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Climate, conflict and forced migration

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ABSTRACT

Despite the lack of robust empirical evidence, a growing number of media reports attempt to link climate change to the ongoing violent conflicts in Syria and other parts of the world, as well as to the migration crisis in Europe. Exploiting bilateral data on asylum seeking applications for 157 countries over the period 2006–2015, we assess the determinants of refugee flows using a gravity model which accounts for endogenous selection in order to examine the causal link between climate, conflict and forced migration. Our results indicate that climatic conditions, by affecting drought severity and the likelihood of armed conflict, played a significant role as an explanatory factor for asylum seeking in the period 2011–2015. The effect of climate on conflict occurrence is particularly relevant for countries in Western Asia in the period 2010–2012 during when many countries were undergoing political transformation. This finding suggests that the impact of climate on conflict and asylum seeking flows is limited to specific time period and contexts.

1. Introduction

The ongoing Syrian conflict, which began in March 2011, has drawn attention from both the scientific community and the media to the question of how climatic conditions can contribute to political unrest and civil war. Recent studies of the Syrian uprising have shown that growing water scarcity and frequent droughts, coupled with poor water management, led to multiyear crop failures, economic deterioration and consequently mass migration of rural families to urban areas (Gleick, 2014; Kelley et al., 2015). Rapid growing population, overcrowding, unemployment and increased inequality put pressure on urban centers and finally contributed to the breakout of political unrest. Should these mechanisms be in place, the effect of anthropogenic climate change on the frequency and intensity of extreme events is expected to affect the risk of violent conflicts by aggravating such drivers of conflicts as poverty, food insecurity and inequalities (IPCC, 2014).

Conflicts bring about a series of negative consequences including premature death, disability, psychological trauma, physical injury and malnutrition (Murray et al., 2002). Likewise, conflict can also be the cause of displacement. There is evidence that violence, in particular, serves as a main push factor in the case of forced migration (Moore and Shellman, 2004; Schmeidl, 1997). If climate change does induce conflict, then indirectly climate change also contributes to forced migration. Indeed, recent media headlines, especially those on Europe's refugee crisis, often cite climate change-induced conflict in the Middle East and Africa as a major driver of the surge of migrants to Europe in the past couple of years. The narrative behind these headlines tends to follow a similar path, claiming climate change reduces availability and alters the distribution of resources such as water, food and arable land, which in turn trigger violent conflict and, as a consequence, migration. However, scientific literature linking climate, conflict and migration together is relatively scarce. The existing literature on the impacts of climate change on conflict and migration commonly assesses how environmental pressures instigate outmigration and consequently how climate change-induced migration promotes conflict in migrant receiving areas. The arrival of climate migrants can put pressure on infrastructure, services and the economy of the receiving area, leading to competition over resources, especially when the resources are scarce (Reuveny, 2007). However, whilst this narrative is common amongst scholars of peace and conflict studies (Homer-Dixon, 1999; Reuveny, 2008, 2007), there is little empirical evidence supporting this claim (Brzoska and Fröhlich, 2016; Raleigh and Urdal, 2007). Generally,

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drivers of migration such as climate, political factors, economic conditions and conflict are considered simultaneously in empirical specifications, without considering the pathway through which migration is determined. Typically, in macro-level studies at the country or regional level, migration flows are estimated using linear models, which control for relevant socioeconomic and political confounding variables. The specific impact of climate on migration is then isolated, often using multivariate models (Piguet, 2010). Beine and Parsons (2015), for instance, include international violence along with climate-related variables in their model and find that the increase in the incidence of international violence corresponds with higher migration flows. Likewise, using the occurrence of a civil war as a proxy for institutional quality, Drabo and Mbaye (2015) report a similar finding, although their result applies only to highly educated individuals. Whilst these models show a closed-form impact of conflict on migration they do not provide inference on any causal links between climatic or environmental factors and conflict and hence do not address the indirect pathway through which climate affects migration through conflict, that is often highlighted in the media.

To the best of our knowledge, there is no scientific study that has empirically established the links between climate change, conflict and migration and identifies the causal pattern in a convincing manner, partly due to the inherent complexity of the task (Fröhlich, 2016). As of now, both the empirical support and theoretical foundations of such relationship are scarce (Brzoska and Fröhlich, 2016). A recent article by Missirian and Schlenker (2017) addresses the relationship between asylum seeking and temperature fluctuations using asylum applications to the European Union between 2000 to 2014 as a proxy of conflict. Climate-induced conflict is thus not measured directly but through the assumption that asylum applications reflect distress-driven migration. Apart from employing a very limited approach and exclusively using temperature as a single climatic indicator, the study does not explicitly examine the causal link between climate and conflict. The lack of scientific rigour of the interpretations of the results offered has caused justifiable criticism by fellow scholars (see for example the discussion in http://wmbriggs.com/post/23581). Another recent study by Owain and Maslin (2018) explores how droughts and temperature variability are related to population displacement and conflict in East Africa. By including both conflict and displacement in the same empirical model, the study tests the relationships between climatic factors and conflict; and climatic factors and migration. In this research design, it is not possible to explicitly disentangle the pathways through which climate influences migration.

This paper aims to empirically establish the causal path from climate change to violent conflict and cross-border migration and explore how climate and conflict interplay in influencing asylum seekers flows. Exploiting bilateral refugee flows data for the years 2006–2015 for 157 countries, we employ sample selection methods for gravity-type models to first estimate the impact of climate on conflict and, secondly, how conflict influences forced migration. To the best of our knowledge, the causal link between climate, conflict and migration is investigated for the first time at this level of statistical rigour. Our study unpacks conflict as a causal mediator between climate change on the one hand and asylum migration on the other. This study thus provides an empirical assessment of scientific evidence on the popular claim regarding the role of climate change on conflict and migration. Our results suggest that climatic conditions, by affecting drought severity and the likelihood of armed conflict, play a statistically significant role as an explanatory factor for asylum seeking exclusively for countries that were affected by the Arab Spring.

The remainder of the paper is organised as follows. Section 2 provides a review of empirical literature on climate, conflict and migration and discusses the underlying mechanisms through which climate can influence migration. Section 3 describes estimation methods and data. Section 4 presents the main results and additional results from robustness checks. Section 5 discusses the main findings and concludes.

2. Review of the literature on conflict, climate and migration

As mentioned in the introduction, there is no study that empirically assesses the existing causal relationships between climate, conflict and migration simultaneously. Empirical studies on the subject tend to be organized along the triplet axes of climate change and migration; climate change and conflict; and conflict and migration. With respect to the first strand of literature, there is no empirical consensus on the relationship and the direction of association between climate change and migration – climatic shocks may induce, constrain or have no impact on migration depending on the particular characteristics of the climatic shock and the region of occurrence. Cross-national studies based on household surveys and micro-censuses report mixed evidence: whilst an increase in temperature is associated with higher international migration in Uganda, outmigration tends to decrease with a temperature rise in Burkina Faso and Kenya, and no relationship is found between migration and temperature anomalies in Nigeria and Senegal (Gray and Wise, 2016; Nawrotzki and Bakhtsiyarava, 2016). Even studies that focus on a particular country usually do not find an identical pattern. Rainfall deficits suppress US-bound migration from rural Mexico according to some studies (Hunter et al., 2013; Nawrotzki et al., 2015) but increase migration according to others (Barrios Puente et al., 2016). Likewise, macro level studies of bilateral migration between countries also report inconsistent findings with international migration increasing with higher temperature on the one hand (Backhaus et al., 2015; Cai et al., 2016; Cattaneo and Peri, 2016) and no relationship being found in other pieces (Beine and Parsons, 2015).

