Environmental Migration

Sarah Blodgett Bermeo (Duke University)
David Leblang (University of Virginia

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The term “environmental migrant” refers to those who leave their homes due to deteriorating environmental conditions or sudden climatic events. Although environmental migrants are not new, several studies and reports suggest that the impacts of climate change will lead to increases in migrant flows. In some situations the case for moving is clear, such as when rising sea levels make land uninhabitable. However, even in these most obvious cases for migration, it is not known what percentage of the movement will be internal and what percent international. In other situations, it is unclear that deteriorating conditions due to climate change necessarily lead to increased migration: while they may increase the push factors making emigration desirable, they also decrease the resources which people have to finance their migration.

Understanding migration due to environmental changes is important for its own sake. It also, however, may shed light on issues related to migration more generally. Like any category of migration, environmental migrants move for various reasons. Many will migrate within their own country. Others will cross national borders because they feel there is little hope that the situation within their country can provide even the most basic support for themselves and their families. This category is what is brought to mind by the increasingly-used term “climate refugee,” although movement on environmental grounds does not confer refugee status under international law. Different groups may migrate in the aftermath of a natural disaster, such as a hurricane, with the intent to return. Others may be physically able to remain in their homeland but, given deteriorating conditions brought about by climatic changes, choose to become labor migrants to wealthier areas.

The long-run purpose of this project is to examine the push factors associated with environment-induced migration, as well as to examine similarities and differences between migration caused by climate change and migration stemming from other causes. What environmental changes lead to increased migration? Do climate refugees follow similar migration patterns to political refugees? Are movements in the wake of climate-related natural disasters similar to those following geological natural disasters? Is there a pattern common to climate-induced labor migrants and more traditional labor migrants, or are they significantly different? Does the study of patterns for environmental migrants provide insight into how we should view more traditional forms of migration?

While ultimately we seek to understand more detailed differences in migration flows, the present analysis takes only a first step. Here we are asking only whether climatic changes - which we measure as positive or negative changes in average precipitation or temperature - affect overall emigration rates from a country. Theoretically, it is not clear that even negative climatic changes would increase emigration. Economic migration is often depicted as following an inverted-U pattern. At low levels of income, increases lead to more emigration as a greater number of people have the financial ability to migrate. As income increases further, the gap between the potential source and host countries decreases, making migration less attractive. If climate change causes a deterioration in living conditions for affected people, their will be a greater desire for movement but also a decreased ability to migrate. Additionally, even those who do migrate may do so internally, with little impact on the emigration rate for the country. Therefore, it makes sense to start by simply asking if climatic changes increase emigration rates.

1 Data

The analysis examines the relationship between changes in two environmental variables, average yearly precipitation and average yearly temperature, and emigration rates. The time frame for emigration is 1985-2012 and the analysis is able to capture 176 countries.

Dependent variable The dependent variable is the log of the emigration rate from country x in year t. The emigration rate is calculated as the flow of migrants from x in year t divided by the country's population in t. The flow captures all reported migrant flows from x recorded by the

OECD as entering an OECD member country in year *t*.[1] Thus it under counts total emigration, since it fails to capture emigration to non-OECD host countries. Future work will incorporate additional migrant flows.

Environmental shock variables The main explanatory variables capture variation in precipitation and temperature within a country. To construct each set of variables, we first took the difference between the average precipitation (temperature) in years *t-1* through *t-5* and the average precipitation (temperature) in years *t-6* through *t-10*. We then construct two separate variables to capture the size of the positive and negative changes. If the difference is positive (precipitation/temperature increases) then the positive shock variable takes on the value of the difference; for observations where the difference is negative the positive shock variable is zero. If the difference is negative (precipitation/temperature decreases) then the negative shock variable takes the absolute value of the difference; for observations where the difference is positive the negative shock variable is zero. Using the absolute value for negative shocks eases interpretation, as it is the size of the shock (either positive or negative) that is likely to be associated with migration. Constructing separate variables for positive and negative changes allows us to test the impact of each on migration, as it is possible that the direction of the environmental shock is important. Once the variables were constructed, we took the natural log of (one plus) the value and used these as our key measures of precipitation and temperature shocks.

