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Via Voltapaletto, 11 – 44121 Ferrara

Quaderno DEM 3/2012

November 2012

Climate Change and Migration: A Gravity Model Approach

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Quaderni DEM, volume 1 **ISSN 2281-9673**

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Abstract

In this paper climate change is analysed as one of the reasons that push people to migrate. Climate change shows through four main channels: temperature change, precipitation change, sea level rise and extreme events. All these channels are considered together by adding anomalies in temperature and precipitation and the number of people affected by natural disasters to a gravity model of migration, where the bilateral migration flow between 182 countries of the world is the unit of analysis. The empirical tests demonstrate a statistically significant relation between migration and climate change, however while anomalies in temperature and precipitation have a positive impact, the effect of extreme events is ambiguous.

Keywords: International migration; Climate change; Natural disasters

JEL classification: F22; Q54

* I would like to thank Prof Lucio Poma, Dr Francesco Nicolli and Dr Giulia Bettin, who tutored me in writing my MSc dissertation that is the basis of this paper.

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1. Introduction.

In 2005 Hurricane Katrina hit the south west coast of the United Stated, leading to the displacement of about 1.5 million people, it has been estimated that only 500,000 have returned and that 300,000 will never return (Grier, 2005; Afifi and Warner, 2008). In 2008 the Cyclone Nargis struck the Irrawaddy Delta region in Myanmar affecting severely 2.4 million people and caused the displacement of 800,000 people. Desertification in Mexico's dryland regions leads annually about 700,000 people to migrate (IOM, 2008). These are just three examples of the existing relation between climate and human migration. Approximately 22-25 million people migrate every year for environment-related causes (Myers, 2005; Afifi and Warner, 2008) due to a number of different phenomena: catastrophic events such as hurricanes, floods, etc. that destroy people's homes and cities force people to migrate, at least temporarily. Other phenomena such as desertification or deteriorating environmental conditions, act slowly but progressively and make living conditions to worsen, until livelihood is no longer possible and people migrate. Migration can be seen as an adaptation strategy: people, migrating, adapt to the new climate condition.

Clearly if these natural events, or their intensity, and frequency are related with climate change, then climate change directly affects migration. This relation will be studied using a gravity model adapted to migrations, bilateral migration flows between any pair of country of the world is the unit of analysis. This work is organised as follows: the next chapter will discuss climate change, its consequences and the effects on economy, chapter 3 will present the migration and climate change relation in the literature, then, the gravity model will be described, chapter 6 concerns the empirical analysis.

2. Climate change: evidences, causes and consequences.

Climate change has been widely discussed in recent years, both in academic and within institutional bodies, however it still has not a unique definition[1]. According to the IPCC (2007), surface temperature rise, precipitation anomalies, catastrophic events and sea level rise are the four ways

[1] The Intergovernmental Panel on Climate Change (IPCC) refers to it as the “change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.” (IPCC, 2007, p. 30). The United Nations Convention on Climate Change (UNFCCC) defines climate change as the “change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (UNFCCC, 1992, art.1).

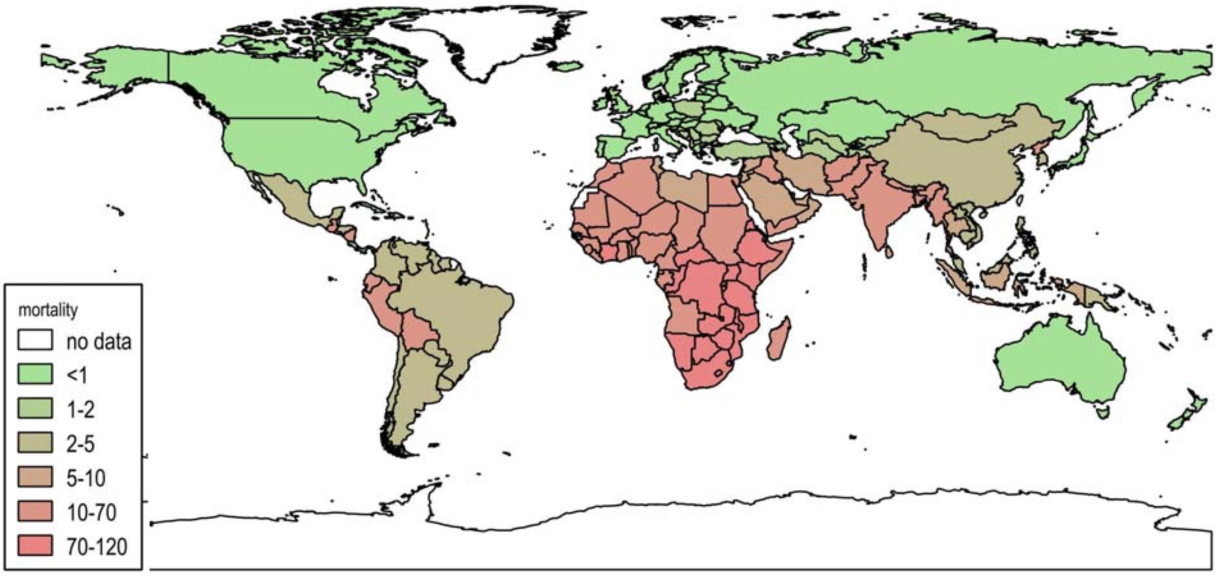
through which climate change shows its potential.