Inconsistency in the existing empirical findings is largely due to heterogeneity in measurement, methods and data used (Beine and Jeusette, 2018). Climate variables include both slow onset and fast onset events. The former captures long-run climatic factors typically measured as levels, deviations, anomalies or variability of precipitation and temperature. Fast onset climatic factors generally capture natural disaster events including temperature and precipitation extremes, floods, storms and droughts. Definitions of what is considered to be deviations from normality and extreme events, for instance, vary across studies. Likewise, migration encompasses different types of mobility including internal and international migration, forced and voluntary migration and is sometimes indirectly measured, for instance, the rate of urbanisation is used as a proxy for internal migration (Barrios et al., 2006). The choices of climate and migration definitions and measures can thus influence the direction and magnitude with which climate affects migration.

Furthermore, the lack of consensus reflected by these findings is partly due to the inherent complexity of migration processes. Climatic impacts on migration might be indirectly mediated through social, demographic, economic, political and environmental factors (Black et al., 2011; Hugo, 2011). The most widely used conceptual framework in the study of environmental migration is that of Black et al. (2011), which states that in addition to exercising a direct influence, environmental change induces changes in other drivers of migration and thus indirectly affects migration decisions. Indeed, some macro-level studies provide support of the indirect effect of climatic factors on international migration which run through reduction of crop yields (Cai et al., 2016), changes in GDP per capita (Cattaneo and Peri, 2016; Coniglio and Pesce, 2015) and wage differentials between origin and destination (Beine and Parsons, 2015). Even considering only the indirect channel, the effect of climatic factors on the mediators is not homogenous. Cattaneo and Peri (2016), for instance, report increased migration with higher temperature for middle-income countries, whilst migration is suppressed in low-income countries.

Climate change can potentially influence the drivers of migration through different climatic hazards such as a rise in sea level, change in the frequency and intensity of tropical storms and cyclones, changes in rainfall patterns, increases in temperature and changes in atmospheric chemistry (Black et al., 2011). These changes directly affect the environmental drivers of migration such as water availability and crop and pasture productivity, as well as provoking a loss of ecosystem services. Climate change also indirectly influences other drivers of migration. For instance, economic drivers are affected through the reduction of household incomes due to a decline in crop, livestock or fisheries productivity. Similarly, climate change exacerbates problems related to the availability of limited resources and violence emerges over access to these resources (Raleigh, 2010). Indeed, a systematic review of 53 studies on environmental change and migration focusing on Africa by Borderon et al. (2018) reports that there is no evidence showing that environmental change is the sole driver of migration. Considering complex interactions between migration drivers is thus essential when examining the link between climate and migration.

As for the second strand of literature on the relationship between climate and conflict, the evidence from large-scale studies appears fairly robust. By analysing 41 African countries during the period 1981–99, Miguel et al. (2004) suggest that rainfall variation affects the probability of the onset of conflicts through its effects on GDP per capita. Thus, short-term drops in the opportunity costs (i.e. from forgone earnings because of drought periods) of being a rebel (or government) soldier significantly increases the incidence of civil conflict. A recent meta-analysis of 60 quantitative studies confirms that the risk of conflict increases substantially with deviations from normal precipitation and mild temperatures (Hsiang et al., 2013). On average, one standard deviation change toward warmer temperatures or more extreme rainfall increases the frequency of interpersonal violence by 4% and intergroup conflict by 14%. Another meta-analysis of 55 studies reports a similar finding whilst emphasising that climate is unlikely to be the sole or even the primary driver of human conflict (Burke et al., 2015). Similar to how climate may affect migration, changes in climate also influence conflict through multiple pathways ranging from agriculture and economic productivity or demographic pressure to psychological mechanisms. However, quantitative research examining the key causal pathways is still in its infancy and more evidence is called for.

The challenges involved in disentangling the direct causal effects of climate variability on conflict occurrence have led to diverse empirical results linking these two phenomena depending upon research designs, variables used, case studies and scales of analysis (Ide, 2017; O'Loughlin et al., 2014). Special issues of the *Journal of Peace Research* and *Political Geography* (see Gleditsch, 2012; Nordås and Gleditsch, 2007) for instance, collect pieces of research on how climate affects conflict occurrence and present mixed evidence on this relationship. Raleigh and Urdal (2007) report a quantitatively small effect of environmental variables on the risk of conflict and highlight the role that freshwater scarcity plays in this relationship, and the results in Bernauer et al. (2012) lead the authors to recommend against the generalization of the link between environmental change and violent conflict. Buhaug et al. (2014) challenge the robustness of the results in Hsiang et al. (2013) by noting that they could be seriously affected by sample selection, since it would be difficult to consider the countries for which results are available (and thus are included in the meta-analysis by Hsiang et al., 2013) as randomly chosen. The issue of sample selectivity in studies assessing the climate-conflict link has also been recently addressed by Adams et al. (2018), who conclude that the fact that this literature has concentrated on few cases may have led to biases in the empirical results reported. In addition, the climate-conflict link may be affected by other variables that interact with environmental pressures, such as ethnical fractionalization (Schleussner et al., 2016), and may depend on the level of geographical granularity at which the phenomenon is assessed (O'Loughlin et al., 2012).

Although there is not much statistical evidence of the link between climate and conflict in Syria, the Syrian uprising provides a case study on how climate change and drought play a role in triggering conflict. During the period 2007–2010, Syria experienced the worst drought likely to be caused by anthropogenic climate change (Kelley et al., 2015). The three-year severe drought resulted in a dramatic reduction of the supply of groundwater. Severe droughts coupled with inadequate water management decisions, poor planning and policy errors led to large-scale multiyear crop failures. Dramatically rising food prices coupled with economic deterioration led to displacement and migration of rural farming families to urban areas (Gleick, 2014). The rapid increase in urban population from 8.9 million in 2002 to 13.8 million in 2010 put pressure on infrastructure, economic resources and social services in the urban areas which were key areas being neglected by the Assad government. The devastating consequences of drought due to poor governance and unsustainable agriculture and environmental policies consequently contributed to political unrest in Syria (Kelley et al., 2015). This narrative describes a pathway trough which climate change triggers conflict by its interactions with other socioeconomic factors. However, the work of Selby et al. (2017) casts doubts on this narrative, arguing that the evidence linking climate change to conflict in Syria is unreliable and that the scale of the migration caused by the drought was small.

