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Climate Variability and Worldwide Migration: Empirical Evidence and Projections

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ABSTRACT: We estimate a bilateral gravity equation for emigration rates controlling for decadal weather averages of temperature, precipitation, droughts, and extreme precipitation in origin countries. Using the parameter estimates of the gravity equation, we estimate global, regional, and country-by-country emigration flows using different population and climate scenarios. Global emigration flows are projected to increase between 73 and 91 million in 2030-2039; between 83 and 102 million in 2040-2049; between 88 and 121 in 2050-59, and between 87 and 133 million in 2060-2069. Changes in emigration flows are mainly due to population growth in the origin countries.

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WORKING PAPERS

Climate Variability and Worldwide Migration: Empirical Evidence and Projections

Prepared by Cristina Cattaneo, Emanuele Massetti, Shouro Dasgupta, and Fabio Farinosi[1]

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Contents

I. Introduction

There is ample archaeological evidence that people have migrated in response to environmental changes. Historians have attributed some large mass migrations of the past to slow-moving changing climatic conditions (Fagan 2008). For example, abrupt changes in climate have been associated with societal collapse (Weiss and Bradley 2001), and urban population growth in three major highland Mexico civilizations was higher in periods with abundant freshwater and lower during drought periods (Lachniet et al. 2017).

Historical evidence has, however, little relevance for present-day societies because socio-economic conditions are very different now compared to centuries ago. Easier mobility and communication facilitate migration, but borders are more tightly controlled than centuries ago. Technological progress allows the smoothing of climate shocks. Aid provides at least temporary relief from food shortages. It is, therefore, unclear if climate change will lead to a higher number of international migrants.

Understanding how people may move in response to climate change is very important because migration has both large positive and negative welfare effects on migrants, origin countries, and destination countries alike. Migration can have large positive effects when it allows individuals to escape the worst effects of climate change and facilitates the reallocation of the labor force in more productive areas (Kahn 2010). Gradual migration from coastal zones can also greatly limit the cost of sea-level rise (Diaz 2016). Restrictive migration policies (Benveniste, Oppenheimer, and Fleurbaey 2020) or resource constraints (Benveniste, Oppenheimer, and Fleurbaey 2022) that may trap people in places where reducing exposure and vulnerability to climate hazards is either too expensive or impossible can have negative consequences on individuals. However, as people move to other places, they may start competing with the local population for scarce land and other finite resources, especially in case of mass migrations. Cultural differences may lead to societal conflict. These negative impacts are hard to quantify but can be very large.

Migration can also have macroeconomic implications as it changes GDP growth potential. Large migration from small countries may jeopardize macroeconomic stability. Migration into aging countries can instead ease long-term macroeconomic constraints. Sound management of migration flows requires plans that must rely on information on the origin, destination, and size of potential flows. The goal of this paper is to provide estimates of migration flows between countries in response to changes in temperature, precipitation, droughts, and excess precipitation under several socio-economic and climate scenarios. Results can support policymakers in the difficult task of regulating migration and provide insights on possible societal challenges and macro-economic impacts from a moving labor force.

The number of studies that quantify the migration response to weather and climatic events using historical data has grown substantially in recent years, as documented by two different meta-analyses (Beine and Jeusette 2021; Hoffmann et al. 2020). However, there are few projections of climate-induced flows, and they often suffer from important limitations. Some early studies assume that migration decisions are exclusively taken to avoid climate risks, ignoring the political, economic, or demographic context (Myers 1993; 2002; Stern 2007). However, people that will be exposed to climate hazards will not necessarily choose to migrate. The cost of migrating may be higher than the benefit, or social, economic, and political factors may constrain individual choices. The assumption that all people at risk from climate hazards will migrate may explain why some studies found that the number of climate migrants could be as large as 200 million per year by 2050, a very large number that has caught the public's attention and the media but is not endorsed by the scientific community.

More recent studies use micro-level data to estimate the relationship between migration and climatic variables empirically, thus accounting for individual preferences and constraints. Econometric estimates of the relationship between climate variables are used to predict the change in the probability of migrating using climate scenarios, assuming everything else remains constant. These studies typically focus on a single country (Bohra-Mishra, Oppenheimer, and Hsiang 2014; Jessoe, Manning, and Taylor 2017; Mueller, Gray, and Kosec 2014; Cattaneo and Massetti 2019). In Mexico, for example, Jessoe, Manning, and Taylor (2017) predict that a medium emissions scenario will increase the probability of migration to urban areas by as much as 1.4 percent and to the USA by as much as 0.2 percent in 2075. This translates into 230,000 additional migrants to urban centers and 40,000 additional migrants to the US each year. Cattaneo and Massetti (2019) forecast 6.3 and 3.6 million additional migrants within Nigeria in the period 2071–2100 considering RCP 8.5 and RCP 4.5 climate scenarios, respectively. While these studies can capture local specificities in response to climate shocks, being geographically narrow, they cannot be used to extrapolate migration patterns globally.

Other studies extend the analysis to many countries using panel data. Marchiori, Maystadt, and Schumacher (2012) analyze the effects of weather anomalies on migration in sub-Saharan Africa. They predict that 1.2 to 5.3 additional migrants every one thousand people will migrate annually from sub-Saharan Africa by the end of the 21st century in response to climate change. By factoring in population change, these predictions translate into yearly climate migration of up to 18.5 million inhabitants in the worst climate scenario. Missirian and Schlenker (2017) forecast an increase in asylum applications to Europe by the end of the century equal to 28 percent and 188 percent under RCP 4.5 and 8.5, respectively. This translates into 98,000 and 660,000 additional asylum applications per year.

These panel studies provide estimates of migration by extrapolating the effect of relatively small, short-term, and unpredictable weather shocks to predict the impact of relatively large, long-term, and at least in part predictable climate change. Only under very restrictive assumptions the short-term weather shocks and long-term climate change have analogous impacts (Hsiang 2016), while in general, they are not the same. Not only do short-term responses and long-term responses differ, but the direction of the “bias” is also difficult to predict (Ionesco, Mokhnacheva, and Gemenne, 2016).

Understanding the future potential impacts of climate change on migration requires modelling how agents adjust and adapt to a changing climate. Cross-sectional variation of migration decisions and climate can be exploited to identify long-run response functions that include adaptation to the historical climate observed in the cross-section, like in Cattaneo and Massetti (2019). The assumption is that cold places will adapt to a future warmer climate as warm places today have already done. However, the omitted variable may bias the cross-sectional estimates. This method also does not account for transition costs.

International migration is widespread, but most of the flows, including those induced by a changing climate, are expected to occur domestically because international moves are more costly and international migration is tightly controlled. For this reason, some studies have focused on migration within countries. Peri and Sasahara (2019) predict two migration response functions to warming, one prevailing in poor countries, where liquidity constraints may prevent migration, and one from middle-income countries, where economic incentives outweigh the cost of migration. According to their estimates, internal migration rates from poor countries are expected to decline from 7.1 percent in 2000 to 5.0 percent and to 5.5 percent by 2080-2100, in the more pessimistic and more optimistic scenario, respectively. In contrast, upper-middle-income countries will face increased internal migration rates, moving from 7.0 percent in 2000, to 7.8 percent in the more pessimistic scenario, or remain constant. The Groundswell Report of the World Bank (Rigaud et al. 2018) predicts that a cumulative number of up to 143 million people could migrate domestically between 2020 and 2050 to escape the slow-onset impacts of climate change in Sub-Saharan Africa, South Asia, and Latin America (4.8 million additional migrants per year, on average). By including East Asia and the Pacific, North Africa, and Eastern Europe and Central Asia, the cumulative number of climate migrants can reach 216 million (Clement et al., 2021), or 7.2 million additional migrants per year, on average.

Finally, attempts to theoretically model the long-term implications of climate change on migration have been pioneered by Desmet, Nagy, and Rossi-Hansberg (2018) and Desmet and Rossi-Hansberg (2015). Building on these papers, Desmet et al. (2021) employ a high-resolution global dynamic equilibrium framework to measure the spatial shifts in population and economic activity induced by coastal flooding. A partial picture is provided by Alvarez and Rossi-Hansberg (2021), which develop a global spatial dynamic model incorporating agents' reactions to temperature rise through migration, trade, and investment. The most comprehensive assessment is Burzyński et al. (2022), which endogenize the effects of multiple climatic drivers, such as changing temperatures, sea levels, and the frequency and intensity of natural disasters on individual decisions to move. They predict 37, 57, and 94 million total international climate migrants over the 21st century under the RCPs 4.5, 7.0, and 8.5, respectively. These estimates represent changes in the aggregate number of migrants relative to the hypothetical scenario of no climate change, where climatic variables remain equal to the 2010 values. They also find that if mobility barriers are hypothetically eased, the number of migrants would increase from 57 to 77 million under the RCP 7.0 scenario.

