Does Environmental Degradation Influence Migration? Emigration to Developed Countries in the Late 1980s and 1990s*

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Objective. The Intergovernmental Panel on Climate Change predicts that climate change will intensify during the 21st century. The exact distribution of impacts will likely be complex in nature. Although some areas may exhibit benefits, many areas will likely experience environmental decline. The objective of this article is to answer the following question: What are the potential implications of deteriorating environmental conditions for human migration? This is not an easy question to answer because the full effects of climate change are not yet completely evident. Yet by studying the impact of environmental forces on migration in recent decades, we can offer some insight to this question. Methods. In implementing this approach, we employ theoretical and empirical methods. Our theoretical model suggests that environmental degradation should promote out-migration from affected areas, all other things being equal. To test this prediction empirically, we conduct a large-N statistical analysis focusing on the role of several environmental factors in emigration to developed countries. Our empirical sample covers the late 1980s and the 1990s. Results. The empirical results suggest that environmental decline plays a statistically significant role in out-migration, pushing people to leave their homes and move to other countries. Conclusions. In the conclusions section of this article, we evaluate the policy implications of these findings for developed countries in the context of climate change and national security.

Integrating many studies, the Intergovernmental Panel on Climate Change (IPCC) argues that global warming will likely continue during this century, promoting global climate change (IPCC, 2001, 2007a, 2007b). The global distribution of the impacts of these forces is complex in nature. Although some areas are expected to exhibit benefits, including longer growing seasons, increased precipitation, and smaller heating expenses,

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many other areas are expected to exhibit costs from inundation due to the sea level rising, fresh water shortages, land degradation, and stronger and more frequent storms, droughts, and other extreme weather events. In many countries, both benefits and costs may be incurred, making it difficult to determine the net impact of global warming and climate change; however, determining the net impact of global warming is not our goal.

We seek to analyze the implications of climate change for international migration. Will people living in adversely affected countries migrate to other countries? This is a difficult question because climate change is an evolving force whose exact effects are still not fully known, and the distribution of impacts may be influenced by cultural and public policy adaptation and mitigation of people living in affected areas. Our premise is that we can gain insight to our migration question by studying impacts of environmental forces on migration in recent decades. We conjecture that environmental degradation leads to out-migration from adversely affected areas. To establish the plausibility of this conjecture, we first sketch two cases.

In the 1930s, the combination of a prolonged drought and strong winds in the U.S. Great Plains produced frequent and intense dust storms. Aggressive tillage loosened the soil from the ground and compounded the problem, lowering the region’s agricultural output. Unable to make a living and maintain payments on farms and equipment and seeking to escape the dust storms, about 2.5 million Americans left the Great Plains in the 1930s (see, e.g., Worster, 1979; UNCCD, 2001; Baumhardt, 2001; PBS Online, 2002).

Bangladesh (East Pakistan before 1971) provides a second example. Like the U.S. Great Plains, poverty-stricken Bangladesh has also depended on agriculture for livelihood. Since the 1950s, the country has experienced increased land erosion, which has reduced land productivity. Population pressures and declining plot sizes due to traditional inheritance laws have increased agricultural land scarcity, pushing people to put marginal lands into agricultural production. As the environment declined, people became increasingly less able to make a living. Intense and frequent storms, floods, and droughts worsened the situation, lowering the quality of life. As a result, 2 million people emigrated to India’s West Bengal region, 12–17 million emigrated to the Indian states of Assam and Tripura, and half a million moved within Bangladesh to the Chittagong Hill Tracts (e.g., Swain, 1996; Homer-Dixon, 1999; Lee, 2001).

It is apparent that human action aggravated natural environmental change in both cases. Which of these two forces, human action or natural change, is more important in causing emigration is an interesting question, but is not a concern in this article. The issue we address is whether a declining environment pushes people to emigrate, regardless of which force is more important in causing the decline. We refer to this type of migration as environmental migration.

Stepping back from these cases to a broader picture, environmental migration is a central part of the environmental security literature, which
argues that environmental decline can lead to violent conflict. The basic argument goes back to Robert Malthus, who suggested that global population growth would eventually lead to environmental decline, famines, and conflict over natural resources. In recent decades, observers have revived this paradigm in a neo-Malthusian view according to which environmental migration is one of the central channels leading from environmental decline to conflict, particularly in less developed countries (LDCs) (e.g., Kaplan, 1994; Homer-Dixon, 1999; Reuveny, 2007). As surveyed by Barnett and Adger (2007), the neo-Malthusian view is not without critics, who argue that environmental problems are not severe (e.g., Simon, 1996; Lomborg, 2001, 2007) and that human ingenuity and cooperation can sufficiently alleviate them (e.g., Boserup, 1981; Simon, 1996; Deudney, 1999; Conca, 2001; Matthew, Gaulin, and McDonald, 2003). These critics notwithstanding, as Diehl and Gleditsch (2001), McLaughlin (2006), and others illustrate, many scholars and policymakers accept the Malthusian logic. The Bush Administration seemed less interested in the neo-Malthusian argument, but other governmental offices were looking into links between environmental decline, conflict, and security (Matthew, 2002). Recently, analysts in the U.S. Department of Defense argued that climate change may harm U.S. national security due to several forces, including climate-change-induced waves of environmental migration (Schwartz and Randall, 2003; New York Times, 2004).

