Rainfall and Migration in Mexico

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Extended Abstract 9/27/2013

Demographers have become increasingly interested over the past 15 years in the natural environment as a driver and consequence of demographic change. This has been motivated in part by a search for exogenous drivers of demographic change, and in part by the larger scientific recognition that human behavior and global environmental change are intimately connected. In this paper, we seek to link these two intellectual strands and also to ground our work in careful empirical analyses. We consider the relationship between rainfall and both temporary and permanent migration in Mexico using prospective data from the Mexican Family Life Survey linked to monthly gridded data on rainfall covering more than 50 years. These data allow us to match local (municipio) levels of rainfall, both over a long time period and in recent years, to out-migration between waves 1 and 2 to the MxFLS (2002 and 2005).

Background

This work builds on studies in Mexico that have primarily used census data on migration rates matched with state-level rainfall measures, with a focus on the impact of short-term changes in rainfall (shocks precipitating migration). This work shows that, on average, lower than normal precipitation seems to push people to migrate in Mexico (Nawrotzki et al., 2013; Munshi, 2003; Feng et al., 2010; Hunter et al., 2011), but the evidence is not entirely consistent. Much of the existing work shows a nonlinear relationship between precipitation change and migration in Mexico (Nawrotzki et al., 2013; Feng, 2010; Deb and Seck, 2009). The effect of deviation from the long-term average rainfall on the likelihood of migration is U-shaped, with individuals living in states recently experiencing greater deviation from average rainfall (both dryer and wetter than normal) exhibiting more out-migration than those living in places with close to the average rainfall. However, one paper suggests that only droughts influence migration, not heavier than normal rainfall (Hunter et al., 2011). These studies also point to specific characteristics that may lead to a stronger relationship between drought and migration, including location in dry regions (Nawrotzki et al., 2013; Cohen et al., 2013), agricultural communities (Deb and Seck, 2009), near the U.S. border (Cohen et al., 2013), historical sending regions, and households with prior migration experience (Hunter et al., 2011). Cohen et al. (2013) also found a relationship between the probability of consecutive dry days and loss of harvested agricultural area in the two Mexican states with the highest migration rates.

The authors focus on different periods of rainfall variability in Mexico. Munshi (2003) found that very short-term rainfall change (4 years or less before the migration) had no effect on the likeliness of migration, but 5 to 7 years before the migration does have a significant effect (Munshi, 2003; Feng et al., 2010). Yet, Deb and Seck (2009) saw an effect of rainfall in the very short-term, two years prior to the migration, while Hunter et al. (2011) found a relationship between migration and a one-year drought shock in the prior year but not a two-year drought. None of these studies look at the association between rainfall variability and migration over time periods longer than 5 to 7 years. The authors suggest that climate or rainfall is exogenous in their models (Feng and Oppenheimer, 2012; Feng et al., 2010; Deb and Seck, 2009), but this may not be the case for long-term rainfall variability, which is interrelated with social institutions in migrant-sending regions of Mexico.

These studies focus on earlier time periods than do our analyses, important because the time covered by earlier studies was a period of extended drought. Nawrotzki et al. (2013) found a strong and significant U-shaped association between drought and international out-migration using Mexican Census data and rainfall data from the Mexican Migration Project (MMP). The authors defined the precipitation decrease in their model as the change between average rainfall in1988-1993 (the reference period) and 1994-1999 (the window for the migration data and a drought period). The authors then divided Mexican states into the dichotomous categories of "wet state" and "dry state," with dry states being those that have average long-term precipitation below the nation-wide, 64-year average and wet states above that average. Overall, dry states experienced a precipitation decline during the study period but wet states did not (Nawrotzki et al., 2013). Once modeled separately, the association between rainfall decline and international out-migration is seen in dry states but not in wet states.

Nawrotzki et al. (2013) also argued that social networks, measured by the presence of return migrants in communities, were the main driver of out-migration in the wet states, rather than precipitation variability. Hunter et al. (2011) also highlighted the importance of community migration experience. They looked at the association between U.S.-bound migration, droughts (defined here as a year of rainfall at least one standard deviation below the 30-year state average) and wet years (one standard deviation above the 30-year state average). Their analyses separated historical migrant-sending regions and other regions. In historical migrant-sending regions, the odds of U.S. migration are higher if the prior year was a drought compared with normal rainfall, but the effect of a two-year drought prior to migration was not significant. A wet year is associated with lower likelihood of migration in these regions. For non-historical sending areas, a drought in the prior year is associated with a decrease in the likelihood of migration to the U.S. and no significant results were found for wet years.