Our paper extends this literature by empirically estimating both total and bilateral flows of migrants. We use a bilateral gravity framework to produce parameter estimates of the effect of climate variables on international migration and generate global, regional, and country-by-country estimates of migration flows for several combinations of socio-economic scenarios (Shared Socio-economic Pathways - SSPs) and Greenhouse Gases emissions scenarios (Representative Concentration Pathways – RCPs) spanning a wide range of future climate and socio-economic scenarios.[1] By combining changes in climate and population conditions, we can provide information on their aggregate effect on migration flows and estimate the relative importance of socio-economic and climate drivers.

First, we empirically estimate a bilateral gravity equation using a panel of 100 origin countries, 166 destination countries over five decades. We regress decadal averages in migration on decadal averages of climate. This study improves the literature in several ways. First, by using decadal averages instead of annual data, our estimated response function can be used to predict medium-term climate change effects more accurately than with yearly fixed effects panel models (Dell, Jones, and Olken 2014). Second, we do not limit the analysis to the impacts of changes in average temperature and precipitation. Despite increasing concerns about the impacts of increased intensity and frequency of extreme weather, the literature has largely neglected their effect, possibly omitting important drivers of migration. Akyapi, Bellon and Massetti (2022) show that extreme temperature, drought, and flood events are more important than average annual temperature in explaining GDP growth globally. Droughts and floods are also the two hydro-meteorological disasters that have historically been responsible for the largest number of deaths.[2] It is thus reasonable to expect that migration will also be affected by these climate extremes. Our analysis continues to use average temperature and precipitation, but

[1] Each SSP provides an internally consistent set of assumptions on economic development, society, and technology. SSPs are used with RCPs to illustrate consistent scenarios of socio-economic development and emissions and play a key role in the literature on climate change mitigation and adaptation (e.g., IPCC 2021). For further details see O’Neill et al. (2014) and Riahi et al. (2017).

[2] See for example the EM-DAT database (https://emdat.be/).

we also include measures of droughts and extreme precipitations that may cause floods. Third, instead of using data from disasters datasets, which infer the existence of a climate disaster from reported impacts, a potential source of endogeneity bias (Felbermayr and Gröschl 2014), we build indicators for floods and droughts using high-resolution precipitation data on the entire world.

We find that warming is a significant driver of emigration. A one percent decadal increase in temperature increases decadal average bilateral migration rates by 1.2 percent. The positive and statistically significant effect of temperature is robust to different specifications, different samples, different ways to compute migration flows, and different estimation methods. We find that emigration flows will rise in all RCP and SSP scenarios, with the most significant increase predicted under the RCP 4.5 and SSP3 (medium warming and limited development with regional rivalry). We project that average decadal emigration flows will be between 73 and 91 million during the 2030 decade. The projected flows for the following decades are between 83 and 102 million (2040), between 88 and 121 million (2050), and between 87 and 133 million (2060). Finally, by decomposing the effect of a changing climate from the effect of a changing population, we find that the most important driver of migration is population growth, while changes in decadal average climatic conditions alone are responsible for a small fraction of the projected migration flows.

The paper is organized as follows. Section 2 describes the data, while Section 3 illustrates the empirical approach. Section 4 provides the in-sample estimated parameters. Section 5 presents the migration projections. Section 6 provides discussion and concludes.

II. Data Description

A. Migration Data

The primary data source on migration is Abel (2018), where the author computes bilateral migration flows by comparing census-based stocks of foreign-born individuals in different countries of the world in different decades after accounting for demographic changes, like births and deaths. The author builds migration flows for almost all pairs of origin-destination countries from 1960 up to 2010. Input data for the period 1960 to 2000 on bilateral migration stock come from the Global Bilateral Migration Database (Ozden et al. 2011), for the subsequent decade from the (United Nations Population Division 2015a), while demographic information on the number of births, deaths, and population comes from the (United Nations Population Division 2015b). This demographic approach addresses the limitation of the original approach that computes flows by differencing two subsequent decades of stock data. Flows generated using the stock differencing approach display a low correlation with equivalent reported migration flows, while flows generated using the demographic accounting method display the highest correlation (Abel and Cohen 2019).

Finally, to generate emigration rates, we divide the bilateral flows by the population of the origin country, taken from the United Nations Population Division (2015b).

B. Climate Data

Historical climate data used in the analysis is from the NASA NOAH Global Land Data Assimilation System (GLDAS v2) Dataset (Rodell et al. 2004). The dataset provides reanalysis gridded data on temperature and precipitation at 1°×1° spatial- resolution and 3-hourly temporal intervals. Temperature and precipitation data at the grid cell levels are aggregated into country-year averages using 2000 population weights from the NASA's Socioeconomic Data Applications Center Gridded Population of the World (CIESIN 2018). The resulting country-level variables are then averaged over each decade.

As precipitation extremes, both floods and droughts, might have a substantial impact on migration, we compute measures of the deviation of the precipitation from the long-term average, considering both excess and scarcity, from GLDAS data. There is little consistency in how precipitation extremes are captured in studies of migration. For example, Gröschl and Steinwachs (2017) use the negative mean of the Standardized Precipitation Evapotranspiration Index-SPEI (Vicente-Serrano, Beguería, and López-Moreno 2010) in a gravity migration equation. Dallmann and Millock (2017) study interstate migration in India and compute indicators of moderate and severe droughts as well as moderate and severe excess precipitation using thresholds of the Standardized Precipitation Index-SPI (McKee, Doesken, and Kleist 1993). Both the SPI and the SPEI are indicators of deviations of average monthly rainfall conditions from their long-term average. While the SPI relies only on precipitation data, the SPEI considers both precipitation and potential evapotranspiration and thus reveals potential water deficits. Finally, Chen et al. (2017) and Mueller, Gray, and Kosec (2014) measure flood-like conditions looking at specific percentiles of the rainfall distribution.

In this paper, to control for drought conditions, we rely on the SPI rather than SPEI, because we need to build all climate data for the past and the future. Projections of potential evapotranspiration needed to calculate future values of the SPEI is not straightforward.[3] We use the 12-month SPI, an indicator of deviations of precipitation from its long-term distribution during the preceding 12 months. The long-term distribution is transformed. This is fit into a normal distribution, and the SPI values represent the number of standard deviations by which the observed 12-month cumulative precipitation deviates from the long-term mean. We calculate SPI values for all the grid cells of the GLDAS global domain. As the impact of droughts is assumed to affect migration via reduced agricultural productivity, we exclude grid cells without crops using land use data from the Global Agro-Ecological Zones database (FAO and IIASA 2022). To focus only on severe droughts, we count the number of months the SPI is below -1.5 in each grid cell with crops as in McGuirk and Burke (2020). Finally, we aggregate at country level using population weights and then calculate decadal country averages.