The environmental security literature suggests that the importance of environmental migration goes beyond its personal implications. But how general is the phenomenon of environmental migration? Outcomes observed in the Dust Bowl and Bangladesh cases discussed above are observed in several other cases (Reuveny, 2007), but this may not imply a general outcome. We explore whether this outcome is in fact supported in a general sense through a large-N statistical analysis, probing for a general relationship. Given data availability, the sample includes all the migration flows to a number of developed countries (DCs) in the late 1980s and 1990s, employing a pooled cross-section time-series analysis. The unit of analysis is the directed-dyad: an ordered country pair that denotes a migration from country j to country k, where k is a DC.

Summarizing our findings, conditions of environmental decline play a contributory role in emigration from affected areas to DCs. The remainder of our article is organized as follows. The next section presents our theoretical model, followed by sections that present our empirical research design and results, and a summary that includes a discussion of policy implications.

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1 Examples include the Clinton Administration in the United States (Gore, 1992; Herman, 1999), Germany’s Environment Minister (Trittin, 2000), former U.S. Senator Sam Nunn (Butts, 1999), the Head of the U.S. Agency for International Development (Sherbinin, 1995), and the Chairman of the World Bank’s Global Environment Facility (Payne, 1998).
Theoretical Model

As in the standard migration literature, we assume potential migrants perform an informal cost-benefit analysis, which considers the time dimension and the value of future costs and benefits. In each period, the actors are assumed to compute the net benefits, the present value of the total benefits minus the present value of the total costs, of staying and of migrating. If the net benefit of migration is larger than that of staying, they migrate and vice versa.

We assume that the net benefits from staying and migrating are not fully known, leading actors to rely on expected net benefits. This is modeled by assuming that the net benefits can be high or low. $B_{MH}(t)$ and $B_{ML}(t)$ denote high and low net benefits from migration, respectively, where $M$ denotes migration, $H$ denotes high, $L$ denotes low, and $t$ denotes a time period. $B_{SH}(t)$ and $B_{SL}(t)$ denote high and low net benefits from staying, respectively, where $S$ denotes staying. The probabilities of high net benefits from migrating or staying are $P_{MH}$ and $P_{SH}$, respectively.

For each period in the decision-making time horizon ($T$), the actors compute the expected net benefits from migrating, $E_{BM}$, or staying, $E_{BS}$:

$$E_{BM}(t) = P_{MH}(t)B_{MH}(t) + (1 - P_{MH})B_{ML}(t)$$

$$E_{BS}(t) = P_{SH}(t)B_{SH}(t) + (1 - P_{SH})B_{SL}(t).$$

The net benefits ($B_{MH}$, $B_{ML}$, $B_{SH}$, $B_{SL}$) and probabilities ($P_{MH}$, $P_{SH}$) are assumed to depend on social forces (SO), economic forces (EC), political forces (PO), and environmental forces (EN) in the origin and destination of migration. Thus, $E_{BM}(t)$ and $E_{BS}(t)$ also depend on these factors. Migrants pay a one-time cost, $C_{M}$, summing up various expenses (e.g., travel, finding a job, legal fees, moving belongings). The importance of factors in the decision-making process is given by weights, $m_{w}$ for migrating and $s_{w}$ for staying ($w = 1, 2, \ldots$). Hence, we can rewrite Equations (1) and (2) as follows:

$$E_{BM}(t) = f[m_{1}(t) \cdot SO_{M}(t) + m_{2}(t) \cdot EC_{M}(t) + m_{3}(t) \cdot PO_{M}(t)$$

$$\quad + m_{4}(t) \cdot EN_{M}(t) - m_{5} \cdot C_{M}(t)]$$

$$E_{BS}(t) = f[s_{1}(t) \cdot SO_{S}(t) + s_{2}(t) \cdot EC_{S}(t) + s_{3}(t) \cdot PO_{S}(t)$$

$$\quad + s_{4}(t) \cdot EN_{S}(t)],$$

where $f$ denotes “a function of.”

