The Effect of Disasters on Migration

Robert Dinterman[*]

Jonathan Eyer, Noah Miller, and Adam Rose[†]

14 August 2016

Abstract

This is the abstract. It consists of two paragraphs.

Introduction

In the United States, annual costs from natural disasters have exceeded $35 billion in nine of the last ten years. Extreme events like Hurricane Katrina and Super Storm Sandy can cause property damage in excess of $100 billion and tens or hundreds of billions of dollars in lost economic output. Moreover, economic costs and loss of life from natural disasters is likely to rise in the future, as population and asset values rise, and as climate change leads to more frequent and more severe disasters (Field 2012). While most disasters are unlikely to have major economic implications for the national econonomy, they can have major economic impacts at the regional level, especially in poor communities (Kousky 2014).

The economic costs of by natural disasters are generally related to the destruction of homes, plants and equipment, housing and infrastructure, and the accompanying loss of employment opportunities (Rose 2004; Rose, n.d.). Such impacts may lead to migration away from the afflicted area. For example, if a resident's home is destroyed by a disaster he has less incentive to stay in the area. Destruction of capital can weaken local economies. If a factory is destroyed, for example, the owner of the business may choose to shut down or relocate operations rather than rebuild in the same community. This results in indirect effects to the local economy as wages and employment decline (**add some cites here**), which might induce residents to migrate

[*]North Caorlina State University
[†]University of Southern California

to areas with better job prospects. Finally, disasters can injure or kill residents. A disaster might provide additional information about the riskiness of an area, leading residents to migrate away from the area toward regions that are safer.

Outflow migration after a disaster is not only a consequence of a disaster, but also an important tool to mitigate potential damages from future disasters (Gráda and O'Rourke 1997). To the extent that migration following a disaster moves people from relatively high-risk regions to relatively low-risk regions, future disasters will be less damaging as a result.

Migration in response to disasters has been well-documented in the case of major events Hurricane Katrina (Levine, Esnard, and Sapat 2007; Vigdor 2007). Little attention has been paid to the margin on which relatively small disasters induce migration. To some extent, small disasters are the margin on which migration can reduce disaster damages the most. A powerful hurricane hitting a large city is certain to cause widespread devastation, and it is unlikely that major cities will depopulate enough to avoid such damages. Rural communities that are frequently struck by smaller disasters, on the other hand, are less populous and it is more likely that migration can reduce the exposure of people and assets to disaster by a larger proportion.

We investigate the effect of disasters on migration utilizing a model in which outflow migration at the county-level is driven by county-level disasters and also affected by attractiveness features of the destination. Because migration and disasters are both spatial phenomenon, we employ a spatial econometric model in which outflow migration can be correlated with outflow migration in neighboring counties and with neighboring disasters. We use data on county-level outflow migration for 3,143 counties between 1992 and 2013, as well as data on **length(unique(countydamages_events$Group.3))** damaging natural disasters.

We contribute to the disaster-induced migration literature in a number of ways. Our paper is the first empirical estimate of disaster-induced migration in the U.S. that utilizes spatial econometric modeling methods. We also provide a comprehensive, national assessment of migration following disasters of all sizes and types, while most previous studies have focused on a single large event. Finally, by observing the destination to which disaster-stricken populations migrate we inform the long-run susceptibility of the U.S. population to disasters.

Disasters and Migration

Migration following disasters is well documented, particularly in the case of major events such as Hurricane Katrina or the Fukushima Nuclear Meltdown in Japan (Landry et al. 2007; Groen and Polivka 2010; Oda 2011). These disasters are particularly well studied because the magnitude of the disaster induced substantial migration, evacuations, and quarantines.

Perhaps the most obvious mechanism through which disasters induce migration is either mandatory or voluntary evacuations. More than 1.5 million people evacuated before Hurricane Katrina, for example, and several weeks later when Hurricane Rita approached Texas, nearly 3 million people evacuated. As the length of time between the evacuation and the potential for return grows, it becomes more likely that evacuees will become permanent migrants (**add cites**).

