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Moving to Adaptation?

Understanding the Migratory Response to Hurricanes in the United States

A. Patrick Behrer
Valentin Bolotnyy

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Abstract

Using data on the paths of all hurricanes in the Atlantic Basin from 1992 to 2017, this paper studies whether migration has served as a form of adaptation to hurricane risk. The findings show that on average hurricanes have little to no impact on county out-migration, with population-weighted exposure to hurricanes increasing slightly over the sample period. Counties with high economic activity see net in-migration in the years after a hurricane. Further, return migration likely plays a role in offsetting any out-migration in the year of the storm. The intensity of pre-hurricane migration between county pairs is a strong predictor of excess migration after a hurricane, suggesting that existing economic and social ties dominate in post-hurricane migration decisions. Given existing policies and incentives, the economic and social benefits that people derive from living in high-risk areas currently outweigh the incentive to adapt to future storms by relocating across counties.

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Moving to Adaptation?
Understanding the Migratory Response to Hurricanes in the United States

A. Patrick Behrer,[1*] Valentin Bolotnyy[2]

[1]The World Bank
Washington, D.C., USA
[2]The Hoover Institution
Stanford University, 434 Galvez Mall, Stanford, CA 94305, USA

[*]To whom correspondence should be addressed; e-mail: abehrer@worldbank.org.

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Introduction

An increase in damaging storms will be one of the most significant consequences of climate change.[1] These disasters impose substantial cost on the communities that they impact through asset destruction, human capital losses, and the loss of human life.[2,3,4] However, the incidence of these storms varies over space and while climate change will increase the frequency, severity, and range of these storms, some areas will be more impacted than others.[1]

As a consequence of this variation in incidence over space, many have suggested that migration away from areas that will be more impacted by these disasters will be an important form of adaptation to climate change.[5,6,7,8] Indeed, calibrated theory-based modeling of the impacts of climate change suggest that in the coming centuries as much as 5% of the world's population will relocate because of changes in local amenities driven by climate change, including by increasing hurricane risk.[9] These projected moves are not solely local, with some estimates suggesting large shifts in population from temperate regions into the Arctic circle.[9]

There are, however, reasons to be skeptical of the hypothesis that migration will lead to population-level reductions in risk and serve as a form of adaptation, at least in the short to medium-term. For migration to be a societal-level adaptation to a given shock, it is necessary that population-level exposure to that shock decline as a consequence of migration. The empirical evidence we have so far – for example, from Indonesia – suggests that storm events have not led to out-migration in ways that reduce future risk.[10]

We advance the existing literature further by using data on the paths of all Atlantic basin hurricanes between 1992 and 2017 to study whether county-to-county migration has reduced risk for migrants in recent history in the United States. In particular, we focus on whether out-migration increases (and net-migration declines) in response to a hurricane and whether migrants relocate to areas that are less exposed to disasters. In doing so, we address a key research challenge to understanding the future of the U.S. Gulf Coast, as articulated by the National Academies of Sciences, Engineering, and Medicine in 2018.[11]

Experiencing a storm may lead to adaptive behavior for a variety of reasons. Experiencing a storm that destroys assets may reduce an individual's connection to a given location and therefore facilitate a move to a location that is less exposed to future storms. Experiencing a storm may also cause an individual to update their expectations about the risk of experiencing future storms and so induce a move to a less risky location. This could occur for classically rational reasons – learning new information about the personal costs of experiencing a disaster, for example[12] – or as a consequence of a variety of behavioral biases. For example, the availability heuristic suggests that salient information, in this case the cost of experiencing a disaster, is overemphasized by people making decisions about the future.[13] Individuals may also move due to changes in the benefits or costs of living in a given location. Amenities destroyed by a storm may not be fully rebuilt and insurance rates may be adjusted upwards after a storm, both of which could induce individuals to relocate.[14]

Despite theoretical reasons why migration might respond to the occurrence of disasters in an adaptive way, it is not clear that realized migration patterns will be adaptive. The drivers of migration are complex.[15,16,17] The hypothesis that migration will be adaptive gives primacy to reducing risk from climate change over many other potential motivations – many of which may be countervailing – for migration.

It is well known, for example, that most migration is driven by existing social networks and takes place over relatively short distances.[18,19] Even long-distance migratory responses to hurricanes are driven by existing social networks.[20] To the extent that social and family networks are geographically concentrated, and the risk of exposure to storms only changes slowly over space, migration along these existing networks may offer little protection from future storms.[21] A clear example of this occurred after Hurricane Katrina, when the majority of migrants from New Orleans fled to Houston,[22] a city that is also highly exposed to hurricanes.[23,24] More broadly, migration intended to reduce flood risk exposure – encouraged by government buy-outs – has been found to be highly local.[25] The evidence for whether these local moves are adaptive is mixed,[25,26] and whether a local move is adaptive depends on how risk profiles change over space. In localities with significant topographical variation, local moves may be highly effective at reducing flood risk. But whether this migration is truly adaptive or not, its local nature suggests more generally that local ties are important in migration decisions.

The process of migration is also expensive. Individuals impacted by disasters have often suffered a substantial negative shock to their wealth and thus may not be able to incur the substantial costs of a significant relocation.[18,27,28] This is exacerbated by the fact that housing costs in less vulnerable areas may be bid up precisely because these areas are less vulnerable.[29]

In the United States there are also a variety of economic and policy conditions that incentivize people to stay put or migrate in non-adaptive ways. While storms lead to destruction of property, federal or state-subsidized insurance often reduces the costs of these losses. Take-up of these policies increases after the occurrence of a disaster – a form of adaptation in and of itself .[30,31] Economic activity in the United States is also disproportionately concentrated along the coasts. More than 50% of GDP in 2014, the last year for which data are available from the National Oceanic and Atmospheric Administration (NOAA), was generated within 50 miles of the coasts.[32] Because of this pattern of economic activity, moving to opportunity may require moving into at-risk areas.

Despite these theoretical reasons to believe that migration may not be an adaptive response to future storms, and evidence from Indonesia that it has not historically served this role,[10] both researchers and policy-makers continue to assume that migration will reduce the future damages of climate change. For example, recent estimates of the damage from climate-driven coastal flooding, to which hurricanes contribute, suggest that changes in investment and migration will reduce damage by as much as 98% over the next 150 years.[33] If, however, individuals choose not to migrate, other – potentially more costly – forms of adaptation (for example, sea barriers that protect low-lying coastline) might instead be implemented. Understanding the extent to which migration patterns have responded to storm events in the past is thus critical for understanding the likely scope for future migration as adaptation.

In this paper, we define adaptive migration as follows: migration away from counties that are frequently impacted by storms and towards counties that are less impacted. Migration need not reduce the risk of future storms to zero in order to be adaptive. But at a minimum, it must reduce risk relative to the expected future risk of the sending location. This implies that at a population level, if adaptive migration is occurring, average exposure weighted by population should be declining over time. It suggests, though does not require, that net migration (in-migration minus out-migration) to storm impacted places should also be negative in the long-run.

We examine two specific empirical questions: (1) do more individuals migrate out of counties in the years following the experience of a hurricane than in non-hurricane years? and (2) after a hurricane, do migrants move to counties that are less at risk than the counties migrants move to in non-hurricane years? As a corollary and weaker condition to the second point, we also ask whether people move to counties that are less at risk than the county they are moving from.

Changes in short-term migration rates after an individual storm are not by themselves evidence of adaptive migration, nor is it a requirement for adaptive migration to be occurring in general. General long-run trends in migration may be adaptive, even if the immediate response to a particular storm shows no evidence of adaptation. As a result, we also examine how population-level exposure has changed over the full 25-year period in our panel.

To perform our analyses, we assemble data from the IRS Statistics of Income (SOI) on aggregate county-to-county migration in the United States and data on the paths of every Atlantic basin hurricane from 1992 to 2017. These data allow us to examine how migration patterns change in counties that are impacted by hurricanes following a storm, relative to the normal patterns of migration from those counties. They also have the advantage of capturing only individuals who file taxes in their new county and so do not include temporary migrants who might relocate only for the length of time it takes to rebuild their home before returning. We use multiple definitions of exposure to hurricanes based on the incidence of flood warnings, wind speeds, and Federal Emergency Management Agency (FEMA) disaster damage determinations. Our results are broadly consistent across all of these definitions. We also collect data on county-level

GDP from the Bureau of Economic Analysis to examine how another important determination of migration – access to economic opportunity – interacts with hurricane exposure.

