Anticipatory Behavior in Household Migration: Responses to Climate Shifts

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Short Abstract: Many migration models are predicated on anticipatory (*ex ante*) behavior. Despite theoretical attention to anticipatory behavior in response to environmental change, empirical migration research has focused on reactive (*ex post)* migration associated with climatic events. In contrast, we study whether anticipatory migration behavior is responsive to climate-associated shocks to neighbors' agricultural yields. We address this unresolved question with a novel strategy that (1) minimizes selection by focusing on community level agricultural outcomes as a function of environmental conditions and (2) is driven by agricultural households' beliefs about future climate-associated agricultural loss. If anticipatory migration is an important adaptation mechanism, projections of future environmental migration may be substantially understated in contexts characterized by slow moving environmental change. Evidence of anticipatory migration may additionally highlight the importance of adaptation to environmental change through 'learning from others' and help explained so-called 'adaptation-gaps' to climate change.

Introduction

Many models of migration behavior are predicated on the assumption of anticipatory behavior. That is, people act in response to expected future conditions and not exclusively to the conditions that prevail when migration decisions are made. Though anticipatory behavior is rarely measured in empirical research, scholars have long-acknowledged the importance of accounting for it when estimating the migration effects of changes to contextual circumstances, like labor market, schooling, and housing characteristics, or policy environments (Bijwaard et al. 2014, Schwartz and Sommers 2014).

The migration literature posits that anticipatory behavior may be particularly relevant in situations with relatively high uncertainty characterized by episodic economic, political, or environmental shocks (e.g., Sander et al. 2014). Among these, the growing uncertainty that has and will likely continue to accompany climate change has attracted considerable interest to social scientists. A growing body of work investigates the role of environmental conditions in individual and household decisions to relocate. This research has emerged from increased recognition that climate changes have—and will likely continue to have—significant impact on agriculture, trade, and even conflict (Dell, Jones, and Olken 2014; Hunter, Luna, and Norton, 2015; Carleton and Hsiang, 2016).

Despite theoretical attention to the role of anticipatory behavior in adaptation to environmental change (e.g., Bardsley and Hugo 2010), most empirical research documents *ex post* or reactive

migration responses to climatic events and long-run shifts in environmental phenomena. Understanding whether, and when, migration is part of an anticipatory response to perceptions about future effects of climate on agricultural yield, for example, is essential to projecting the population effects of ongoing trends in temperature and precipitation.

In this study, we combine high-resolution data on environmental conditions with rich, longitudinal data on households clustered within agricultural communities to test for evidence of *ex ante*, or anticipatory, migration in the presence of climate change. *Specifically, we document whether individual and/or household migration behavior is responsive to climate-associated changes in neighbors' agricultural yields. Under a set of testable assumptions, the evidence provides a novel, concrete test of anticipatory migration behavior in the context of climate change.*

Environmental Change and Migration Behavior

Climate events can trigger increased population mobility or suppress it by intensifying constraints on the resources required for migration. *Ex post* migratory responses are diverse and mediated by both (1) the nature of environmental shocks and (2) national, household and community factors, like income level, wealth, access to credit and networks. To date, a number of studies indicate that environmental phenomena that worsen agricultural returns tend to increase internal (rural to urban) and international migration (Halliday, 2006; Feng, Krueger, Oppenheimer, 2010; Dillon, Mueller, and Salau, 2011; Gray and Mueller, 2012; Gray and Bilsborrow, 2013; Hunter, Murray, and Riosmena, 2013; Gröger and Zylberberg, 2016; Nawrotzki and DeWaard, 2016; Cattaneo and Peri, 2016).

This scholarship is largely silent on the *ex ante* relationship between environmental change and population mobility.[1] In particular, little is known about whether migration strictly follows climatic events or if, in contrast, households also engage in anticipatory migration based on their perceptions of future environmental risk. In other words, *ex post* migration can be conceived of as a direct or immediate, reactionary pathway through which environmental change impacts population mobility. *Ex ante* migration may, on the other hand, operate through a distinct behavioral pathway whereby shifts in expectations about future environmental risk may also result in anticipatory migration decisions. Importantly, changes in beliefs regarding future environmental risk may be based on own experiences as well as what is learned from the experience of others in the face of shifting environmental risk.