If climate nevertheless does influence conflict, the next question is how conflict is linked with migration. The evidence from the third strand of literature on conflict and migration suggests that countries that experience different types of violent conflict tend to have higher outmigration and refugee flows (Beine and Parsons, 2015; Drabo and Mbaye, 2015; Gröschl and Steinwachs, 2016; Hatton and Williamson, 2003). However, not all conflicts result in migration: push factors play a role in determining outmigration flows whilst the area of destination is determined by pull factors attracting migrants to a specific region. Similar to the relationship between climate and migration, it is unlikely that conflict alone is a major driver of mobility and displacement but traditional push and pull factors such as differences in per capita income between origin and destination, population size and distance also influence outmigration considerably (Czaika and Kis-Katos, 2009; Lozano-Gracia et al., 2010). However, when conflict involves violence as measured by e.g. the ratio of victims of massacres, migration outflows increase with violence at the origin and migration inflows decreases as violence intensifies at the destination (Lozano-Gracia et al., 2010).

Likewise, it is also plausible that the influence of conflict on outmigration is indirect. Conflict affects many factors that may in turn induce migration, such as income loss, the breakdown of social relations and institutional failure. Some studies, for instance, do not find a direct effect of armed conflicts on migration but an indirect one working through the reduction in GDP per capita in origin countries (Coniglio and Pesce, 2015).

Note that the relationship between conflict and migration can be a reverse one. Literature in peace and conflict studies, in particular, often perceives conflict as an outcome of environmental migration (Raleigh, 2010; Reuveny, 2008, 2007). Environmental degradation and resource scarcity are assumed to lead to population movements in response to environmental pressure. The increase in the number of migrants can contribute to conflict in migrant receiving areas in many different ways. This ranges from competition over natural and economic resources, ethnic tensions, socioeconomic tensions and burden on infrastructure and services. Reuveny (2007) emphasises that in the context of neo-Malthusian resource scarcity, climate change-induced migration is particularly prone to creating conflict in the destination area because large and rapid migration flows prevent the receiving areas to smoothly incorporate migrants. There is however not much empirical support for this theoretical model, especially because the evidence on climate-induced mass migration is weak (Brzoska and Fröhlich, 2016; Fröhlich, 2016) and there are many other factors (e.g. political stability, economic conditions and capacity of government to provide services) that appear empirically more relevant than migration (Burrows and Kinney, 2016). The lack of evidence is supported by a recent study by Cattaneo and Bosetti (2017). The study finds no significant relationship between the presence of international climate migrants and conflict in destination countries. Therefore, a reverse causation of climate-induced

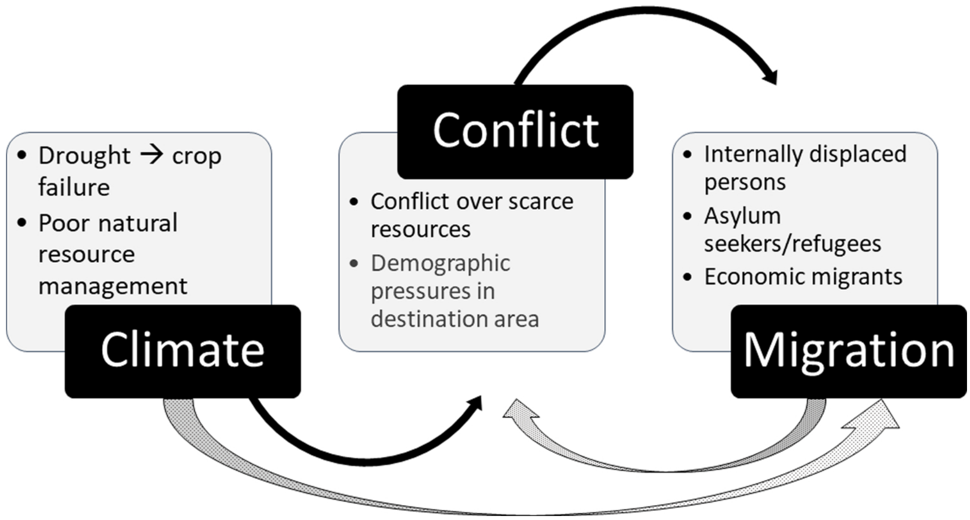

Fig. 1. Conceptual model of climate, conflict and migration.

migration leading to conflict is unlikely in our case.

Based on the empirical literature on the relationships between climate and conflict, as well as between conflict and migration, the impact of climate change on migration can be thought of as being mediated through conflict in the structure presented in Fig. 1. The relationship between climate change, conflict and migration is likely to follow the sequence of climate change exacerbating human conflict due to competition over scarce resources. For instance, recurrent severe droughts due to climate change can lead to conflict and instability in a country with poor management of natural resources. Consequently, climate-induced conflict outbreak drives displacement and outmigration. Fig. 1 also presents a possibility of the reverse causation depicted by grey arrows whereby climate change first drives outmigration and subsequently migrant pressure contributes to conflict.

To model the causality structure of the relationship between climate, conflict and migration, the analysis should be done in two steps, by first looking at how climate influences conflict and secondly how conflict drives migration. Nevertheless, generally, drivers of migration (e.g. climate, political factors, economic conditions and conflict) are assessed simultaneously in the literature without considering the causal structure through which migration is determined. To this end, this study aims at empirically establishing the causal path from climate change to violent conflict and to cross-border migration, and to explore how climate and conflict interplay in influencing cross-border migration. Exploiting bilateral asylum seeking flow data for the years 2006–2015 for 157 countries, we employ a gravity-type model with endogenous selection to estimate the impact of climate on conflict and secondly to assess how conflict influences forced migration. This study thus provides an empirical assessment of the popular claim regarding the role of climate change on conflict and migration.

3. Modelling global asylum-seeking flows and data

3.1. Model specification and estimation methods

Our modelling framework aims at assessing quantitatively the determinants of asylum seeking flows using a gravity equation setting similar to that proposed for bilateral migration data (Cohen et al., 2008) but addressing explicitly the statistical problems of endogenous selection in origin-destination pairs and non-random treatments. In this sense, our statistical problem is similar to those often encountered in health care studies, where for example the enrollment in a healthcare maintenance organisation (treatment) affects a person's decision on both whether to use healthcare at all (extensive margin) and how much to spend for healthcare (intensive margin), given a positive decision.

In our setting, however, conflict (treatment) itself is not randomly 'assigned' across the population of origin countries, that is, we have to consider the treatment itself to be endogenous as well. As with the healthcare example given above, this treatment (conflict) potentially affects the probability that we observe non-zero flows between some origin-destination country pairs (extensive margin). In other words, we have to account for a selection of countries in sending out migrants to a certain country of destination. Furthermore, conflict potentially affects the number of migrants seeking asylum in some destination countries. The number of migrants, however, is only observed in the case of actual flows and thus has to be considered as being potentially (non-randomly) censored.