We estimate the impact of experiencing a storm in a linear regression model that allows for separate intercepts for each county in our data. We also include year and state fixed effects to account for correlated shocks to migration with states or years (e.g. the Great Recession or the Bakken Shale boom) and state-year trends that account for long-term state-specific trends in migration. Our main model estimates the change in migration that occurs in the year a county experiences a storm relative to the migration that county experiences in a non-storm year. We also apply a model with lags that estimates the change in migration in the years following a storm compared to non-post storm years. We estimate similar models for the change in net migration and the average risk of the counties that receive migrants from a storm-impacted county in storm years versus non-storm years.

Results

Out-migration does not increase after storms

On average, migration out of impacted counties declines by -0.42% in years in which a storm occurs (t-stat: -0.44). This is, in effect, a precisely estimated null effect of storms on out-migration (Figure 1 Panel C & Table SI-1). We can reject positive changes in out-migration of greater than 1.5% at 99% confidence. A 1.5% change in out-migration represents less than a tenth of the standard deviation in year-to-year out-migration over our sample period.

The change in out-migration that occurs in a storm year is both economically and statistically insignificant. Our central estimate suggests that out-migration may decline in storm years, but even the most positive numbers in the 99% confidence interval represent an economically insignificant change in the out-migration rate in storm years relative to non-storm years.

As Panel C in Figure 1 shows, when we allow for five years of lags in the impact of storms on out-migration, we see effects that are not different from our primary result. Changes in out-migration remain small and on average negative for the five years following a storm. The sum of lags indicates no meaningful change in migration in the year of and five years following a storm.

We find that net migration is positive on average in storm years and in the years following a storm. We define net migration as in-migration minus out-migration, such that a positive number indicates more individuals moving into a county than out of a county. In storm years, net migration increases by 10.28% relative to non-storm years (t-stat: 3.28 , Figure 1 Panel D & Table SI-1). This effect persists for the year following a storm, before declining to near zero in years 2 through 5. In total, the sum of the lags in a 5-lag model suggests that net migration is on average 22.9% higher (t-stat: 1.47) over the year of and five years following a storm.

We find consistent effects of storms on migration using alternative definitions of exposure to storms. Defining exposure based on wind speed (Table SI-2) and flood warnings (Table SI-3), rather than just hurricane incidence, yields qualitatively and quantitatively similar estimates. We map the counties exposed to storms under each of these definitions in Figure SI-1.

Storm migration does not reduce exposure

The average migrant in a storm year does not move to areas that are meaningfully less exposed to storms than migrants who leave in non-storm years. On average, migrants who leave in a storm year move to counties that experience -0.18% (t-stat: -0.59) fewer storms than counties that migrants from the sending county move to in non-storm years (Table SI-4). The average county in our sample experiences 2.5 storms over our sample period, translating the 0.2% reduction into 0.005 fewer storms.

An alternative way of measuring whether migrants systematically reduce their risk after storm years is to examine the average difference in exposure between the sending county and all receiving counties in a given year and then compare changes in this measure between storm and non-storm years. We calculate this for each sending county as the average of sending county risk minus receiving county risk for a given year. If migrants after storms substantially reduce their risk, this difference should be substantially larger and more positive in storm years. We find that it is not. In Table SI-4, we show that the difference in this measure between storm and non-storm years is slightly negative. The point estimates are not statistically significant, but suggest that migrants in fact move to areas that are slightly more exposed relative to their home county when they move after a storm than in a normal year.

Our regression results are confirmed by both visual inspection and simple t-tests of means. Panel E of Figure 1 shows the average number of migrants to counties around the United States, only including those who move during years in which their origin county did not experience a storm. Panel F displays the same statistics, but focuses on those who move during a storm year.

The differences between Panel E and F are minor. The most noticeable difference is that slightly more individuals who move after a storm move to large coastal cities (New York, Miami, and Houston) compared to those who move in non-storm years. A t-test of the average number of storms experienced by sending counties and receiving counties, restricting the sample to storm year migration, confirms this (Table SI-5) with a (statistically insignificant) 0.04 (t-stat: 0.46) increase in the average number of storms in receiving counties relative to sending counties.

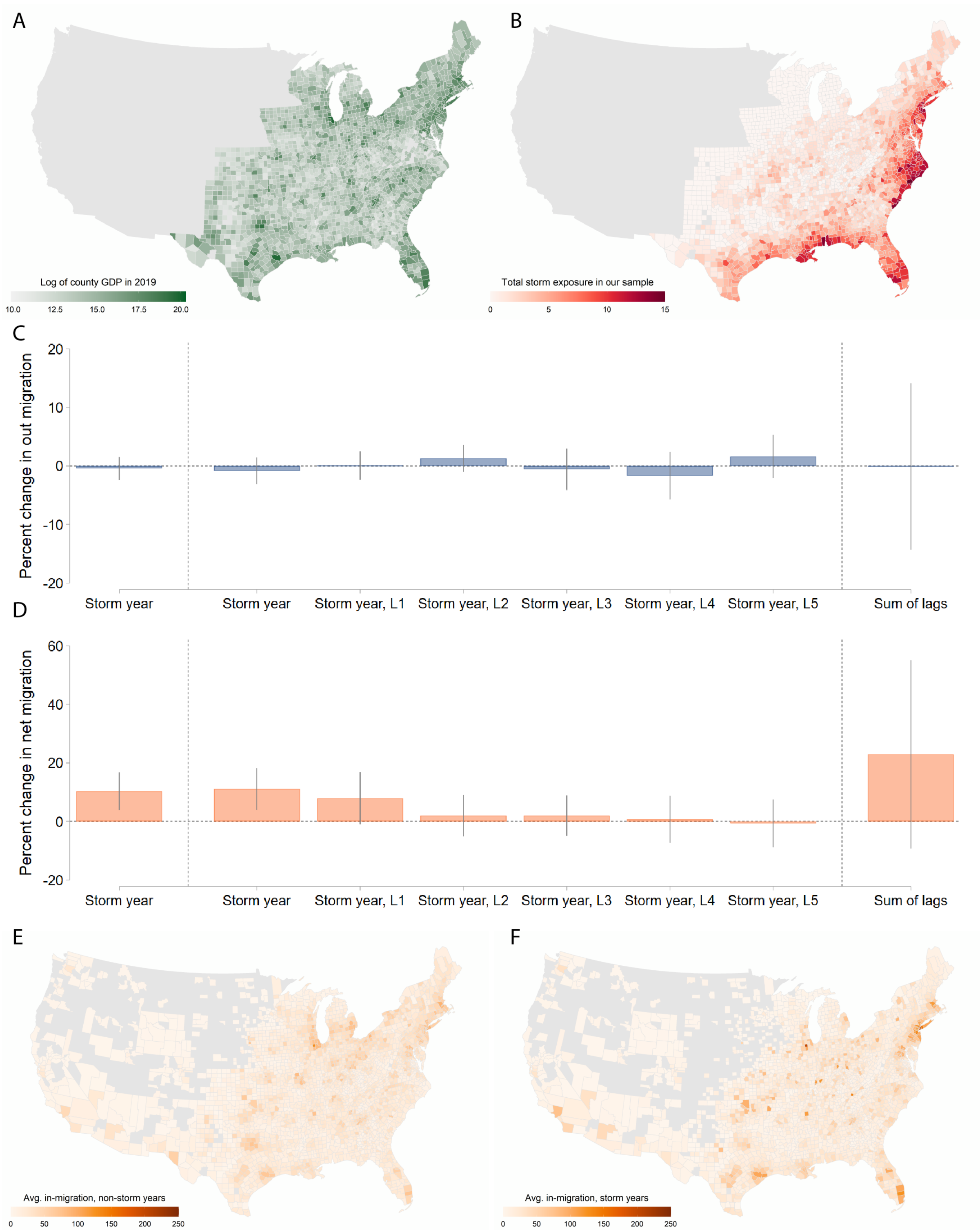


Figure 1: Migration and hurricanes–Panel A plots county GDP in 2019 from the Bureau of Economic Affairs. Panel B plots the total number of storms by county over our sample period. Panels C and D plot the coefficients from a panel fixed effects regression of out-migration and net migration, respectively, on whether a county experienced a hurricane. The first bar plots the coefficient from a regression with only contemporaneous storms. The next six bars show coefficients from a separate regression that includes contemporaneous storms and five year lags. The final bar shows the sum of the coefficients from the lags regression. Panel E shows migrant-receiving counties in our sample period and the average number of migrants received in non-storm years. Panel F shows the same but in storm years.

