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Heterogeneous effects of weather shocks on out-migration risk: Evidence from Indonesia

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1. Introduction

Empirical research on environment-induced migration has increased markedly in recent years, advancing this literature beyond the overwhelmingly conceptual work that preceded it. Much existing evidence suggests that, on average, migration odds are sensitive to changes in the natural environment (e.g., Dillon et al. 2011, Gray 2009, Gray and Mueller 2012a, Gray and Mueller 2012b, Henry et al. 2004, Massy et al. 2010). However, little attention has been paid to the factors that differentiate affected individuals' ability or propensity to do so (exceptions include Gray and Bilsborrow 2013, Mueller et al. 2014). This lack of attention to differential responses within affected populations arguably represents one of the main limitations to existing knowledge on this topic.

This paper addresses this gap by assessing potential sources of heterogeneity in individuals' odds of migration within weather shock-affected contexts in Indonesia. In particular, it analyzes whether differences in wealth, livelihood, and migration networks help explain heterogeneity in migration responses to weather shocks. This study contributes to existing theories of migration and vulnerability, and demonstrates an approach for exploring potential causal mechanisms underlying environment-induced migration.

2. Research focus

This paper focuses on three factors that may differentiate persons' ability or propensity to migrate in response to weather shocks: wealth, livelihood, and migration networks. Baseline wealth is likely to affect whether persons utilize migration as response to an environmental shock. On the one hand, poor persons lack savings or 'buffers' to protect themselves against the economic effect of shocks. As such, they may be more sensitive to environmental changes, and therefore either more or less likely to migrate than others. On the other hand, migration—particularly of long distance or duration—often requires substantial resources. The poor may therefore be less able to use migration as a coping strategy, leaving populations 'stranded' or immobilized as a result of environmental shocks (UK Government Office of Science 2011). Existing empirical evidence has shown, for example, that drought was associated with declines in marriage migration in Ethiopia (Gray and Mueller 2012b). Whether, and how baseline wealth may affect the impact of environmental shocks on migration is likely to be contingent upon the type of migration in question.

Persons' exposure, or sensitivity to environmental change is also contingent upon their livelihoods. Many environmental shocks—including the temperature and rainfall shocks I consider in this paper—are hypothesized to primarily affecting migration by changing income, food security, and other sources of material resources. In most rural areas of developing counties, the effects of shocks on agricultural production—and thus income and/or food supply—are likely to be salient. Rice is perhaps the most important crop in the Indonesian context; and previous research in the country has shown a strong correlation between rainfall patterns and rice production (Naylor et al. 2007). If rainfall and heat shocks do indeed affect migration through changes in crop production, we would therefore expect the effect of a given shock on migration odds to vary according by dependence on (rain-fed) rice production or other agricultural income sources.

Finally, migration networks have been shown to affect migration decision-making processes by reducing information barriers, costs, and risks associated with migration (Massey 1990, Massey et al. 1993, Stark 1985, Taylor 1986, Yang 2008). During rapid onset natural disasters, such as hurricanes, social networks connecting affected persons to potential destinations may facilitate short-term evacuation (Thiede and Brown 2013). Spatially dispersed social networks may have other functions as well. Networks that facilitate remittance flows and other forms of resource redistribution may mitigate the impact of shocks (Savage and Harvey 2007). Persons involved in such networks may therefore be less affected by shocks, with clear implications for their odds of moving relative to other households. In sum, migration networks may facilitate migration in contexts of environmental stress or reduce the impact of that stress on exposed households.

3. Data

The analysis draws upon data from the first through fourth waves of the Indonesian Family Life Survey (IFLS), and climate data from NASA's Prediction of Worldwide Energy Resources (POWER) project. The IFLS provides a uniquely rich source of longitudinal data for over 30,000 individuals between 1993 and 2008. This survey has a number of strengths, including a remarkably high follow-up rate (including among migrants), detailed migration histories, and a broad geographic scope. The analytic sample used in this study includes individuals from over 300 communities across 13 provinces.

Data from NASA's POWER project—specifically the Modern-Era Retrospective Analysis for Research and Applications (MERRA)—includes daily precipitation and temperature estimates from 1984 to present at a half-degree resolution (NASA 2012, Rienecker et al. 2011). Like other re-analyses, MERRA integrates numerous previously collected, often spatially- and temporally-irregular data to develop a spatially complete dataset. These particular data utilize surface and satellite data products available from the start of the satellite era (1979) to present. Importantly, MERRA was developed with the particular goals of improving the hydrologic cycle models used in previous generations of re-analysis, and developing a product adequate for climate and weather studies (Rienecker et al. 2011: 3625).

4. Empirical strategy

This analysis will explore the relationship between weather shocks and migration odds, with a particular emphasis on potential sources of heterogeneity in that relationship. The analysis will consider migration among persons aged 15 years or older at the baseline of a given inter-survey period. Among possible weather shocks, I focus on rainfall and temperature. Specifically, I consider indicators of absolute temperature and rainfall, deviations from long-term means in temperature and rainfall, and weather conditions during the monsoon season (Naylor et al. 2007, Skoufias et al. 2012).