This setting leaves us with three simultaneous equations, where two of them contain our common endogenous binary regressors (i.e. conflict onset). In order to estimate this framework of simultaneous equations, we apply a simple two-step estimation technique proposed by Kim (2006). Translated to our context, we are interested in the following sample selection model:

$$c_i^* = Z_{c,i}^{'}\gamma_1 + \varepsilon_{c,i},\ \ c_i = I(c_i^* > 0) \quad (1)$$

$$s_{ij}^* = Z_{s,ij}^{'}\gamma_2 + c_i\beta_2 + \varepsilon_{s,ij},\ \ s_{ij} = I(s_{ij}^* > 0), \quad (2)$$

$$a_{ij}^* = Z_{a,ij}^{'}\gamma_3 + c_i\beta_3 + \varepsilon_{a,ij},\ \ a_{ij} = a_{ij}^* s_i, \quad (3)$$

where Eq. (1) specifies the occurrence of conflict ($c_i = 1$) in country i, Eq. (2) addresses whether a non-zero flow of asylum seeking applications takes place from country i to country j ($s_{ij} = 1$) and Eq. (3) models the size of the flow of applications in logs (a_{ij}) from origin country i to destination country j for origin-destination pairs with non-trivial flows. $I(x)$ is an indicator function taking value one if x is true and zero otherwise and the exogenous controls for each one of the equations in the model are summarized in the vectors $Z_{c,i}$, $Z_{s,ij}$ and $Z_{a,ij}$, respectively. The error terms, $\varepsilon_{c,i}$, $\varepsilon_{s,ij}$ and $\varepsilon_{a,ij}$, are assumed jointly multivariate normal and potentially correlated, thus capturing the endogenous selection of origin countries that present non-zero asylum applications to destination countries. Following Kim (2006), this sample selection model with a common endogenous regressor in the selection equation and the censored outcome equation is estimated as a hybrid of the bivariate probit and the type-II Tobit model containing the common endogenous binary conflict indicator. This implies that we have to control for the endogeneity caused by c_i and the selection bias caused by the censoring indicator s_{ij} at the same time.

Instead of a simulation assisted Full Maximum Likelihood (FIML) approach, we follow Kim (2006) and employ a simple two-step estimation technique by first estimating the bivariate probit model with structural shift (Eqs. (1) and (2)) and further use the estimation results of this first stage as control functions for the censored outcome equation using a simple Generalized Method of Moments (GMM) estimator. This way we can interpret the model as a Type V-Tobit model with bivariate selection and parameter restrictions. This approach bears the advantage of being numerically robust and easy to implement since it relaxes the strong normality assumptions imposed when using the FIML approach.

For the empirical identification, we impose exclusion restrictions, that is, for each regression we include regression-specific covariates that identify treatment and selection, respectively. These regression-specific covariates affect the main dependent variable (i.e. number of asylum applicants) only through the instrumental variable (endogenous treatment or selection identifier in our case) and not directly. This statistical approach allows us to directly discuss potential climate related effects on conflict and thus - through the imposed statistical structure - on asylum seeker flows.

3.2. Data and measurement

3.2.1. Asylum-seeking flows data and patterns

Bilateral data on asylum applications are sourced from the United Nations High Commissioner for Human Rights (UNHCR) (UNHCR, 2018). The data are provided to UNHCR by a mixture of sources. In more developed countries, host governments are generally the sole data provider, whilst in developing countries UNHCR field offices and other NGOs play a more important role in data collection.

Asylum seekers are defined as individuals who have sought international protection and whose claims for refugee status have not yet been determined. The UNHCR data contains information about asylum applications by year and the progress of asylum-seekers through the refugee status determination process starting in the year 2000. We focus on asylum seeking applications for two reasons. First, asylum seeking can be linked to conflict more directly than regular migration which is driven by various other push and pull factors. Second, whilst refugee flows are also likely to be driven by conflict, they are endogenous to a host country's specific policy in granting a refugee status. We therefore use asylum application data since actual stock and refugee figures are prone to be strongly affected by country-specific political actions.

Fig. 2 shows chord diagram plots depicting cumulative bilateral links for asylum seekers in the periods 2006–2010 and 2011–2015 based on bilateral data from the UNHCR. In the first period considered, the largest source of asylum seekers was from Sub-Saharan Africa, with many of them making applications within the region. Additionally, Western Europe received a large volume of asylum applications, especially from Northern Africa and Western Asia, Sub-Saharan Africa and Southern Asia. In the period 2011–2015, the number of asylum applications in Sub-Saharan Africa remained large (about 1.8 million asylum seekers). However, the origin regions of the largest number of asylum seekers in this period were Northern Africa and Western Asia (over 2.4 million), predominantly in Syria and other countries affected by the Arab spring. Many of those seeking asylum from these countries made applications in countries of Southern Europe and Western Europe.

3.2.2. Conflict data

Information on battle-related deaths are from the Uppsala Conflict Data Program (UCDP) Georeferenced Event Dataset (GED) Global version 17.1 (UCDP, 2018). The dataset contains 135,181 events and the dataset covers the entirety of the globe (excluding Syria), with information ranging from January 1989 to December 2016. The figures for Syria are obtained from the UCDP Battle Related Deaths Dataset 17.1, which contains conflict-year and dyad-year information on the number of battle-related deaths in conflicts from 1989 to 2016. The most recent version is version 17.1. Conflict is defined by the existence of at least one yearly battle-related death, although robustness checks are carried out using a threshold of 25 casualties.

3.2.3. Climate data

Climatic factors are measured using the Standardised Precipitation-Evapotranspiration Index (SPEI). The SPEI is a multiscalar drought index based on climatic data and used for determining the onset, duration and magnitude of drought conditions with respect to normal conditions in a variety of natural and managed systems (e.g. crops, ecosystems, rivers). SPEI data are obtained from the Global SPEI database, which offers historical information about drought conditions at the global scale, with a spatial resolution of 0.5° and monthly periodicity (Beguería et al., 2010). The current version of the dataset covers the period between January 1901 and December 2015 based on Climatic Research Unit's TS 3.23 input data (monthly precipitation and potential evapotranspiration (Harris et al., 2014).

