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## Climate variability and international migration: The importance of the agricultural linkage

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### ABSTRACT

While there is considerable interest in understanding the climate–migration relationship, particularly in the context of concerns about global climatic change, little is known about its underlying mechanisms. In the paper, we combine a rich panel data on annual bilateral international migration flows with an extensive data on climate variability across the countries to investigate in-depth the climate–migration link. We find a positive and statistically significant relationship between temperature and international outmigration only in the most agriculture-dependent countries, consistent with the widely documented adverse impact of temperature on agricultural productivity. Further, the temperature–migration relationship is nonlinear and resembles the nonlinear temperature–yield relationship. In addition, migration flows to current major destinations are especially temperature-sensitive. Policies to address issues related to climate-induced international migration would be more efficient if focused on the agriculture-dependent countries and especially people in those countries whose livelihoods depend on agriculture.

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### Introduction

Climate change has become an increasing global concern as its current and future impacts are understood in greater detail (IPCC, 2014). One widely cited response to such impacts is the potential for large-scale displacement of segments of human population (Myers, 2002; Stern, 2007; Warner et al., 2009; Marchiori et al., 2012). Among all climate-induced migrants, those crossing the political borders would be a matter of particular concern as both receiving and sending countries are affected. Identification of the mechanisms underlying the climate–migration relationship would be useful to national governments and international agencies devising policies to manage migration flows.

Despite growing interest from policymakers and the general public, the quantitative literature on weather- and climate-induced migration is still in its infancy. The empirical results so far are mixed. While many studies support a significant relationship between migration and climatic factors such as natural disasters, temperature, and precipitation (Reuveny and

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Moore, 2009; Feng et al., 2010; Feng and Oppenheimer, 2012; Marchiori et al., 2012; Gray and Mueller, 2012; Feng et al., 2012; Bohra-Mishra et al., 2014), some researchers find climate to be an inconsequential factor compared to other drivers of migration (Mortreux and Barnett, 2009; Naudé, 2010). The apparent inconsistencies among the outcomes of various studies arise partly because such studies are mostly context-specific. They differ in the geographic regions covered and the time frames of study. The effects of climate on human migration are likely to be heterogeneous across time and space, as climate may interact with region-specific factors, such as other environmental and socio-economic conditions, cultural and lifestyle characteristics, and social networks (Black et al., 2011).

To move this literature forward and gain a more complete picture of the climate–migration relationship, one can either continue to accumulate such context-specific evidence or conduct the analysis at a more aggregate level and focus on the most important linkage(s). This paper takes the second approach, and considers agriculture to be a possible intermediate link between climate and (international) migration. We do so for the following reasons. First, a large body of literature has already established a significant sensitivity of crop yields to climatic changes, especially temperature increases (Lobell et al., 2008, 2011; Schlenker and Roberts, 2009). In particular, recent studies such as Schlenker and Roberts (2009) find extreme heat to be particularly harmful for crop yields. Second, agriculture is an important economic sector in many countries, especially in the developing world, where a large proportion of the population still directly depends on agriculture for a living. Thus it is a plausible hypothesis that agriculture plays an important role in the climate–migration relationship.

In this paper, we use a comprehensive bilateral annual migration dataset covering 163 origin countries and 42 destination countries over the period of 1980–2010 to study the climate–migration relationship empirically. We first estimate a reduced-form model that links origin country weather variations to its international outmigration, while controlling for an important migration determinant – income (approximated by GDP per capita) – as well as unobserved time-invariant country-pair factors and country-specific time trends. To investigate the role of agriculture, interaction terms between weather and agricultural dependence are included in the model.<sup>1</sup> We find that the effect of temperature on outmigration is positive and statistically significant only for the agriculture-dependent countries.

We then provide some additional pieces of supplementary evidence to show the role played by agriculture in the observed weather–migration relationship. First, we show that the temperature effects on migration are nonlinear and match up with the nonlinear yield–temperature relationship documented in the literature. Extreme heat is correlated both with lower crop yields and higher outmigration flows. Second, as agricultural countries are usually also low-latitude hot countries and tend to be poor, we interact temperature with latitude and GDP, respectively, to rule out the possible “hot” effect and “poor” effect. Lastly, we show that the GDP of agricultural countries are more negatively affected by higher temperature than non-agricultural countries and in a nonlinear fashion, which also provides indirect evidence on the importance of the role of the agricultural channel.

Although it is impossible to completely dismiss the possible roles played by many other factors, such as health shocks (Deschenes and Moretti, 2009), violence and conflict (Jacob et al., 2007; Hsiang et al., 2011), and institutions (Dell et al., 2012), our results do suggest that, globally, agriculture is an important intermediate link between climate/weather and international migration. It should be noted that this paper focuses on the sensitivity of international migration to annual variations in temperature. The relationship between future climate/weather variability and migration may change due to shifts in the demographic, economic, and social context as well as many uncertainties. Nevertheless, we believe historical evidence provides insights on possible future climate-driven migration and informs current policy discussions.

The rest of the paper proceeds as follows. The next section reviews the existing literature on climate-induced migration. We then introduce the data and present our empirical strategy, followed by the empirical results. The final section concludes with a brief policy discussions. Details about the data sources are included in the appendix.

## Literature review

There is a large literature on the determinants of human migration that encompasses several disciplines. Income maximization is usually considered to be one of the most important migration determinants (Roy, 1951; Borjas, 1989; Clark et al., 2007; Mayda, 2010). Simply put, a potential migrant is assumed to compare the income difference between origin and several destinations and the cost of migration, and select a destination which maximizes income. The income maximization framework can be extended to utility maximization in order to incorporate non-pecuniary determinants of migration (Borjas, 1989), such as cultural and linguistic distance, political pressures, conflicts and wars, networks of family and friends, educational and social benefits, immigration policies, subjective well-beings, and amenities (Massey et al., 1993; Borjas, 1999; Clark et al., 2007; Pedersen et al., 2008; Mayda, 2010; Ortega and Peri, 2013; Cai et al., 2014; Adsera and Pytlikova, 2015.).

During recent decades, the migration literature has paid more and more attention to climatic and environmental factors, such as sea level rise, environmental degradation, weather-related crop failures, and extreme weather events (Hugo, 1996; Myers, 2002; Warner et al., 2009; Piguet et al., 2011; Foresight, 2011; Gray and Mueller, 2012). Many studies found a

<sup>1</sup> Agricultural dependence is a dummy variable, where the top 25% agriculture-dependent countries (in terms of the share of agricultural value-added in GDP) are assigned with a value of 1, and the remaining countries are assigned with a value of 0.

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