Control variables We include several control variables that might affect migration rates. We code an indicator for civil war as 1 if the country experiences a civil war in year *t*, based on the

[1]Data are from OECD.stat.

coding in the PRIO dataset[2] Democracy is measured as the average of a country's scores on civil liberties and political rights, as measured by Freedom House, inverted so higher values are more democratic.[3] Income is measured as the log of GDP per capita in constant dollars from the World Development Indicators[4]. Because the relationship between income and migration is expected to be nonlinear, the square of this variable is also included. Growth of income per capita, also from the World Development Indicators, is included.

2 Preliminary Results

Results of this preliminary analysis are presented in Table 1. The analysis uses ordinary least squares regression with year fixed effects and robust standard errors calculated by clustering on country; p-values are in parentheses. The analysis covers emigration for the period 1985-2012. Because of the lag structure explain above, this means that the earliest environmental changes included are the differences between the average for the period 1975-79 and 1980-84. To test for nonlinearity in the relationship between environmental change and migration, models were initially estimated both with and without squared values of the shock variables included. For precipitation there was no evidence of nonlinearity so these were dropped; they are included for temperature as their does appear to be nonlinearity in the relationship between temperature changes and migration rates.

The results suggest that environmental changes do increase migration. Model 1 includes the

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[2]Gleditsch et al, 2002; most recent version of dataset used. Civil war is coded as 1 if there was a type 3 or 4 war occurring in the country according to PRIO.

[3]Freedom in the World, available at www.freedomhouse.org.

[4]accessed 5/22/14.

measures of positive and negative changes in precipitation, while Model 2 probes the relationship between temperature changes and emigration rates. In both models the nonlinear relationship between income and emigration is apparent, as is the correlation between past and current migration.

Model 1 shows a positive relationship between both positive and negative changes in precipitation and the rate of emigration. To put it in perspective, if the negative difference in precipitation from one five year period to the next moves from zero to its value at the 50th percentile, emigration increases by nine percent. Increasing the negative shock to the 75th percentile is associated with an increase in the emigration rate of 13.5%, while a shock at the 90th percentile is associated with a 17.7% increase. Similar percentile changes are associated with positive changes in precipitation.[5] Figure 1 shows predicted values for the emigration rate associated with both negative and positive changes in precipitation.

It is worth noting that these effects are likely lower bounds on the overall effect of changes in precipitation on emigration rates. The models control for income and conflict - yet both are possible pathways through which climatic changes might affect migration. They also control for previous emigration - if precipitation change has been underway and contributed to past migration as well, then controlling for this would underestimate the effect of precipitation changes. What is depicted here is the net effect of precipitation changes, after controlling for some of the indirect ways in which changes in precipitation can affect migration.

[5] All calculations are performed using the software Clarify, with the year set at 2010, initial precipitation changes set at zero, and all other variables at their means.

	Model 1	Model 2
Negative Precipitation Shock	0.059*	
	(0.09)	
Positive Precipitation Shock	0.056**	
	(0.03)	
Negative Temperature Shock		1.314**
		(0.02)
Negative Temperature Shock Squared		-1.608
		(0.16)
Positive Temperature Shock		0.662*
		(0.05)
Positive Temperature Shock Squared		-1.149**
		(0.02)
Civil War	-0.070	-0.073
	(0.27)	(0.24)
Democracy	0.082***	0.083***
	(0.00)	(0.00)
Income	0.877***	0.875***
	(0.00)	(0.00)
Income squared	-0.051***	-0.051***
	(0.00)	(0.00)
Income growth	0.002	0.002
	(0.72)	(0.77)
Emigration (lagged 5)	0.695***	0.699***
	(0.00)	(0.00)
Constant	-5.763***	-5.646***
	(0.00)	(0.00)
Fixed Effects	year	year
Observations	2909	2907
Countries	176	176

Table 1: OLS, robust standard errors clustered on government (not reported); p-values in parentheses. Dependent variable is the log of the emigration rate. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$