SPEI measures the intensity and spatial distribution of droughts. It is

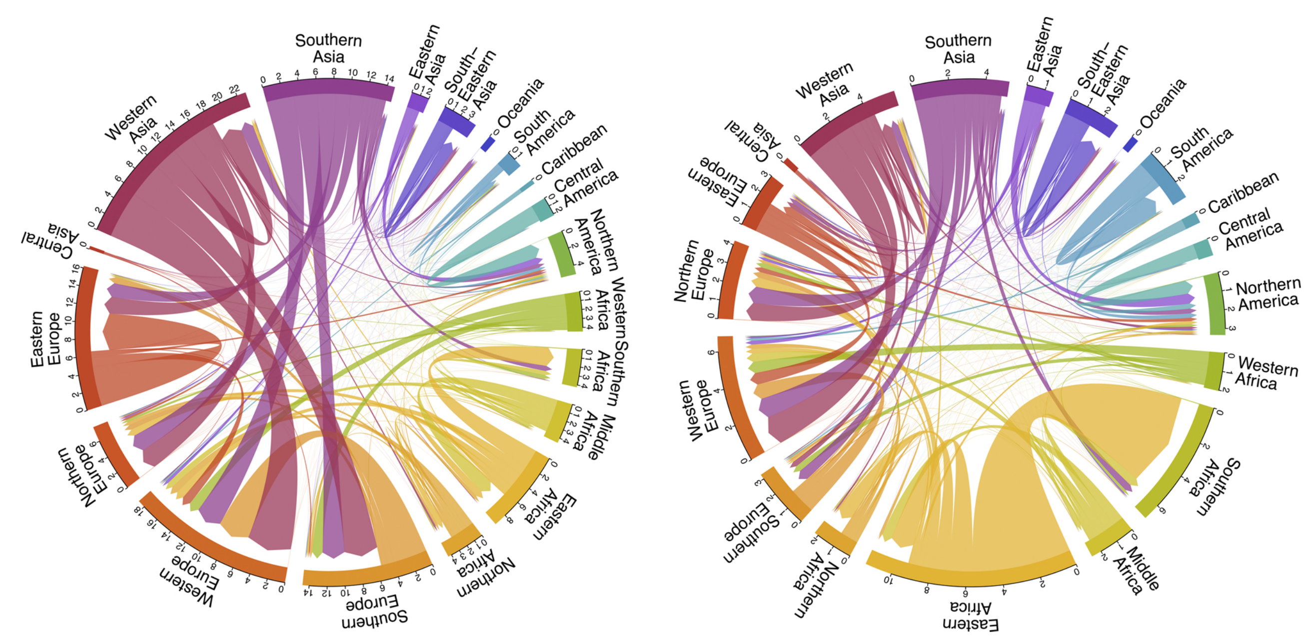

Fig. 2. Asylum seeking flows by world region, 2006–2010 and 2011–2015.

considered superior to other drought indices, since it captures the effects of evaporation and transpiration caused by temperature, along with precipitation (Vicente-Serrano et al., 2010). SPEI is measured on an intensity scale with negative values, indicating drought conditions, and positive values, indicating wet conditions. The index can be used to further categorise drought conditions into mild (-1 < SPEI < 0), moderate (-1.5 < SPEI ≤ -1), severe (-2 < SPEI ≤ -1.5), and extreme (SPEI ≤ -2) (Mckee et al., 1993; Paulo and Pereira, 2006).

3.2.4. Socioeconomic and geographic data

The information on the remaining covariates employed in our model is obtained from a variety of sources. Additional variables in Eqs. (1) and (2) include variables which are a standard battery of controls previously used in the literature when considering determinants of conflict (Collier and Hoeffler, 2002, 1998; Fearon and Laitin, 2003; Miguel et al., 2004). Variables such as ethnic polarization measures, economic performance approximated by log-transformed GDP per capita before the observational period and the level of democratization are included to control for potential confounders of conflict.

For the estimation of asylum-seeking flows, we include standard control variables: distance between country of origin and country of destination, whether countries share a common language, a dummy variable measuring whether the countries have a colonial relation, population size at the country of origin and destination and migrant networks. The choice of covariates is based on the previous literature that employs gravity models to estimate bilateral migration flows in the context of climate change (Backhaus et al., 2015; Beine and Parsons, 2015). This set of control variables captures bilateral and country-specific push and pull factors different from conflict in the country of origin.

The data for the variables in the gravity model that builds the third stage of our empirical specification is partly sourced from Mayer and Zignago (2012), with data on the distance between countries based on capital cities. The results of our analysis are qualitatively unchanged when most populated areas or country centroids are used instead of capital cities. The measurement of a country's political status is measured using the Polity IV index (Marshall et al., 2017), normalized between 0 (autocracy) and 1 (democracy). Our ethnic polarization measurement is obtained from the Geographical Research On War, Unified Platform (Bormann et al., 2015). When data are missing, the CIA Factbook is used as a source of information. For the calculation of the ethnic polarization index, we apply the Garcia-Montalvo (Montalvo and Reynal-Querol, 2005) and compute

$$4\sum_{i=1}^{N}\pi_i^2(1-\pi_i)$$

Here, π_i is just the proportion of people that belong to the ethnic (religious) group i and N is the number of groups. We also estimated our model using conventional fractionalization indices, given by $1-\sum_{i=1}^{N}\pi_i^2$, yielding no qualitative changes to the results of our analysis. Socioeconomic indicators such as GDP per capita and population figures are sourced from Feenstra et al. (2015) and missing information in this dataset is interpolated making use of the International Monetary Fund's WEO Database (IMF, 2018).

4. Results

4.1. Main results

Tables 1 and 2 present the parameter estimates of Eqs. (1)–(3), obtained using the method described in Kim (2006) for cross-sectional data corresponding to different 5-year subperiods (2006–2010, 2011–2015), as well as three-year periods (2007–2009, 2010–2012 and 2013–2015). The parameter estimates for the equations modelling conflict and selection to asylum seeking are presented in Table 1. These results indicate that armed conflict tends to be persistent, with countries that have experienced a large number of battle-related deaths prior to the period under study having a higher probability of conflict. Countries with levels of medium democracy, on the other hand, tend to present a higher probability of conflict when compared to their fully democratic or autocratic counterparts. Differences in the severity of drought episodes (related to lower values of the SPEI) are able to significantly explain differences in the onset of conflict in the period between 2011 and 2015, but not for 2006–2010. The predictive power of the variable is mostly driven by its ability to explain conflicts occurring in the interval 2010–2012 and thus appear related to the emergence of armed conflict in the context of the Arab spring and the Syrian war, in addition to war episodes in Sub-Saharan Africa. As can be inferred from the significant positive parameter estimate of the conflict dummy in the asylum seeking selection equation, countries that experience war tend to be systematically more prone to present non-zero asylum seeking applications to the rest of the world. Countries with a history of asylum seeking linkages (be it as an origin or a destination) tend to have a higher probability of sending or receiving asylum seeking applications, and this probability is also higher for nations which are geographically close to each other.

The marginal effects of the SPEI variable on conflict and selection to asylum seeking for the 2010–2012 period are presented in Fig. 2 for all countries in our dataset. It should be noticed that the nonlinearity embodied in the link between climate, conflict occurrence and refugee flows implies that the quantitative effect of changes in drought probabilities on asylum seeking depends on the rest of the variables of the model. The model therefore allows for global and regional economic conditions to affect the probability of a given climatic shock creating asylum seeking flows and predicts different effects by country. Aggregating marginal effects by world region, our results indicate that the effect of changes in the SPEI index appears particularly large in Sub-Saharan African countries, some Central and South American nations, as well as in Asia. The combined average marginal effect for the SPEI variable in the period 2010–2012 implies that a one (within-country) standard deviation decrease in the SPEI leads on average to an increase of approximately 0.03 in the probability of asylum seeking flows from the country experiencing this change in climatic conditions. Such a link between changes in drought severity and asylum seeking flows is mediated by the increase in conflict probability caused by the change in the climatic variable, which can be very large in some world regions, as shown in the first panel of Fig. 3.