The scientific community agrees that "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations". It is also likely that extreme events have a human cause, in fact "it is *more likely than not* that human influence has contributed to a global trend towards increases in area affected by drought since the 1970s and the frequency of heavy precipitation events"(IPCC, 2007, p.39-40).

GHGs emissions are mainly attributable to power station, industrial production and transportation both civil and freight. Agriculture, fossil fuel related activities, residential and commercial activities and land use are other sources of GHGs emissions (EDGAR[2]). Therefore human everyday activities contribute to GHGs emissions and, as a consequence, to climate change.

Climate change impacts differently on human societies depending on regions and economic positions, with those on the weakest economic position often being the most vulnerable (IPCC, 2007). Figure 1 shows that the most of the deaths attributed to climate change have been observed in Africa, particularly Sub-Saharan Africa, and south Asia. Stressing that less developed countries seem to suffer more consequences due to climate change[3] and, in turn, economic development is negatively affected by a changing climate (Deschenes and Greenstone, 2007; Dell et al, 2008; Ahmed et al, 2009; Barrios et al, 2010).

Figure 1: Death attributable to climate change, 2000.



Data source: McMichael et al, 2004.

[2] The Emission Database for Global Atmospheric Research is publicly available at http://edgar.jrc.ec.europa.eu/index.php

[3] According to Mendelsohn et al (2001) empirical findings suggest that increasing development reduces cli-

The climate-economy relation is a complex issue, indeed there are many channels through which this relationship appears. While the most logic effect of climate change is on agriculture (Deschenes and Greenstone 2007; Guiteras 2007), an easier access to technologies and irrigation possibilities change the direction of the impact[4]. Other researchers focused on ocean fisheries, fresh water access, tourism, coastal flooding, malnutrition, diseases and mortality (IPCC, 2007). It has also been established a linkage between temperature and crime (Field, 1992), and drought and conflicts (Miguel et al 2004). Dell et al (2008) tested temperature and precipitation on economy showing a negative effects of higher temperatures on economic growth, but only in poor countries, suggesting that the gap between richer and poorer country could deepen due to climate change. They also found a negative effect not only on agriculture but also on industrial production, aggregate investment and on political stability. Similarly Barrios et al (2010) demonstrate that trends in rainfalls have affected economic growth rates in Sub-Saharan Africa (SSA) but did not in other developing countries. This is due to an African peculiarity: high importance of agriculture and its dependence on rainfalls, and the high reliance of African countries, compared to other developing countries, on hydropower for electricity generation (Magadza, 1996), that in turn affects industries. According to Barrios, Bertinelli and Strobl (2010, p.363) "if rainfall had remained at previous levels, the current gap in GDP per capita relative to other developing countries could have been between 15% and 40% lower".

Worsening economic conditions, political instability, difficult access to water resources are, among other factors, motivations that push people to migrate. According to the so-called push-pull model, coming from Lee's revision of the original Ravenstein's laws of migration, two main forces act as push and pull factors: on one side the Malthusian theory, where population growth increases pressure on natural and agricultural resources, pushing people out of rural areas. On the other side economic conditions (wages) pull people into cities and industrialised countries (De Haas, 2008). Even if this approach is more an analytical framework than a theory itself (De Haas 2008), it has been largely used by researchers interested in analysing migration and climate change relationship, as we will see below. A synthesis of the different approaches to migration theory[5] brings to say that when migrating, "people compare utility differentials across different alternative locations and these utility differentials are a function of both economic and non-economic (quality of life) factors" (Biagi et al, 2011, p.113). Specifically their decision will be based on a comparison of expected utili-

mate sensitivity.

[4] Deschenes and Greenstone (2007) suggest that profits in the US agricultural sector will rise because increasing temperature will extend the growing season, instead Guiteras (2007) estimates dramatic consequences for Indian agriculture. Cline (2007) expects a halved productivity in some areas of Africa and South America while in other areas, such as Scandinavia, a consistent increase is predicted, incorporating also the effects of fertilisation.

[5] For a review of diverse migration theories see Massey et al, 1993.

ties. Moreover, individual characteristics and how each decision unit (would it be a single person or the household) weights push and pull factors are very important, otherwise it could not be understandable why some people migrate and others do not.

3. Migration and climate change literature review.

The connections between migration and climate change was already pointed by the IPCC in the 1990 and in the recent years it gained consideration again. Migration is an adaptation strategy[6]: when living in a specific place is no longer possible, people adapt, moving.

According to Barrios, Bertinelli and Strobl (2006) that use the simple arithmetic mean of precipitation as a proxy for climate change, shortages in rainfall caused an increase in urbanisation rate in SSA, but did not in other developing countries. Also Marchiori, Maystadt and Shumacher (2010) concentrate on SSA, using anomalies in precipitations and temperature. They find only an indirect effect of climate change on migration: climate change lower wages in agricultural sectors, this pushes rural workers to urban centres, increasing urbanisation. In turn, this causes negative externalities that lower urban wages. When urban wages are minor than urban benefits, people migrate to other countries.