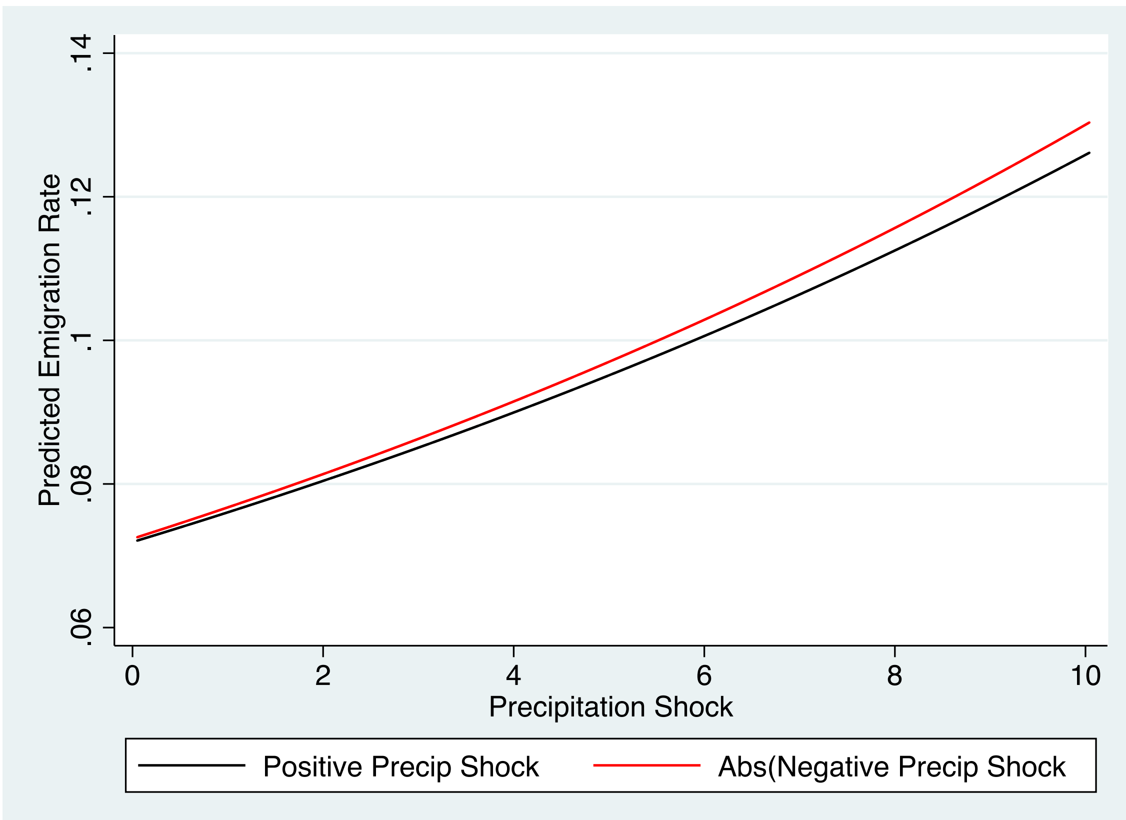

Figure 1: Impact of Precipitation Changes on Emigration Rates

Model 2 incorporates variables measuring positive and negative changes in temperature. Once again, we see that these are associated with an increased emigration rate. Here, however, the relationship appears to be nonlinear, with the impact of the shock on emigration rates declining or even reversing with the severity of the shock. This may indicate that particularly extreme shocks have an income effect large enough to make migration difficult, although future analyses will need to probe this relationship in more depth before such a conclusion is warranted. Figure 2 graphically depicts the marginal effects of temperature shocks on emigration rates. Comparing Models 1 and 2, as well as the associated figures, suggests that shocks to precipitation and temperature may not have analogous effects on emigration rates.

2.1 Do Starting Points Matter?

While the results in Table 1 are suggestive, it is likely that the underlying temperature or precipitation level influences the effect of shocks on emigration. For instance, a particularly cold place that experiences a temperature rise may see living conditions improve, while a particularly hot location may suffer adverse effects from positive temperature shocks. It is important to evaluate the impact of positive or negative shocks for countries with different underlying conditions. In Table 2 we examine the effects of positive precipitation shocks in already wet places, negative precipitation shocks in dry places, positive temperature shocks in hot locations and negative temperature shocks in cold places.