The parameter estimates for Eq. (3), which have a direct specification as (semi-)elasticities, are presented in Table 2. A higher number of asylum seeking flows are found in destination countries which share the same language as the origin country. Asylum seeking applications tend to take place from countries with relatively low indicators of democracy to countries where civil liberties and political rights are well developed. Depending on the subsample on which the estimation is carried out, the point estimates in Table 2 imply that existence of conflict in the origin country increases the flow of asylum seeking applications to a given destination by 95 to 146 percent.

Based on the experience of the current decade, our results lend support to the existence of a mechanism whose causality runs in a first stage from climate to conflict and in a second stage from conflict to sending out asylum seekers and subsequently the size of asylum seeking flows. This causal linkage, however, is mostly related to the experience of conflicts in the years 2010–2012, a sub-period that was dominated by the birth of military conflicts in Libya, Egypt, Syria and South Sudan.

4.2. Robustness checks

The main results suggest that the influence of climate on conflict occurrence and subsequent asylum seeking flows applies to a specific geographical context and time period. In order to understand how the experience of particular world regions in the period studied and the

Table 1
Parameter estimates: Conflict and selection to asylum seeking equations.

	2006–2010	2011–2015	2007–2009	2010–2012	2013–2015
Conflict					
αT	−1.92***	−1.66*	−1.26·	−1.79*	−0.87
	(0.58)	(0.75)	(0.65)	(0.75)	(0.63)
Battle Deaths$_{t\text{-}1}$	0.31***	0.34***	0.43***	0.31***	0.49***
	(0.05)	(0.05)	(0.09)	(0.05)	(0.12)
SPEI Index$^{12}{}_{t\text{-}1}$	−0.72	−1.01·	−0.19	−1.24*	−1.45·
	(0.57)	(0.52)	(0.55)	(0.51)	(0.86)
Democratization$^{o}{}_{t\text{-}1}$	3.41	3.68	2.02	6.78*	1.23
	(2.68)	(3.03)	(2.26)	(2.83)	(2.66)
(Democratization$^{o}{}_{t\text{-}1}$)^2	−3.22	−3.60	−2.25	−6.63**	−1.55
	(2.42)	(2.86)	(2.05)	(2.53)	(2.48)
Diaspora$^{o}{}_{t\text{-}1}$	−3.09	−3.15	−9.75**	−2.78	−3.00
	(2.77)	(3.55)	(3.76)	(2.55)	(2.77)
Ethnic Polarization$^{o}{}_{t\text{-}1}$	0.53	−0.15	1.01	−0.54	−0.37
	(0.62)	(0.75)	(0.72)	(0.57)	(0.57)
Selection					
αS	−3.01***	−3.25***	−3.75***	−3.43***	−4.21***
	(0.18)	(0.20)	(0.19)	(0.20)	(0.22)
Distance	−0.26***	−0.24***	−0.27***	−0.24***	−0.19***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Distance^2	−0.03	−0.05*	−0.04*	−0.05*	−0.07**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Total Outmigration$^{o}{}_{t\text{-}1}$	0.19***	0.19***	0.22***	0.20***	0.23***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Total Immigration$^{d}{}_{t\text{-}1}$	0.24***	0.27***	0.30***	0.28***	0.31***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Endogenous Treatment					
Conflict	0.53***	0.54***	0.45***	0.53***	0.49***
	(0.13)	(0.12)	(0.10)	(0.13)	(0.11)
Control Terms					
ρ_{120}	−0.29*	−0.39***	−0.29*	−0.33***	−0.41*
	(0.12)	(0.09)	(0.13)	(0.08)	(0.18)
ρ_{121}	−0.19*	−0.15	−0.15*	−0.30*	−0.16*
	(0.09)	(0.10)	(0.07)	(0.12)	(0.07)
Log Likelihood	−18496.99	−17229.64	−15956.40	−17182.41	−15176.29
AIC	37,023.98	34,489.28	31,942.80	34,394.82	30,382.58
BIC	37,145.48	34,610.78	32,064.30	34,516.32	30,504.07
Number of observations (all)	24,336	24,336	24,336	24,336	24,336

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ·$p < 0.1$.
Standard errors clustered at country of origin and country of destination.
Natives in destination measured as log-transformed stock of the respective origin natives in the destination country.
Distance is measured as geodesic distance between origin and destination countries.
Colonial Relation indicates, whether there has ever been a colonial relationship between origin and destination ('Mother Country').
Democracy measures the democratic or autocratic tendency of a countries political rule from 0 (autocratic) to 1 (democratic).
GDP measures the Gross domestic production of country i measured in logs.
μ_{ij} are the respective auxiliary parameters used in the GMM second stage estimation. (See Kim (2006)).

definition of conflict affect our results, we perform a robustness check using different model specifications. In particular, for the period where we find a significant effect of climate on asylum seeking flows (2010–2012), we change the definition of conflict by using a threshold of 25 battle-related deaths and reestimate our main model excluding the regions of Western Asia and Northern Africa. These were the parts of the world affected by the Arab Spring in the period under study.

Table 3 presents the parameter estimates for the conflict and selection to asylum seeking equations (Eqs. (1) and (2)) for the period 2010–2012. We also perform a similar robustness check for the third equation, estimating asylum seeking flow size. The results for the estimates of this equation are robust and is provided in the Supplementary Material.

Changing the definition of our conflict variable and the sample of countries employed in the estimation substantially modifies the results of the conflict and selection equations and thus provides valuable information about the nature of the effect of climate on asylum seeking. In particular, the redefinition of the conflict variable, as well as the exclusion of countries in the Western Asian and Northern African region (both individually and as a single region, named Arab Spring region in Table 3), renders the effect of the climate variable insignificant in the period under consideration. These results imply that the effect of SPEI on conflict occurrence is specific to relatively small conflicts (as defined by battle deaths) and to countries which were affected by the Arab Spring in the period 2010–2012.

5. Discussion and conclusions

Existing frameworks for the study of migration drivers tend to define five categories of factors affecting migration flows (see Lee, 1966) and the embedding of this framework in climate change research by (Black et al., 2011): economic drivers (differences in income and employment opportunities that act as determinants of migration flows), political drivers (with conflict being one of its most important materializations), demographic drivers (related to the size and composition of populations in origin regions, as well as health-related factors), social drivers (that include cultural practices) and environmental drivers (linked to ecosystem services). Our study concentrates on how environmental and political drivers interact with each other as determinants of forced migration as measured by asylum seeking applications. Our analysis assesses quantitatively the climate-conflict-migration association at a global level using an econometric model that aims at

Table 2
Parameter estimates: Asylum seeking flow size.