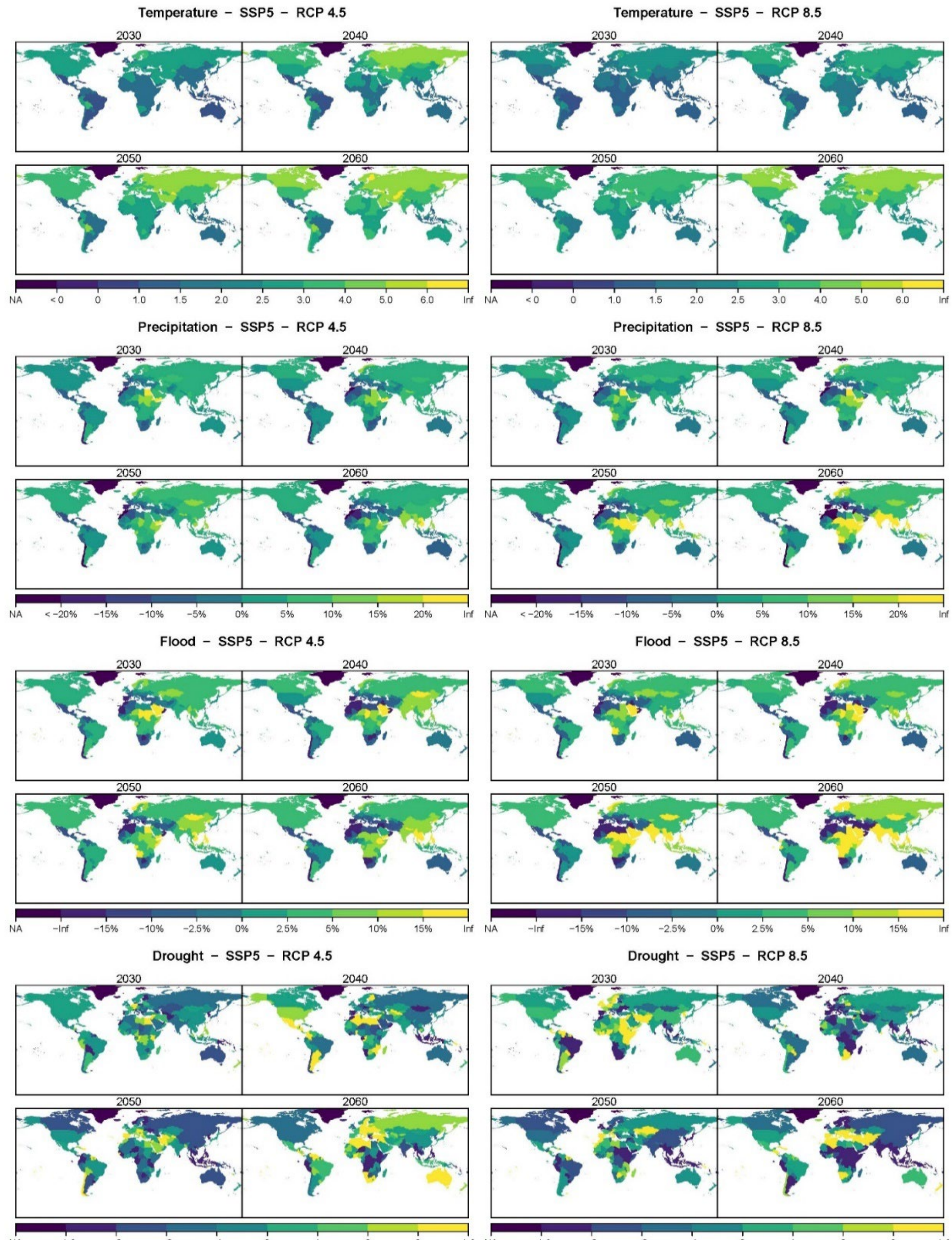
To control for heavy rainfall events potentially indicating flood-like conditions, we use the 90th percentile of the annual distribution of daily precipitation in each grid cell, similarly to Chen et al. (2017) and Mueller, Gray, and Kosec (2014). We use population weights to calculate yearly country averages and then calculate decadal country averages.

The same methods are used to calculate temperature, precipitation, SPI, and flood-like conditions from gridded scenarios of future climate generated by models used for the Coupled Model Intercomparison Project Phase 5 (CMIP5). In particular, we use the ensemble mean of temperature and precipitation for medium (RCP4.5) and extreme (RCP8.5) emission scenarios from 5 climate models derived from the NASA Earth Exchange Global Daily Downscaled and Bias Corrected Projections - NEX-GDDP (Thrasher et al. 2012).

Table A.1 in the Appendix presents measurement units and summary statistics of historical climate data. Figure 1 displays changes of climate variables with respect to the period 1960-2010 for different decades and different scenarios. Global warming is likely to affect unevenly all countries and regions, intensifying over time.

[3] It is necessary to use projections for many variables (such as minimum and maximum temperature, humidity, wind speed, down- and up-welling radiations, and pressure) in a model of evapotranspiration.

Figure 1. Change of Climate Variables with Respect to the Period 1960-2010



Note: Climate scenarios from five Global Circulation Models (GCM) of the NASA Earth Exchange Global Daily Downscaled and bias corrected Projections (NEX-GDDP), prepared for the Coupled Model Intercomparison Project Phase 5 (CMIP5). Temperature change is measured in ºC. Change in precipitations and in the occurrence of flood-like conditions in measured in percentage. Change of the drought indicator are measured in months during which the SPI has a value less than -1.5.

Temperature increase is not uniform across countries and is projected to be particularly more noticeable at the higher latitudes. Changes in global precipitation patterns are instead more varied, with some countries expected to be receiving more abundant rainfall and some likely to experience drier conditions. As the planet warms, the uneven distribution of precipitation patterns across countries is expected to become even more unbalanced. While precipitation patterns vary differently, extreme precipitation events are expected to increase in most countries. In several regions, the increase in total precipitation is associated with more frequent extreme precipitation events. Droughts, and generally drier conditions are expected to be experienced more frequently in some regions, notably around the Mediterranean and in the Middle East, but are declining in other parts of the world.

C. Population Scenarios

Population data from gridded population projections developed for the SSPs (O'Neill et al. 2017) is used both for weighting climate variables and for predicting migration flows. SSPs are the socio-economic counterparts of RCPs. While the emission scenarios in the RCP4.5 can be matched with the narratives of all the five SSPs, the extreme level of emissions in RCP8.5 is compatible only with the fast growth and intensive fossil fuels use assumed in SSP5. For this reason, we match RCP4.5 with SSP1 (sustainable development), SSP3 (fragmented world) and SSP5 (fossil-fueled development), while we match the SSP5 with only the RCP8.5, as in the most recent IPCC scenario design (see, for example IPCC 2022).

III. Empirical Approach

A. Specification

We specify a reduced form model for bilateral emigration rates using a gravity model as follows:

$$\frac{M_{ij,t}}{N_{ii,t}} = \exp\left(\alpha T_{i,t} + \beta P_{i,t} + \delta D_{i,t} + \theta F_{i,t} + o_i + d_{j,t} + \psi_{ij}\right) + \varepsilon_{ij,t} \qquad (1)$$

The dependent variable is the bilateral emigration rate, which is the emigration flow ($M_{ij,t}$) from country *i* to *j* in the decade beginning with year t (= 1960, 1970, 1980, 1990, 2000), divided by the population in the origin country *i* in the corresponding decade ($N_{ii,t}$). $T_{i,t}$ is the natural logarithm of the average temperature of the decade in the origin country *i*; $P_{i,t}$ is the natural logarithm of average precipitation; $D_{i,t}$ and $F_{i,t}$ are drought and flood, respectively, as described in Section 2.2.

We do not control for socio-economic controls that affect migration because they are themselves affected by climate, potentially introducing over-controlling bias (Dell, Jones, and Olken 2014). In this way, we capture the total effect of climate change on migration, regardless of the specific mechanism in place. Other papers follow the same approach in a unilateral context (Cattaneo and Peri 2016; Missirian and Schlenker 2017) and a bilateral context (Beine and Parsons 2017).

Empirical evidence shows that while climate at origin matters, climate conditions do not exert a relevant influence on the choice of destination. After the move, it could happen that migrants, in particular low-income and socially excluded, cluster in high-density areas that are themselves exposed to flooding and landslides (de Sherbinin et al. 2011; McMichael, Barnett, and McMichael 2012). Benveniste, Oppenheimer, and Fleurbaey

(2020) report that the choice to move to areas less exposed to climatic shocks than the origin areas is not intentional but depends on other destination characteristics that happen to be correlated with climate shocks. Therefore, our specification controls only for the origin countries' climate.

The specification includes source-country fixed effects (o_i), a set of destination-time fixed effects, ($d_{j,t}$) and a set of bilateral dummies (ψ_{ij}). The inclusion of a rich set of fixed effects is essential, given our choice to use a parsimonious specification. For example, destination–time fixed effects capture time-varying destination factors, such as immigration policies or the level of development. This term can also control the multilateral resistance to migration, representing the confounding influence that the attractiveness of alternative destinations could exert in the choice of the destination (Beine, Bertoli, and Fernández-Huertas Moraga 2016; Beine and Parsons 2015). Bilateral dummies absorb origin-destination time-invariant factors, such as geographical distance, linguistic and cultural proximity. Given this set of controls and fixed effects, identification comes from random variation in origin countries decadal averages of weather and migration from their long-term means.[4]

We estimate Equation (1) using Poisson-pseudo maximum likelihood. This method allows for zeroes in the dependent variable while also giving unbiased estimates should any of the covariates of Equation (1) be correlated with higher moments of the error term, which is often the case in log-linear models (Santos Silva and Tenreyro 2006). We cluster standard errors at the dyadic level (ij).