In addition to these few past studies in Mexico, there are a small number of recent studies addressing the rainfall-migration relationship in other rural or agriculture-dependent regions. In Bangladesh and various parts of Africa, work on the relationship between rainfall and migration is conflicting, with evidence that drought and flooding both drive and constrain migration for different groups (Henry, 2004; Lewin et al., 2012; Gray and Mueller, 2012a; Gray and Mueller, 2012b). Using a longitudinal dataset for 1994-2010, Gray and Mueller (2012b) found a nonlinear relationship between flooding and migration. More specifically, moderate flooding increases local mobility and decreases long-distance mobility, especially for women and poor households. The authors also looked at the relationship between drought-related crop failure and migration. Households that did not experience crop failure located in districts that experienced severe crop failure were the most likely to send more migrants, and drought was also associated with a greater increase in women's mobility compared with men's (Gray and Mueller, 2012b). These results suggest that household-level and district-level shocks can have different effects on migration, and that climate-related migration is short distance.

Gray and Mueller's (2012b) recent work provides additional evidence for Henry et al.'s (2004) suggestion that recent rainfall declines limit long-distance moves. They found that a three-year rainfall deficit in Burkina Faso does increase the likelihood of making a long-term move (two years or more) to other rural areas for men, but decreases the likelihood of a short-term move (three months to two years) to urban areas and international destinations. Women are more likely to make permanent, long-distance moves following wetter years, because these are largely marriage migrations that can be delayed by drought and limited resources (Henry et al., 2004; Gray and Mueller, 2012a). Yet in Ethiopia, as conditions change from no drought to severe drought, the rates of total mobility and long-distance mobility increase for men (Gray and Mueller, 2012a). Women with children are especially unlikely to migrate as a result of drought, unlike in Bangladesh (Gray and Mueller, 2012b), and men from land-poor households are more likely to migrate in drought times (Gray and Mueller, 2012a). Gray and Mueller (2012a) investigated the possibility that attrition in their panel data for Ethiopia was biased by drought, but they found no association between total number of droughts reported by the household and attrition. Also, Henry et al.'s (2004) work in Burkina Faso highlights the importance of considering multiple types of migration. People reliant on rain-fed agriculture living in dryer regions with consistently lower average rainfall over time are more likely to migrate internally short-term or move permanently to other rural areas in general. Those living in wetter areas are more likely to migrate internationally long-term (Henry et al., 2004).

Conversely, Lewin et al. (2012) found that a five-year drought reduces migration overall in Malawi, with the theory being that households do not have the capital to move after a shock. However, the effect of a ten-year deviation from average rainfall on migration was not significant, suggesting that long-term variability may not be noticeable to households. For those that did migrate, the shock was more likely to be after the migration even than before (Lewin et al., 2012), perhaps signaling that migration is a reaction to drought in Malawi rather than a diversification strategy. The authors also uniquely looked at where migrants are going and found that people choose to move to communities that have low rainfall variability, where long wet and dry periods are less common (Lewin et al., 2012).

Approach

Based on existing work in Mexico and other parts of the world, we focus on agriculture-dependent communities, distinguish between long-term and short-term rainfall measures, and examine the importance of social capital (previous migration experience in the community). We improve on past work in Mexico by examining a more recent time period (migration 2002-2005), by using fine spatial resolution precipitation data, and by examining internal and international migration as well as both temporary migration and longer-term migration.

We take as our sample at risk of migration individuals age 15+ living in communities dependent on agriculture in Wave 1 of the Mexican Family Life Survey (2002). The sampling design of the MxFLS is probabilistic, stratified, multi-staged and by cluster. The data are representative of Mexico's population, taking representation at the national, urban-rural and regional levels into account, and rural communities (<2,500) were oversampled to be sure enough were selected. The MxFLS is useful for studying migration as more than 90% of respondents were followed between 2002 and 2005, regardless of a change in residence internally within Mexico or internationally. The total MxFLS sample is size is 35,764 individuals from 8,440 households surveyed in 2002. For this project, the sample is restricted to individuals 15 years of age and over living in places where agriculture and ranching are reported as productive activities in the community. Individuals that are missing data for any of the independent variables are also excluded from the models. This brings our sample to 14,541 individuals from 5,712 households.

We then track these individuals in the Wave 2 data, from 2005, to classify whether they have left the household (permanent or longer-term migration) and to an internal or international destination. We also examine the same group to determine whether they engaged in temporary migration during the 2003-2005 time period. These variables are dependent variables in an individual-level multinomial logistic regression of out-migration (internal, international, non-mover) and in an individual-level logistic regression model of temporary migration (yes or no). There is a small percentage of the sample that we further lose due to loss to followup, or to missing information on migration destination. Our final sample for the analysis of out-migration between the two waves is 13,077, while the final sample for the analysis of temporary migration (limited to people who were reinterviewed in the home household in 2005) is 11,060.