High damage storms increase migration

Unlike average storms, storms in the top 10% of the damages distribution do lead to increased out-migration in the year of the storm. We use data from FEMA on total compensation paid to disaster victims to isolate the most damaging storms – those that result in at least 10 million dollars in compensation. These storms increase out-migration in the year of the storm by 6.16% (t-stat: 1.69) relative to years that do not experience a storm (Table SI-6). The impact on migration increases monotonically as the damage threshold increases. The most damaging storms, representing fewer than 1% of storm-county years in our data, have the largest impacts on out-migration. These effects persist in the years following a storm. Our lags model indicates that the year after a storm also sees elevated out-migration, but this impact begins to decline by year three (Figure SI-2 & Table SI-7).

The migration that occurs after high damage storms does not reduce the risk that migrants face from future storms. Migrants leaving counties impacted by high damage storms move to counties that are at no lower risk than the counties they leave (Table SI-8). Over our sample period, counties that receive migrants from counties experiencing a high damage storm experience 7.72 storms on average while sending counties experience 7.65 storms (difference t-stat: -0.62).

Return migration in the years following high damage storms appears to offset much of the out-migration that occurs in the year of the storm for all but the most damaging storms. We restrict our analysis to flows between counties experiencing a high damage storm and counties that receive migrants in the same year. We compare changes in net migration flows between these counties in the year of the storm and subsequent five years to years in which there is no storm in the sending county. On average, net migration (migration into high damage storm impacted county minus migration out of it) is highly negative in the storm year, consistent with our previous results. However, for storms that cause fewer than $80 million in compensated damages, this is offset by what appears to be substantial return migration in the following year (Table SI-9). The total change in net migration over five years is not statistically different from zero. For storms causing over $80 million in compensated damages, return migration does not appear to offset the initial out-migration, but we note that these storms are very rare in our data – fewer than 1% of storm-county years – and estimates of their effects are dominated by the effects of Hurricane Katrina (Figure SI-4).

Population-level exposure is growing

We find that individuals do not migrate county-to-county after experiencing a hurricane, unless the hurricane was particularly damaging. Even in the cases of highly damaging hurricanes, it appears that initial out-migration is offset by significant in-migration and, on average, involves afflicted migrants moving to counties that are no less at risk of future storms than the sending county.

However, a lack of migration after individual storms does not necessarily indicate the absence of adaptive migration. It is possible that the average trends in migration result in movement away from at-risk areas and towards lower-risk areas. To examine whether this is occurring, we consider how exposure to storms has changed at the population level over our full sample period.

We find that with respect to both all storms and the set of the most damaging storms, overall population exposure to hurricanes has increased over our sample period (Figure 2a). We calculate the average exposure to each type of storm – high and low damage – across all the counties in our sample in each year of the sample, weighting each year individually based on the population living in the county in that year. This holds exposure to storms constant at a county level and reallocates risk across years based on changes in county populations. Migration is not the only determinant of county population, but if there is systematic migration to places that reduce population level risk – adaptive migration – the overall population risk would be declining, holding storms constant. We observe the opposite. The blue and dashed orange line in Figure 2a are both increasing relative to the solid gray and dashed gray lines, which represent the population-level risk had the distribution of population remained the same across counties.

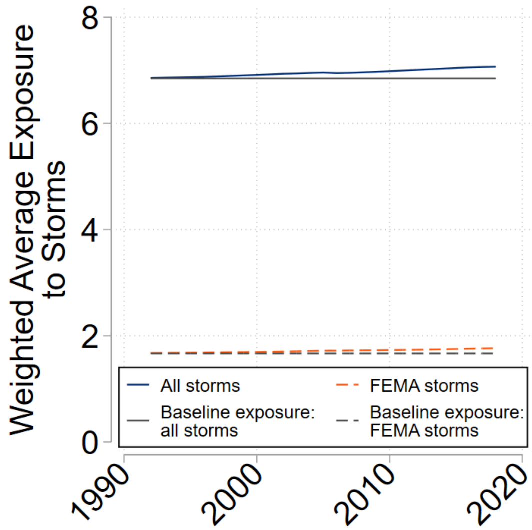
We also find that the total number of storms a county experiences over our 25-year sample and the total net migration it experiences are positively correlated. In Figure 2b, we show that the z-score of total storms and the z-score of total net migration is positively correlated. That is, counties that experience more storms in our sample have on average more migrants moving in than moving out. This relationship is somewhat weak, but is statistically significant. It is also inconsistent with migration patterns where individuals systematically move away from locations that experience storms.

Moving to opportunity versus moving to adaptation

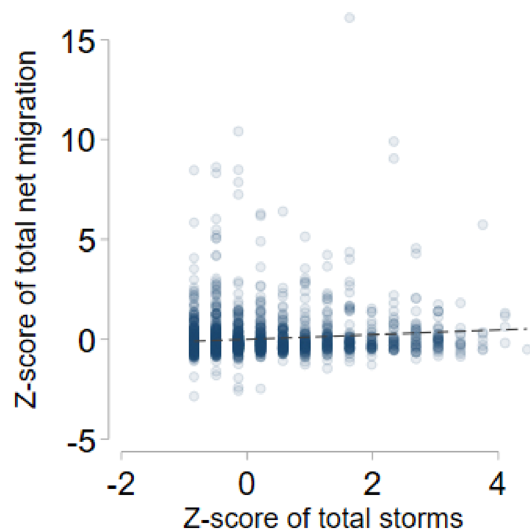
Migration is often driven by economic opportunity, with individuals choosing to relocate to locations with better economic prospects. Even migration that occurs after weather shocks may be motivated by economic opportunity.[34] Using data on county level GDP as a proxy for economic opportunity, we observe that higher county GDP is strongly positively correlated with total net migration over our sample period (Figure 3a). Using the same data, we examine the extent to which there is a trade-off between moving to economic opportunity and moving to places that face lower storm risk.

We find that places with greater economic opportunity, proxied by higher county level GDP

Figure 2



(a) Trend in population-weighted exposure: We plot the weighted average number of storms across all counties in our sample. Weights are the county population in each year. The number of storms in each county is the sum over the sample and so remains constant across years. The change in the trend line is due to changes in where people live. The flat grey lines show weighted average if populations had not changed from 1990 levels - that is if no one had moved. The solid lines show all storms. Dashed lines show storms with at least 10 million dollars in damages according to FEMA.



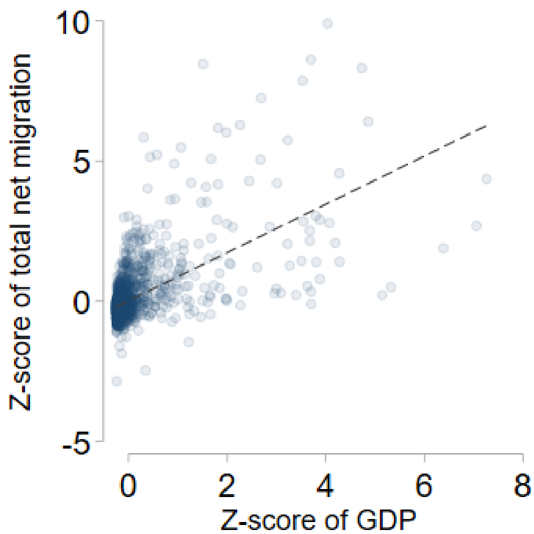
(b) Correlation between net-migration and total storms: Z-score of total net migration is the z-score across all counties of the sum of net-migration (in-migration minus out-migration) within the county across all years in the sample. Z-score of total storms is the z-score across all counties of all storms over our sample period. All points are shaded equally, darker areas on the graph indicate a greater density of counties.

in 2019, face greater storm risk. The correlation between economic activity and the number of storms that a county experiences in our sample is positive (Figure 3b). The positive correlation between GDP and storms suggests that migrants do face a trade-off between moving to areas with greater economic activity and those with lower storm risk.

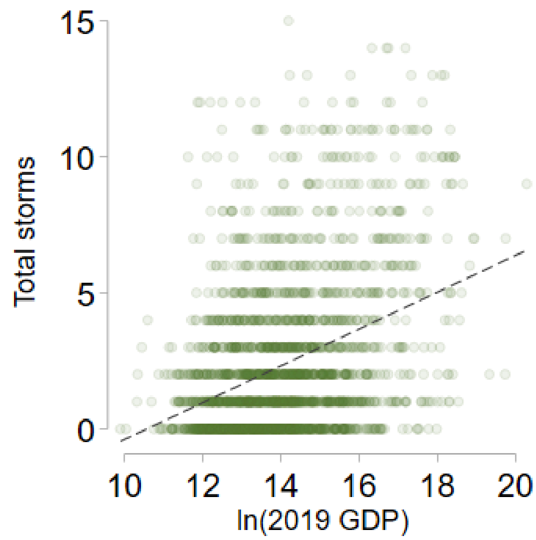
Combined with our finding that population-weighted exposure to storms has increased slightly over time, these results suggest that the benefits of economic opportunity currently outweigh the costs associated with the risk of greater storm exposure that people face. To test this directly, we run a horse-race where we allow net migration to be a function of both a county's storm risk and its GDP in 2019.