To do this analysis, we first construct the indicator variables *Dry, Wet, Hot,* and *Cold.* An observation receives a value of 1 for the variable *Dry* if its average precipitation level for years *t-6* to *t-10* (the initial period used to calculate changes) is less than the 25th percentile for all observations; *Dry* is coded zero for all other observations. A value of 1 is assigned for the

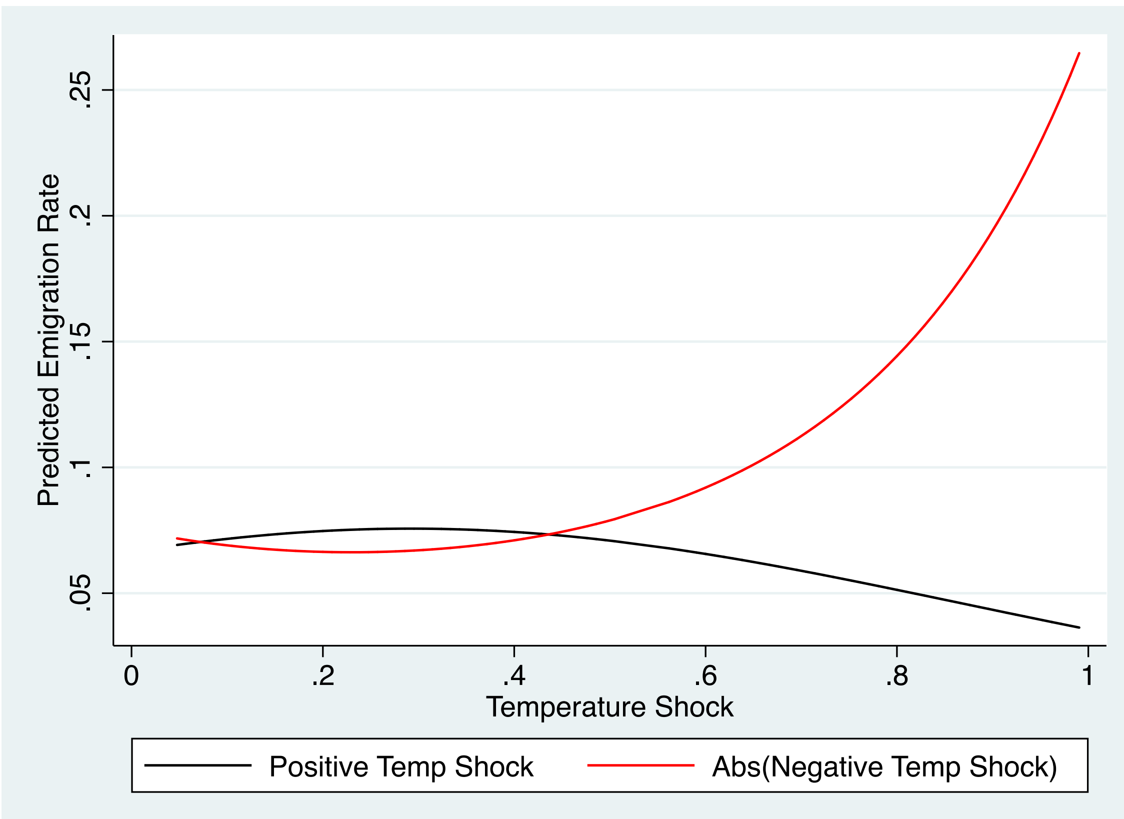

Figure 2: Impact of Temperature Changes on Emigration Rates

variable *Wet* if the average precipitation level for years *t-6* to *t-10* is higher than the 75th percentile. The variables *Cold* and *Hot* are analogous, with the 25th and 75th percentiles for temperature being used to code these variables.

After constructing these indicators, we created interaction terms with the shock variables: for instance, we interact the variable *Positive Temperature Shock* with *Hot* and *Negative Temperature Shock* with *Cold* because the impact of the temperature shock might depend on the underlying average temperature for that country. The same is done to create interaction terms between *Positive Precipitation Shock* and *Wet* as well as *Negative Precipitation Shock* and *Dry*. We drop the quadratic terms on temperature because interpretation becomes difficult with both interactions and quadratics in the model.

Results of analyses including these interactions are presented in Table 2, where only relevant coefficients are displayed with p-values in parentheses. The top half of Table 2 examines changes in precipitation while the bottom half contains the analysis for temperature changes. As the results show, the effect of shocks to precipitation and temperature are not analogous.