Such migration carries important equity implications. Groen and Polivka (2010) examine the return of migrants following Hurricane Katrina and find substantial socio-demographic variation in the type of person who returned to New Orleans following evacuation. They broadly found that whites were more likely than blacks to return, and those residents with low income and education were less likely to return than relatively wealthier and educated evacuees. This is consistent with S. Danziger and Danziger (2006), who found that the deleterious effects of disasters fall disproportionately on low-income residents. Similarly, Myers, Slack, and Singelmann (2008) find that areas with a relatively high proportion of low-income residents are more likely to experience outflow migration after disasters than relatively wealthy areas, although this does not allow for the possibility that disasters lead the wealthiest residents of a poor area to migrate, while the poor are unable to move.

In addition to disasters directly inducing migration, disasters can also weaken the local economy, thereby inducing further migration. In the case of the Tohuku earthquake/tsunami and the ensuring Fukushima nuclear reactor meltdown, for example, Higuchi et al. (2012) find that unemployment and underemployment remained high in the affected prefectures following the disaster. Similarly, they report substantial increases in outflow migration, although they do not attempt to identify the direction of causality. Venn (2012) documents not only the effect of large-scale natural disasters on local labor markets but also examines the range of government policies that have been undertaken to support local economies following disasters.

Natural disasters may also provide information to residents about the likelihood and severity of natural disasters, leading residents to update their beliefs about the risks of living in an area. If a disaster leads to an increase in the expected cost of natural disasters in an area, residents may choose to migrate to avoid future losses. Following Hurricane Katrina and Hurricane Rita, evacuees overestimated the likelihood of a subsequent hurricane, and risk perception influenced their stated preference to return to New Orleans (Baker et al. 2009). This path may be unlikely, however, as studies on hurricane evacuation behavior tend to suggest that previous disaster experience does not appear to drive evacuation behavior (See **add cites here**).

Disasters do not induce migration with certainty, however. Paul (2005) finds no evidence of outflow migration following a major tornado in Bangladesh. He further notes that post-disaster aid counteracts the push to migrate following a disaster. Gray and Mueller (2012) find only modest effects of flooding on migration and Halliday (2006) actually finds that an earthquake in El Salvador reduced outflow migration rather than increasing it.[1]

While most studies of migration and disasters are related to a single disaster, there are a few studies that examine disaster-induced migration regionally, without focusing on a single dominating disaster. Bohra-Mishra, Oppenheimer, and Hsiang (2014) follow more than 7,000 Indonesian households and find substantial migration in response to temperature variation and minor response to variation in rainfall. Surprisingly, they do not find that disasters result in appreciable migration. Saldaña-Zorrilla and Sandberg (2009) use a spatial econometric model to estimate outflow migration from over 2,000 municipalities in Mexico, and find that regions that are more often affected by disasters have higher migration rates, and that migration is more likely for an educated individual than an uneducated person. They also document the effect of local economic conditions - as measured by crop prices - on migration, although this does not allow for a relationship between disasters and local economic conditions. Because the destination of migrants matters in assessing future disaster exposure, it is also important to note that Saldaña-Zorrilla and Sandberg (2009) focus only on migration outflows and are unable to delineate the destination of migrants.

[1] Halliday suggests that this could be an increase in the need for laborers to stay at homd to rebuild, or that it could suggest a reduction in financial ability to migrate.

While our paper focuses on migration in response to natural disasters, there is a related literature that focuses on migration in response to wars and human conflict. Lozano-Gracia et al. (2010) find that conflict-related migration tends to be toward relatively safer regions, although the pull effect toward safer regions may be muted in the case of natural disasters because human conflict is an ongoing risk disaster-migration decisions are generally made after the immediate threat has subsided.

Models of Migration

Econometric studies of human migration tend to rely on a gravity model (Greenwood 1985; Borjas 1989), in which the decision to migrate is driven by the expected benefits of migration relative to its expected costs. The benefits of migration are typically improvements in economic conditions or amenities in the destination relative to the origin, while the expected costs capture the transporation and relocation expenditures and are usually modeled as a function of distance. As the difference in amenity quality between the origin and the destination increases, the likelihood of migratory flow grows as well. Conversely, as the distance between the two regions grows, the likelihood of migration falls due to, for example, travel costs. The attribute that generally matters the most in migratory gravity models is the wage differential between the origin and the destination. As economic conditions are better in a prospective destination relative to the origin, migration is more prevalent.