We use a sample with 100 origin and 166 destination countries (see Appendix B for the list of countries). As climate likely plays a minor role in explaining migration from richer countries (Cai et al. 2016), we follow (Cattaneo and Peri 2016) and exclude migration flows from OECD countries, with the exception of Mexico and Chile because of their important outmigration. In a robustness check, we also drop Mexico and Chile.

The analysis covers years from 1960 to 2010, grouped in decades indexed with their first year, from t = 1960 up to t = 2000. As described above, the input stock data to build the flows over this time period comes from two different datasets: the Global Bilateral Migration Database (Ozden et al. 2011) and the United Nations Population Division (2015a). The Global Bilateral Migration Database covers the longest period, but it ends in the decade starting in 1990. The United Nations Population Division dataset is used for the decade starting in 2000. Migration stocks in the Global Bilateral Migration Database were constructed to be homogeneous concerning essential issues such as the definition of migrants, any changes that occurred in the borders and identity of the countries, the aggregation of the origin countries recorded in censuses. In cases where census data were missing, different forms of imputation were used. This harmonization process makes the data consistent between 1960 and 2000, but it could make problematic the comparison between this and the other dataset, that starts in 2000. To test if differences in standardization rules affect our results, we include a robustness test using only the Global Bilateral Migration Database from 1960 to 2000.

Finally, as an additional robustness check, we employ a different approach to compute flows from stocks. While in the main estimation we use Abel's migration flows predicted using a demographic accounting method, in a

[4] The use of our rich set of fixed effects addresses the critics raised in Beyer, Schewe, and Lotze-Campen (2022) on the limitation of gravity model to predict migration dynamics. In principle, the larger order of magnitude of the spatial, compared to the temporal variation in the migration flows limit the ability of gravity models to capture temporal patterns. However, estimations that include origin, destination, and bilateral fixed effects, exploit within country-pair variation, and does not rely on across country variation in the data.

robustness check, flows are computed as a difference between two subsequent decades of the stock using the Global Bilateral Migration Database.

B. Simulations

We predict future emigration rates using parameters estimated with Equation (1) and climate variable computed using scenarios from General Circulation Models. We generate bootstrap confidence intervals using 1,000 repetitions. Finally, we transform future emigration rates ($\hat{y}_{ijT}$) into migration flows (M_{ijT}) by multiplying times population levels in each origin country from the SSP population scenarios ($N_{ii,T}$):

$$M_{ijT} = \hat{y}_{ijT} * N_{ii,T}.$$

We also project the impact of a globally uniform temperature increase equal +1°C, +2°C, and3°C, while all the other climatic indicators remain as observed in the past. This hypothetical uniform warming scenario allows us to isolate the effect of temperature change.

The use of bilateral as opposed to unilateral data allows us to predict the outflows of migrants and the corresponding inflows of migrants in the different destination countries. Therefore, we can predict specific patterns of migration induced by climate change, which has never been done before at such granularity.

IV. In-Sample Results

Table 1 presents the results for the gravity equation described in Equation (1). Column (1) reports results using our baseline specification, including our full dataset. Column (2) excludes average precipitation from the list of climatic controls, while Column (3) does not include controls for droughts and floods. Column (4) replaces origin-destination dummies with specific bilateral controls, such as bilateral distance, being contiguous countries, common colonial history and common language, and Column (5) excludes Chile and Mexico from the sample of origin countries, which then includes only non-OECD countries. Finally, Column (6) runs specification (1), but it excludes years after 2000 to check if changing the source of the stock migration data for years after 2000 affects our results. Across all six specifications, the estimated parameters for temperature are consistent in magnitude and significance. The point estimates indicate that if temperature increases by 1 percent, bilateral migration rates increase by 1.2 percent over a decade, except for specification (6), which indicates a slightly larger increase equal to 1.5 percent. Differences in the estimates of temperature effects are never statistically significant across the six specifications.

Average precipitation is not an important driver of migration. The coefficient in Column (1) is not statistically significant, and if we exclude precipitation from the regression, results remain unchanged (Column, 2). This finding confirms the evidence in the literature of a limited role of changes in precipitation levels in migration (Hoffmann et al., 2020).

The coefficients of droughts and floods are not statistically significant. However, when we use only data from the Global Bilateral Migration Database that ends in 2000 (Column, 6), the coefficients of deficit and excess of rain turn statistically significant. In this case, we find that an increase in drought and flood conditions significantly reduces migration rates. A one standard deviation increase in our average measure of drought, which corresponds to 0.3 months in which the SPI is below -1.5 (Table A.1) reduces emigration rates by 7.7

percent. If rain increases by one millimetre during the rainiest days of the year (approximately a 10 percent shock if compared to the sample mean) (Table A.1), emigration rates decrease by 18.7 percent. While empirical evidence on the effect of droughts is mixed (Cattaneo et al. 2019), there are studies that document negative effect of floods on migration rates. Chen et al. (2017) for example documents a significant negative relationship between migration and extreme flooding in Bangladesh. Similarly, Cattaneo and Massetti (2019) find that in Nigeria, in areas where precipitations are very high, additional precipitations reduce migration. In many cases, floods induce temporary migration over short distances (Cattaneo et al. 2019).

To sum-up, results indicate that temperature is the most robust factor that induces migration, which confirm the conclusion from a meta-analysis that temperature-level changes exert the strongest effects on migration (Hoffmann et al., 2020).

Table 1. Historical Estimations

	(1)	(2)	(3)	(4)	(5)	(6)
	up to 2010	**no P**	**only T P**	**no pair FE**	**No Mex/ CH**	**up to 2000**
ln(temperature)	1.168***	1.155***	1.226***	1.223***	1.176***	1.469***
	(0.283)	(0.278)	(0.307)	(0.330)	(0.286)	(0.318)
ln(precipitation)	0.332		0.139	0.512	0.348	0.457
	(0.574)		(0.374)	(0.646)	(0.577)	(0.728)
Drought	-0.080	-0.109		0.010	-0.082	-0.256**
	(0.110)	(0.091)		(0.116)	(0.111)	(0.129)
Flood	-0.082	-0.066		-0.036	-0.083	-0.187**
	(0.063)	(0.053)		(0.087)	(0.064)	(0.080)
Observations	74,437	74,437	74,437	74,437	72,860	59,307
Origin FE	yes	yes	yes	yes	yes	yes
Destination*decade FE	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	no	yes	yes

Notes: the dependent variable is the emigration rate from country, i to country j, in decade t. Column (4) includes pair time-invariant controls, such as ln(distance), a dummy for being contiguous, a dummy for a common language and a dummy for a common past colonial history. Origin countries included are non-OECD plus Chile and Mexico, except for Column (5), where Chile and Mexico are excluded. Method of estimation is PPML. Reference periods for the analysis: 1960-2010, except for Column (6), which ends in 2000. Standard errors, clustered at origin-destination levels, in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The t-test on the difference between the parameters estimated in Columns (1) and (6) is -0.71.

Table 2. Historical Estimations, Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
	PPML		**OLS**			
	cluster origin - 2010	**delta stock**	**up to 2010**	**up to 2000**	**squared**	**First-difference**
ln(temp)	1.168*	0.995	0.878***	1.304***	0.754***	2.185***
	(0.699)	(1.055)	(0.075)	(0.101)	(0.114)	-0.17
ln(temp)^2					-0.157	
					(0.112)	
ln(prec)	0.332	-1.951***	-0.804***	-0.650***	-0.806***	-0.459***
	(0.842)	(0.569)	(0.139)	(0.155)	(0.118)	-0.16
Drought	-0.080	-0.070	-0.095***	-0.252***	-0.094***	-0.336***
	(0.189)	(0.139)	(0.029)	(0.033)	(0.028)	-0.035
Flood	-0.082	0.257***	-0.029*	-0.220***	-0.029**	-0.236***
	(0.096)	(0.080)	(0.015)	(0.016)	(0.013)	-0.019
Observations	74,437	43,505	74,437	59,307	74,437	59,140
Origin FE	yes	yes	yes	yes	yes	yes
Dest*decade FE	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes

Notes: in Columns (1) and (2) the dependent variable is the emigration rate from country i to country j, in decade t and the method of estimation is the PPML; in Columns (3) to (5) is the natural logarithm of the emigration rate from country i to country j, in decade t; in Column (6) is the difference between the (natural log of) emigration rates in decade t and decade t-1. The method of estimation in columns (3) to (6) is OLS. In Column (2) the bilateral migration flows are computed as the differences between stocks in two consecutive Censuses. Reference period for the analysis: 1960-2010, except for Column (4), which ends in 2000. Standard errors, clustered at origin level in Column (1) and at origin-destination levels in Columns (2) to (6), in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2 presents additional robustness checks. Column (1) uses the same PPML model as in Column (1) of Table 1, but in this case, standard errors are clustered at the origin country level instead of at the destination country level. Column (2) computes emigration flows as a difference between stocks in two subsequent decades rather than using Abel's indirect estimation method. Columns (3) to (6) report OLS estimates using the natural logarithm of emigration rates as the dependent variable.[5] Column (3) mimics the specification presented in Column (1) of Table 1. Column (4) uses only data from 1960 to 2000. Given that agriculture productivity and temperature display a nonlinear relationship and that agriculture is possibly the main channel driving climate-induced migration, we may expect that the temperature–migration relationship is nonlinear. To test this non-linearity, the model used for Column (5) adds temperature and the squared deviation of temperature from the country mean.[6] Finally, Column (6) applies OLS to first differences of annual migration and weather variables.

