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The influence of climate variability on internal migration flows in South Africa

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ABSTRACT

This work investigates the impact of climate variability on internal migration flows in post-apartheid South Africa. We combine information from South African censuses and climatic data to build a panel database covering the waves 1997–2001 and 2007–2011. The database enables the examination of the effect of spatiotemporal variability in temperature and precipitation on inter-district migration flows defined by five-year intervals. We employ a gravity approach where bilateral migration flows are explained by climate variability at the origin, along with a number of geographic, socio-economic and demographic factors traditionally identified as potential drivers of migration. Overall, we find that an increase in positive temperature extremes as well as positive and negative excess rainfall at the origin act as a push effect and enhance out-migration. However, the significance of the effect of climate on migration greatly varies by migrant characteristics. Particularly, flows of black and low-income South African migrants are strongly influenced by climatic variables whereas those of white and high-income migrants exhibit a weak impact. We also argue that agriculture may function as a transmission channel through which adverse climatic conditions affect migration.

1. Introduction

Environmental factors are increasingly recognized as a possible driver of cross-border and internal human migration (Laczko and Aghazarm, 2009). Indeed, adverse environmental conditions — ranging from natural disasters and extreme weather events, to more gradual variations in climate — might induce people to use migration as an adaptation strategy (McLeman and Smit, 2006). Quantifying the effects of the environment on human migration is crucial to better monitoring and predicting internal and international migration flows and, especially in the context of least developed countries (LDCs), is crucial to effectively managing issues associated with the movement of people. Moreover, a better understanding of the environment-migration link would aid in the development of strategies and policies to cope with the challenges posed by projected climate change.

Environmental factors influence individual migration decisions and shape migration flows through a complex web of causal links. Adverse environmental conditions could reduce, either abruptly or more gradually, the safety of homes or communities, worsen individual health, and decrease household-asset value through land and property degradation. Environmental factors may also interact in non-trivial ways with economic activity and indirectly affect individual migration decisions. For example, changes in climatic conditions may reduce agricultural productivity and raise food-commodity prices (Porter et al., 2014). The impact can be more severe in LDCs lacking sufficient capital to invest in innovative technologies for climate-change mitigation and adaptation (Lybbert and Sumner, 2012). This may negatively affect income and employment opportunities of people working in the agricultural sector (or in industries strongly dependent on it), and influence household consumption, possibly boosting urbanization via rural–urban migration, and ultimately affecting migration decisions of urban households resulting in international migration (Marchiori et al., 2012). Furthermore, recent findings suggest that environmental factors may also limit movement of the most

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vulnerable populations due to financial constraints (Gray and Mueller, 2012).

Motivated by these lines of evidence, we explore whether and how climate variability has affected internal migration flows across South Africa in the post-apartheid period (1996–2001; 2007–2011). Review of the literature (see Appendix B) indicates that the climate-migration link has not been addressed there so far. Nevertheless, South Africa is a relevant case study for a number of reasons. First, it is characterized by high internal migration rates (between 2007 and 2011, approximately 2.3m people, i.e. 5% of the country's population, moved across districts), particularly since the end of the apartheid, when the laws constraining the movement of people on the basis of ethnicity were abolished (see Appendix A). Second, South Africa is already experiencing significant changes in climate. Average annual temperature has exhibited positive trends between 1960 and 2000, with an increase by about 0.13 °C per decade (Kruger and Shongwe, 2004). Average annual rainfall trends are weak, but there is a tendency towards a significant decrease in the number of rainy days combined with an increase of inter-annual variability in precipitation (DEA, 2013). IPCC scenarios (van Oldenborgh et al., 2013) project that these trends will intensify by the end of this century (see Appendix A). Third, South Africa is characterized by persistent poverty and racial inequalities that are partially a consequence of decades of apartheid, and that could potentially make some specific population sub-groups particularly vulnerable to climate change. According to World Bank (http://wdi.worldbank.org), in 2010 the share of population below national poverty line was 53.8%, while the income Gini coefficient was estimated to be 63.4% in 2011, which makes South Africa one of the most unequal countries in the world (see Appendix A). Fourth, although the economy of South Africa is increasingly dominated by the tertiary sector (i.e., service industry), which makes up almost two-thirds of GDP, agriculture is still relevant for the development and stability of the country because of the economic importance of its commercial sector and the ubiquity of subsistence and rainfed, small-holder farming (see Appendix A), Therefore, one could argue that, if climate variability influences migration decisions, this may occur through its impact on people directly or indirectly via the agricultural channel.