Rainfall measures were created from global gridded reanalysis data with a monthly temporal resolution from 1950 through 2001 and a spatial resolution of 0.5 by 0.5 degrees (approximately 30km by 30km). The survey data have geographic identifiers to the municipio level. We therefore merged the rainfall history for the grid cell with the center point closest to the geographical center of the municipio. We then aggregated the rainfall values to a yearly time scale, summing up the rainfall in the agricultural season for each calendar year. We used those yearly values of rainfall to construct the long-term average rainfall for each municipio for 1950-2001, and the short-term average from 1997-2001. In our regression models, we use the long-term average and the short-term deviation from the long-term average (short-term average – long-term average).

In addition to these two data sources, we include a control variable drawn from the Mexican census in 2000. Each municipio was classified on a five-point scale of strength of migration to the United States.

We present here some descriptive statistics for the sample for the out-migration analysis, and preliminary analyses of both out-migration and temporary migration. Table 1 shows the descriptive statistics for the models of out-migration (no longer in the household in wave 2). Table 2 shows the out-migration analysis and Table 3 shows the analysis of any temporary migration in the 2003-2005 interval, among people who were still household members in 2005. These models show the impact of rainfall patterns on all types of migration. Interestingly, they show that long-term average rainfall has a positive effect on all types of migration. Short-term deviations from the long-term average only have significant effects on temporary migration, and there have positive effects. We have done some initial tests for alternative functional forms or specifications of rainfall effects and found no significant results. Specifically, we have tested quadratic effects of average rainfall, effects of short- and long-term variability in rainfall (using the coefficient of variation for the 1950-2001 and 1997-2001 periods), and interactions between average rainfall and community international migration experience and between average rainfall and employment in agriculture. We additionally tested whether the single year deviation from the long-term average for 2002 was significantly related to these measures. We plan to continue developing these analyses in advance of posting a final paper later in the year.

Table 1. Descriptive statistics for the out-migration analyses

	Mean or Percentage	SD	Minimum	Maximum
Individual-level (N=13,077)				
Out-migration				
Remained in HH	92.79			
Internal	1.75			
International	5.46			
Female	54.74	–	0	1
Age	37.24	16.71	15	98
Married/In a union	61.22	–	0	1
Household head or spouse	62.78	–	0	1
Educational attainment				
None	10.50	–	0	1
Primary	41.62	–	0	1
High school	40.43	–	0	1
College	7.46	–	0	1
Occupation in agriculture/ranching	11.12	–	0	1
Household-level (N=5,050)				
Owns a non-agricultural business	15.29	–	0	1
Land owned (hectares)				
No land	78.34	–	0	1
More than 0 and <5	15.31	–	0	1
5 or more and <10	2.89	–	0	1
10 or more	3.47	–	0	1
Community-level (N=109)				
Community population	219,710	404,276	300	1,646,319
Credit available and used	36.70	–	0	1
Credit options inside community	24.77	–	0	1
Enough roads in the community	67.89	–	0	1
Percent of households with electricity				
Less than 75%	8.26	–	0	1
76% to 94%	25.69	–	0	1
95% or more	66.06	–	0	1
Municipality-level (N=101)				
Level of US migration experience (2000)				
None	35.64	–	0	1
Low	39.60	–	0	1
Medium	8.91	–	0	1
High	15.84	–	0	1
Long-term (1976-2001) average rainfall (mm)	919.81	571.44	144.42	3,460.97
Short-term (1996-2001) dev from ltavg (mm)	-60.61	81.60	-293.99	256.45

Source: Mexican Family Life Survey (2002); Mexican Census (2000)
Note: Sample restricted to individuals age 15 and over at the time of the survey, living in primarily agricultural or ranching communities. Also excludes individuals that were lost to follow-up between 2002 and 2005.

Table 2. Results from multinomial logit model of 2005 permanent migration status and destination on 2002 individual, household, community, and municipality-level variables, including long-term (1976-2001) average rainfall and short-term (1996-2001) deviation from long-term average rainfall.