Model 3 show results for negative precipitation shocks (lower precipitation) interacted with already dry conditions. One might expect that the effects of negative shocks would be most extreme where it is already dry. However, this does not appear to be the case. Given the interactive nature of the model, the coefficient on the variable *Negative Precipitation Shock* depicts the relationship between negative shocks and emigration for observations where *Dry* is zero, i.e. those countries that are not particularly dry to begin with. We see that in these countries a negative precipitation shock is associated with increased emigration. This effect is *not* more pronounced in the driest areas - when a negative precipitation shock occurs in an already dry area people are *less* likely to emigrate - the negative coefficient on the interaction term is more than twice the size of the coefficient on the variable measuring the negative precipitation shock. One possible interpretation of this is that the income effect of a negative shock in an already dry area is so severe that fewer people can afford to leave. On the other end of the spectrum, positive changes to precipitation do not appear to influence emigration once we control for underlying wet conditions: countries with wet climates see more emigration, but that does not seem to be exacerbated by positive precipitation shocks.

For temperature shocks the situation is different, as shown in the bottom half of Table 2. Temperature changes appear to be associated with increased migration only at the outer parts of the underlying temperature distribution. A positive temperature shock (increased temperature) does not increase migration in cold or average climates, but is associated with a higher emigration rate if it occurs in an already hot environment. Analogously, negative temperature shocks (decreased temperature) only appear to be associated with increased emigration in already cold climates.

3 Discussion

The results presented here are the first stage of a longer project that will examine the drivers of environmental migration and compare the resulting flows to those associated with non-environment related migration push factors. These preliminary results are suggestive. First, it does appear that changes in both precipitation and temperature are associated with increased emigration rates. However, the relationship is nuanced and suggests that both push factors and income constraints may be important components of the explanation. As Table 2 shows, temperature shocks are most likely associated with increased emigration rates when they exacerbate underlying hot or cold conditions. Yet Table 1 shows that the relationship between the size of the shock and emigration may be nonlinear, with larger shocks *less* likely to lead to higher emigration. An interpretation consistent with these findings is that temperatue shocks can increase

	Model 3	Model 4	Model 5	Model 6
Negative Precipitation Shock	0.084**			
	(0.01)			
Dry (bottom 25%)	-0.009			
	(0.93)			
Negative Shock*Dry	-0.218**			
	(0.03)			
Positive Precipitation Shock		-0.009		
		(0.79)		
Wet (top 25%)		0.186*		
		(0.06)		
Positive Shock*Wet		0.016		
		(0.77)		
Positive Temperature Shock			0.128	
			(0.37)	
Hot (top 25%)			-0.123	
			(0.23)	
Positive Shock*Hot			1.164**	
			(0.02)	
Negative Temperature Shock				-0.657
				(0.11)
Cold (bottom 25%)				0.023
				(0.80)
Negative Shock*Cold				1.315**
N	2909	2909	2907	2907
Countries	176	176	176	176

Table 2: OLS, robust standard errors clustered on government (not reported); p-values in parentheses. Dependent variable is the log of the emigration rate. Additional controls included but not shown: income, income squared, income growth, civil war, democracy, lagged emigration. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

the incentive for migration, yet severe shocks may make the desire to migrate difficult to achieve.

For precipitation the results may also be consistent with both incentive and capability explanations, although in a different way. Reduced precipitation is associated with increased emigration, but *not* in the areas that are already driest. This suggests that drier conditions are a push factor leading to increased emigration. However, in areas that are already dry, negative precipitation shocks actually decrease the emigration. This suggests that the capability to migrate may also be affected by climatic shocks.

The response of policy makers to the effects of climate change will depend on how they expect the affected populations to respond. It appears that the impact on migration may be different across types of shocks - such as the differences seen above for changes in temperature and precipitation. In some cases, policy responses will need to focus on migration and its effects for both the home and host countries. In other cases, shocks may lead to increased poverty and decreased mobility, suggesting that different interventions are necessary.

We welcome comments as we continue to shape this project going forward. We intend to further probe the effect of climatic changes on migration patterns. We are also working on an analysis that compares migrants who move for reasons related to environmental/climatic changes to those who move for other reasons. When do environmental migrants follow similar patterns to labor migrants? To political refugees? To victims of non-climate related natural disasters? Are climatic changes more likely than other push factors to lead to permanent migration, as large-scale storms, sea-level rise and increased salinity, or desertification become the norm in some areas? Do individuals migrating due to environmental changes have similar financial ability and social networks to other migrants, or are they facing different situations? Comments as we push the project forward on any of these directions are appreciated.