Actors are assumed to value future expected net benefits less than current expected benefits. In each period, they compute the present values of

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1 For reviews of the use of cost-benefit analysis in standard migration literature, see Massey et al. (1993), Borjas (1994), Cohen (1996), and Martin and Widgren (2002). The standard literature does not focus on the role of the environment in out-migration.
expected net benefits from migrating ($PV_M$) and staying ($PV_S$), using time horizon ($T$) and a discount rate ($r$):

$$PV_{M(t)} = \sum_{t=1}^{T} \frac{EB_M(t)}{(1+r)^t},$$  \hspace{1cm} (5)

$$PV_{S(t)} = \sum_{t=1}^{T} \frac{EB_S(t)}{(1+r)^t}. \hspace{1cm} (6)$$

In deciding whether to migrate, individual $i$ in country $j$, $j = 1, 2 \ldots n$, computes each period the expected net benefits $PV_M$ and $PV_S$ for each destination. The individual maximizes the difference ($PV_M - PV_S$) across all destinations $k = 1, 2 \ldots n$.

$$\max \left[ \left( \frac{PV_M}{PV_S} \right)_{ij1t}, \left( \frac{PV_M}{PV_S} \right)_{ij2t}, \ldots, \left( \frac{PV_M}{PV_S} \right)_{ijn0} \right]$$  \hspace{1cm} (7)

The individual chooses to migrate to the destination that gives him or her the largest ($PV_M - PV_S$) value, as long as this difference is positive. If this difference is negative, the individual stays.

It is customary to categorize migration forces as push and pull forces. Push forces operate in place $j$ and cause people to leave $j$. Pull forces operate in $k$ and attract people to $k$. The net benefit from migration ($EB_M$) rises as these forces rise, and the net benefit from staying ($EB_S$) rises as these forces decline. Economic push forces include factors like low wages, unemployment, and low levels of development, food security, and public health, while economic pull forces include factors like high wages, employment, and high levels of development, food security, and public health. Sociopolitical push forces include elements such as war, genocide, and dissident violence, while sociopolitical pull forces include the absence of these factors.$^3$

A number of studies have employed economic and sociopolitical forces in statistical models of migration (e.g., Karemera, Oguledo, and Davis, 2000; Dumont and Lemaitre, 2005; Moore and Shellman, 2004), but have not included environmental determinants in the model. These determinants can be broadly categorized into four groups: weather–related natural disasters (e.g., storms), cumulative environmental degradation (e.g., land scarcity or degradation), production accidents (e.g., chemical spill), and development projects (e.g., artificial lakes). We employ an empirical analysis to study aspects of the first two categories.

$^3$States may also curtail out-migration (e.g., the USSR), or push others to do so (e.g., U.S. pressure on Mexico). One might also consider psychological forces (e.g., attachment to the destination). These complex forces are better studied in separate analyses.
Empirical Research Design

To our knowledge, the empirical literature on environmental migration has so far relied on case studies. This methodology allows scholars to study situations in detail, but the results may not generalize to other cases. The alternative methodology, large-$N$ statistical analysis, also faces limitations, particularly unavoidable limitations concerning data availability, indicator construction, and loss of visibility of particular cases in a large sample. However, the large-$N$ statistical approach can yield insights that apply on average to all cases. We employ this methodology here, while remaining aware of its limitations.

Formulating our empirical model, we employ the directed-dyad-year unit of observation, migration flow from one country to another in a year, as the unit of analysis. Although the logic of environmental migration applies to both interstate and intrastate moves, data on intrastate migration from origin to destination, and the appropriate socioeconomic and political variables, are generally not available on a systematic basis for many countries and years. Therefore, we analyze interstate migration only, defining our dependent variable as the number of people who migrated from country $j$ to country $k$ in a given year and utilizing a pooled cross-sectional time-series sample structure.

Next, we make the following adjustments to our design in order to limit the chance of econometric problems and enhance our ability to draw valid inferences. To address the possibilities of heteroscedasticity and serial correlation, we use ordinary least squares regression with robust standard errors clustered on the $jk$ directed-dyad, which yield consistent estimates. To reduce the impact of potential outliers, we use a robust regression estimator (Berk, 1990). Given data availability, we are constrained to an examination of DC destinations. Migrants seeking to enter DCs may face restrictions that are not observed systematically across directed-dyads; thus, the actual number of migrants might be censored, or smaller, than the number of those wishing to migrate. To counteract censoring, we employ a Tobit estimator (McDonald and Moffitt, 1980). If the results we obtain from ordinary least squares regression, robust migration, and the Tobit estimator are similar, it would suggest the above potential problems are not severe. Finally, we compute the variance inflation factors for our variables to detect the possibility of multicolinearity.

It should be noted that our large-$N$ research design does not speak directly to our postulated individual cost-benefit analyses. This limitation is not unique to our article. Rational choice analyses, of which our model is a variant, typically do not speak directly to assumed individual preferences. Rather, they use empirical analyses to inspect observed implications of theoretical models. Another issue to be noted is that our empirical analysis informs us about the effect of environmental forces on international migration, not on intrastate migrations. The analysis of environmentally
influenced migration includes especially complex theoretical processes. It follows that one analysis effort cannot encompass all implications; there is ample room for additional empirical research.

