Exploring the Long-Term Nexus of Climate Change, Extreme Hydrological Events, and Migration Patterns

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1. Motivation and objective

In the two decades from 2000 to 2019, the Emergency Events Database (EM-DAT) cataloged 7,348 disaster events worldwide. These calamities resulted in the loss of approximately 1.2 million lives and impacted over 4.03 billion individuals. On average, 367 disaster events occurred annually, with a significant portion being extreme hydrological events, including floods and storms. Asian countries experienced the highest frequency of these events, with China reporting the greatest number of incidents. The intensification of extreme weather events and worsening environmental conditions due to global warming are exacerbating poverty levels and increasingly driving forced migration. According to a report by the United Nations, weather-related disasters, though typically temporary, have become a significant cause of global displacements, with around 21 million people displaced annually since 2008. Previous literature indicates a complex interplay between extreme hydrological events and socio-economic dynamics. Research highlights that drought-induced decreases in local water mass and an intensifying water cycle significantly elevate the likelihood of social conflict in affected regions. Agricultural water scarcity, particularly in rain-fed areas, has detrimental spatial spillover effects on economic activities, extending up to 300 kilometers. On the other hand, displacement due to floods can be temporary or permanent, depending on the situation of the communities before, during, and after the disaster. Thus, studying how long-term migration decisions are affected by extreme hydrological events in the developing world offers insights into the human costs of these disasters and adaptation measures, such as relocation, both voluntary and mandatory. The goal of our empirical estimation is to capture the causal effect of extreme hydrological events on migration patterns over 10-year periods, by utilizing the Palmer Drought Severity Index (PDSI) data and a comprehensive national population census in China. We further investigate the long-term nexus under climate change by incorporating further PDSI variations under climate change scenarios.

2. Data and estimation strategy

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For our study, we use county-aggregated data from the National Bureau of Statistics (NBS) of China for the years 2000, 2010, and 2020. In China, migrants are categorized into two types: those who move to a new county without obtaining local household registration (floating migrants) and those who move and obtain local household registration (registered migrants). We use population, birth, and death counts from the population census to calculate two migration measures: net out-migration flows of all types of migrants and immigration flows of floating migrants. Additionally, we collect Palmer Drought Severity Index (PDSI) data from TerraClimate for the years 2000 to 2020, as well as other annual weather data from the China Meteorological Administration. Our approach involves examining the occurrence of extreme hydrological events over two 10-year periods, 2000-2010 and 2010-2020, to identify the causal effects of hydrological disasters. The main challenge of this study is that extreme hydrological events, such as water scarcity, are often closely linked with economic activity. Regions with high economic level, which attract immigrants with more job opportunities, are also likely to experience high levels of water scarcity. Additionally, urbanization alters land use conditions over the long term, leading to increased migration and greater vulnerability to storms. To address these challenges, we employ a long-difference approach and instrumental variable (IV) estimation in our analysis. Following previous study, we use the interaction of the number of precipitation extremes per year with yearly municipal average temperature changes, as well as river density as the instrument variables. We estimate the following 2SLS model: $M_{it} = \beta EH_{it} + \delta W_{it} + \theta X_{it} + \eta_i + \lambda_t + \varepsilon_{it}$ (1), $EH_{it} = \beta I_{it} + \delta W_{it} + \theta X_{it} + \eta_i + \lambda_t + \mu_{it}$ (2), where M_{it} denotes two measures of migration in county i and period t: the net-out-migration ratio, which is the fraction of people leaving a county minus new arrivals and deaths, and destination-based immigration ratio, which is the fraction of people entering a county but with their residence registration in the origin during the two 10-year periods. EH_{it} measures the occurrence of extreme hydrological events in county i during period t. W_{it} is the index of weather controls, including the long-differences of temperature, precipitation, wind speed, sunshine duration, and humidity. X_{it} is a county control variable. The county fixed effect η_i controls for unobservable time-invariant county characteristics. λ_t is a year effect common to all counties in period t, which controls for national mobility policy over time. ε_{it} denotes the error term. Equation (2) illustrates the first stage of our empirical strategy. Additionally, we employ a spatial analysis approach to examine location preferences related to migration due to extreme hydrological events. Finally, simulation models are utilized to evaluate potential migration patterns under climate change scenarios.

3. Expected results

We expect that extreme hydrological events significantly influence internal migration in China. The persistent occurrence of such events over the long term is expected to reduce the population in affected counties. Additionally, we assume that the magnitude of these migration flows varies across different types of migration and demographic compositions. Furthermore, we expect that extreme hydrological events are more likely to increase the net population of neighboring counties that experience fewer such events.