	2006–2010	2011–2015	2007–2009	2010–2012	2013–2015
Exogenous Variables					
α	1.41*	0.53	3.69***	1.28*	1.40
	(0.61)	(0.64)	(0.64)	(0.62)	(0.85)
Natives in Destination$_{t-1}$	0.21	0.19	0.18	0.19	0.18
	(0.53)	(0.50)	(0.60)	(0.55)	(0.62)
Distance	0.32·	0.30·	0.29	0.30·	0.32·
	(0.18)	(0.17)	(0.19)	(0.18)	(0.19)
Distance^2	−0.09	−0.12	−0.04	−0.09	−0.12
	(0.36)	(0.33)	(0.37)	(0.35)	(0.35)
Common Language	0.60***	0.34***	0.49***	0.39***	0.16·
	(0.07)	(0.07)	(0.07)	(0.07)	(0.09)
Colonial Relation	0.02	0.26·	0.16	0.22	0.13
	(0.14)	(0.15)	(0.14)	(0.14)	(0.17)
Democratization$^{o}_{t-1}$	−0.97***	−1.18***	−0.65***	−0.94***	−0.99***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)
Population$^{o}_{t-1}$	−0.08	−0.09	−0.10	−0.07	−0.03
	(1.73)	(1.64)	(1.80)	(1.72)	(1.81)
GDP$^{d}_{t-1}$	0.19	0.18	0.08	0.15	0.06
	(1.02)	(0.97)	(1.07)	(1.02)	(1.09)
Democratization$^{d}_{t-1}$	0.36*	0.91***	0.41**	0.69***	0.37*
	(0.14)	(0.14)	(0.14)	(0.15)	(0.18)
Population$^{d}_{t-1}$	0.07	0.12	0.01	0.06	0.13
	(1.75)	(1.65)	(1.82)	(1.74)	(1.82)
Treatment					
Conflict	1.27***	1.46***	0.95***	1.30***	1.30***
	(0.13)	(0.13)	(0.13)	(0.13)	(0.16)
Control Terms					
μ_{11}	−0.24**	−0.17*	−0.45***	−0.33***	−0.11
	(0.09)	(0.08)	(0.07)	(0.10)	(0.08)
μ_{12}	−2.33***	−2.34***	−2.38***	−2.14***	−2.37***
	(0.11)	(0.11)	(0.10)	(0.11)	(0.12)
μ_{01}	−0.53***	−0.59***	−0.01	−0.42***	−0.65**
	(0.10)	(0.09)	(0.12)	(0.08)	(0.20)
μ_{02}	−1.72***	−1.68***	−1.94***	−1.62***	−1.62***
	(0.10)	(0.10)	(0.10)	(0.09)	(0.12)
AIC	63,798.19	67,187.72	57,747.92	61,042.74	63,773.28
BIC	63,927.78	67,317.31	57,877.52	61,172.33	63,902.88
Number of observations (all)	24,336	24,336	24,336	24,336	24,336
Number of observations (truncated)	6140	6363	5271	5769	4745
Number of observations (treated)	6240	5928	7020	6708	6864

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ·$p < 0.1$.
Standard errors clustered at country of origin and country of destination.
Natives in destination measured as log-transformed stock of the respective origin natives in the destination country.
Distance is measured as geodesic distance between origin and destination countries.
Colonial Relation indicates, whether there has ever been a colonial relationship between origin and destination ('Mother Country').
Democracy measures the democratic or autocratic tendency of a countries political rule from 0 (autocratic) to 1 (democratic).
GDP measures the Gross domestic production of country i measured in logs.
μ_{ij} are the respective auxiliary parameters used in the GMM second stage estimation. (See Kim (2006)).
Specification uses I(Battle deaths > 0) as treatment on the full distribution of origin-destination pairs.

identifying these links explicitly. In addition, the choice of an econometric framework that explicitly assesses sample selection allows us to interpret our results in a causal manner. In particular, the methodology developed by Kim (2006), which we apply in our analysis, explicitly assesses the biases that may be implied by the lack of random selection in the outbreak of conflict and in the existence of non-zero asylum applications. By overcoming the problem of endogenous selection, this method allows us to identify our estimates as measuring the actual causal link going from climate to conflict and asylum seeking. In contrast to the analysis carried out by Missirian and Schlenker (2017), our results indicate that there is no empirical evidence backing the existence of a robust link between climatic shocks, conflict and asylum seeking for the full period 2006–2015. The estimates of our model support these causal linkages only for the period 2010–2012, where global refugee flow dynamics were dominated by asylum seekers originating from Syria and countries affected by the Arab spring, as well as flows related to war episodes in Sub-Saharan Africa.

Excluding these regions from the analysis provides further statistical evidence, that the link between climate shocks, conflict and subsequent migration flows might rather be interpreted as a local phenomenon and therefore very specific to these regions. Indeed, our study shows that an increase in drought episodes can drive outmigration through exacerbating conflict in a country with some level of democracy. This is confirmed by the finding that climate contributes to conflict only in a specific period of 2010–2012 and specifically to certain countries, particularly those in Western Asia and Norther Africa experiencing the Arab Spring. Climate change thus will not generate asylum seeking everywhere but likely in a country undergoing political transformation where conflict represents a form of population discontent towards inefficient response of the government to climate impacts.

In line with Miguel et al. (2004), the results of our study imply that policies to improve the adaptive capacity to deal with the effects of climate change in developing economies may have additional returns by reducing the likelihood of conflict and thus forced migration outflows. From a policy point of views, our empirical analysis provides empirical backing to some of the arguments put forward, among others, by Barnett (2003), who argues for conceptualizing global responses to climate change also in the framework of national security