The importance of water in Africa has been noticed by Tsegai and Le (2010) that, using the mean annual rainfall and the standard deviation of annual rainfall, find that Ghanian net receiving districts are characterised by high employment rate, high rainfall variability and less important agrarian sector. Suitable water and soil quality seem to be worldwide the most significant determinants of migration, among a number of other environmental factors[7] (Afifi and Warner, 2008). Therefore environmental degradation[8] is another factor causing migration (Reuveny and Moore, 2009) in addition to social, economic and political factors.

Other authors use natural disasters as a proxy for climate change: Drabo and Mbaye (2011) empirically demonstrate a significant and positive effect of natural disasters; Alexeev et al (2011) find out that an increase in weather extreme events induce out-migration, however positive rainfall shocks in rural Ethiopia lower the probability of migration (Millok et al, 2011). Hence the effects of

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[6] Adaptation can move from expanding water storage and conservation technique, adjustment of crop variety, to improved climate sensitive disease surveillance, from shifting ski slopes to higher altitudes, to energy efficiency and relocation of human settlements (IPCC, 2007).

[7] Afifi and Warner use a number of environmental indicators related to the sending country, covering 172 countries: overfishing, earthquakes, tsunamis, floods, hurricanes, desertification, potable water shortage, occurrence of soil salinity, deforestation, sea level rise, air pollution, soil erosion, soil pollution.

[8] Environmental degradation is expressed by three indicators: arable land, crop land and disasters. Population was also considered to give the dimension of pressure on the environment (Reuveny and Moore, 2009).

extreme events can have both a positive or a negative sign, depending on the characteristics of the impacted area.

These remarkable works, together with a number of others, try to demonstrate empirically the nexus between migration and climate change, but none known to the author consider precipitation, temperature and disasters in a gravity model. These phenomena are in fact caused by climate change (IPCC, 2007) and there is no apparent reason to exclude one of them[9].

Chapter 5 concerns the variables that will be used in the regression, while the next chapter explain the gravity model applied to migration.

4. A gravity model of migration.

The concept of centres of attractions and distance dates back to Ravenstein's laws of migration: currents of migration are attracted towards big industrial and commercial centres, that work as “centres of absorption” but these currents “grow less with the distance proportionately” (Ravenstein 1885). However the gravity model derives directly for Newton's “law of universal gravitation” and was firstly formalised by Tinnbergen (1962) and Pöyhönen (1963) to study international trade flows (Van Bergeijk and Brakman, 2010). The basic gravity equation is:

$$T_{ij} = \frac{GDP_i^{b_1} GDP_j^{b_2}}{D_{ij}^{b_3}}$$

where T_{ij} indicates bilateral trade between country i and country j; GDP measures the economic size of country i and j respectively and D_{ij} is the distance between country i and country j. The parameters b_1, b_2 and b_3 are estimated applying a logarithmic transformation:

$$logT_{ij} = a + b_1 logGDP_i + b_2 logGDP_j - b_3 logD_{ij}$$

This rather simple and flexible approach, and its adaptability to a number of theories[10] spread its utilisation among many different branches of study. It is particularly useful when researching the determinants of flows between countries.

In the migration context the gravity model equation can be modified as follows:

$$\text{(I)} \qquad M_{ij} = A\frac{P_i^{b_1} P_j^{b_2}}{D_{ij}^{b_3}}$$

[9] See also Raleigh et al 2008, Martin 2010 and Renaud 2011 on categories of environmental migrants.

[10] See for example the different studies reported in Van Bergeijk and Brakman, 2010, in the sole context of international trade.

that becomes: (II) $logM_{ij} = a + b_1 logP_i + b_2 logP_j - b_3 logD_{ij} \quad \forall i \neq j$

where: M_{ij} is the migration flow between country *i* and country *j*; P_i and P_j refer to the population of, respectively, country *i* and country *j*, D_{ij} is the distance between the two countries; and *a* is a constant. The distance in this equation can be intended in a number of ways: firstly geographically, it is expected that the farer countries are, the lesser the migration among these two countries will be, all else being equal. Moreover distance can be intended in terms of economic distance, for example in term of GDP or per capita GDP: it is expected that positive differences in destination's GDP positively affect migration. Third distance can be viewed as cultural distance, namely all the characteristics of a country that make migration easier, such as a common language, a common past (i.e. formerly the two countries were one country or have been colonised by the same nation). All these factors can be push of pull factors, that make people to migrate from country *i* to country *j*. These factors are specific characteristics of the two countries:

$$\text{(III)} \quad m_{ij} = a + \underbrace{characteristics_i}_{\text{PUSH}} + \underbrace{characteristics_j}_{\text{PULL}} \qquad \forall i \neq j$$

where $m_{ij} = \log M_{ij}$

Literature on migration identifies a number of characteristics that act as pull and push factors: difference in wages, differences in expected income, unemployment rate, but also public services, social and cultural amenities, wars and political stability, climate and temperature (Todaro, 1969; Harris and Todaro, 1970; De Haas, 2008; Afifi and Warner, 2008; Biagi et al, 2011).