**Empirical Model and Expected Effects**

This section describes our empirical model and the expected effects of its variables on out-migration. To move from our stylized decision-theoretic model to a specific empirical model, we focus on the migration flow from country j to country k, implicitly aggregating across individuals. The empirical model identifies push factors operating in j (PUSH$_j$) and pull factors operating in k (PULL$_k$), in time t, which correspond to the migration cost, and social, economic, political, and environmental forces entering our theoretical model.

For the statistical analysis of migration flows, we employ the following functional forms:

\[
PUSH_j = \alpha_1 S_j \alpha_2 E_j \alpha_3 P_j \alpha_4 N_j \alpha_5 C_M
\]
\[
PULL_k = \beta_1 S_k \beta_2 E_k \beta_3 P_k \beta_4 N_k
\]

where notations $\alpha$ and $\beta$ denote coefficients to be estimated. The migration flow from j to k, M$_{jk}$, rises with PUSH$_j$ and PULL$_k$. One way to capture this mathematically is set out below:

\[
M_{jk} = M_{jk0} \text{PUSH}_j \text{PULL}_k,
\]

where M$_{jk0}$ is a constant term, measuring the intrinsic propensity of people from j to move to k in the absence of other stimulants.\(^4\)

Substituting Equations (8) and (9) into Equation (10) and taking the natural log (ln) of the result, we get:

\[
\ln(M_{jk}) = \ln(M_{jk0}) + \alpha_1 \ln(S_j) + \alpha_2 \ln(E_j) + \alpha_3 \ln(P_j) + \alpha_4 \ln(N_j) + \alpha_5 \ln(C_M) + \beta_1 \ln(S_k) + \beta_2 \ln(E_k) + \beta_3 \ln(P_k) + \beta_4 \ln(N_k).
\]

The coefficients in Equation (11) can be estimated using regression analysis.\(^5\)

Table 1 presents expected effects of our empirical measures for Equation (11). The dependent variable, MIGRATION, is the log of the number of events.

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\(^4\)For a similar modeling approach with a sample including only the United States as the receiving country and without environmental variables, see Karemera, Oguledo, and Davis (2000).

\(^5\)When a variable’s range includes 0, we add 1 to it before taking the log. For a binary measure, we use the value as is, which is equivalent to using natural logs, coding 1 for no event and $e$ for an event.
migrants from origin to destination. These data are available systematically only for a number of DCs. We use source data from the OECD Statistics Portal (2006), which provides migration flow measures for Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Japan, the Netherlands, Norway, Portugal, Sweden, Switzerland, and the United Kingdom during the 1990s and 2000. Data for the United States as a destination since the late 1980s come from the 1996 and 2003 Statistical Yearbooks of the U.S. Citizenship and Immigration Services office. These sources do not address illegal migration and often contain categories that are compilations of states that send few migrants; for example, “Other African.” We cannot correct this problem, but the residual flows for these categories are small and should not bias our analysis.

For our sample, we employ environmental conditions in the country of origin, assuming $\beta_4 = 0$. Additional runs demonstrate the level of fit for a model with $\beta_4 \neq 0$ is smaller than for a model with $\beta_4 = 0$. This result is not surprising because our destinations are all DCs. By the late 1980s, environmental quality in DCs was fairly high and livelihoods generally did not depend on the environment. As such, environmental concerns in the DCs were not likely to assist migrants in choosing among DCs in migration. Additionally, the DCs already had in place strong aid and insurance programs that ameliorated environmental calamities. Potential DC-destined migrants are assumed to consider environmental conditions in DCs as a constant, which does not affect their calculations.

### TABLE 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Expected Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARABLE LAND</td>
<td>Negative</td>
</tr>
<tr>
<td>CROP LAND</td>
<td>Positive</td>
</tr>
<tr>
<td>DISASTER</td>
<td>Positive</td>
</tr>
<tr>
<td>POPULATION ORIGIN</td>
<td>Positive</td>
</tr>
<tr>
<td>GNPPC ORIGIN</td>
<td>Negative</td>
</tr>
<tr>
<td>GNPPC DESTINATION</td>
<td>Positive</td>
</tr>
<tr>
<td>CALORIE</td>
<td>Negative</td>
</tr>
<tr>
<td>COST</td>
<td>Negative</td>
</tr>
<tr>
<td>BORDER</td>
<td>Positive</td>
</tr>
<tr>
<td>NUMBER OF BORDERS</td>
<td>Negative</td>
</tr>
<tr>
<td>DEMOCRACY ORIGIN</td>
<td>Negative</td>
</tr>
<tr>
<td>DEMOCRACY DESTINATION</td>
<td>No Effect</td>
</tr>
<tr>
<td>CIVIL WAR</td>
<td>Positive or Negative</td>
</tr>
<tr>
<td>WAR</td>
<td>Positive or Negative</td>
</tr>
<tr>
<td>POPULATION DESTINATION</td>
<td>Positive or Negative</td>
</tr>
<tr>
<td>GENOCIDE</td>
<td>Positive or Negative</td>
</tr>
<tr>
<td>DISSIDENT</td>
<td>Positive</td>
</tr>
</tbody>
</table>
Since the environment is multidimensional, we employ several measures. Given limitations of data availability and missing values, we use three indicators for which we found a reasonable amount of data: land farmed with permanent crops, arable land, and weather-related natural disasters. To these indicators we add an indirect indicator, population size, which stands as a general proxy for pressure on the environment.