If anticipatory migration is an important adaptation mechanism, projections of future environmental migration may be understated, especially in contexts characterized by slow moving environmental change. *Ex ante* migration, and other forms of anticipatory adaptation within agriculture or away from it, may help explain so-called 'adaptation gaps' where households' (*ex post*) adaptive measures to environmental shocks appear to be suboptimal (Hsiang and Narita, 2012; Hornbeck, 2012; Deryugina, 2013; Annan and Schlenker, 2015; Carleton and Hsiang, 2016). Furthermore, evidence in support of *ex ante* migration may point to the importance of 'learning from others' in adaptive responses to climatic events, a concept from the technological adoption literature in economics (Foster and Rosenzweig, 1995; Munshi (2004); Bandiera and Rasul, 2004; Conley and Udry, 2010) that has yet to receive considerable attention in the context of human responses to environmental change.

[1] This is with the exception of Dillon, Mueller, and Salau (2011) who find that that households from four rural villages in northern Nigeria migrate domestically in response to both *ex ante* and *ex post* risk, though results for *ex post* risk are more robust.

It is with this context in mind that we propose to study how extreme weather events influence the *ex ante* migration decisions of agricultural households in Mexico. Mexico is well suited for assessing the role of environmental shocks on migration for several reasons, including that the climate in Mexico varies widely, particularly in terms of diversity in agro-ecological zones and vegetation (Améndola et al., 2006). Furthermore, migration and diversified income portfolios are common in rural areas and vary substantially across the country (Hanson and McIntosh, 2010). Agricultural production, in particular is strongly correlated with household investment decisions, especially migration, in Mexico (Feng, Krueger, and Oppenheimer, 2010). Poor rural households in Mexico that rely on smallholder agricultural production for their livelihoods may be especially vulnerable to sudden and slow-moving environmental phenomena (Porter et al., 2014). For instance, increases in the frequency of severity of environmental shocks may motivate households to send additional migrants to locations where income risk is uncorrelated with their origin community (or less severe), while it may instead compel households to retain potential migrants either due to lack of funds to finance migration journeys or to participate in local adaptation measures. *The decisions of rural households in Mexico, especially those who have not experienced a drop in agricultural production themselves but observe others in their community who have suffered agricultural loss due to environmental change, provide a window into whether ex ante migration is an important adaptation measure to climatic events.*

Methods

Data: The research draws on two data sources: (1) rich, longitudinal, multilevel household and community data from 8400 households in 150 communities in Mexico, and (2) high resolution, spatially-referenced data on temperature and precipitation. We link the data at the municipality level.

The first wave of the Mexican Family Life Survey (MxFLS) was fielded in 2002 and interviewed members of 8,400 households in 150 communities across Mexico. In total, the rural sample includes more than 4,200 households drawn from 66 municipalities (48 of which consist of one community and 18 of which consist of 2 or more communities). At the household-level, re-interview rates achieved 90% in both the second and third waves, fielded in 2005-6 and 2009-12, respectively.

The MxFLS includes detailed migration histories for all adults. In the second and third survey rounds, information about household members who move between waves is collected. The survey also collects household production information, including land use, agricultural yield, and agricultural practices. The community level data provide detailed information about infrastructure, including improved water resources. Because the survey is clustered at the community level—on average, we observe data for 55 households in each community—and because households are randomly sampled within communities, we are able to generate household-specific estimates of agricultural yield among *other households* in the community.

We link information on daily and monthly measures of precipitation and air temperature conditions over the study period from (1) the University of East Anglia's Climate Research Unit (CRU) via Terra Populus, as well as (2) the National Aeronautics and Space Administration's (NASA) Agricultural Modern-Era Retrospective Analysis for Research and Applications Climate Forcing Dataset for Agricultural Modeling (AgMERRA). The combination of the climate data provides environmental information at a sufficiently fine level of resolution to characterize the incidence and intensity of extreme precipitation and air temperature events at the municipality level across

Mexico, reflecting contemporaneous variation at daily or monthly time units over space. This data is available for the decades prior to the MxFLS study period, which facilitates constructing historical measures of precipitation and air temperature to account for the potentially cyclical nature of climatic events.