Introducing some of these factors the equation becomes:

$$\text{(IV)} \quad m_{ij} = a + \underbrace{b_1 p_i}_{\text{PUSH}} + \underbrace{b_2 p_j}_{\text{PULL}} + \underbrace{b_3 d_{ij}}_{\text{PULL}} + \underbrace{b_4 \delta GDPpc_{ij}}_{\text{PUSH/PULL}} + \underbrace{b_5 cult_{ij}}_{\text{PULL}} + \underbrace{b_6 climate_i}_{\text{PUSH}}$$

where $p_i = \log P_i$

$p_j = \log P_j$

$d_{ij} = \log D_{ij}$ represents the geographical distance between country *i* and country *j*

$\delta GDPpc_{ij} = \log \Delta GDPpc_{ij}$ as economic distance

$cult_{ij}$ as cultural distance

$climate_i$ represents the climate characteristics of the country of origin

It is expected that the lower the GDP per capita in the sending country is, the more the people living in it will be willing to migrate to other countries for improving their living conditions; the higher the GDP per capita in the receiving country, the more the people will be attracted to this country. Geographical distance between country of origin and country of destination is expected to have a negative impact on migration flow: the higher the distance the lower the migration flow. Cultural proximity intended as common language or have been colonised by the same nation are expected to be positively related with migration because it is easier to relocate in similar countries, where the same language is spoken for example, instead than in a totally different country where they speak another language. Hence a small cultural distance is expected to play a "pulling" role. Climate characteristics and in particular worsening climate conditions are expected to act as push factors: extreme events, anomalies in rainfall and temperature (obtained standardising the observed value in the year 1999) in the sending country push people to migrate to another country. However it has already been noticed how some authors see a negative relation for some countries, but in a world analysis it is expected that a positive relationship prevails.

It is important to notice that push and pull factors can be seen also in term of expected costs and benefits. In fact bigger geographical distance implies higher transportation costs, bigger cultural distance implies higher relocation costs: e.g. the direct cost for attending a course in order to learn the language spoken in the destination country. Increasing frequency and impact of extreme events imply higher costs due to, for example, re-building or repairing houses, firms or farmlands. Anomalies in rainfalls can make costs or savings depending on where they happen: positive rainfall anomalies in dry countries bring a benefit because of increased agriculture production and easier water access. Similarly temperature anomalies depend on the country where they happen: positive temperature anomalies could bring benefit in cold countries, but can cause great costs in warm countries.

Migrants are in conclusions pushed and pulled by a number of factors and they choose whether and where to migrate according to the expected costs deriving from the decision to migrate or stay.

5. Dataset description.

The unit of analysis, as it has been pointed out above, is the gross migration flow between any two countries M_{ij} , where $i = [1,2,...,n]$ and $j = [1,2,...,(n-1)]$ therefore the bilateral dataset contains $n \times (n-1)$ observations, where $n = numberofcountries = 182$. The regression is a cross section analysis referred to year 2000. Migration data come from the World Bank global bilateral migration database that provides data on a 10-year basis on the stocks of migrants over the period 1960-2000, the only year 2000 has been used. The database is primarily built on the concept of foreign-born[11]. The dependent variable (gross bilateral migration flows) will be explained according to equation IV. Below all the explicative variables and the database used are explained, finally all the variables

[11] For more information see World Bank 2011.

will be merged in the estimated equation.

Population living in country of origin p_i and country of destination p_j are the base of the gravity model applied to migration. Data (in thousands) for the sole year 1999 come from the Penn World Table (Heston et al, 2011), the variables are called: *pop_i* and *pop_j*.

Geographical distance d_{ij} is represented by *dist_ij*. An additional variable called *contiguity* considers countries that share a border, since crossing two borders even if distance is shorter, can be more difficult than crossing just one, even if farer. Data are provided by the CEPII's Geodist Database that makes available a set of gravity variables developed by Mayer and Zignago (2005). The database is commonly used in estimating gravity equations describing bilateral trade flows.

The database gives also information about common languages among any pair of countries (*comlang_off* and *commlang_ethno*), common coloniser after the 1945 (*comcol*), common colonial link (*colony*). In building the database one country has been considered coloniser if it "has governed the other over a long period of time and contributed to the current state of its institutions" (Mayers and Zignago,2005,p.12). Additionally two common languages dummies are provided: two countries share a common official or a primary language (*comlang_off*); a language is spoken by at least 9% of the population in both countries (*comlang_ethno*). Cultural variables and contiguity are dummy variables.

Economic distance is measured by *relyeqa* that represents the ratio of GDP ppp per equivalent adult at 2005 constant prices for the previous year in the country of origin and the country of destination, defined as:

$$relyeqa_{ij} = \frac{GDPeqa_i}{GDPeqa_j}$$

GDP data come from the Penn World Tables. As suggested by Mayda it cannot be asserted that income is strictly exogenous, since possible migrants' remittances may affect both destination and home country income. However "it is plausible to assume that they are predetermined, in the sense that immigrant inflows – and third factors in the error term – can only affect contemporaneous and future wages" (Mayda, 2010, p.1263). For this reason in the analysis I have used the lagged value of income.