**ARABLE LAND** is the log of arable land per capita in the country of origin. It is an important environmental measure because it indicates the size of land that can be used for agriculture and grazing. We expect that a rise in arable land will reduce migration because it increases abundance and economic opportunities. The data come from the GEO Data Portal (2005).

**CROP LAND** is the log of the share of total land in the country of migration origin that is used to grow permanent crops. This is an important environmental indicator because it includes grains consumed by humans and domestic animals, which are, in turn, consumed by, and generate food for, humans. In LDCs, domestic animals are also used in agriculture, further highlighting their importance. Countries have finite amounts of land that can be used for growing permanent crops. As crop land grows, less land remains for people who may want to grow crops in the future, suggesting that out-migration should rise as crop land rises. The data come from the GEO Data Portal (2005).

**DISASTER** is the log of the total number of people affected by weather-related natural disasters in the origin country. People “affected by a disaster” include those needing immediate assistance with food, shelter, water, or medical help, and people left homeless or killed. Our measure includes droughts, extreme temperatures, floods, ground and mud slides, water waves, water surges, wild fires, and all types of wind storms (e.g., hurricanes, typhoons). We expect that a rise in the number of people affected by natural disasters in a country will increase out-migration. The data come from the GEO Data Portal (2005).

**POPULATION ORIGIN** is the log of population size in the country of origin. We expect a rise in this variable will increase out-migration because it implies greater pressure on the environment and inevitably greater environmental degradation, all other things being equal. The data come from Fearon and Laitin (2003).

As indicated by our theory, migration is also affected by economic, social, and political factors, our control variables. Beginning with economic variables (EC in the theoretical model), we use gross national product per capita (GNPPC) as a proxy for average wage. GNPPC ORIGIN and GNPPC DESTINATION are the logs of real GNP per capita for the countries of migration origin and destination, respectively. They are computed by dividing GNP data from the World Bank’s World Development Indicators by population data from Fearon and Laitin (2003). A rise in GNPPC ORIGIN is expected

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6We replace missing GNP values with data from Banks (2006), where available.
to reduce out-migration, as people prefer to stay at home when the economy improves. A rise in GNP\textsubscript{PC \textsc{destination}} is expected to promote out-migration, pulling people to migrate by offering them higher incomes elsewhere.

\textsc{calorie} is the log of average calories per capita in the origin country, which serves as a proxy of food security and public health. We expect that higher caloric intake values in a country will reduce out-migration. The data come from the GEO Data Portal (2005).

\textsc{cost} (one component of $C_M$ in the theoretical model) measures cost of the movement from origin to destination. It is given by the log of the ratio of distance (from origin to destination) to the origin’s GNP per capita. This measure implies that as distance rises, cost rises, but as the origin GNP per capita rises, cost falls (the move is less expensive relative to one’s income). A rise in \textsc{cost} is expected to reduce migration. The data come from Moore and Shellman (2005).

\textsc{border}, a second cost measure, is a binary variable, with a value of 1 indicating the presence of a shared ground border between origin and destination, or a shared water border of less than 200 kilometers. A move across adjacent borders should be relatively low cost, raising migration.

\textsc{number of borders}, our third cost indicator, is the number of borders the country of origin shares with other countries. Across-the-border destinations are less expensive to reach than others. A rise in this variable should reduce migration to any given destination, since it indicates more migration choices, and therefore inexpensive substitute destinations. The data come from Shellman (2001).

Consider next the political variables in the theoretical model (PO). \textsc{democracy origin} and \textsc{democracy destination} are the logs of the levels of democracy in the origin and destination, respectively, which are composed as the difference between the democracy and autocracy scores of each country. A fall in democracy in the country of origin should promote out-migration, as people are less content with the state of affairs. The effect of a rise in democracy in our destinations on migration is expected to be statistically insignificant because this variable is almost constant in our sample. The data come from the Polity IV Project (2006).