The analysis will center upon a series of discrete-time event history models. These statistical models will estimate how exposure to temperature and rainfall shocks at time t_n (or lagged) affects individuals' odds of out-migration during the following period t_n to t_{n+k}. I will model three outcomes: binary (no move v. move), multinomial (no move v. move by distance/duration), and Poisson (count of moves). For each outcome, I will explore potential sources of heterogeneity by comparing estimates from a main effects-only model with interaction models, as well as models disaggregated by wealth, livelihood, and migration networks. The modeling strategy will account for community fixed effects and clustering.

5. Descriptive statistics

Preliminary analyses show that on average, 12-14% of individuals aged 15 years of older at baseline of a given period migrated—crossed a village boundary for more than 6 months—at least once during that period (Table 1). Among those that moved, the mean number of moves ranged from 1.20 to 1.59 (Table 1). These differences in part reflect uneven duration of inter-survey periods, which were not adjusted for in these preliminary analyses.

Table 1. Summary of individuals' migration, by period

Period	N	% 1+ inter-survey moves	Mean (SD) inter-survey moves/mover
IFLS1 - IFLS2	11618	14.14	1.20 (0.47)
IFLS2 - IFLS3	15428	14.34	1.27 (0.53)
IFLS3 - IFLS4	14068	12.06	1.59 (0.83)
Person-periods	41114		

Analyses also demonstrate variability in weather conditions over time and across locations (Table 2). For example, in the year prior to IFLS1, mean annual rainfall was 223.7cm with a standard deviation of 68.0cm. During this year (1992), the average community experienced annual rainfall 1.2 standard deviations below the long-term mean (1984-present) for that location. In contrast, the year prior to IFLS3 (1999) saw high levels of annual rainfall on average (304.0cm, SD=58.8). In fact, the average community experienced annual rainfall 1.0 standard deviations above the long-term mean for that location. Similar differences were observed with respect to temperatures.

Table 2. Summary of rainfall and temperature in IFLS communities

		IFLS1	IFLS2	IFLS3
Annual rainfall (cm)				
	t-1	223.7 (68.0)	273.7 (62.8)	304.0 (58.8)
	t-2	233.9 (80.9)	266.8 (73.7)	232.9 (61.2)
Deviation from mean annual rainfall (*z*)				
	t-1	(-)1.2 (0.5)	0.2 (0.4)	1.0 (0.7)
	t-2	(-)0.9 (0.8)	(-)0.1 (0.6)	(-)1.0 (0.5)
Annual mean daily max temperature (°C)				
	t-1	28.0 (0.9)	27.8 (0.9)	27.8 (0.9)
	t-2	28.1 (1.0)	28.1 (0.9)	28.6 (0.9)
Deviation from mean annual daily max temperature (*z*)				
	t-1	0.1 (0.3)	(-)0.7 (0.3)	(-)0.7 (0.3)
	t-2	0.6 (0.5)	0.4 (0.4)	2.4 (0.5)

Finally, preliminary analyses found significant correlations between inter-survey migration—coded as a dummy variable—and rainfall and temperature—measured with respect to annual levels of rain and heat, and deviations from long-term means. Overall, these simple correlations suggest that persons exposed to negative rainfall shocks (i.e., rainfall deficits) in the one or two years prior to a period's baseline were less likely to migrate during that period. The correlation between migration and temperature indicates a negative association between temperature and migration. Persons exposed to above average temperatures were less likely to migrate than those exposed to below average temperatures. Together, these preliminary results indicate that rainfall deficits and abnormally high temperatures—which often have adverse effects on agricultural production—are associated with lower rates of migration.

Table 3. Correlation between rainfall and migration, by period

		IFLS1-IFLS2	IFLS2-IFLS3	IFLS3-IFLS4
Annual rainfall (cm)				
	t-1	0.030**	0.055***	0.021*
	t-2	0.039***	0.057***	0.064***
Deviation from mean annual rainfall (*z*)				
	t-1	0.038***	0.017*	0.050***
	t-2	0.056***	0.049***	(-)0.056***

*p<0.05 **p<0.01 ***p<0.001

Table 4. Correlation between temperature and migration, by period

		IFLS1-IFLS2	IFLS2-IFLS3	IFLS3-IFLS4
Annual mean daily max temperature (°C)				
	t-1	(-)0.049***	(-)0.042***	(-)0.044***
	t-2	(-)0.052***	(-)0.042***	(-)0.029**
Deviation from mean annual daily max temperature (*z*)				
	t-1	0.029**	0.002	(-)0.051***
	t-2	(-)0.223*	(-)0.045***	(-)0.035***

*p<0.05 **p<0.01 ***p<0.001

6. Plan of research

This study will build upon these preliminary findings by transitioning into a discrete time event history framework, refining measures of weather shocks and explanatory variables, and modeling other migration outcomes, including migration by distance and duration and number of moves. Final analyses will also account for uneven inter-survey periods, endogeneity, and clustering at the household and community levels.

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