We find that GDP is substantially more predictive of net migration than storm risk (Table SI-10). The effect of a standard deviation change in GDP has more than double the effect on net migration of a standard deviation change in storm exposure. We find, additionally, that storms have a positive impact on net migration in our full sample, even after controlling for GDP. We believe this to be a result of unmeasured positive correlation between storm exposure and non-GDP amenities of some major urban areas. When we split the sample based on whether the receiving county has above or below median GDP, our results appear to confirm this hypothesis. In the below median GDP sample, we see the expected negative effect of storm exposure on net migration, although the estimates are insignificant. In above median GDP counties, we see a positive effect of storm exposure, but one that is only marginally significant. In both cases the impact of GDP remains strongly significant and our results are consistent with the benefits of economic opportunity dominating the costs of storm risk.

Figure 3



(a) Correlation between net migration and GDP: Z-score of total net migration is the z-score across all counties of the sum of net-migration (in-migration minus out-migration) for each county across all years in the sample. Z-score of GDP is based on county GDP in 2019, as measured by the Bureau of Economic Analysis. All points are shaded equally, with darker areas on the graph indicating a greater density of counties. We omit three outliers with GDP Z-scores>10. We show a version of this figure that includes the outliers in Figure SI-5.



(b) Correlation between number of storms and GDP: Total storms is the sum of hurricanes hitting each county across all years in our sample. ln(2019 GDP) is the natural log of county GDP in 2019, as measured by the Bureau of Economic Analysis. All points are shaded equally, with darker areas on the graph indicating a greater density of counties.

Discussion

Migration out of U.S. counties hit by average hurricanes did not increase between 1992 and 2017. The migration that did occur after hurricanes, even some of the most damaging ones, generally did not involve movement to counties that are at substantially lower risk of future hurricanes than the sending county. Rather, we find that the population of impacted counties may actually increase after storms, consistent with prior evidence that demand for homes in impacted counties exceeds supply in the years after hurricanes.[35] We also find evidence that exposure to hurricane risk has increased between 1992 and 2017 at the population level due to changes in the geographic distribution of the U.S. population. Taken together, these results suggest that migration has not been occurring in adaptive ways.

There are many reasons why migration may not be adaptive. It is well documented that individuals move for many reasons and there may be a number of reasons why adaptation to climate change would not be a primary motivation for migration in the U.S.

We find evidence that a trade-off exists in the U.S. between moving to locations with more economic opportunity and moving to those that are at lower risk from future hurricanes. Many of the most productive economic counties in our sample (e.g. New York County, Harris County, and Miami-Dade County) are also among the most exposed to storms. It appears that the agglomeration benefits offered by locating in these cities may currently outweigh the incentives to adapt to future storms by relocating. This is a consequence of the particular economic geography of the U.S. and of particular policies. Migration to adaptation in the U.S. might thus still happen in the future, but our results suggest that it will not happen without significant changes in the economic, social, and policy landscape.

One response to our results could be that the gravity-type models that urban and trade economists have used for years have long recognized the importance of agglomeration and economic opportunity as dominant forces driving migration. We acknowledge those models, but point out that this same class of models is often used to show that migration will occur in ways that substantially reduce the risks of climate change, implying that individuals move away from at-risk areas.[9,33] In showing that those at-risk areas are often centers of economic opportunity – at least in the U.S. – and that this opportunity appears to dominate the adaptive motivation for migration in the data, our paper complicates these existing models. Specifically, our empirical results suggest that the relative weights given to economic opportunity and climate change in gravity model calibration may need to be revised. Consistent with this conclusion, recent work utilizing these models calibrated to U.S. county data finds that migration may have a negligible impact on aggregate losses from climate change.[36]

Our results are also subject to several significant caveats. First, it is difficult to prove a null effect. We have shown relatively precise zero effects across a variety of sensible specifications and ways of measuring exposure to hurricanes. However, it remains possible that particular sub-populations or geographies are in fact experiencing adaptive migration. This is particularly true given that our measure of migration relies on individuals filing tax returns. Very low income or other vulnerable populations may not file returns and so may not appear in our data. The migratory responses of these individuals may therefore be different from what is documented here.

Second, we cannot measure within-county migration. This may be an important dimension of adaptation, as individuals move from more to less-exposed areas within the same county. We cannot capture this form of adaptive migration and so may underestimate the extent of adaptive migration that has occurred between 1992 and 2017. However, recent work utilizing data from U.S. Census tracts finds little to no evidence that migration within U.S. counties has reduced a composite of climate change risk.[26] This result, using aggregate data examining all moves, is contrary to work that focuses on movement after targeted buy-out programs.[25,37] Hence, whether and how migration is a form of adaptation remains an active area of research.

Third, there are many other natural disasters whose frequency will increase as a result of climate change. Our evidence does not indicate that adaptive migration in response to these other disasters is not occurring. Different kinds of disasters may lead to different kinds of migratory responses.

The decision of whether or not to migrate occurs in a specific economic, social, and policy context. It is possible, for example, that our results are driven by existing policy supports and insurance markets that do not fully price-in the effects of climate change, leading people to face lower-than-optimal costs of storm damage.[31,38] Similarly, high-risk areas could be lowering the costs of future hurricanes to individuals by investing in more hurricane-resilient infrastructure and thus lowering incentives for adaptive migration. To the extent that all of these forces are at play, there is a significant role for policy to play in encouraging adaptive responses.[39,40,2] Non-policy changes in economic and social conditions in which the decision to migrate occurs may also change in ways that cause migration to be more adaptive. The increasing prevalence of remote work in the aftermath of the COVID-19 pandemic is one example. If forces like remote work reduce the agglomeration benefits of coastal cities, they may reduce the trade-off between moving to economic opportunity, staying socially connected, and adapting to climate change. The increasing frequency and intensity of storms due to climate change may also make damages a more salient feature of the migration decision in the future.

Future research is needed to understand what factors currently lead to the limited migratory response to hurricanes in the United States. Such research will be useful for informing discussions of managed retreat. The contrast between our results and those focusing on targeted buy-out programs suggests these programs may have substantial effects relative to a counterfactual of no policy intervention. Migration in the face of climate change will certainly occur in the future as some coastal areas become uninhabitable. Understanding why current migration patterns appear to be leading to larger, rather than smaller, populations in these at-risk areas is critical to understanding how to minimize the costs of this future migration.

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Supplementary Information

SI-1 Materials and Methods

SI-1.1 Data

We use data on the tracks of every Atlantic basin hurricane that has struck the continental United States from 1988 to 2018.[1] These data are based on information tracked by the NOAA Storm Events database and the National Hurricane Center. They provide us with information on the track, rainfall totals, and wind speeds associated with the storms, as well as the counties that experienced a flood event as a consequence of each storm.

We define counties as exposed to a hurricane in three ways. In our primary analysis, a county is considered exposed if it experienced a flood warning within one day of the track of the storm passing through it OR if it experienced winds greater than 21 m/s in the same time period. In alternative analyses, we use the flood warning definition and the wind speed definition individually to assign exposure. In Figure SI-1, we show the counties effected by hurricanes under these alternative definitions in our sample. We choose 21 m/s as our wind threshold because this is (a) the wind speed at which NOAA indicates structural damage to buildings will begin to occur and (b) approximately the lower bound for wind speed for a storm to be considered a tropical storm. It is substantially below the minimum wind speed on the Saffir-Simpson scale for a Category 1 hurricane. We note, however, that our results are robust to using higher wind speed thresholds and that, as one increases the wind speed threshold to the Category 1 threshold, the set of impacted counties collapses to those that would be included based on the flooding definition. We show in the supplementary materials that our results are robust to using only those counties that meet this flooding threshold.

We supplement these data with data from FEMA on the total payments made to individuals for every disaster declared by FEMA since 1954.

Our migration data come from the IRS Statistics of Income's county-to-county migration flows. The IRS publishes data on the number of migrants leaving each county and their destination based on aggregated tax return data for each year from 1991 to 2019.

From these data sets, we assemble a balanced panel that lists all migration to and from all counties in the United States and the number of storms each county experienced from 1992 to 2017.