As noted above, in order to consider the different channels of climate change we will use anomalies in temperature, anomalies in rainfalls and the total number of people affected by extreme events[12].

Anomalies in temperatures and rainfalls have been obtained as:

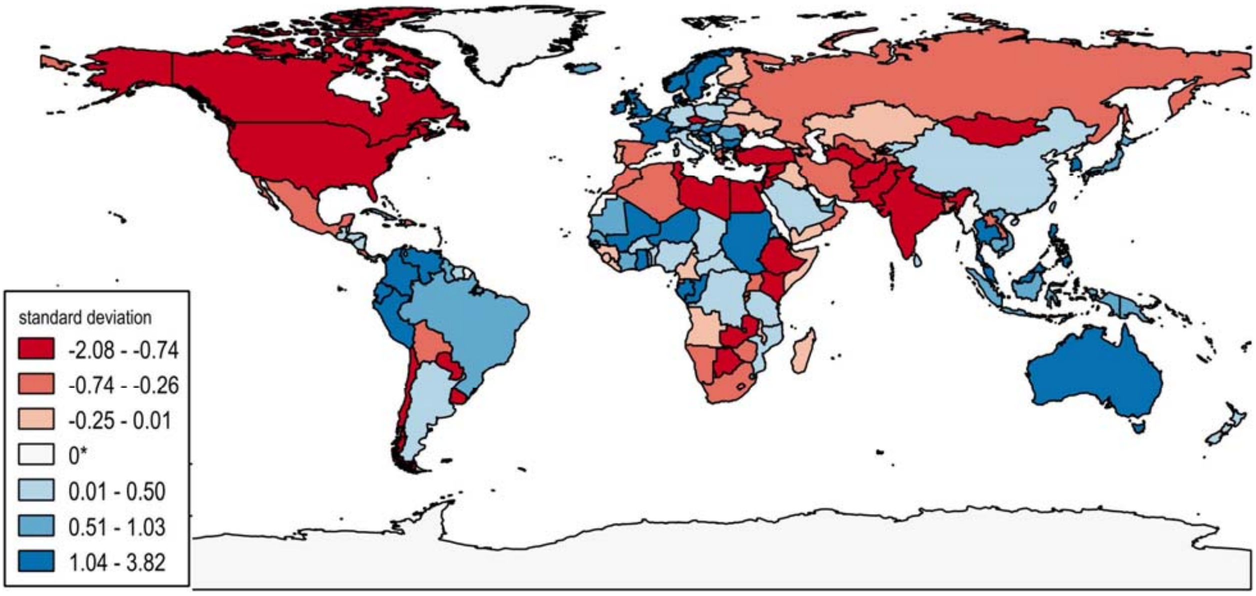
[12] A number of aggregated indices were also considered, however for the purpose of this paper none of them seem able to capture those changes I am interested in. For a list of indices see for example OECD (2002).

$$Aprec_{it} = \frac{prec_{it} - \mu_{prec_i}}{\sigma_{prec_i}} \quad \text{and} \quad Atemp_{it} = \frac{temp_{it} - \mu_{temp_i}}{\sigma_{temp_i}}$$

where $Aprec_{it}$ and $Atemp_{it}$ are respectively the anomaly in precipitation and temperature of country i in the year t, μ_{preci} and μ_{tempi} are respectively the mean of registered precipitation and temperature for country i during the interval of time (1950-2000) and σ_{preci} and σ_{tempi} are the respective standard deviations. Data come from the TYN CY 1.1[13], elaborated by Mitchell, Carter, Jones, Hulme and New (2002). The database covers 9 main variables of which I use daily mean temperature in Celsius degrees and precipitation in millimetres[14]. Data have been specifically built for combining climatic information with demographic, cultural and socio-economic information for non-climatology-researchers[15]. The original dataset refers to 289 countries and territories[16], however, in order to make climatic data homogeneous with migration data some modification to the original TYN CY 1.1 have been done and data on 182 countries resulted for the year 1999.

Anomalies in temperatures and precipitations are shown in figures 2 and 3. These figures con-

Figure 2: Anomalies in precipitations by country, 1999.



