNE
Other types of emergencies	0.46	0.01	0.90	0.18	1995-2000	CNE
Control Variables						
Socioeconomic						
Child mortality (per 1000 births)	13.1	0.5	12.21	13.6	1995	Salud
Classrooms in good condition (%)	71.6	1.2	80.4	65.8	1995	MEP
School enrollment (%) b	59.0	1.3	63.1	56.4	1995	MEP
Growth of employees in social security	0.04	0.00	0.06	0.03	1987-1995	CCSS
Residential power consumption (KWts)	2.4	0.1	3.0	2.0	1995	ICE
Industrial power consumption (tens of MWts)	1.6	0.4	2.8	0.9	1995	ICE
Social marginalization Index	5.5	0.3	3.3	6.9	1984	INEC
Homicides (per 1000 people)	4.6	0.8	3.2	5.4	1995	OIJ
Restaurant and Hotel Services (per 1000)	2.9	0.2	2.0	3.4	1990	INEC
1994 Abstentionism (%)	17.8	0.5	16.7	18.5	1994	TSE
Demographic						
Population size 5 years or older (thousands)	41.1	4.9	57.9	30.6	1995	INEC
Population aged less than 20 (%)	49.6	0.5	46.2	51.7	1984	INEC
Population between 20 and 29 (%)	19.1	0.2	20.2	18.4	1984	INEC
Population between 30 and 39 (%)	11.9	0.1	13.1	11.2	1984	INEC
Population between 40 and 49 (%)	7.6	0.1	8.0	7.4	1984	INEC
Population between 50 and 64 (%)	7.4	0.1	7.9	7.1	1984	INEC
Population aged 65 or more (%)	4.3	0.1	4.6	4.1	1984	INEC
Urban Population (%)	31.0	2.7	47.8	20.5	1984	INEC
Geographic						
Neighboring cantons dummy	0.06	0.00	0.06	0.06	1995-2000	IGN
Distance between canton capitals (tens of km.)	15.7	0.1	12.4	17.7	1995-2000	MOPT
Area (Square kiloSJMers)	630.9	83.5	104.3	957.4	1980	IGN
Climatic						
Average precipitation Januray d	61.5	9.9	32.2	79.6	c/	IMN
Average precipitation February d	46.3	6.9	25.5	59.3	c/	IMN
Average precipitation March d	45.5	5.4	28.2	56.2	c/	IMN
Average precipitation April d	93.2	7.7	72.0	106.3	c/	IMN
Average precipitation May d	289.6	10.9	266.2	304.1	c/	IMN
Average precipitation June d	309.3	9.6	280.2	327.3	c/	IMN
Average precipitation July d	258.4	12.3	201.0	294.0	c/	IMN
Average precipitation August d	315.3	19.4	295.9	327.4	c/	IMN
Average precipitation September d	362.2	12.9	338.9	376.6	c/	IMN
Average precipitation October d	383.0	14.6	344.7	406.7	c/	IMN
Average precipitation November d	214.3	12.1	168.9	242.5	c/	IMN
Average precipitation December d	111.6	13.8	63.0	141.8	c/	IMN
Mean temperatures (Celsius degrees)	21.8	0.4	18.9	23.5	1950-2000	Clim
Observations	81		40	41		

Percentages (%) range from 0 to 100. Rates range from 0 to 1. (a) Relative to the population of the canton of origin in 1995. (b) Includes enrollment in primary and secondary school. (c) The time span varies according to the precipitation station. Observations taken from preciptiation stations been active for at least 15 years. (d) miliSJMers

Table 3 Effects of hydro-meteorological emergencies on cross-canton migration between July of 1995 and July of 2000

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Period	1995-2000	1995-2000	1995-2000	1995-2000	1995-2000	1995-1999
	GLM	GLM	GLM	OLS	GLM	GLM
Between canton pairs	0.0014***	0.0013***	0.0014***	0.0043***	0.0010***	0.0012***
Overall effect in origin[a]	0.11	0.10	0.11	0.34	0.08	0.10
Controls						
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effects by origin	Yes	No	Yes	Yes	Yes	Yes
Regional fixed effects by destination	No	Yes	Yes	Yes	Yes	Yes
Emergencies 90-95	No	No	No	No	Yes	No
Observations	6480	6480	6480	6480	6480	6480

*, **, *** represent significance at 10%, 5% and 1% respectively

a: To obtain the overall effect in the affected cantons, we multiply the estimated coefficient by the number of destinations (80)

Table 4 Effect of emergencies on cross-canton migration between 1995 and 2000 by consequences and by type of emergency. GLM marginal effect evaluated at the mean of each sample.