SI-1.2 Empirical Approach

Our base specification is a two-way fixed effects model of the form:

$$Y_{ist} = \beta_1 \mathbb{1}\left[\text{Storm}_{ist}\right] + \sum_{\tau=1}^{5} \beta_t \mathbb{1}\left[\text{Storm}_{is,t+\tau}\right] + \alpha_{is} + \chi_t + \eta_s + \epsilon_{it} \tag{1}$$

where, in our first analysis, Y_{ist} is the number of out-migrants (or net migration) from county i in state s and year t. We estimate models using the inverse hyperbolic sine (IHS) transformation of these outcomes, as well as a Poisson specification. $\mathbb{1}\left[\text{Storm}_{ist}\right]$ is an indicator for whether a county experiences a storm in a given year. We define exposure in a variety of ways (e.g., maximum wind speed, flood warnings, cost of damage), taking advantage of the range of data we have on each hurricane. In some specifications, we also allow storms to have a 5-year lag effect. α_{is} is a county fixed effect, χ_t is a year fixed effect, and η_s is a state by year trend.

In our second analysis we estimate the following model:

$$\Delta E_{ist} = \beta_1 \mathbb{1}\left[\text{Storm}_{ist}\right] + \alpha_{is} + \chi_t + \eta_s + \epsilon_{it} \tag{2}$$

where our outcome, ΔE_{ist}, is the weighted average difference in exposure to storms between the counties receiving migrants from county i over our full sample and county i. We weight by the number of migrants heading to each receiving county in a given year. In other words, if county i sends migrants to five other counties over our sample, we take a weighted average of the number of storms experienced by those five counties during the sample, where the weights are the number of migrants sent by county i, and then take the difference between the storms experienced by county i and this weighted average. In this specification, exposure is defined as the sum of the storms each county experiences in our sample period. We also estimate a version of this model where the outcome is the weighted average exposure of counties receiving migrants from county i, where the weights are the number of migrants in year t.

The purpose of this analysis is to measure whether migrants move to counties with lower storm risk when they move after a storm. We also examine whether the migrants who move after a storm move to counties with different levels of storm risk, regardless of how that risk level relates to their home county, and whether such patterns are different for migrants who move in a non-storm year.

SI-2 Robustness Checks

SI-2.1 Placebo specification

Our core analysis assumes that hurricane strikes in any given year in any given location are essentially random. That is, some counties may receive more hurricanes on average, but whether or not a hurricane strikes a county in a particular year is driven by quasi-random weather patterns. This implies a testable proposition: hurricane strikes in the years following any given year (i.e., with respect to 2005, strikes in 2006, 2007, etc.) should not influence migration in that year. In Table SI-11, we show that hurricane strikes in years after a particular year have no significant impact on migration in that year. Generally, the coefficients are small and oscillate around zero. This is true whether we regress only leads or include both leads and lags out to five years.

SI-2.2 Accumulation of storms

It is possible that while individual storms may not lead to out-migration, experiencing several storms in close succession may increase out-migration. While our lagged framework goes some way towards accounting for this, another way to test the hypothesis is to include either (1) a control for the total storms in the preceding five years or (2) the interaction of the total number of storms in the preceding five years with our measure of storms in a given year. We do both in Table SI-12 by augmenting Equation 1 with a measure of the total storms that a county experienced in the preceding five years in columns 1 and 3, and then interacting this with our measure of storms in a given year in columns 2 and 4. We do not find that more storms in the preceding five years changes our estimates of the impact on out-migration or net-migration of receiving a storm in a given year in either specification. Our estimates of out-migration remain close to zero and statistically insignificant and our measures of net migration remain reasonably large, positive, and statistically significant. The coefficient on the interaction term suggests that more storms in the preceding years increases net-migration after a storm occurs and - although noisily estimated - decreases out-migration. While far from conclusive evidence, this pattern of results is consistent with more storms potentially causing more destruction and driving down property values, while also destroying wealth and reducing individuals' capacity to move.

SI-2.3 County pair estimates

Recent work on the impact of local shocks on migration has suggested that failure to consider the events in receiving counties can lead to model mis-specification and bias in estimates.[2] Because we only consider the total out-migration or net-migration from storm-impacted counties, our primary specification does not account for shocks in the receiving counties.

To account for the potential bias, in Table SI-13, we estimate our primary specification at the county-to-county level. That is, instead of collapsing all migration from a given county into an aggregate, we preserve the individual county-to-county flows in each year. This allows us to add a county-to-county fixed effect, but more importantly, it allows us to control for the incidence of storms in the receiving counties. This is important because it might be the case that our main result - that storms do not lead to out-migration - is driven primarily by the fact that potential out-migrants after a storm want to move to other counties that are also impacted by *the same* storm. If that were the case, we should fine that out-migration increases when we also control for storms in receiving counties. We do not. If anything, results in Table SI-13 suggest that out-migration is lower when accounting for storms that occur in the same year in receiving counties.

SI-2.4 Learning over time

Awareness of climate change - and the link between climate change and hurricanes - has increased over time. Our data span a range of years during which climate change was not widely thought of as a pressing policy problem. It is therefore possible that as awareness has increased, the migratory response to the occurrence of hurricanes has also changed. Specifically, as people have become more aware of the potential for climate change to increase the frequency and severity of hurricanes in recent years, they may have become more likely to migrate after experiencing a hurricane. By including many years of data prior to widespread understanding of the risks of climate change, our results would then be biased downward relative to estimates using only years with higher levels of awareness (which might be a better indicator of future migratory responses).

To test this possibility, we split our sample into pre- and post-2006 and estimate our primary specification separately on each sub-sample. If changes in awareness of climate change are driving greater migratory responses after hurricanes in recent years, we should see differences in these coefficients. Specifically, the coefficient on the post-2006 period should be more positive than on the pre-2006 period.

As is clear from Table SI-14, we do not see evidence that the migratory response to hurricanes is becoming more positive over time. If anything, our results suggest it is becoming more negative. This is not sensitive to the choice of year on which we split the sample. All years between 2003 and 2008 yield similar results. There is no year on which the data can be split after 2000 that yields a positive and statistically significant coefficient on out-migration.

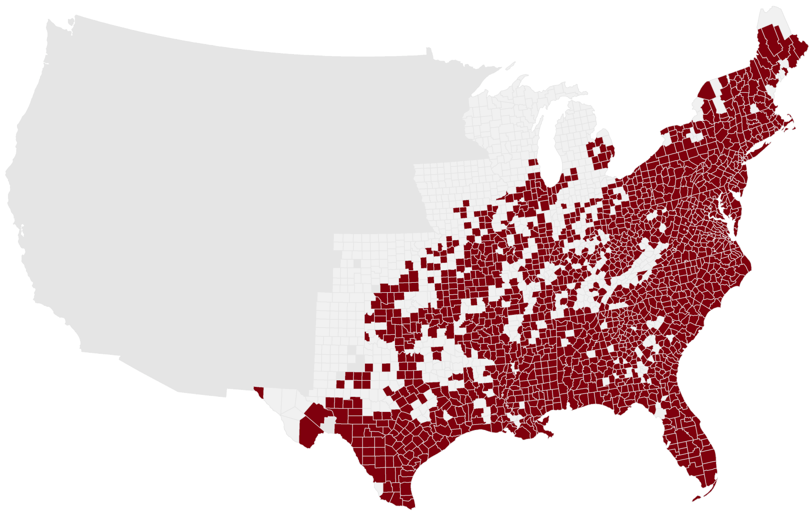
SI-2.5 A note on treatment heterogeneity

In this paper, we are aiming to estimate a population-level migratory response to hurricanes. This is, by its nature, an average response across all sub-groups (geographic or socioeconomic) within the study area. It is possible, and in fact likely, that some sub-groups may have a different response than what is estimated here.[3]

This heterogeneity in effects has important implications for who bears the burden of climate damages and the distributional consequences of climate change. These are worthy of study in their own right and merit future work. However, we believe that the existence of treatment effect heterogeneity does not invalidate the usefulness of the average response we estimate here, if the goal is to understand what is happening to population-level exposure.