Simply controlling for distance in the migration model does not sufficiently account for the spatial correlation in the gravity model, however, if a region affects its neighbors (Porojan 2001). As a result it is necessary to explicitly model the spatial dependence in order to prevent standard errors from being biased. These models tend to follow LeSage and Pace (2008) in specifying a weights matrix to explicitly relate neighboring regions. By interacting a spatial weights matrix with a vector of dependent variables and optionally a matrix of independent variables, it is possible to estimate migration flows under a wide range of assumptions about spatial dependence. These models can be estimated via maximum likelihood and the fit compared using a Lagrange Multiplier type test.

Data

Migration Data

The IRS reports annual, county-level migration based on the change in location at which tax returns are filed. These reports include not only those filings that change counties but also the number of claimed exemptions that change counties and the annual gross adjusted income associated with the filings. The IRS reports both outflow migration (tax returns and exemptions that leave a county) as well as inflow migration (tax returns and exemptions that enter a county), and we compute net migration by subtracting outflow migration from inflow migration. Therefore a positive net migration number indicates that on-net people are moving to a county, while a negative number indicates that on-net people are leaving a county. The IRS data also includes the number of filings and exemptions that do not move, providing a base-level population value that is comparable to the migration data. Figure **ref{mapnum}** presents the portion of each county's population that migrated in 2013.

In addition to the county-level migration in-flow and out-flow data, the IRS also reports migration between pairs of origin and destination counties. Like the aggregated data, this information is derived from changes in the filing location of tax returns. In order to preserve anonymity of specific migrating individuals, the IRS only reports the number of migrants between origin-destination pairs if there are more than **XX** migrants that migrated between a given origin and destination pair. As a result, migration from particularly low-population counties and migration toward low-population counties are relatively less likely to appear in the dataset than migration between high-population counties.

Finally, we note that between 2011 and 2013 the IRS reported out-flow and in-flow migration at the county-level stratified by income.

There are several important considerations surrounding the interpretation of these data. First, the IRS migration data contains only information on filers and exemptions. Households that did not file an income tax return are excluded from the sample. If one expects that the unemployed or seniors who live off of Social Security or other retirement benefits are disproportionately more or less likely to move than workers, our results will be biased. Filers are slightly more likely than non-filers to migrate (Molloy, Smith, and Wozniak 2011). Similarly, because the IRS measurement of residence is determined by filing location, we are unable to observe temporary migration if the migrant does not live in the destination region long enough to be required to file a tax return. The IRS migration data conveys the benefit, though, that we are able to differentiate medium and long term migration from evacuation.

Disaster Data

The National Oceanographic and Atmospheric Administration (NOAA) Storm Events Database contains data on a wide range of meteorological disasters. For each disaster in the database, NOAA reports crop damage, property damage, and deaths at either the county-level or at the NOAA zone-level. Zones are generally smaller than counties and usually do not overlap county lines. In these instances, we aggregate damages up to the county-level. When NOAA zones overlap county lines, we disaggregate the damages across counties based on the areal proportion of the zone that overlaps each county.

NOAA categorizes disasters into 73 categories. Table **ref{categorylist}** lists the ten NOAA disaster types that resulted in the most property damage between 2005 and 2015, as well as the corresponding crop damage and deaths for these events. The most damaging disaster category is storm surges and extreme tides, although these disasters resulted in a relatively low number of deaths. Hurricanes and tornados have each resulted in approximately 1,000 deaths between 2005 and 2015, as well as substantial amounts of property and, in the case of hurricanes, crop damage. Some disasters, such as those that are related to extreme wind, result in a relatively high number of fatalities but only moderate property and crop damage. Because our migration data are available on the annual basis, we aggregate damages for each county to the annual level.

Methodology

We present two models of migration, one focusing on net migration from each county and the other examining migration between pairs of counties.[2] The net migration models focuses on the total number of people

[2]These will likely result in two papers but for now we lay out the outline of both approaches.

entering or leaving a county, regardless of their destination. This avoids some data censoring in cases in which county-to-county flows are censored to maintain anonymity. The county-to-county approach allows much more focus on the characteristics of the destination that influence migration, although it is computationally much more complex than the net migration models.