We find that even if we cluster standard errors at the origin country level, the coefficients of warming remain statistically significant. Using a different approach to compute flows based on stock data does not alter the magnitude of the temperature coefficient, even if the coefficient turns not statistically significant (Column 2). OLS estimates produce a similar migration response to climatic shocks compared to our PPML baseline

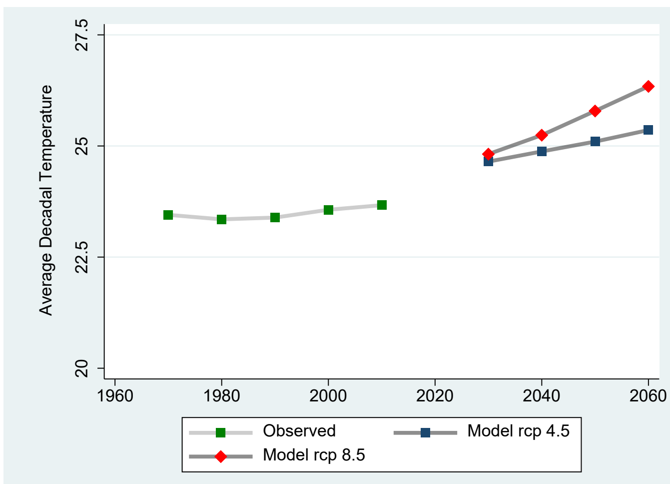
[5] To keep a comparable sample with the PPML estimates and deal with the issue of zero flows, we add one to all migration flows before calculating migration rates and apply the logarithm.

[6] As identification comes from deviations of variables from their country panel mean, we introduce the square of the deviation from the log temperature partialled out of fixed effects in the OLS regression.

estimates. In agreement with the PPML estimates, the OLS estimate of warming in the shorter panel (4) is slightly larger than the coefficient in the more extended panel (3). The results of Column (5) reject the nonlinear temperature effect on migration, a result in line with (Cattaneo and Peri 2016). Finally, if we run a first difference model, we still find that migration flows positively respond to warming while they shrink in response to floods and droughts.

To avoid over-controlling bias, our baseline specification is very parsimonious. However, some omitted variables may be correlated with temperature. In particular, the positive trend in warming (Figure 2) may be correlated with the positive trend in the number of college-educated workers (Burzynski, Deuster, and Docquier 2020). As the level of education has a direct effect on migration rates, the coefficient of temperature may be biased by the confounding effect of rising levels of education. To check the presence of bias in the temperature coefficient due to omitting education, we run Equation (1), adding control for the proportion of college graduates from Barro and Lee (2013). Results are not comparable because the sample of countries in this new specification is different from our baseline sample, due to many missing values in education. However, a test on the similarity of the coefficients of temperature when we omit or add education in this restricted sample cannot reject the hypothesis that the coefficients are equal (t-test= -0.149).

Figure 2. Comparison of Average Decadal Historical and Future Temperature



Notes: The figure shows the average historical temperature and projected temperature for the origin countries included in the sample. Projected temperatures are taken from 5 Global Circulation Models (GCM), of the NASA Earth Exchange Global Daily Downscaled and bias corrected Projections (NEX-GDDP), belonging to the Coupled Model Intercomparison Project Phase 5 (CMIP5). See Appendix B for the complete list of countries.

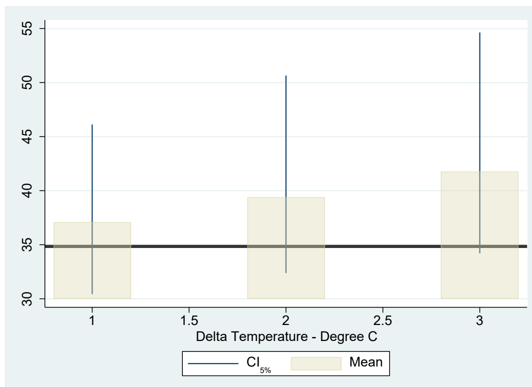
V. Projections

We use estimates of coefficients of climate variables from our preferred specification (Column (1) of Table 1) to project migration flows using first a simplified, globally uniform increase of mean annual temperature of +1° to +3°C and then by using internally consistent combinations of emission scenarios (RCP 4.5 and RCP 8.5) and socio-economic scenarios (SSP1, SSP4 and SPP5), as described in Section 3. This is a *ceteris paribus* exercise because we assume that all the other driving factors of migration remain unchanged. We start by looking at the total global flow of migrants, and we conclude by presenting results by country and bilateral flows among continents.

A. Uniform Warming Scenario

The uniform global warming scenario is a useful benchmark to focus on the effect of temperature change alone. From the positive and significant coefficient found with our baseline specification, we expect that warming increases total migration, keeping everything else unchanged. We indeed find that the total level of migration increases with warming when compared to the historical average (Figure 3). However, the impact of warming on migration is not large, and the projections are never significantly different from the average historical flow at the 95 percent level. By using full climate change and population scenarios, the next exercises provide a more realistic projection of migration flows, but the relative unimportance of climate change is confirmed.

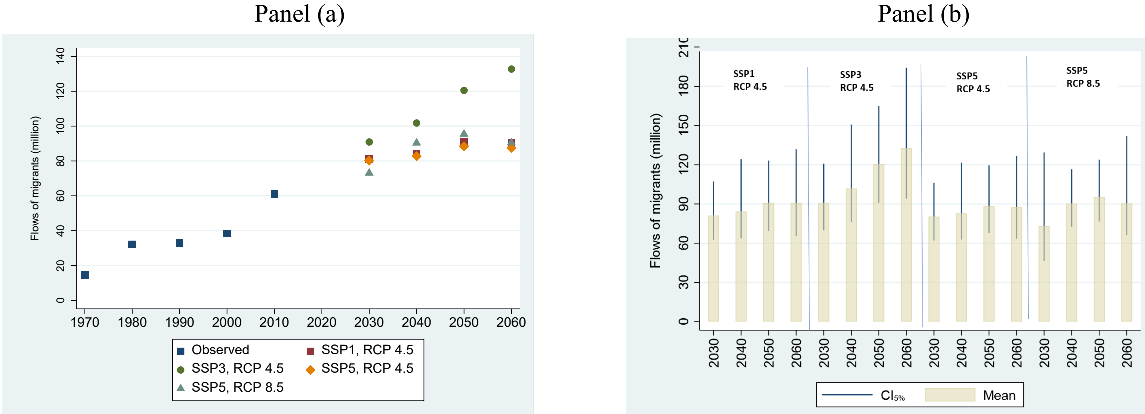
Figure 3. Global Decadal Outflows of Climate Migrants (Uniform Scenario)



Notes: The bars show the predicted flows under +1°, +2°, and +3°C warming, whereas the blue vertical lines illustrate the 95 percent confidence intervals generated from 1000 samples drawn from the joint distribution of the model parameters. The horizontal reference line indicates the observed historical average flows.

Figure 4. Predicted Global Decadal Outflows of Climate Migrants. Historical Comparison

Panel (a) Panel (b)



Notes: we use the parameter estimates from Column (1) of Table 1 to generate projections of migration flows due to climate and population change. Panel (a): blue square dots show the observed historical flows. Panel (b): the bars show predicted flows, whereas the lines illustrate 95 percent bootstrap confidence intervals.