Outcome compared with base (in HH)†	International Mig		Internal Migration	
	ß	**e^ß**	**ß**	**e^ß**
Individual-level				
Female	-0.846*** (0.157)	0.429	0.265** (0.086)	1.304
Age	-0.038 (0.034)	-	-0.004 (0.017)	-
Age squared	-0.0003 (0.0005)	-	-0.0003 (0.0002)	-
Married/In a union	0.453** (0.214)	1.573	0.623*** (0.108)	1.865
Household head or spouse	-1.637*** (0.261)	0.195	-2.881*** (0.157)	0.056
Educational attainment				
Primary	0.013 (0.359)	1.013	0.569 (0.268)	1.766
High school	0.000 (0.999)	1.000	0.592* (0.271)	1.807
College	-1.036 (0.578)	0.355	0.684* (0.297)	1.982
Occupation in agriculture/ranching	0.426** (0.207)	1.532	0.340* (0.153)	1.406
Household-level				
Owns a non-agricultural business	-0.032 (0.201)	0.968	0.016 (0.111)	1.017
Land owned (hectares)				
Greater than 0 and <5	0.317 (0.166)	1.373	-0.167 (0.119)	0.846
Greater than or equal to 5 and <10	-1.592** (0.605)	0.204	0.080 (0.198)	1.084
10 or more	-1.762* (0.725)	0.172	-0.649* (0.264)	0.523
Community-level				
Community population	0.000 (0.000)	1.000	0.000 (0.000)	1.000
Credit available and used	0.703*** (0.203)	2.020	-0.036 (0.141)	0.965
Credit options inside community	-1.299*** (0.293)	0.273	-0.089 (0.169)	0.915
Enough roads in the community	0.317* (0.166)	1.472	0.063 (0.090)	1.065
Percent of households with electricity				
Less than 75%	0.863*** (0.239)	2.370	0.196 (0.167)	1.217
76% to 94%	-0.040 (0.201)	0.961	0.180 (0.104)	1.197
Municipality-level				
Level of US migration experience (2000)				
None	-2.924*** (0.268)	0.054	-0.149 (0.154)	0.334
Low	-1.889*** (0.220)	0.151	0.006 (0.150)	1.007
Medium	-0.763*** (0.226)	0.466	-0.098 (0.196)	0.906
Long-term average rainfall (mm)	0.0003* (0.0001)	1.0003	0.0002* (0.0001)	1.0002
Short-term deviation from lt avg (mm)	0.003* (0.001)	1.0003	0.0006 (0.0005)	1.0006
Constant	-0.681		-2.497	
Log likelihood	-3,092.52		-3,092.52	
AIC	6,285.05		6,285.05	
BIC	6,658.98		6,658.98	
Observations	13,077		13,077	

Source: Mexican Family Life Survey (2002-05); Mexican Census 2000

Note: Sample restricted to individuals age 15 and over at the time of the survey, living in primarily agricultural or ranching communities. Reference groups are male, not married or in a union, not household head or spouse, no education, occupation not in agriculture and ranching, does not own a non-agricultural business, no land owned, credit not available or used, no credit options in the community, not enough roads in the community, 95% or more of households with electricity, and high level of US migration experience.

* p ≤ .05; ** p ≤ .01; *** p ≤ .001

Table 3. Results from binary logit model of temporary migration 2003-05 on 2002 individual, household, community, and municipality-level variables, including long-term (1976-2001) average rainfall and short-term (1996-2001) deviation from long-term average rainfall. Migrated for less than a year at least once =1; Did not migrate temporarily =0.

	ß
Individual-level	
Female	-0.463***
	(0.126)
Age	0.005
	(0.022)
Age squared	-0.0002
	(0.0002)
Married/In a union	-0.422*
	(0.180)
Household head or spouse	0.006
	(0.211)
Educational attainment	
Primary	0.032
	(0.238)
High school	0.213
	(0.262)
College	0.407
	(0.313)
Occupation in agriculture/ranching	0.307
	(0.187)
Household-level	
Owns a non-agricultural business	-0.059
	(0.164)
Land owned (hectares)	
Greater than 0 and <5	-0.068
	(0.168)
Greater than or equal to 5 and <10	0.181
	(0.300)
10 or more	-0.532
	(0.394)
Community-level	
Community population	0.000
	(0.000)
Credit available and used	-0.046
	(0.203)
Credit options inside community	-0.208
	(0.236)
Enough roads in the community	0.133
	(0.130)
Percent of households with electricity	
Less than 75%	0.069
	(0.245)
76% to 94%	-0.002
	(0.149)
Municipality-level	
Long-term average rainfall (mm)	0.0003**
	(0.0001)
Short-term deviation from lt avg (mm)	-0.001
	(0.001)
Constant	-3.453
Log likelihood	-1,365.35
AIC	2,774.70
BIC	2,935.55
Observations	11,060

Source: Mexican Family Life Survey (2002-05)

Note: Sample restricted to individuals age 15 and over at the time of the survey, living in primarily agricultural or ranching communities. Reference groups are male, not married or in a union, not household head or spouse, no education, occupation not in agriculture and ranching, does not own a non-agricultural business, no land owned, credit not available or used, no credit options in the community, not enough roads in the community, and 95% or more of households with electricity.

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

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