\textsc{civil war} is set to 1 when there is a civil war in the country of origin during a given year and set to 0 otherwise. The data come from the Correlates of War Project, identifying intrastate conflict as a civil war if it produced more than 1,000 deaths in a given year (Sarkees, 2000). Civil war may promote out-migration, as people seek to flee the violence, but it may also reduce out-migration as people may not be able to leave a country in disarray, or may decide to join one of the sides of the conflict.

\textsc{war} is set to 1 when an interstate war takes place in the origin’s territory during a given year and set to 0 otherwise. The data come from the Correlates of War Project, which identifies interstate conflicts as wars if they produced at least 1,000 battle deaths (Sarkees, 2000). We use data from Moore and Shellman (2004) to determine if the war took place on the
origin’s land. War in the country of origin could promote migration, as people flee the conflict, or discourage migration, as people may not be able to leave due to the war or stay to defend the homeland.

Turning to the social variables (SO in the theoretical model), POPULATION DESTINATION is the log of population size in the destination. Recalling that our receiving countries are DCs, a larger population implies a larger economy, offering more opportunities to migrants. However, a larger population in the destination also implies greater competition for jobs and resources. So, the effect of population destination on migration could be positive or negative. The data come from Fearon and Laitin (2003).

GENOCIDE is the log of number of people killed in genocide and politicide in the country of origin (Harff, 2003). The effect of a rise in this variable on out-migration can be positive, as people seek to leave the country, or negative, as the pool of potential migrants may fall due to the killings and as the level of domestic unrest associated with the genocide may decline following the near elimination of one of the sides.

DISSIDENT is the log of the sum of riots and guerrilla warfare events in the origin country. The data come from Banks (2006), where a riot is a demonstration or clash of more than 100 citizens involving force, and guerrilla warfare is an armed activity, sabotage, or bombings carried out by irregular forces seeking to overthrow the regime. The effect of this variable on migration is expected to be positive, as people seek to flee guerrilla warfare and riots at home.

**Statistical Analysis**

To evaluate the statistical significance of our findings, we employ one-tailed tests when our theoretical expectations are one sided; otherwise we employ a two-tailed test. This strategy leads us to employ one-tailed tests for COST, GNPPC ORIGIN, GNPPC DESTINATION, DEMOCRACY ORIGIN, BORDER, NUMBER OF BORDERS, CALORIE, POPULATION ORIGIN, DISSIDENT, CROP LAND, ARABLE LAND and DISSIDENT. For POPULATION DESTINATION, DEMOCRACY DESTINATION, WAR, CIVIL WAR, and GENOCIDE, we employ a two-tailed test.

As called for by our research design, we investigate the possibility of multicollinearity among our variables by examining the variance inflation factor (VIF) score for each variable. None of the variables produce a score greater than 10; hence, multicollinearity is not a cause for concern in this article. Next, recall that we take the logarithm for all the right-hand side variables except for WAR, CIVIL WAR, and BORDER, which are dichotomous, and

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7Our DC destinations did not exhibit wars on their lands, civil wars, dissidence, or any genocide, in our period. Our statistical program, STATA, drops these constant variables from the regression.

8For studies taking a similar approach, see, for example, Morrow, Siverson, and Tabares (1998), Oneal and Russett (1999), Li and Reuveny (2003), and Barbieri and Reuveny (2005).
Our dependent variable is also log-transformed. This reduces the risk of heteroscedasticity. We further control for the possibilities of heteroscedasticity and serial correlation in the estimation, as called for by our research design.

Table 2 reports the results. Column 1 reports the results for ordinary least squares regression with robust standard errors clustered by directed-dyad, Column 2 reports the results for robust regression, and Column 3 reports the results for Tobit regression.

Beginning with the economic variables, the effect of a rise in GNPPC ORIGIN on migration is negative and statistically significant in all regression models. The effect of a rise in GNPPC DESTINATION on migration is positive and significant across the models. When GNP per capita in the country of origin rises, out-migration falls, and when GNP per capita in the destination rises, out-migration rises, as expected. The effect of a rise in CALORIE on migration is negative across the models, and is statistically significant in Models 2 and 3, suggesting that when public health and food security improves in the country of origin, out-migration falls, again as expected.

Consider next the indicators of cost. The effect of a rise in COST on migration is always negative and statistically significant, as expected. Hence, as the cost of the movement rises, out-migration declines. Migration also
rises significantly when \textsc{border} rises from 0 to 1, indicating that when the origin and destination countries of the migration share a border the move is easier. The migration to a certain destination declines when \textsc{number of borders} increases, indicating that more destination alternatives are available to potential migrants. These two border-related findings are in line with our theoretical expectations.

Turning to the political variables, as \textsc{democracy origin} rises, migration falls significantly. Hence, as democracy at home rises, fewer people migrate out, as expected. The effect of a rise in \textsc{democracy destination} on out-migration is positive, but statistically insignificant. As noted, the insignificance seems to reflect the virtual nonvariability of democracy for our destinations in our period.