SI-3 Supplementary Figures

(a) Flood warning counties



(b) High-wind counties

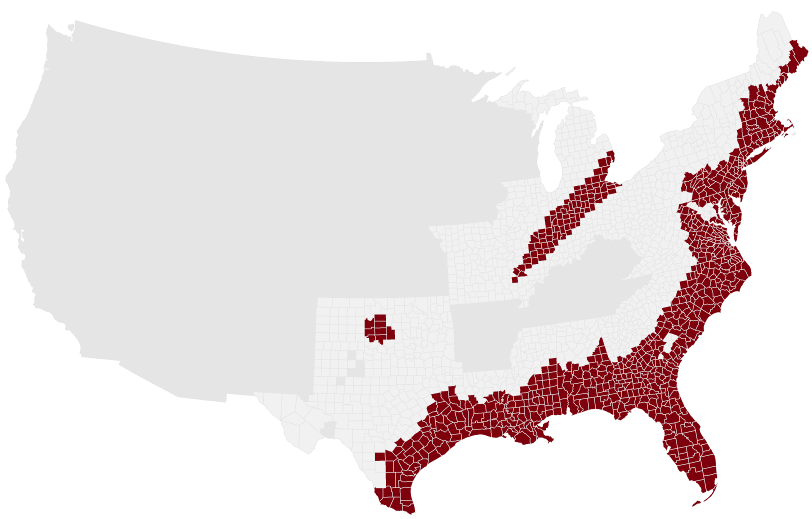


Figure SI-1: Storm counties–Panel A shows the counties that experience a flood in our sample. Panel B shows the counties that are exposed to wind greater than 21 m/s - the speed at which structural damage begins to occur - in our sample.

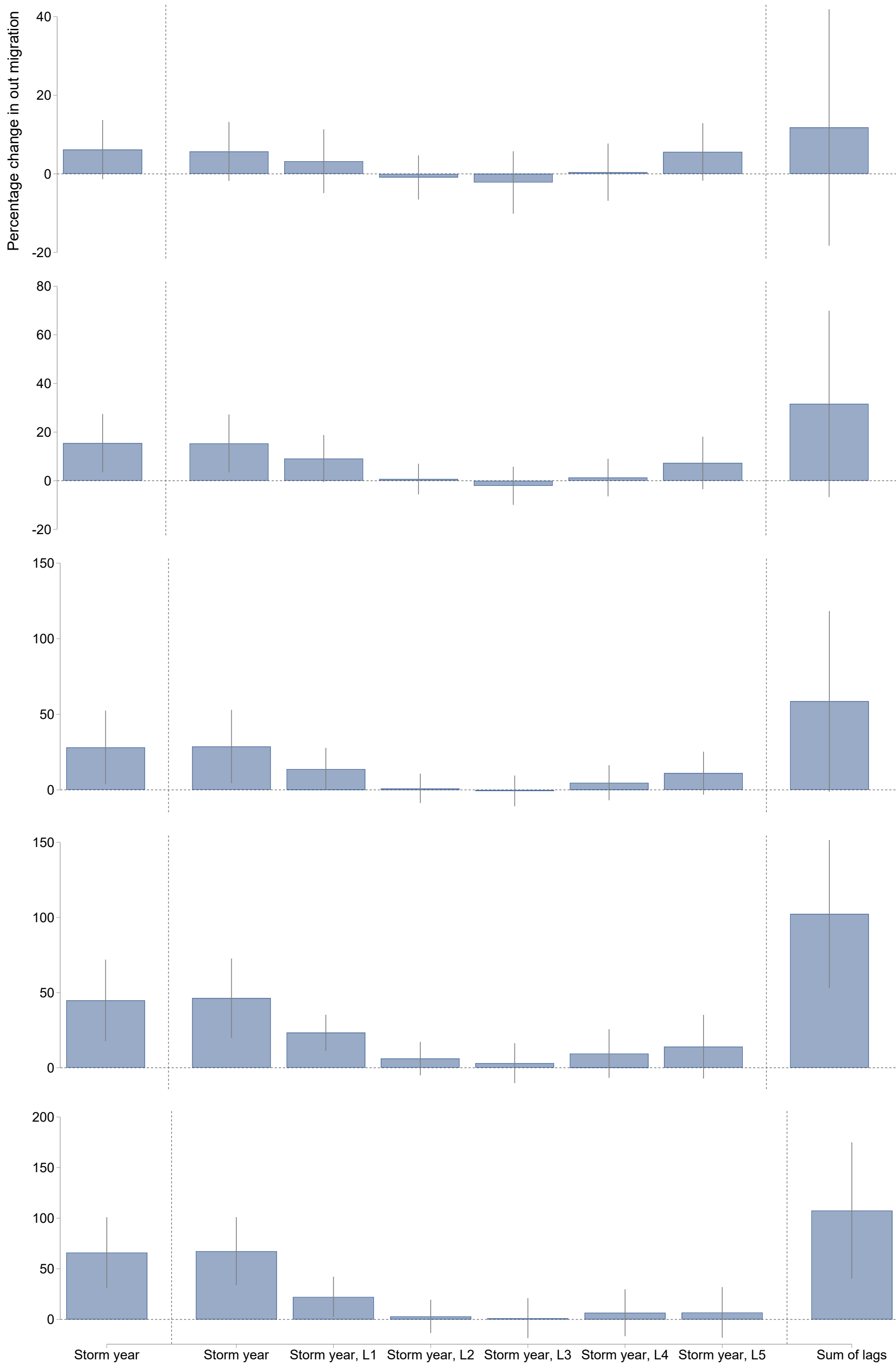


Figure SI-2: Impact of high damage storms on out-migration–All panels plot the coefficients from a panel fixed effects regression of out-migration on whether a county experienced a hurricane. The first bar plots the coefficient from a regression with only contemporaneous storms. The next six show coefficients from a separate regression that includes contemporaneous storms and the five years after a storm. The final bar shows the sum of the coefficients from the lags regression. Starting from the top, the first panel shows the results from a sample with storms causing at least 10 million dollars in damages, then 20 million dollars, 40 million dollars, 80 million dollars, and lastly only storms causing at least 160 million dollars in damages.