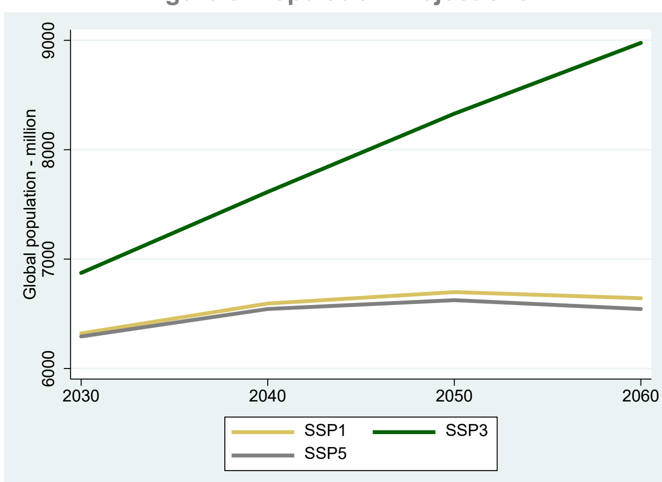
B. Climate and Population Scenarios

Panel (a) of Figure 4 displays the predicted future flows of migrants until 2060 together with the observed decadal flows from 1970 to 2010. Panel (b) presents the same estimates, by scenario and year, with 95 percent bootstrap confidence intervals.

The total number of international migrants for the pairs of 100 origins and 166 destinations covered by our study increases in all scenarios along a trajectory that is not too dissimilar from the historical trend. Total decadal flows increase from 60 million in 2010 to between 73 and 91 million in 2030, to between 83 and 102 million in 2040, and to between 88 and 121 million in 2050.

The increase in migration and the range of these estimates is in large part explained by growing population and by differences in population scenarios. Changes in the climatic variables included in our study play a minor role. This is immediately revealed by comparing migration flows between the SSP5-8.5 and SSP5-4.5 scenarios. Despite having two different levels of warming (Figures 1 and 2), as they share the same population scenario, they have very similar migration flows. SSP3-4.5, the high-population growth scenario (Figure 5), has the largest migration flows, while SSP1-4.5 and SSP5-4.5, with identical climate but lower population growth, are at the bottom of the range.

Figure 5. Population Projections



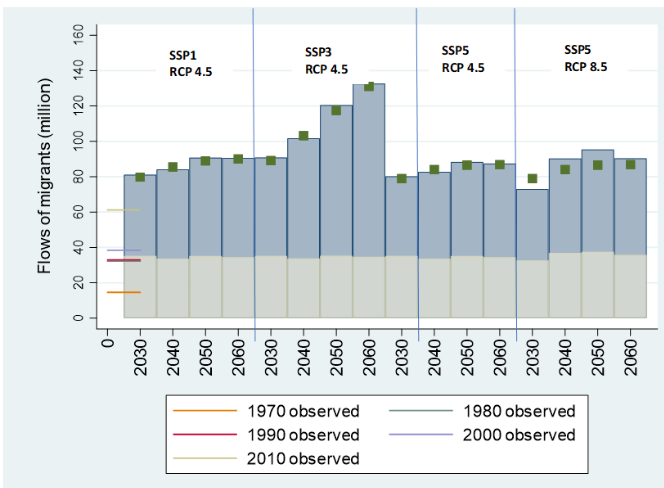
Notes: The numbers are computed by aggregating the population projections of the origin countries included in the sample. See Appendix B for the complete list of countries.

We gain a more accurate assessment of the relative importance of population and climate scenarios by decomposing the effect of changes in the climate variables from the effect of a changing population on future migration flows. First, we predict emigration rates using climate change scenarios, but we use the historical population in the origin country. Second, we predict emigration rates using the historical average climate over the panel decades, but we allow the population to grow. The results of these two exercises are displayed in Figure 6. We find that the effect of future climate is essentially like the effect of historical climate. The number of climate migrants when the population is constant is shown using light grey bars and is approximately equal to the average number of migrants from 1970 to 2010 (coloured lines). There is virtually no difference across climate scenarios and across decades. In most cases, climate change increases the outflows of migrants by much less than 5 million per year. This estimate is in line with the most recent empirical work in the literature.

Burzyński et al. (2022) find that the additional number of climate migrants from 2010 to 2070 ranges from 37 to 94 million, or 0.6 to 1.6 additional migrants per year, depending on the emission scenario. These estimates include the impact of sea-level rise that we do not include. A recent study by the World Bank estimates 7 million internal climate migrant per year from 2020 to 2050 (Clement et al., 2021). As internal migration, for example to urban areas, is less costly than international migration, it is reasonable to expect that international climate migrants will be less numerous than internal climate migrants.

On the contrary, population growth explains the increase in migration over time and across scenarios. The number of migrants when the population grows, and the climate stays constant is displayed by the green square dots. The predicted flows match the projections displayed in Figure 4, panel (b), which is also reproduced in Figure 6 by the blue bars, which are generated by combing the future climate models and the future population projections. The strong influence of population growth on migration is in line with Dao et al. (2021), which report that future trends in international migration are mainly driven by changes in country population size and in educational attainment.

Figure 6. Global Decadal Outflows of Climate Migrants. Decomposition for Climate and Population



Notes: the height of the blue bars displays the projections of migration flows due to climate and population changes; the height of the grey bars displays the projections of migration flows due to only climate change; the green square dots indicate the projections of migration flows due to only population changes. Horizontal lines indicate the observed historical flows for ‘70, ‘80, ‘90, ‘00 and ‘10.

C. Regional Outlook

Total migration flows displayed in Figures 4 and 6 are obtained by summing projected flows from the sample of countries with outmigration. The rich bilateral nature of the data allows us to dive deep into the results and disaggregate the projected flows by specific origin countries and by pairs of origins and destinations. This is an important contribution of the paper to the literature. By predicting both inflows and outflows, we provide useful information to assess the exposure of both origin and destination areas.

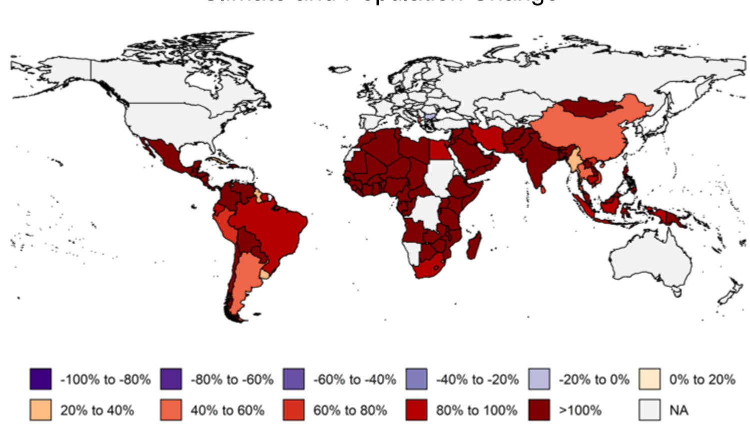
One way to look at our results is to focus on emigration flows by specific origin countries. Figure 7 displays the changes in migration projections in 2030 compared to the observed flows in 2010, for the SSP3-4.5 scenario. If we let both climate and population change (top panel), the projected climate-induced migration flows will double in nearly half of the countries of origin. This will happen primarily in African countries and, to a smaller extent, in

Asian countries. If we keep the population at the 2010 level and we let only climate change (bottom panel), the percentage change in migration is much smaller, as expected from the global analysis, but there are interesting geographic patterns. In particular, the intensification of drought and flood episodes reduce migration in all countries that see an intensification of these events, as indicated by the negative coefficients of these variables in the estimation.