*0 = no data
Data source: TYN CY 1.1

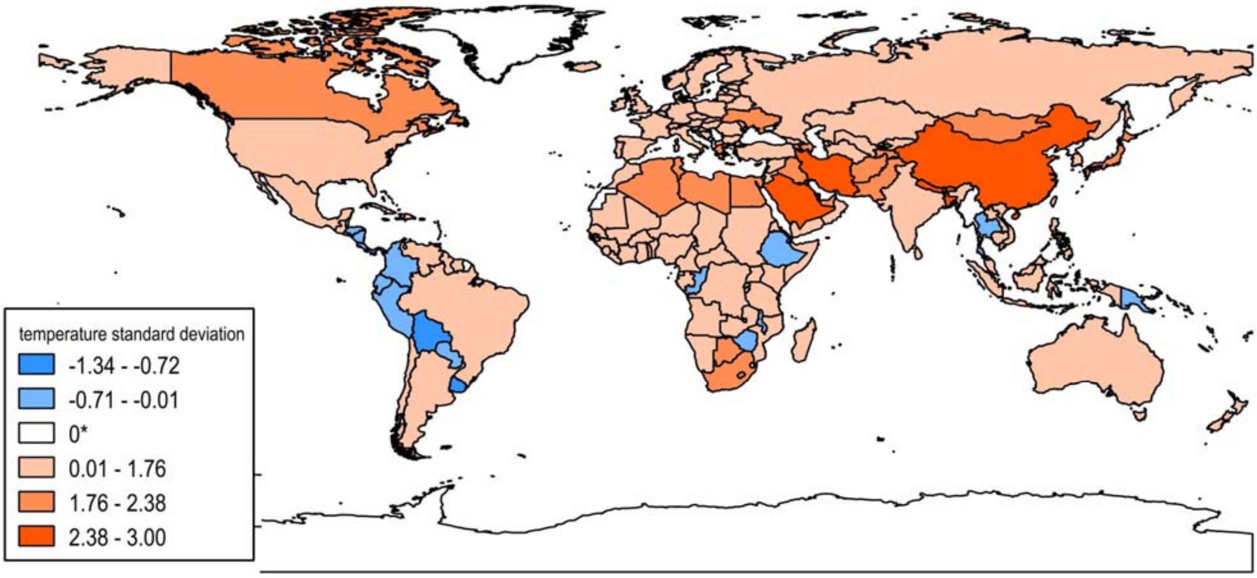
[13] The dataset is publicly available at http://www.cru.uea.ac.uk/~timm/cty/obs/TYN_CY_1_1.html

[14] The other being: daily minimum temperature (degrees Celsius); daily maximum temperature (degrees Celsius); daily temperature range (degrees Celsius); frost day frequency (days); wet day frequency (days); vapour pressure (hectaPascals); cloud cover (percentage).

[15] For further information about the building and weighting process see Mitchell et al (2002) and New et al (1999 and 2000).

[16] For the complete list of available countries and territories data see the dataset website.

Figure 3: Anomalies in temperatures, by country, 1999.



*0 = no data
Data source: TYN CY 1.1

firm higher temperatures for the most of the countries, instead anomalies in precipitations do not show an evident positive or negative trend however their irregularity compared to the long term mean can be appreciated.

Disasters are represented by three variables, *clim_affect_i*, *meteo_affect_i* and *hydro_affect_i* given the number of people affected in 1999 according to disasters type[17]: climatological disasters, meteorological disasters, hydrogeological disasters. The Emergency Events Database EM-DAT[18] provided by the Center for Reasearch on Epidemiology of Disasters (CRED) seems to be very useful for the purpose of this work, since it furnishes data organised by country and by type of disasters[19]. Figure 4 shows the total number of people affected by natural disasters by country in 1999: a number of countries have experienced extreme events affecting people, across all the continents.

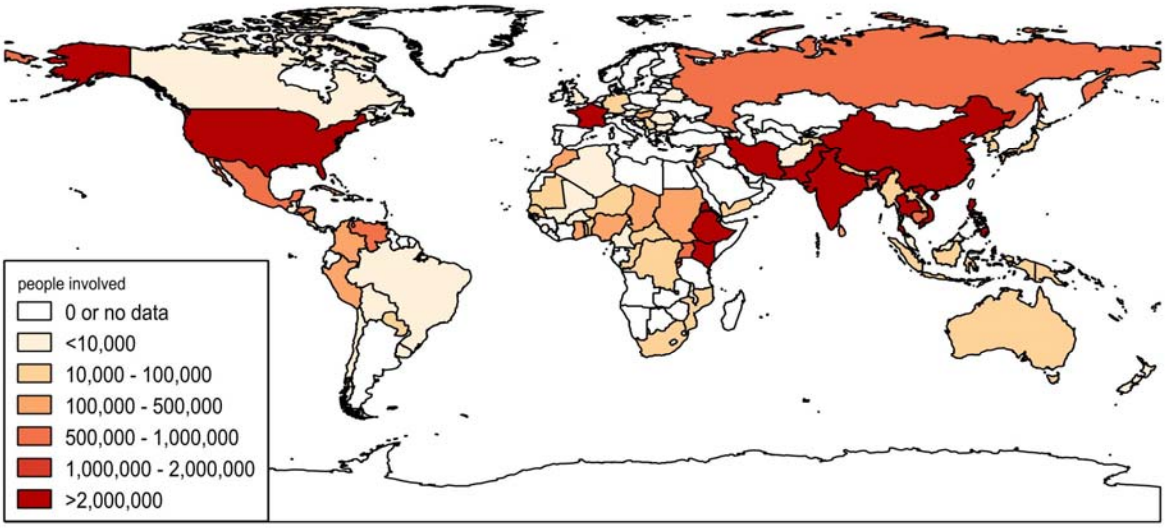
Also in this case some doubts about strict exogeneity of climate related variables may arise. For example, situation of mass migration can cause worsening environmental conditions in host area: deforestation could take place for making space for shelters, in addition wood can be used as construction material, and similarly coastal sands. This general environmental degradation "not

[17] Meteorological disasters include tropical storm, cyclone and local/convective storm; hydrological disasters are flood, mass movement (wet), landslide, avalanche, subsidence; climatological disasters include extreme temperature, drought and wild fire. For a full classification of disasters see http://www.emdat.be/

[18] The database is publicly available at http://www.emdat.be/database

[19] The database has been built according to the criteria that at least one of the following conditions must be met in order to make a disaster enter into the database: ten or more people reported killed; hundred or more people affected; declaration of state of emergency; call for international assistance (http://www.emdat.be/).