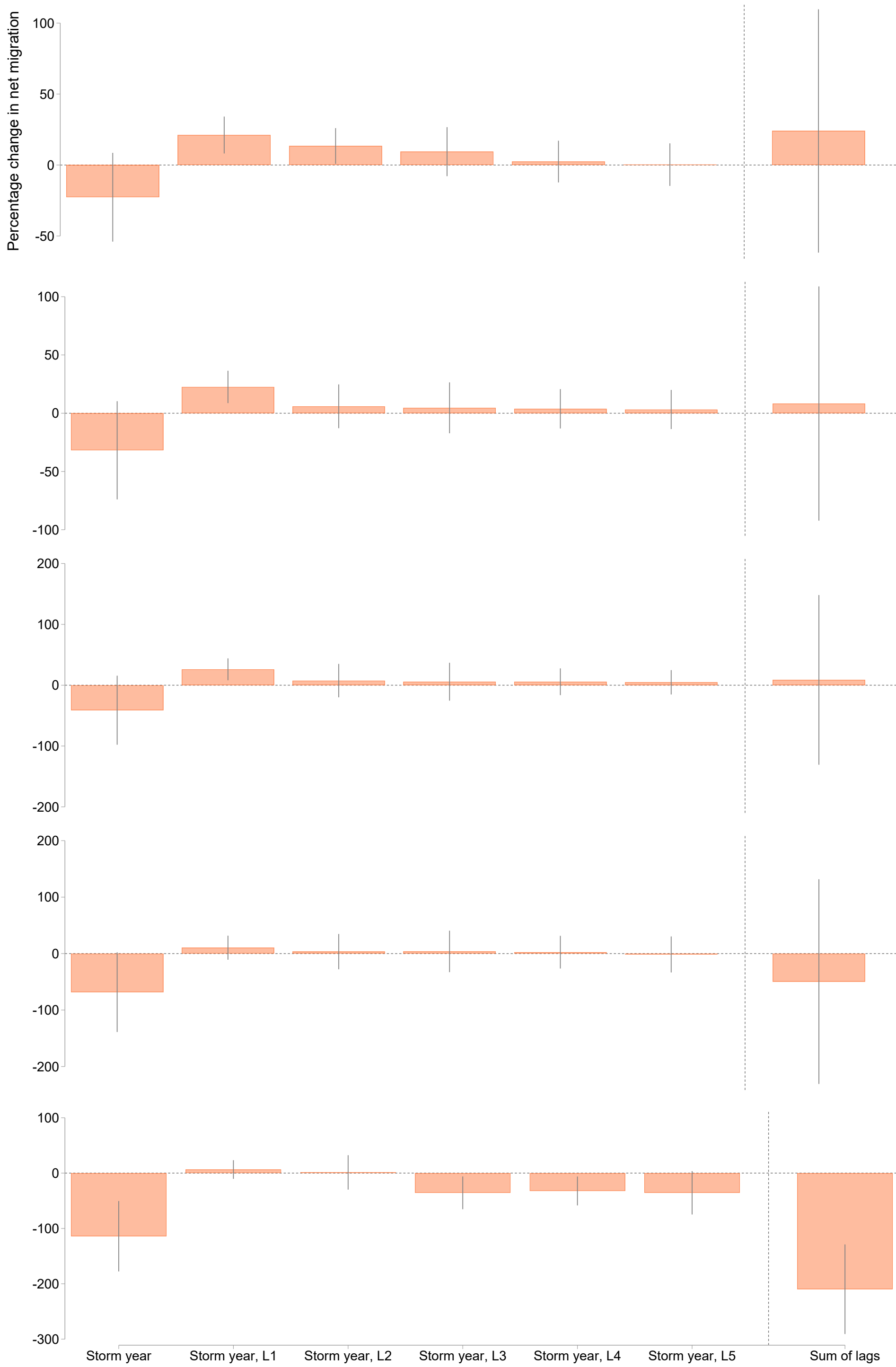


Figure SI-3: Impact of high damage storms on net migration–All panels plot the coefficients from a panel fixed effects regression of net migration on whether a county experienced a hurricane. The first bar plots the coefficient from a regression with only contemporaneous storms. The next six show coefficients from a separate regression that includes contemporaneous storms and five year lags after a storm. The final bar shows the sum of the coefficients from the lags regression. Starting from the top, the first panel shows results from a sample with storms causing at least 10 million dollars in damages, then 20 million dollars, 40 million dollars, 80 million dollars, and lastly only storms causing at least 160 million dollars in damages.

Figure SI-4: Counties impacted by high damage storms–All panels plot counties impacted by high damage storms. For all panels, a county is considered impacted if it meets either the flooding or wind speed threshold. To be considered impacted in the top-left map, a county must have been impacted by at least one storm that caused at least 10 million dollars in damages over our sample period. In the subsequent panels, from left to right, the damage threshold is 20 million dollars, 40 million dollars, 80 million dollars, and 160 million dollars.

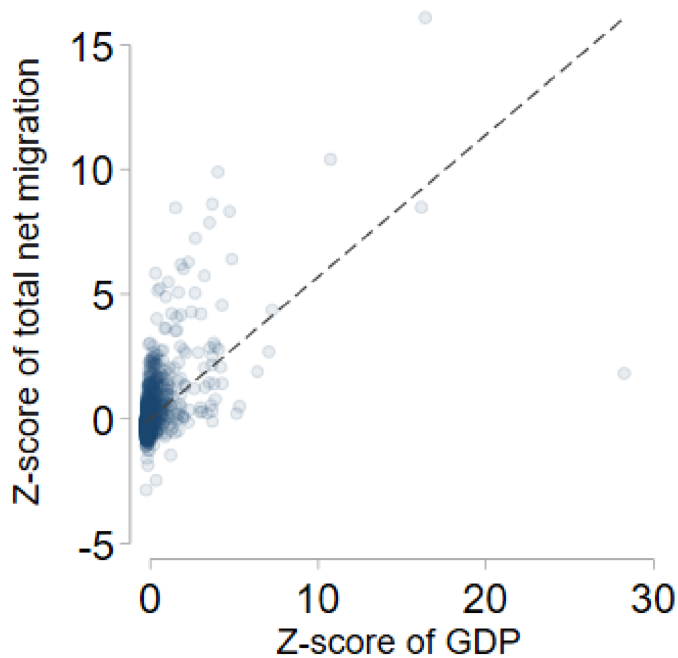


Figure SI-5: Correlation between net migration and GDP–Z-score of total net migration is the z-score across all counties of the sum of net-migration (in-migration minus out-migration) for each county across all years in the sample. Z-score of GDP is based on county GDP in 2019, as measured by the Bureau of Economic Affairs. All points are shaded equally, with darker areas on the graph indicating a greater density of counties.

SI-4 Supplementary Tables

Table SI-1: Migration impacts of storms

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.004	-0.008	0.103***	0.111***
	(0.009)	(0.011)	(0.031)	(0.035)
1(Storm year), t-1=1		0.001		0.079*
		(0.012)		(0.043)
1(Storm year), t-2=1		0.013		0.020
		(0.011)		(0.034)
1(Storm year), t-3=1		-0.006		0.020
		(0.017)		(0.034)
1(Storm year), t-4=1		-0.017		0.007
		(0.020)		(0.039)
1(Storm year), t-5=1		0.016		-0.007
		(0.018)		(0.040)
N	64,449	52,514	64,368	52,448
$\Sigma_{i=0}^{5} Storm_{t-i} = 1$		-0.001		0.229
		(0.069)		(0.156)
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

NOTES: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-2: Migration impacts of storms based on wind speed

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.017	-0.038**	0.112*	0.162***
	(0.011)	(0.015)	(0.056)	(0.050)
1(Storm year), t-1=1		-0.006		0.072
		(0.012)		(0.080)
1(Storm year), t-2=1		0.009		-0.038
		(0.013)		(0.040)
1(Storm year), t-3=1		0.009		0.033
		(0.015)		(0.064)
1(Storm year), t-4=1		-0.004		-0.064
		(0.019)		(0.089)
1(Storm year), t-5=1		0.028*		0.002
		(0.015)		(0.046)
N	49,248	40,128	49,167	40,062
$\Sigma_{i=0}^{5} Storm_{t-i} = 1$		-0.002		0.166
		(0.052)		(0.149)
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

NOTES: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Counties are defined as exposed to a storm if the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-3: Migration impacts of storms based on flood declarations

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.004	-0.001	0.108***	0.104***
	(0.011)	(0.012)	(0.033)	(0.037)
1(Storm year), t-1=1		0.003		0.076*
		(0.013)		(0.040)
1(Storm year), t-2=1		0.016		0.035
		(0.014)		(0.045)
1(Storm year), t-3=1		-0.002		-0.007
		(0.019)		(0.041)
1(Storm year), t-4=1		-0.014		0.032
		(0.021)		(0.037)
1(Storm year), t-5=1		0.011		-0.000
		(0.018)		(0.046)
N	64,449	52,514	64,368	52,448
$\Sigma_{i=0}^{5} Storm_{t-i} = 1$		0.013		0.239
		(0.080)		(0.181)
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-4: Change in exposure for migrants

	Destination exposure	Difference in exposure
1(Storm year)=1	-0.002	-0.005
	(0.003)	(0.007)
N	62,877	44,886
Fixed Effects:		
County	Yes	Yes
Year	Yes	Yes

NOTES: All columns report the results of a fixed effects specification. The outcome in column 1 is the IHS transformation of the average total number of storms experienced over our full sample in each of the counties that received migrants from a given sending county in a given year. The outcome in column 2 is the IHS transformation of the average difference in exposure between a sending county and all the counties that received migrants from that county in a given year. We calculate this difference as exposure in the sending county minus exposure in the receiving county for each sending-receiving pair in a given year, then averaged within sending counties and years. A more positive difference indicates that migrants moved to places with lower storm risk. This measure is the outcome in our regressions so a positive coefficient indicates that the average exposure difference is larger and more positive in storm years relative to non-storm years. That, in turn, indicates that in storm years migrants move to places with a greater reduction in risk between the county they leave and where they go compared to migrants who move in non-storm years. Regressions are weighted by the total migrants from a county in each year. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. *p=0.1, **p=0.05,***p=0.01.

Table SI-5: Difference in storm exposure in storm-year migration, all storms

	Mean	SE	*t-stat*
Receiving county storms	7.39	4.38	
Sending county storms	7.35	5.04	
Difference	0.04		0.46

NOTES: For counties that experience a storm, we calculate the total number of storms that county experiences over our full sample (Sending county storms). In each year a sending county experiences a storm, we calculate the weighted average total number of storms that the counties receiving migrants from that county in that year experience over our sample (Receiving county storms). Receiving counties are weighted based on the number of migrants they receive from a given county in a given year. We report the difference (a positive difference indicating that receiving counties experience more storms on average) and a t-test of the significance of that difference.

Table SI-6: Migration impacts of high damage storms

	$> 10MM$	$> 20MM$	$> 40MM$	$> 80MM$	$> 160MM$
1(Storm year)=1	0.062	0.154**	0.281**	0.448***	0.661***
	(0.037)	(0.058)	(0.118)	(0.132)	(0.169)
N	64,449	64,449	64,449	64,449	64,449
Fixed Effects:					
County	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes	Yes

NOTES: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year and the total value of compensation approved by FEMA was greater than indicated in the column heading. Roughly 90% of storms in our sample result in less than 10$millioninapprovedcompensation.95\%resultinlessthan$50 million in approved compensation. *p=0.1, **p=0.05,***p=0.01.