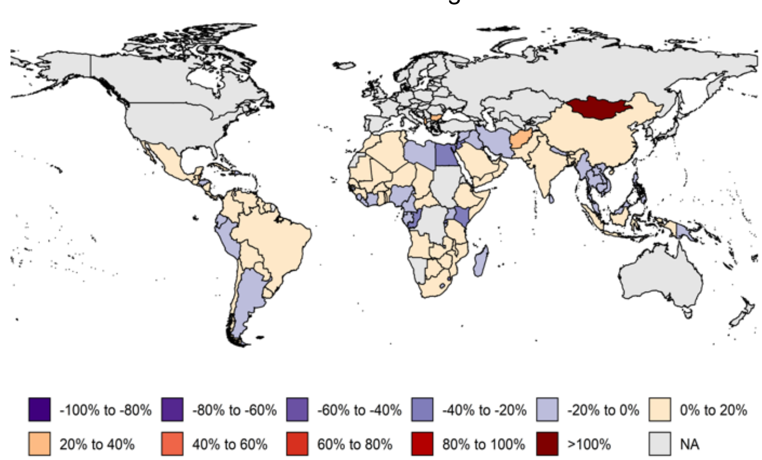
Another way to present the result is by showing bilateral projections. Figure 8 displays the projected bilateral flows within and between continents in 2030, if both climate and population change as in the SSP3-4.5 scenario. We find that the migration flow from Africa towards all other destination continents increases. The projected flows from Africa to Europe would double from 3.4 million, its current level, to 7 million in 2030. Migration flows between Asian countries would increase by nearly fifty percent. Conversely, the flow from Asia to Europe shrinks from 5.7 million in 2010 to 4.3 million in 2030. Similarly, flows from Latina America directed to Europe would drop from 3.4 million to 2.1 million. The flow of migrants from Latin America to North America increases instead by approximately 50 percent.

Figure 7. Percentage Change in Outflows Compared to Historical Outflows - Year 2030

Climate and Population Change

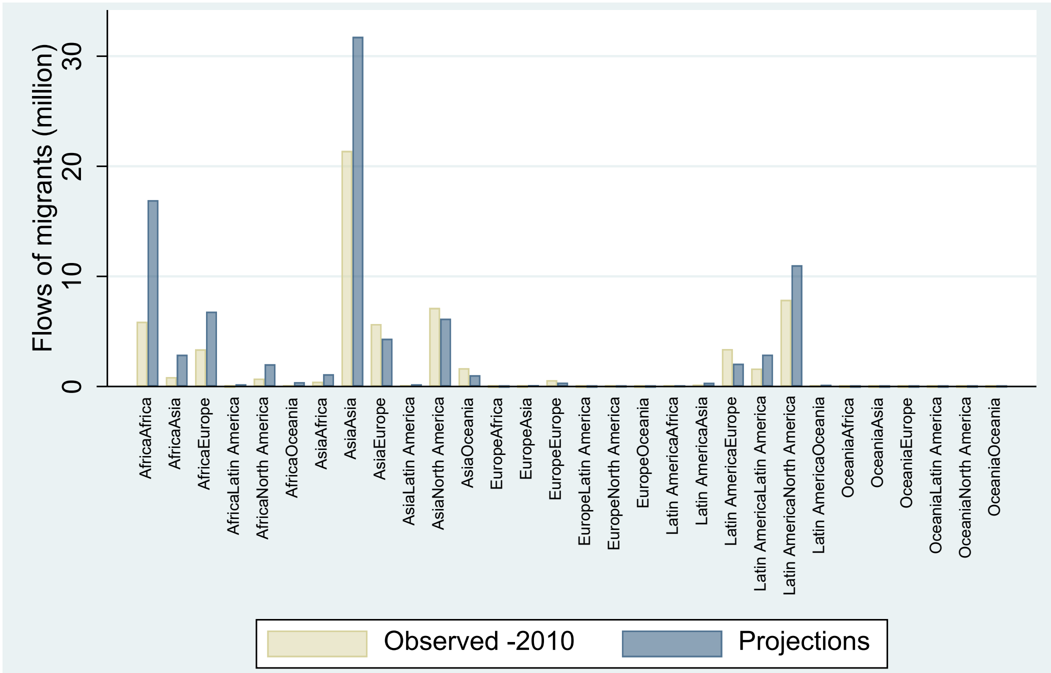


Climate Change



Notes: projections of changes in migration outflows due to climate and population change (top panel) and only climate change (bottom panel). Scenarios under SSP3 and RCP 4.5.

Figure 8. Bilateral Flows by Continent. SSP3, RCP 4.5 - Year 2030



Notes: Blue bars display the projections of migration flows due to climate and population changes; light grey bars display historical flows.

VI. Discussion and Conclusion

The exercise we run is informative, but it should be interpreted with caution. First, we are assuming that only climate and population change, while future migration will also be affected by socio-economic developments in both origin and destination countries, technology, and policy. Second, the further we go into the future (2060) and the more pessimistic the climate scenario (RCP 8.5), the larger the long-term difference of climate variables with respect to their historical level compared to the observed variance over the estimation period. In other words, for scenarios of very high warming in the far future, we push our model considerably out-of-sample. It is not easy to predict the direction of the bias. Historical temperature change is often small and may not capture disruptive or highly nonlinear responses that may occur with much larger temperature changes. If this is the case, we underestimate the responsiveness of migration to future climate. Alternatively, the projections might have a positive bias if, for example, a permanent warming scenario will induce countries to engage in forms of adaptation, which our model does not capture well.

Migration can be an important adaptation to climate change because it allows to re-allocate labour to more productive areas and to minimize health damages and loss of life. Receiving countries may benefit from positive impacts to long-term growth and offset low or negative population dynamics. Origin countries may benefit from reducing climate change pressures, but economic activity may further drop and cause downward spirals. Societal implications for both destination and origin countries are unpredictable but could be significant. The emotional cost of abandoning native countries and migration risks could also be very large.

Our results suggest that these concerns may be motivated because migration flows in future decades will increase, but the role of global warming and intensification of some extreme events appears to be marginal.

The main driver of long-term migration pattern is population growth in our results. Economic and societal factors are likely to play a more important role than climate change, but we have not studied them.

If our model is correct, there is no evidence that high-income countries will face large waves of climate migrants in the coming decades. They may face growing migration flows, but not primarily due to climate factors. Our results suggest that climate-induced migration may not be a security threat for destination countries. The majority of climate-related migration is likely to happen within countries, probably because populations affected by natural disasters tend to move only temporarily, or due to restrictions to cross-border migration (Cattaneo et al. 2019).

Restrictive border policies, by limiting the possibility of leaving areas more exposed to climate change, do not contribute to reduce vulnerability to climate change impacts (Benveniste, Oppenheimer, and Fleurbaey 2020). Policies to facilitate temporary migration in the case of extreme events would be beneficial. If destination countries are concerned about increasing migration flows, they can implement policies that lead to slower population growth and higher economic development in origin countries. For example, investing in women's empowerment can boost economic development and result in slower population growth.

Annex I. Additional Tables

Table AI.1. Summary Statistics

Variable	Obs.	Mean	Sd	Min	Max
Emigration Rate (*1000) – bilateral	74,437	0.257	3.171	0	215.845
Emigration Flows – bilateral	74,437	2,408	40,200	0	5,077,120
Temperature (Degree C) – unilateral	74,437	23.484	5.053	0.082	32.347
Precipitation (annual mm) - unilateral	74,437	1185	743	28	3377
Droughts (weighted number of months) - unilateral	74,437	0.225	0.274	0	1.000
Flood (mm per day) - unilateral	74,437	9.113	6.555	0	27.011