The effect on out-migration of a rise in \textsc{civil war} from 0 to 1 in the country of origin is positive and statistically significant in all models. Countries engaged in civil war experience greater out-migration than if civil war is absent, supporting the idea that people emigrate to flee violence. The effect of a rise in \textsc{war} from 0 to 1 in the origin’s territory on migration is negative in all three models, but is only significant in Model 1. This showcases the ambiguity of people’s response to war noted in our empirical model section, but partially supports the idea that when international war occurs in a country, out-migration tends to decline, perhaps as people choose to defend their homeland or meet greater difficulty migrating during wartime.

Turning to the sociological factors, the effect of increasing \textsc{population destination} on migration is positive and significant. In our sample, a larger population in the destination area also indicates a larger economy, which pulls migrants. The effect of \textsc{genocide} in the country of origin on migration is always negative and statistically significant in Models 2 and 3, suggesting that once genocide reduces the pool of potential migrants and thereby the level of unrest in the country, out-migration falls. As \textsc{dissident} in the origin rises, out-migration rises, but the effect is not statistically significant. All these results fall within our theoretical expectations.

Because the control variables performed as expected theoretically, our modeling platform can be judged to be statistically sound and therefore used to analyze the effect of the environmental variables on migration. As with the control variables, the results obtained for the environmental variables are similar in terms of their signs and sizes across the three regressions and are largely similar in terms of their significance levels.

The effect of a rise in \textsc{arable land} in the country of origin on migration is negative across the three models. The effect is statistically significant in Model 2, and is insignificant in Models 1 and 3. Recalling that \textsc{arable land} is land that can be used in agriculture and grazing, this result also supports our theoretical expectation: less scarcity of productive land in the origin increases economic opportunities, thereby reducing out-migration.

The effect of a rise in \textsc{crop land} in the country of origin on out-migration is positive and statistically significant across the three regressions, as
expected. Since each country has a finite amount of arable land, more agricultural land farmed with permanent crops means that less is available for other people, which promotes out-migration.

The effect of disaster on out-migration is statistically significant and positive across all three models. A rise in the number of people affected by weather-related natural disasters in the country of the migration’s origin raises out-migration from that country, as expected.

Finally, the effect of a rise in population origin on out-migration is positive and statistically significant across all models, as expected. This result supports a Malthusian interpretation, according to which a larger population in the origin country indicates a larger pressure on the environment, which pushes more people to leave that country.

Next, we discuss the sizes of the effects of variables in the model. Recalling that our dependent variable, independent variables, and most of our control variables are measured in log-form, each estimated coefficient in these cases is the ratio between the percentage change of the dependent variable (denoted as $y$) and the percentage change of the particular right-hand side variable (denoted as $x$): $\beta = \Delta y/\Delta x$, where $\Delta$ denotes change and $\beta$ denotes an estimated coefficient. For the nonlogged right-hand side variables, the expression $\beta = \Delta y/(100\Delta x)$ holds.

In reporting the sizes of effects, we employ a range based on the three models if they produce significant coefficients. When a model does not produce a significant coefficient, we interpret the sizes of effects based on the other models and note which model(s) we use. Beginning with the environmental variables, a 1 percent rise in arable land reduces emigration by 0.05 percent (Model 2); a 1 percent increase in crop land leads to a 0.1 to 0.13 percent increase in the number of emigrants; a 1 percent increase in disaster produces a 0.01 to 0.014 percent increase in emigration; and a 1 percent rise in population origin produces a 0.382 to 0.399 percent rise in emigration.

How do these effects compare with the sizes of the statistically significant sociopolitical-economic effects? A 1 percent rise in GNPPC origin reduces emigration by 0.0000432 to 0.0000494 percent; a 1 percent rise in GNPPC destination raises emigration by 0.289 to 0.334 percent; a 1 percent rise in calorie reduces emigration by 0.468 to 0.927 (Models 2 and 3) percent; a 1 percent rise in cost reduces emigration by 0.397 to 0.4 percent; a 1 unit rise in number of borders reduces emigration by 7.4 to 10.7 percent; a 1 percent rise in democracy origin reduces emigration by 0.227 to 0.292 percent; a 1 percent rise in population destination raises emigration by 0.429 to 0.439 percent; and a 1 percent rise in genocide reduces emigration by 0.512 to 0.602 percent (Models 2 and 3).

Turning to the binary variables, a rise in border from 0 to 1 raises emigration by 50.1 to 52.4 percent; a rise in civil war from 0 to 1 raises emigration by 44.6 to 52 percent; and a rise in war from 0 to 1 reduces emigration by 76.3 percent (Model 1). The sizes of the binary effects seem
large, but recall that a rise from 0 to 1 implies a change of 100 percent, not 1 percent. Heuristically, recalculated to terms of 1 percent rises (dividing effects by 100), the sizes of these binary effects are generally similar to above-mentioned level effects.