Net Migration

Our basic model involves estimating the net migration from a county based on natural disaster damages. We then proceed by adding increasing layers of spatial and temporal specificity to the estimating equation.

Our primary estimating equation is:

$$netmig = damage\beta + population\gamma + X\delta + \epsilon \tag{1}$$

where *netmig* is the net migration from a county, damage is the magnitude of disaster damages affecting that county, population is the county's population and X is a matrix of additional explanatory variables that could affect migration in a county. The explanatory variable matrix X can include attributes such as unemployment levels, income, or racial composition. In the basic model, ϵ is an iid error term. Our variable of interest β measures how contemporaneous natural disaster damages affect migration away from a county while γ controls for the size of the county prior to the migration.

Next, we note that there may be a spatial component associated with outflow migration (**cites here**). A county that experiences substantial outflow migration due to, for example, a weak local economy is likely to be geographically close to other counties that have weak local economies.

We therefore respecify the error term as:

$$\epsilon = \lambda W\epsilon + \eta \tag{2}$$

where W is a spatial weights matrix that relates the counties in our sample to one another so that $\lambda W\epsilon$ is the spatial portion of the error term that is driven by nearby counties' errors, and η is the idiosyncratic error term in the traditional sense. We substitute equation 2 re-arrange equation 1 ,and re-estimate.

$$netmig = \rho W netmig + damage\beta + population\gamma + X\delta + \epsilon. \tag{3}$$

Note that in this estimating equation net migration in each county depends explicitly on the net migration in nearby counties, as defined by the spatial weights matrix, W.

In order to examine the effect of income on the ability to migrate following a disaster, we next estimate the effect of disasters on net migration while differentiating by income strata. In particular, we estimate:

$$netmig^k = damage\beta^k + population^k\gamma^k + X^k\delta^k + \epsilon \tag{4}$$

which is identical to equation 1 except for the introduction of the superscript k which indicates the income strata. This equation estimates a separate coefficient, β^k, for each of the income strata, indicating the effect of damages on net migration among individuals in income strata k. Note that *damage* is not differentiated by income strata.

Origin-Destination Models

Finally, in order to examine the destination of disaster-related migrants, we specify an origin-destination model in which we estimate the migration from county j to county k as

$$mig_{jk} = damage_j\beta_o + damage_k\beta_d + X_j\gamma_o + X_k\gamma_d + \epsilon. \tag{5}$$

mig_{jk} is the flow of migration from county j to county k, and β_o and β_d capture the effect of disaster damage in the origin and destination counties, respectively, on the migration decision. The matrices X_j and X_k contain additional explanatory variables at the origin and destination, such as cost of living, unemployment rates, racial composition and local amenities. The perceived safety vulnerability in the destination location can either be captured by the $damage_k$ term or included in the X_k matrix.

Results

To be completed.

Conclusion

To be completed.

Tables and Figures

Not Sure.

References

Baker, Justin, W Douglass Shaw, David Bell, Sam Brody, Mary Riddel, Richard T Woodward, and William Neilson. 2009. "Explaining Subjective Risks of Hurricanes and the Role of Risks in Intended Moving and Location Choice Models." *Natural Hazards Review* 10 (3). American Society of Civil Engineers: 102–12.

Bohra-Mishra, Pratikshya, Michael Oppenheimer, and Solomon M Hsiang. 2014. "Nonlinear Permanent Migration Response to Climatic Variations but Minimal Response to Disasters." *Proceedings of the National Academy of Sciences* 111 (27). National Acad Sciences: 9780–5.

Borjas, George J. 1989. "Economic Theory and International Migration." *International Migration Review*. JSTOR, 457–85.

Danziger, Sheldon, and Sandra K Danziger. 2006. "Poverty, Race, and Antipoverty Policy Before and After Hurricane Katrina." *Du Bois Review* 3 (01). Cambridge Univ Press: 23–36.