Origin Countries

ISO3	Name	Continent	ISO3	Name	Continent
AFG	Afghanistan	Asia	LBN	Lebanon	Asia
AGO	Angola	Africa	LBR	Liberia	Africa
ALB	Albania	Europe	LBY	Libya	Africa
ARE	United Arab Emirates	Asia	LKA	Sri Lanka	Asia
ARG	Argentina	Latin America	LSO	Lesotho	Africa
BDI	Burundi	Africa	MAR	Morocco	Africa
BEN	Benin	Africa	MDG	Madagascar	Africa
BFA	Burkina Faso	Africa	MEX	Mexico	Latin America
BGD	Bangladesh	Asia	MLI	Mali	Africa
BGR	Bulgaria	Europe	MMR	Myanmar	Asia
BLZ	Belize	Latin America	MNG	Mongolia	Asia
BOL	Bolivia	Latin America	MOZ	Mozambique	Africa
BRA	Brazil	Latin America	MRT	Mauritania	Africa
BRN	Brunei	Asia	MWI	Malawi	Africa
BTN	Bhutan	Asia	MYS	Malaysia	Asia
BWA	Botswana	Africa	NER	Niger	Africa
CAF	Central African Republic	Africa	NGA	Nigeria	Africa
CHL	Chile	Latin America	NIC	Nicaragua	Latin America
CHN	China	Asia	NPL	Nepal	Asia
CIV	Cote d'Ivoire	Africa	OMN	Oman	Asia
CMR	Cameroon	Africa	PAK	Pakistan	Asia
COG	Congo, Rep.	Africa	PAN	Panama	Latin America
COL	Colombia	Latin America	PER	Peru	Latin America
CRI	Costa Rica	Latin America	PHL	Philippines	Asia
CUB	Cuba	Latin America	PNG	Papua New Guinea	Oceania
DJI	Djibouti	Africa	PRY	Paraguay	Latin America
DOM	Dominican Republic	Latin America	PSE	West Bank and Gaza	Asia
DZA	Algeria	Africa	RWA	Rwanda	Africa
ECU	Ecuador	Latin America	SAU	Saudi Arabia	Asia
EGY	Egypt, Arab Rep.	Africa	SEN	Senegal	Africa
ETH	Ethiopia (excludes Eritrea)	Africa	SLE	Sierra Leone	Africa
GAB	Gabon	Africa	SLV	El Salvador	Latin America
GHA	Ghana	Africa	SOM	Somalia	Africa
GIN	Guinea	Africa	SUR	Suriname	Latin America
GMB	Gambia, The	Africa	SWZ	Swaziland	Africa
GNB	Guinea-Bissau	Africa	SYR	Syrian Arab Republic	Asia
GNQ	Equatorial Guinea	Africa	TCD	Chad	Africa
GTM	Guatemala	Latin America	TGO	Togo	Africa
GUY	Guyana	Latin America	THA	Thailand	Asia
HND	Honduras	Latin America	TUN	Tunisia	Africa
HTI	Haiti	Latin America	TZA	Tanzania	Africa
IDN	Indonesia	Asia	UGA	Uganda	Africa

ISO3	Name	Continent	ISO3	Name	Continent
IND	India	Asia	URY	Uruguay	Latin America
IRN	Iran, Islamic Rep.	Asia	VEN	Venezuela	Latin America
IRQ	Iraq	Asia	VNM	Vietnam	Asia
JOR	Jordan	Asia	YEM	Yemen, Rep.	Asia
KEN	Kenya	Africa	ZAF	South Africa	Africa
KHM	Cambodia	Asia	ZAR	Congo, Dem. Rep.	Africa
KWT	Kuwait	Asia	ZMB	Zambia	Africa
LAO	Lao PDR	Asia	ZWE	Zimbabwe	Africa

Destination Countries

ISO3	Name	Continent	ISO3	Name	Continent
ABW	Aruba	Latin America	LAO	Lao PDR	Asia
AFG	Afghanistan	Asia	LBN	Lebanon	Asia
AGO	Angola	Africa	LBR	Liberia	Africa
ALB	Albania	Europe	LBY	Libya	Africa
ARE	United Arab Emirates	Asia	LCA	St. Lucia	Latin America
ARG	Argentina	Latin America	LKA	Sri Lanka	Asia
ATG	Antigua and Barbuda	Latin America	LSO	Lesotho	Africa
AUS	Australia	Oceania	LUX	Luxembourg	Europe
AUT	Austria	Europe	MAC	Macao	Asia
BDI	Burundi	Africa	MAR	Morocco	Africa
BEN	Benin	Africa	MDG	Madagascar	Africa
BFA	Burkina Faso	Africa	MDV	Maldives	Asia
BGD	Bangladesh	Asia	MEX	Mexico	Latin America
BGR	Bulgaria	Europe	MLI	Mali	Africa
BHR	Bahrain	Asia	MLT	Malta	Europe
BHS	Bahamas, The	Latin America	MMR	Myanmar	Asia
BLZ	Belize	Latin America	MNG	Mongolia	Asia
BOL	Bolivia	Latin America	MOZ	Mozambique	Africa
BRA	Brazil	Latin America	MRT	Mauritania	Africa
BRB	Barbados	Latin America	MTQ	Martinique	Latin America
BRN	Brunei	Asia	MUS	Mauritius	Africa
BTN	Bhutan	Asia	MWI	Malawi	Africa
BWA	Botswana	Africa	MYS	Malaysia	Asia
CAF	Central African Republic	Africa	NCL	New Caledonia	Oceania
CAN	Canada	North America	NER	Niger	Africa
CHE	Switzerland	Europe	NGA	Nigeria	Africa
CHL	Chile	Latin America	NIC	Nicaragua	Latin America
CHN	China	Asia	NLD	Netherlands	Europe
CIV	Cote d'Ivoire	Africa	NOR	Norway	Europe
CMR	Cameroon	Africa	NPL	Nepal	Asia
COG	Congo, Rep.	Africa	NZL	New Zealand	Oceania
COL	Colombia	Latin America	OMN	Oman	Asia
COM	Comoros	Africa	PAK	Pakistan	Asia
CPV	Cape Verde	Africa	PAN	Panama	Latin America
CRI	Costa Rica	Latin America	PER	Peru	Latin America
CUB	Cuba	Latin America	PHL	Philippines	Asia
CYP	Cyprus	Europe	PNG	Papua New Guinea	Oceania
DEU	Germany	Europe	POL	Poland	Europe
DJI	Djibouti	Africa	PRI	Puerto Rico	Latin America
DNK	Denmark	Europe	PRK	Korea, Dem. Rep.	Asia
DOM	Dominican Republic	Latin America	PRT	Portugal	Europe
DZA	Algeria	Africa	PRY	Paraguay	Latin America

ISO3	Name	Continent	ISO3	Name	Continent
ECU	Ecuador	Latin America	PYF	French Polynesia	Oceania
EGY	Egypt, Arab Rep.	Africa	QAT	Qatar	Asia
ESP	Spain	Europe	REU	Reunion	Africa
ETH	Ethiopia (excludes Eritrea)	Africa	ROM	Romania	Europe
FIN	Finland	Europe	RWA	Rwanda	Africa
FJI	Fiji	Oceania	SAU	Saudi Arabia	Asia
FRA	France	Europe	SEN	Senegal	Africa
FSM	Micronesia, Fed. Sts.	Oceania	SGP	Singapore	Asia
GAB	Gabon	Africa	SLB	Solomon Islands	Oceania
GBR	United Kingdom	Europe	SLE	Sierra Leone	Africa
GHA	Ghana	Africa	SLV	El Salvador	Latin America
GIN	Guinea	Africa	SOM	Somalia	Africa
GLP	Guadeloupe	Latin America	STP	Sao Tome and Principe	Africa
GMB	Gambia, The	Africa	SUR	Suriname	Latin America
GNB	Guinea-Bissau	Africa	SWE	Sweden	Europe
GNQ	Equatorial Guinea	Africa	SWZ	Swaziland	Africa
GRC	Greece	Europe	SYC	Seychelles	Africa
GRD	Grenada	Latin America	SYR	Syrian Arab Republic	Asia
GTM	Guatemala	Latin America	TCD	Chad	Africa
GUF	French Guiana	Latin America	TGO	Togo	Africa
GUY	Guyana	Latin America	THA	Thailand	Asia
HKG	Hong Kong, China	Asia	TMP	East Timor	Oceania
HND	Honduras	Latin America	TON	Tonga	Oceania
HTI	Haiti	Latin America	TTO	Trinidad and Tobago	Latin America
HUN	Hungary	Europe	TUN	Tunisia	Africa
IDN	Indonesia	Asia	TUR	Turkey	Asia
IND	India	Asia	TZA	Tanzania	Africa
IRL	Ireland	Europe	UGA	Uganda	Africa
IRN	Iran, Islamic Rep.	Asia	URY	Uruguay	Latin America
IRQ	Iraq	Asia	USA	United States	North America
ISL	Iceland	Europe	VCT	St. Vincent and the Grenadines	Latin America
ISR	Israel	Asia	VEN	Venezuela	Latin America
ITA	Italy	Europe	VNM	Vietnam	Asia
JAM	Jamaica	Latin America	VUT	Vanuatu	Oceania
JOR	Jordan	Asia	WSM	Samoa	Oceania
JPN	Japan	Asia	YEM	Yemen, Rep.	Asia
KEN	Kenya	Africa	ZAF	South Africa	Africa
KHM	Cambodia	Asia	ZAR	Congo, Dem. Rep.	Africa
KIR	Kiribati	Oceania	ZMB	Zambia	Africa
KOR	Korea, Rep.	Asia	ZWE	Zimbabwe	Africa
KWT	Kuwait	Asia			

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PUBLICATIONS

Climate Variability and Worldwide Migration: Empirical Evidence and Projections.

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