In this work, we study the patterns and determinants of South African inter-district bilateral migration flows in the periods 1997–2001 and 2007–2011. In particular, we employ an augmented gravity model where, in addition to geographic, socio-economic and demographic determinants, we introduce a number of covariates to control for the spatiotemporal distribution of climatic factors. We further test climate-migration sensitivity of different demographic sub-groups within South Africa. In particular, we condition migration flows by age, gender, ethnic group and income. Finally, we ask whether agriculture could act as a potential transmission channel from climate to migration, in line with the empirical findings in recent studies (Feng et al., 2012; Mueller et al., 2014).

2. Materials and methods

2.1. Data

The main sources of data are South Africa's 1996, 2001, and 2011 censuses, and the 2007 community survey (CS). Data for 1996 and 2007 are taken from the IPUMS (Integrated Public Use Microdata Series, International) available at https://international.ipums.org (Minnesota Population Center, 2013), whereas the 2001 and 2011 censuses come from Statistics South Africa (statssa.gov.za). A number of migration-related studies have previously employed these data, see for example Kok et al. (2003, 2005), Dinkelman (2013), Facchini et al. (2013), Garcia et al. (2014) and Choe and Chrite (2014). In principle, census and CS data cover the entire universe, but data are only available for a nationally-representative 10% sample together with individual and household weights, which we used throughout our analysis. Census and CS data cover a wealth of information about demographics, general health and fertility, education and employment, mortality, housing, households and services, and migration. In particular, each census wave contains data on current and past residence of individuals. However, the geographic resolution of the past residence data varies widely across waves. The only past residence data that are consistently available are at the province level. Since South Africa only features 9 provinces, this choice would strongly limit the cross-sectional variability of our data. Therefore, we choose to track individual movement from origin to destination at the level of the 52 South African district councils using solely the 2001 and 2011 waves. The data further provides information on the year of last move, which we utilize to determine the migration status of individuals. More precisely, an individual is defined as a migrant if s/he moved between two different district councils within the 5 years prior to the 2001 or 2011 census year included (see Appendix C for more details on the characteristics of migrants and the statistical patterns of migration flows in South Africa). We choose 5-year intervals to compute migration flows because we employ the 1996 census and the 2007 CS to build a set of demographic and socio-economic variables, to be used as lagged covariates in our regression exercises (see Section 2.2).

Climate data (gridded at 0.25° resolution) are taken from the African Drought and Flood Monitor project (hydrology.princeton.edu/monitor/), see Sheffield et al. (2006, 2014). The system monitors hydrological conditions of land surface in Africa employing the Variable Infiltration Capacity (VIC) model and provides data on a variety of climatic indicators including precipitation, temperature, and soil moisture.

2.2. Econometric framework

We explore the determinants of inter-district migration flows with the following panel gravity model, which we estimate using Poisson Pseudo Maximum-Likelihood (PPML) with errors clustered at the dyadic level (ij):

$$m_{ij,t} = \kappa \cdot \exp\{\psi_i + \phi_{j,t} + \boldsymbol{\beta}\mathbf{Z}_{ij} + \boldsymbol{\theta}\mathbf{X}_{i,\tau(t)} + \boldsymbol{\mu}\mathbf{C}_{i,\omega(t)}\} \cdot \varepsilon_{ij,t} \quad (1)$$

where $i \neq j$ = 1, ..., 51 are origin and destination district councils (from the list of 52 district councils in 2011 Buffalo Metropolitan Municipality has been removed and its flows have been aggregated with those of Amathole District, which contained Buffalo Metropolitan Municipality in 2001); t = 2001, 2011 are census years; $m_{ij,t}$ are 5-year individual migration flows from i to j (i.e. defined for the time interval $[t-4, t]$); κ is a constant; ε_{ij}^t is an error term with mean equal to 1; ψ_i are origin fixed effects; ϕ_j^t are time-destination fixed effects; $\mathbf{Z}_{ij}$ is a vector of bilateral variables, i.e. log of geographical distance between i and j and a contiguity dummy; $\mathbf{X}_{i,\tau(t)}$ is a vector of lagged demographic and socio-economic origin controls at year $\tau(t)$ = 1996, 2007, and $\mathbf{C}_{i,\omega(t)}$ is a vector of origin climatic variables computed over the 5-year time intervals $\omega(t)$ = [1996–2000], [2006–2010]. Since we are mostly interested in assessing the role of climate and other origin covariates as push effects, we do not use any time-varying covariate at the destination, but we control for all cross-section, time-dependent unobserved heterogeneity in pull factors using time-destination fixed effects (ϕ_j^t). We also employ time-independent origin fixed effects (ψ_i) to pick up unobservable spatial heterogeneity across districts that is due to structural differences across origins, including historical climate. Note that