Figure 4: Total number of people affected by natural disasters, 1999.



Data source: CRED EM-DAT.

only accelerate deforestation and soil erosion, they also limit water drainage capacity" as a consequence "once innocuous rainfalls may lead to serious floods and mudslides" (IOM, 2007, p.4). However these consequences occur after the migration flow, namely migration today impacts on environmental condition in the future. Therefore, as already done for income variable, in the final specification I use the lagged value of all the climate change variables in order to overcome the possible problem of endogeneity.

Introducing all these components and applying a logarithmic transformation:

$$lmig = a + b_1\, lpop\_i + b_2\, lpop\_j + b_3\, ldist\_ij + b_4\, lrelyeqa + b_5\, comcol + b_6\, colony + \\ + b_7\, commlang\_off + b_8\, commlang\_ethno + b_9\, Aprec\_i + b_{10}\, Atemp\_i + \\ + b_{11}\, lmeteo\_affect\_i + b_{12}\, lclim\_affect\_i + b_{13}\, lhydro\_affect\_i + \varepsilon_{ij}$$

6. Econometric results.

Two types of regressions have been run: OLS and zero inflated negative binomial (ZINB), since the model tested suffer from a high presence of zeros. This was expected since, as already discussed above, there are a number of factors that determine the migration flow, and between many countries no migration is expected because of cultural barriers (French speaking African countries tend to migrate to France rather than the UK) or unappealing destination (a poorer country)[20].

[20] Since data are not normally distributed, the OLS regression could not estimate well. The negative binomial or the Poisson models should be preferred if there are not an excess of zeros or if data are not overdispersed. Given the high presence of zeros (roughly 14.000 zero obs. over roughly 33.000 obs.) and overdispersion,

Table 1 resumes regression results: it can be observed that the basic gravity model applied to migration is confirmed, populations of both the origin and destination country has a key role in the migration decision and the bigger the population the higher the migration flow is, all else being equal. Distance, as expected, has a negative influence: the bigger the distance, the lower the flow or, in other words, the higher the probability of zero migrants. Sharing a border has a positive influence on migration.

Interpreting distance as economic and cultural distance all the predicted signs result: a colonial relationship and a common language are important factors in the migration process and lower the probability of a zero-flow. Incomes ratio (country of origin over country of destination) shows the expected negative (in OLS regression) sign and high significance: higher income ratio lower the migration flow, therefore the probability of a zero-flow increases (ZINB).

In OLS, anomalies in precipitations and temperatures are significant and positive factors that lead people to migrate. Extreme events are more difficult to interpret, since climatological and hydrological disasters are highly significant but negative while meteorological events are positive (and still highly significant), both when they have been analysed alone (4) and together with temperature and rainfall anomalies (5-5a). However, ZINB (6a) confirms a positive, even if small, influence for all the climate change variables. This is not surprising, since in a world-based analysis it is not expected to have climate change as the main driver of migration, however climate change plays a part in the migration decision.

In conclusion the role of climate change in migration has been demonstrated: anomalies in temperatures and precipitations have a positive and significant effect on migration flow; the number of people affected by natural disasters is a significant determinant of migration too, however its direction is ambiguous.

7. Conclusions, Policy Implications and further research.

This work shows how climate change is one of the main issues of our time: temperature change, irregular rainfalls, increase in extreme events' frequency and magnitude and sea level rise are hitting worldwide. These phenomena in turns impact on ecosystems and human systems, affecting human well being and security. Food security, water resources access and health are just a few vulnerability examples. Nevertheless climate change is a direct consequence of human activities, of the nowa-

Zero-Inflated Negative Binomial regression has to be preferred. These considerations are confirmed by the Vuong test (1989) and the zip option (see table 1).

Table 1. Determinants of bilateral migration flow.