Time frame	(1) 1995-2000	(2) 1995-1999		(3) 1995-2000	(4) 1995-1999
By type			By consequence		
Floods	0.0006*	0.0000	Loss of lives	-0.0096***	-0.0094***
Landslides	0.0013***	0.0012	Less severe emergencies	0.0010***	0.0006
Other emergencies	0.0045**	-0.0017			
Controls					
Control variables	Yes	Yes		Yes	Yes
Fixed effects by origin	Yes	Yes		Yes	Yes
Fixed effects by destination	Yes	Yes		Yes	Yes
Emergencies 90-95	Yes	Yes		Yes	Yes
Observations	6480	6480		6480	6480

*, **, *** represent significance at 10%, 5% and 1% respectively

Table 5 Effects of hydro-meteorological emergencies on cross-canton migration between 1995-2000 by zone and by canton's development. GLM Marginal Effects evaluated at the mean of each sample.

Overall Effect	Origin	1995-2000 Destination SJM	1995-2000 Destination No SJM	Origin	1995-1999 Destination SJM	1995-1999 Destination No SJM
	SJM	0.0015***	0.0003**		0.0058***	0.0008***
	No SJM	0.0018***	0.0000		0.0003	-0.0004

Emergencies split by impact	Origin	1995-2000 Destination SJM	1995-2000 Destination No SJM	Origin	1995-1999 Destination SJM	1995-1999 Destination No SJM
Loss of Lives	SJM	0.0278	-0.0077***		-0.0016	-0.0113***
	No SJM	0.0021	-0.0116***		0.0015	-0.0111***
Less severe emergencies	SJM	0.0015***	0.0003***		0.0060***	0.0013***
	No SJM	0.0017***	0.0002		0.0003	0.0000

*, **, *** represent significance at 10%, 5% and 1% respectively
a. Marginal effects
Loss of lives, and less severe emergencies are included simultaneously in each zone-specific regression.

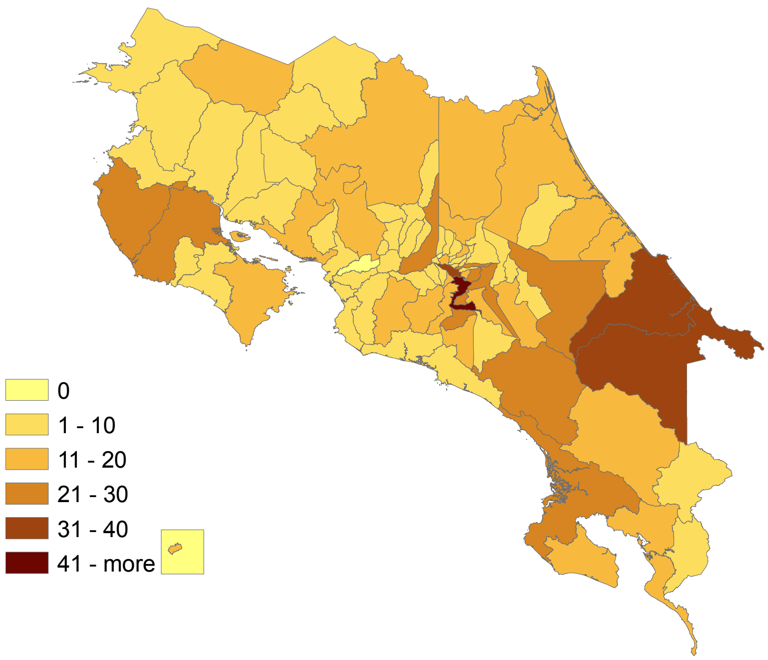

Figure 1 Hydro-meteorological emergencies