Field, Christopher B. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Gráda, Cormac Ó, and Kevin H O'Rourke. 1997. "Migration as Disaster Relief: Lessons from the Great Irish Famine." *European Review of Economic History* 1 (1). Oxford University Press: 3–25.

Gray, Clark L, and Valerie Mueller. 2012. "Natural Disasters and Population Mobility in Bangladesh." *Proceedings of the National Academy of Sciences* 109 (16). National Acad Sciences: 6000–6005.

Greenwood, Michael J. 1985. "Human Migration: Theory, Models, and Empirical Studies." *Journal of Regional Science* 25 (4). Wiley Online Library: 521–44.

Groen, Jeffrey A, and Anne E Polivka. 2010. "Going Home After Hurricane Katrina: Determinants of Return Migration and Changes in Affected Areas." *Demography* 47 (4). Springer: 821–44.

Halliday, Timothy. 2006. "Migration, Risk, and Liquidity Constraints in El Salvador." *Economic Development and Cultural Change* 54 (4). JSTOR: 893–925.

Higuchi, Yoshio, Tomohiko Inui, Toshiaki Hosoi, Isao Takabe, and Atsushi Kawakami. 2012. "The Impact of the Great East Japan Earthquake on the Labor Market: Need to Resolve the Employment Mismatch in the Disaster-Stricken Areas." *Japan Labor Review* 9 (4): 4–21.

Kousky, Carolyn. 2014. "Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters." *Energy Economics* 46. Elsevier: 576–92.

Landry, Craig E, Okmyung Bin, Paul Hindsley, John C Whitehead, and Kenneth Wilson. 2007. "Going Home: Evacuation-Migration Decisions of Hurricane Katrina Survivors." *Southern Economic Journal*. JSTOR, 326–43.

LeSage, James P, and R Kelley Pace. 2008. "Spatial Econometric Modeling of Origin-Destination Flows." *Journal of Regional Science* 48 (5). Wiley Online Library: 941–67.

Levine, Joyce N, Ann-Margaret Esnard, and Alka Sapat. 2007. "Population Displacement and Housing Dilemmas Due to Catastrophic Disasters." *Journal of Planning Literature* 22 (1). Sage Publications: 3–15.

Lozano-Gracia, Nancy, Gianfranco Piras, Ana Maria Ibáñez, and Geoffrey JD Hewings. 2010. "The Journey to Safety: Conflict-Driven Migration Flows in Colombia." *International Regional Science Review* 33 (2). SAGE Publications: 157–80.

Molloy, Raven, Christopher L Smith, and Abigail Wozniak. 2011. "Internal Migration in the United States." *The Journal of Economic Perspectives* 25 (3). American Economic Association: 173–96.

Myers, Candice A, Tim Slack, and Joachim Singelmann. 2008. "Social Vulnerability and Migration in the Wake of Disaster: The Case of Hurricanes Katrina and Rita." *Population and Environment* 29 (6). Springer: 271–91.

Oda, Takashi. 2011. "Grasping the Fukushima Displacement and Diaspora." The.

Paul, Bimal Kanti. 2005. "Evidence Against Disaster-Induced Migration: The 2004 Tornado in North-Central Bangladesh." *Disasters* 29 (4). Wiley Online Library: 370–85.

Porojan, Anca. 2001. "Trade Flows and Spatial Effects: The Gravity Model Revisited." *Open Economies Review* 12 (3). Springer: 265–80.

Rose, Adam. 2004. "Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation." In

Modeling Spatial and Economic Impacts of Disasters, 13–36. Springer.

———. n.d. "Economic Aspects of Earthquake Lsos Estimation." In *Handbook of Earthquake Engineering*. CRC Press.

Saldaña-Zorrilla, Sergio O, and Krister Sandberg. 2009. "Impact of Climate-Related Disasters on Human Migration in Mexico: A Spatial Model." *Climatic Change* 96 (1-2). Springer: 97–118.

Venn, Danielle. 2012. "Helping Displaced Workers Back into Jobs After a Natural Disaster." OECD Publishing.

Vigdor, Jacob L. 2007. "The Katrina Effect: Was There a Bright Side to the Evacuation of Greater New Orleans?" *The BE Journal of Economic Analysis & Policy* 7 (1).