In sum, the empirical results discussed in this section indicate that out-migration is affected not only by social, economic, and political forces, but also by environmental forces. Deteriorating environmental conditions in a country promote out-migration from that country, all else being equal.

Policy Implications

In this article, we theorize that environmental decline promotes out-migration. To evaluate this theory empirically, we employ a large-N statistical analysis. Although the standard migration literature has essentially ignored the role of the environment in migration, we find that environmental decline promotes out-migration from affected countries, and the size of this force is generally similar to the sizes of the standard economic, social, and political forces.

Scholars typically assume that empirical analyses that are able to explain historical data may also tell us something about the future. Although our finding that environmental decline promotes out-migration may strike some readers as unsurprising, we think this reaction only serves to demonstrate its importance. In coming decades, climate change is expected to significantly degrade the environments of many regions in various ways, including increasing the number and scope of weather-related disasters, degrading lands, and raising the sea level. If existing environmental decline plays a role in migration to DCs, climate-change-induced environmental decline, which may be more severe than the current decline, will likely have an even greater impact on migration. Stated another way, immigration issues now may seem quite mundane compared to what may happen in the future under severe climate change.

Viewing our finding in the context of conflict, the literature on environmental security finds that environmental migration is often associated with violent conflict, suggesting that minimizing climate-change-induced environmental migration is a worthy goal. In this context, there are two important policy audiences: the governments of DCs and LDCs. Unlike the governments of DCs, the governments of LDCs will not likely be able to mitigate climate-change-induced environmental damages on their own in light of financial and technological constraints (IPCC, 2001, 2007b). We therefore focus on the governments of DCs.

In recent years, migration pressures of LDCs on DCs have risen (Martin and Widgren, 2002; BCIS, 2003). In response, DCs have made entry into their territories more difficult (Andreas and Snyder, 2001; IMR, 2002; Wood, 2001). We believe this response will eventually fail to stem immigration pres-
sure. As climate change continues, environmental degradation will rise in some areas, promoting out-migration; migrants will most likely come from LDCs, which are more dependent on the environment for livelihood and cannot defend effectively against environmental decline. This is especially likely because the most negative effects from climate change are projected in LDCs (IPCC, 2001, 2007b). As a result, there may be more legal and illegal attempts to enter DCs, which may ultimately lose control over incoming migration.

The security implications of uncontrollable migration are especially alarming. The environmental security literature suggests that environmental migration may promote bad feelings among the migrants and absorbing populations, fostering a fertile ground for terrorism recruitment. Environmental migration may also lead to conflict between migrants and residents in the receiving areas, particularly when these areas are poor and depend on the environment for their livelihood. Although our empirical findings have implications for the role of the environment in migration to DCs, environmental degradation may also promote migration between LDCs, but the implications are even broader. Key LDCs could experience political instability due to an influx of environmental migrants, drawing their major benefactors into disputes. Major powers may blame each other for being the ultimate contributors to the problem through their excessive use of fossil-fuel-based energy.

One might argue that economic growth in LDCs can solve the problem, as critics of the neo-Malthusian view argue, but this would raise LDC demand for energy, which could, with the current reliance on fossil-fuel-based energy, accelerate climate change. A better approach is to counter expected damages from climate change in LDCs vulnerable to environmental migration. Such a program may include, for example, building sea walls to defend LDCs from a rising sea level, or reducing the dependence of LDCs on the environment for their livelihood, such as information-technology-related service sectors.

These programs will likely be very expensive, which brings up an important question: Who should cover the cost? Recall that the key cause of climate change has been the unchecked reliance of DCs on fossil fuels, generating greenhouse gases. These gases are, in essence, a form of pollution, and therefore should follow “the polluter pays” rule that DCs implement at home. In other words, the DCs should finance most of the efforts required to defend LDCs against climate-change-induced environmental migration, thereby reducing the risk posed to their own societies.

The execution of this plan may face hurdles. DCs will probably reject it, and there may be collective-action problems as countries try to shift burdens to others. Our plan may be initiated eventually in response to a visible, tangible, or severe climate-change-induced crisis, but such a crisis may also cause irreversible damages. We think it is imperative that DCs invest in climate change mitigation and social-economic development in LDCs if they want to successfully regulate their own borders. In the end, whether the
DCs will do so depends on their risk attitudes: Are they willing to spend money now to prevent very costly disasters in the future even when the probabilities of same are small? This logic suggests it is better to invest in climate change mitigation today when risks are relatively low rather than relying on future adaptation when risks are higher.

REFERENCES


Does Environmental Degradation Influence Migration?