Approach: We ask whether individual and/or household migration is associated with climate-associated patterns of agricultural yield observed among other households within rural communities. To avoid conflating *ex ante* and *ex post* responses to changing agricultural conditions, we limit the analytical sample to households in 2002 in which members **do not** report significant agricultural losses during the five years prior to the survey date. That is, we limit the sample to include members of households whose migration behavior cannot plausibly be attributed to climate-driven reductions in household agricultural income. We then test whether migration behavior in these households is associated with changes in agricultural yield reported by *other members* of their community. Interpreting this association as evidence of anticipatory, or *ex ante* behavior, requires several key assumptions, which we describe further below.

Formally, we create an indicator that member(s) of household h in community c and municipality m in 2002 migrated outside of the municipality by 2005 (M_{hcm}). We regress this measure on an indicator of the agricultural outcomes experienced during the three years preceding the 2002 interview (2000-2002) of all other sampled households in the community (represented by J). In practice, this amounts to measuring community agricultural outcomes (Y_{Jc}) as a 'leave-one-out' variable for all other households other than h. The intuition underlying the approach is that members of households who do not themselves experience agricultural loss but who observe the agricultural loss of neighbors, following extreme weather, may change their expectations about future environmental risk and engage in *ex ante* migration strategies.

$$M_{hcm} = \beta_1 Y_{Jc} + \beta_2 \boldsymbol{Z}_{ht} + \beta_3 \boldsymbol{X_{cm}} + \omega_S + \varepsilon_{hJcms} \quad (1)$$

We control for a vector of household level covariates (Z_{ht}) including household size, agricultural crop mix and management practices, income generating activities, expenditures and previous migration, a vector of community controls (X_{cm}) including elevation, water sources, access to infrastructure and population, and state fixed effects (ω_S). State fixed effects (ω_S) are included in to improve precision by focusing identification off of variation in household adaptation decisions and community-level agricultural outcomes within states (s), which are more likely to share historical, institutional, and agro-climatic features.

To address potential selection into communities, we instrument for community agricultural outcomes (Y_{Jc}) using measures of precipitation and air temperature at the municipality level (E_m). We measure short-term indicators of heat and draught during the 2000-2002 period, as well as long-term indicators of patterns in temperature and precipitation during the previous two decades. A strength of this approach is that it allows us to minimize selection and explicitly link the impact of environmental conditions on migration through neighbors' agricultural outcomes. It does, however, also require substantial variation in household agricultural outcomes within and across communities.

The approach relies on several key assumptions. First, the climate data must predict agricultural yield among community members. This is testable and initial assessments confirm that it does. Second, the climate data cannot influence the migration behavior of members of the focal household through mechanisms other than the agricultural yields of other community members.

The third assumption is perhaps the most obvious and concerning. To avoid conflating anticipatory and reactive migration behavior, we have limited the sample to households that do not experience agricultural loss in the five years preceding the survey date. The estimates are identified off a comparison of 'exposed' households—those in communities affected by temperature and precipitation changes in comparison to 'unexposed' households—those in communities largely unaffected by these environmental changes over the study period. Importantly, the vector of community measures and the instrumental variable approach reduces the role of unobserved community-level variation in this comparison. The sampled households in the 'unexposed' group will be the modal households in the community. On the other hand, the sampled households in the 'exposed' group may be 'distinct' in some unmeasured way. This raises the question: How does a household remain protected from environmental change while neighboring households in the community do not?

If these 'distinct' households have already engaged in adaptive behavior to environmental change (in a way not captured in these specifications), we would expect members to be less responsive in the form of migration than if the household was the modal household in the community. If the households reside in a particularly protected part of the community because of unmeasured variation in topography, we would also expect members to be less responsive to observing climate-associated loss than the modal household in the community. In both cases, the estimates generated here will be, if anything, ***lower*** bounds on the true estimates of anticipatory behavior.

By contrast, the estimates here will be upwardly biased if household migration behavior appears anticipatory but is actually explained, at least in part, by risk aversion or other preferences. The latter two rounds of the MxFLS collect information regarding risk aversion and time preferences. These data allow us to assess **how** distinct protected households in unprotected communities are, and as a result, the extent to which exceptional preferences may explain *ex ante* adaption.

Finally, we will test the robustness of our findings using several checks: (1) first-differenced regressions over time that incorporate the third round of MxFLS data and effectively remove the pre-shock behavior of households that may spuriously explain *ex ante* adaption; and (2) a set of placebo tests. These draw on the migration behavior of households whose income and consumption is not agriculturally-dependent.

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