Regression / Variable	(1) OLS	(1a) OLS robust	(2) OLS robust	(3) OLS robust	(4) OLS robust	(5) OLS	(5a) OLS robust	(6a) ZINB robust
lpop_i	0.454***	0.454***	0.444***	0.438***	0.473***	0.468***	0.468***	-0.418*** (inflate)
lpop_j	0.394***	0.394***	0.443***	0.427***	0.425***	0.428***	0.428***	-0.352***(inflate)
ldist_ij	-1.496***	-1.496***	-1.237***	-1.206***	-1.244***	-1.230***	-1.230***	1.000*** (inflate)
comcol			-0.112*	-0.154***	-0.093**	-0.115*	-0.115*	0.312*** (inflate)
colony			3.399***	3.324***	3.270***	3.225***	3.225***	-4.208** (inflate)
commlang_off			0.409***	0.466***	0.420***	0.452***	0.452***	-0.294*** (inflate)
commlang_ethno			0.943***	0.939***	0.847***	0.855***	0.855***	-0.704*** (inflate)
contig			2.642***	2.690***	2.713***	2.729***	2.729***	-17.110***(inflate)
lrelyeqa			-0.403***	-0.449***	-0.470***	- 0.493***	- 0.493***	0.221*** (inflate)
Aprec_i				0.110***		0.120***	0.120***	0.011*
Atemp_i				0.220***		0.110***	0.110***	0.056***
lclim_affect_i					-0.022***	- 0.015***	- 0.015***	0.004***
lhydro_affect_i					-0.044***	- 0.046***	- 0.046***	0.007***
lmeteo_affect_i					0.086***	0.081***	0.081***	0.016***
constant	8.188***	8.188***	5.892**	5.439***	5.810***	5.609***	5.609***	----
Mig year	2000	2000	2000	2000	2000	2000	2000	2000
Obs.	32942	32942	32942	32942	32942	32942	32942	32942
F-test	5543.77***	5079.14	2344.88***	1928.33***	1835.28***	1734.35***	15783.28***	
Hettest[21]	Reject H_0					Reject H_0		
White's test[21]	Reject H_0					Reject H_0		
Wald chi2								504.65***
alpha=0[22]								1197.43***
Vuong[23]								1.70**

*p<0.10; ** p<0.05; *** p<0.01

days patterns of production and consumption. Power stations, industrial production, transportation, fossil fuels, agriculture and residential sectors contribute to greenhouse gas emissions, thus a re-definition of current habits would be needed. In addition richer countries and people seem to suffer less the direct consequences of climate change, because of an easier access to, sometimes rather expensive, adaptation strategies.

Migration can be viewed as an adaptation behaviour: by migrating people adapt to the changing environment where they live. These people are forced to migrate because alternative livelihood is no longer possible in the hit area or because they do not want to live in a risky area, in both cases they move because of environmentally related reasons. Livelihood impossibility can derive from both slow or rapid onset hazards: extreme events can destroy houses or lands but also desertification affect year by year larger part of territories, exposing to vulnerability an increasing number of persons. Being vulnerable however does not mean being a migrant, since people in marginal regions have developed a great variety of alternative adaptation mechanisms, which strengthen their ability to cope with climate-related events (Raleigh et al, 2008). Nonetheless, given the climatic prediction, a number of authors expect that temperatures will rise all over the globe and also rainfalls unpredictability will increase and extreme events frequency and strength will become higher. Therefore, despite resilience, an expected increase of environmentally induced migrants is also likely to happen. If migration decision is viewed as an expected cost-benefit analysis, when one has lost nearly everything migration becomes an appealing opportunity, higher work opportunities and higher wages act as pull factors while climate change, and particularly climate worsening, act as a push factor.

A number of push and pull factors have been tested using a gravity model in order to analyse the existence of a statistically significant relations between climate change and migration flows among 182 countries of the world. The gravity model gives the opportunity to study bilateral flows between countries. Given the model, about 33,000 observations related to migration in the year 2000 have been tested, the hypothesis is that anomalies in temperature and precipitation and the number of people affected by natural disaster happened the previous year (1999) have pushed people to migrate. Traditional migration drivers have also been added: cultural (common languages, colonial relation) and economic (difference in per capita income). Populations of the two countries according to the gravity modelling together with distance play also an important role in the migration decision.

Traditional migration gravity model variables are confirmed, countries dimensions (in terms of people) have a positive effect on international migration, while distance affect it negatively, sharing a border has a positive effect. Cultural proximity, such as common languages and a colonial relationship act as pull forces.

The regressions confirm a relation between climate change and migration, also when the large presence of zeros have been tested. In other words climate change is statistically significant for the migration flow prediction. Anomalies in temperature and precipitation generally push people to migrate, while disasters have a difficult interpretations. Hydrological and climatological events could have a negative impact on migration, it can be due to a few reasons: affected people have lost the most of their goods and means, hence they cannot undertake an expensive and time consuming travel to migrate internationally, similarly a relocation policy could be implemented (this dataset does not detect internal migration); reconstruction requires capital and labour force, hence displaced people will be involved in reconstruction and foreign workers at any level of qualification will be needed (from doctors for sick and injured persons to bricklayer for re-building houses), thus a disaster could generate in-migration; people living in frequently hit areas have get use to disaster's threats and are more resilient to move, hence they stay despite bad events and circumstances.

However when testing considering the high presence of zeros, all the extreme events variables result positive. Further studies will be needed to investigate deeply the relationship between migration and climate change. Testing lagged or panel would be also useful to highlight historical trends and people resilience, since migration decision in many cases is a lifetime decision that needs time to be taken, if one is not forced because of total impossibility to live in the hit area. Adding internal migration, political instability and wars variables would be useful. Government policies are also expected to be important when deciding whether to stay or to move, since effective or ineffective reconstruction and aid policies can make the difference from livableness or unlivableness.

Policies to help and improve people's livelihood are needed in hit countries, but also in those that today are not apparently suffering from the problem or seem to be able to cope with it. Effective policies against climate change, especially if taken in the countries that contribute more to it, will in fact let people live where they want and avoid forced mass migration and all the consequent problems.

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