Table SI-7: Lagged migration impacts of high damage storms

	$> 10MM$	$> 20MM$	$> 40MM$	$> 80MM$	$> 160MM$
1(Storm year)=1	0.057	0.153**	0.287**	0.463***	0.675***
	(0.036)	(0.058)	(0.118)	(0.128)	(0.163)
1(Storm year), t-1=1	0.032	0.091*	0.138*	0.233***	0.223**
	(0.039)	(0.047)	(0.068)	(0.058)	(0.097)
1(Storm year), t-2=1	-0.009	0.007	0.010	0.061	0.030
	(0.027)	(0.031)	(0.047)	(0.054)	(0.080)
1(Storm year), t-3=1	-0.022	-0.021	-0.006	0.031	0.013
	(0.039)	(0.038)	(0.049)	(0.065)	(0.096)
1(Storm year), t-4=1	0.004	0.013	0.047	0.095	0.066
	(0.035)	(0.038)	(0.056)	(0.079)	(0.112)
1(Storm year), t-5=1	0.056	0.073	0.110	0.140	0.069
	(0.035)	(0.052)	(0.069)	(0.103)	(0.121)
N	52,514	52,514	52,514	52,514	52,514
$\Sigma_{i=0}^{5} Storm_{t-i} = 1$	0.118	0.316	0.586	1.023	1.076
	(0.146)	(0.186)	(0.290)	(0.239)	(0.327)
Fixed Effects:					
County	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year and the total value of compensation approved by FEMA was greater than indicated in the column heading. Roughly 90% of storms in our sample result in less than $10millioninapprovedcompensation.95\%resultinlessthan$50 million in approved compensation. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-8: Difference in storm exposure in storm-year migration, high damage storms

	Mean	SE	*t-stat*
Receiving county storms	7.65	4.38	
Sending county storms	7.72	5.07	
Difference	-0.06		-0.62

Notes: For counties that experience a high-damage storm, we calculate the total number of storms each county experiences over our full sample (Sending county storms). In each year a sending county experiences a storm, we calculate the weighted average total number of storms that the counties receiving migrants from that county in that year experience over our sample (Receiving county storms). Receiving counties are weighted based on the number of migrants they receive from a given county in a given year. We report the difference (a positive difference indicating that receiving counties experience more storms on average) and a t-test of the significance of that difference. We restrict the sample to those counties that have at least $20 million in approved FEMA compensation (the top 90% of storm impacted counties).

Table SI-9: Return migration after high damage storms

	$> 10MM$	$> 20MM$	$> 40MM$	$> 80MM$	$> 160MM$
High Damage County=1	-0.247	-0.346	-0.453	-0.721*	-1.089**
	(0.152)	(0.208)	(0.279)	(0.327)	(0.328)
N	410,616	283,635	180,036	119,259	72,765
Fixed Effects:					
County	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of return-migrants to a county in the five years following a high damage storm as the outcome. We only include migration from counties that received migrants from the storm-impacted county in the year of the storm. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to appear - during a hurricane in the year and if the damage payments from FEMA in response to the storm exceeded the totals indicated in the column headings. *p=0.1, **p=0.05,***p=0.01.

Table SI-10: Impact of GDP and storms on net migration

	Full sample	Below median GDP	Above median GDP
2019 GDP (MM)	0.124***	3.971***	0.100***
	(0.038)	(1.085)	(0.028)
Total storms	0.500***	-0.032	0.251*
	(0.143)	(0.079)	(0.131)
N	2,332	1,133	1,199
Impact of 1SD change in GDP	2.772	88.991	2.237
Impact of 1SD change in storms	1.383	-0.088	0.694
Fixed Effects:			
State	Yes	Yes	Yes

NOTES: All columns report the results of a fixed effects specification with the IHS transformation of the number of net-migrants over our sample period from a county as the outcome. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Total storms is the sum of the storms the county is impacted by in our sample. *p=0.1, **p=0.05,***p=0.01.

Table SI-11: Migration impacts of storms, leads and lags

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.004	-0.003	0.108***	0.120***
	(0.006)	(0.007)	(0.034)	(0.036)
1(Storm year), t+1=1	-0.004	0.004	0.032	0.037
	(0.007)	(0.008)	(0.035)	(0.035)
1(Storm year), t+2=1	-0.011	-0.001	0.021	0.018
	(0.007)	(0.012)	(0.031)	(0.038)
1(Storm year), t+3=1	-0.010	0.000	0.023	0.049
	(0.007)	(0.008)	(0.036)	(0.033)
1(Storm year), t+4=1	0.002	0.018	-0.038	-0.015
	(0.013)	(0.013)	(0.030)	(0.032)
1(Storm year), t+5=1	0.001	0.012	0.020	0.040
	(0.008)	(0.010)	(0.035)	(0.029)
1(Storm year), t-1=1		0.010		0.081*
		(0.010)		(0.041)
1(Storm year), t-2=1		0.015*		0.034
		(0.008)		(0.038)
1(Storm year), t-3=1		-0.018		0.060*
		(0.013)		(0.030)
1(Storm year), t-4=1		-0.006		0.024
		(0.012)		(0.035)
1(Storm year), t-5=1		0.046*		-0.004
		(0.025)		(0.046)
N	52,514	40,579	52,448	40,528
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-12: Migration impacts of storms with total storms

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.005	0.004	0.111***	0.055*
	(0.011)	(0.016)	(0.034)	(0.032)
All storms in t-5 years	-0.005	-0.002	0.054*	0.041
	(0.014)	(0.015)	(0.030)	(0.030)
1(Storm year)=1 × All storms in t-5 years		-0.012		0.072**
		(0.011)		(0.028)
N	64,449	64,449	64,368	64,368
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Columns 1 and 3 control for the total number of storms in the county in the previous 5 years. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. *p=0.1, **p=0.05,***p=0.01.

Table SI-13: Migration impacts of storms with paired counties

	Impact on out-migration		Impact on net migration	
	(1)	(2)	(3)	(4)
1(Storm year)=1	-0.018**	-0.023**	0.022	0.028
	(0.009)	(0.010)	(0.016)	(0.018)
1(Storm year), t-1=1		-0.017		0.018
		(0.010)		(0.014)
1(Storm year), t-2=1		-0.007		0.013
		(0.009)		(0.015)
1(Storm year), t-3=1		-0.008		0.013
		(0.011)		(0.013)
1(Storm year), t-4=1		0.002		0.000
		(0.010)		(0.011)
1(Storm year), t-5=1		0.014		-0.022**
		(0.012)		(0.010)
N	2,908,370	2,369,765	2,377,137	1,936,912
$\Sigma_{i=0}^{5} Storm_{t-i} = 1$		-0.040		0.049
		(0.037)		(0.059)
Fixed Effects:				
County pair	Yes	Yes	Yes	Yes
Sending County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. In all regressions we control for storms in the receiving counties. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damages begins to occur - during a hurricane in the year. 1(Storm year), t-# indicates that the county experienced a storm # years previously. *p=0.1, **p=0.05,***p=0.01.

Table SI-14: Migration impacts of storms over time

	Impact on out-migration		Impact on net migration	
	Pre-2006	Post-2006	Pre-2006	Post-2006
1(Storm year)=1	0.018^{*}	-0.034^{*}	0.115^{***}	0.071
	(0.011)	(0.018)	(0.035)	(0.053)
N	33,418	31,031	33,376	30,992
Fixed Effects:				
County	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
State×Year	Yes	Yes	Yes	Yes

Notes: All columns report the results of a fixed effects specification with the IHS transformation of the number of out-migrants from a county as the outcome in columns 1-2 and the IHS transformation of net migration as the outcome in columns 3-4. Net migration is defined as in-migration minus out-migration so that negative net migration indicates a declining population. Counties are defined as exposed to a storm if at least one hurricane resulted in a flood warning during the year or the county experienced wind speeds of at least 21 m/s - the speed at which structural damage begins to occur - during a hurricane in the year. Our results are not sensitive to the choice of 2006 as the year to split the sample. Any year between 2003 and 2008 yields qualitatively similar results. *p=0.1, **p=0.05,***p=0.01.

Supplementary References

[1] GB Anderson et al. “Hurricaneexposuredata: Data Characterizing Exposure to Hurricanes in United States Counties”. In: *R Packag. version 0.1* (2020).

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[3] Solomon M Hsiang and Daiju Narita. “Adaptation to cyclone risk: Evidence from the global cross-section”. In: *Climate Change Economics* 3.02 (2012), p. 1250011.