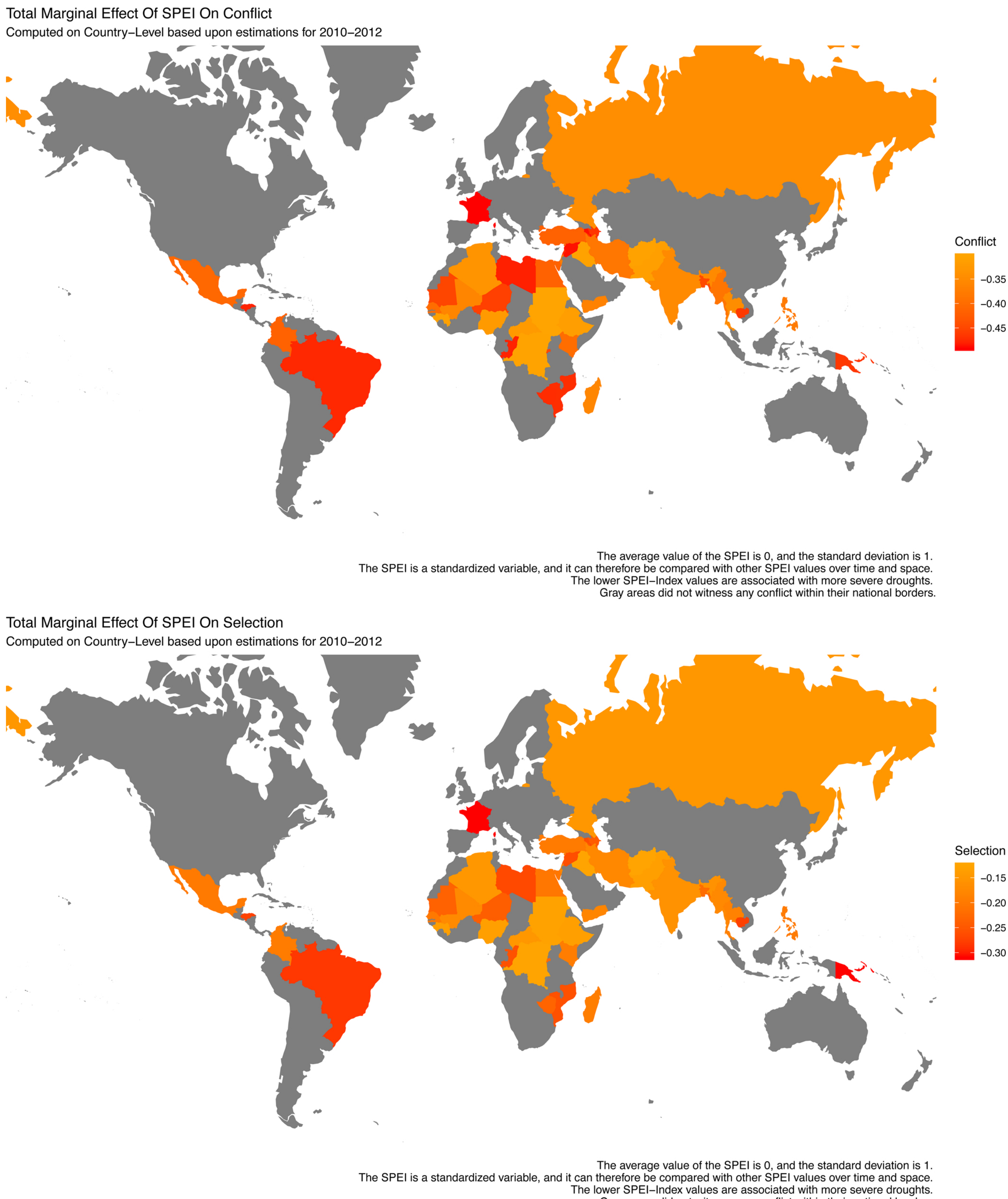

Fig. 3. Marginal effects of SPEI on conflict and selection to asylum seeking for the 2010–2012 period.

considerations and human security concerns. The integration of concerns related to conflict-driven forced migration in the current policy discourse concerning actions to combat climate change appears particularly urgent in the context of the targets defined by the Sustainable Development Goals (SDGs). The link between climate change and migration is not made explicit in the SDGs, which focus on adaptation measures and do not treat forced migration and climate change as interrelated phenomena which may be moderated by conflict onset. The results presented provide empirical backing to the connection of these two policy goals in the design of climate change responses at the global

Table 3
Robustness check: Conflict and selection to asylum seeking equations for the period 2010–2012.

	Baseline	25 Battle Deaths	Without Western Asia	Without Northern Africa
Conflict				
αT	-1.79^{*}	-1.90^{*}	$-1.65^{\cdot}$	-2.03^{*}
	(0.75)	(0.81)	(0.89)	(0.81)
Battle $Deaths_{t\text{-}1}$	0.31^{***}	0.38^{***}	0.28^{***}	0.31^{***}
	(0.05)	(0.07)	(0.05)	(0.05)
SPEI $Index^{12}{}_{t\text{-}1}$	-1.24^{*}	-1.00	-0.77	$-1.04^{\cdot}$
	(0.51)	(0.70)	(0.59)	(0.53)
$Democratization^{o}{}_{t\text{-}1}$	6.78^{*}	2.46	7.08^{*}	7.26^{*}
	(2.83)	(3.19)	(3.40)	(2.97)
$(Democratization^{o}{}_{t\text{-}1})^2$	-6.63^{**}	-2.56	-6.69^{*}	-6.91^{**}
	(2.53)	(3.20)	(2.91)	(2.63)
$Diaspora^{o}{}_{t\text{-}1}$	-2.78	-0.75	-11.37	-2.28
	(2.55)	(4.89)	(7.73)	(2.59)
Ethnic $Polarization^{o}{}_{t\text{-}1}$	-0.54	-0.61	-0.40	-0.51
	(0.57)	(0.87)	(0.69)	(0.57)
Selection				
αS	-3.43^{***}	-3.46^{***}	-3.43^{***}	-3.52^{***}
	(0.20)	(0.19)	(0.21)	(0.20)
Distance	-0.24^{***}	-0.24^{***}	-0.22^{***}	-0.23^{***}
	(0.03)	(0.04)	(0.04)	(0.03)
$Distance^2$	-0.05^{*}	-0.05^{*}	-0.06^{**}	-0.05^{*}
	(0.02)	(0.02)	(0.02)	(0.02)
Total $Outmigration^{o}{}_{t\text{-}1}$	0.20^{***}	0.21^{***}	0.21^{***}	0.20^{***}
	(0.02)	(0.02)	(0.02)	(0.02)
Total $Immigration^{d}{}_{t\text{-}1}$	0.28^{***}	0.28^{***}	0.28^{***}	0.29^{***}
	(0.02)	(0.02)	(0.02)	(0.02)
Endogenous Treatment				
Conflict	0.53^{***}	0.40^{**}	0.44^{**}	0.47^{***}
	(0.13)	(0.13)	(0.14)	(0.13)
Control Terms				
ρ_{120}	-0.33^{***}	-0.36^{***}	-0.31^{***}	-0.31^{***}
	(0.08)	(0.11)	(0.08)	(0.08)
ρ_{121}	-0.30^{*}	-0.04	-0.27^{*}	-0.27^{*}
	(0.12)	(0.09)	(0.13)	(0.12)
Log Likelihood	−17182.41	−14623.27	−13011.41	−15558.13
AIC	34,394.82	29,276.54	26,052.81	31,146.27
BIC	34,516.32	29,398.04	26,170.85	31,266.59
Number of observations (all)	24,336	24,336	19,321	22,500

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.
Standard errors clustered at country of origin and country of destination.
Natives in destination measured as log-transformed stock of the respective origin natives in the destination country.
Distance is measured as geodesic distance between origin and destination countries.
Colonial Relation indicates, whether there has ever been a colonial relationship between origin and destination (‘Mother Country’).
Democracy measures the democratic or autocratic tendency of a countries political rule from 0 (autocratic) to 1 (democratic).
GDP measures the Gross domestic production of country i measured in logs.
μ_{ij} are the respective auxiliary parameters used in the GMM second stage estimation. (See Kim (2006)).
Specification uses I(Battle deaths > 25) as treatment on the full distribution of origin-destination pairs.

level, a proposal recently voiced also by Stapleton et al. (2017).

Gaining a deeper understanding of the characteristics of migration flows which are driven by climate shocks is a potentially promising path of further research. The availability of data for refugee populations (see Buber-Ennser et al., 2016, for example) should enable future empirical studies which will shed light on the particular mechanisms through which climate change acts as a push factor through its role as a catalyst of conflict. While our analysis concentrates on asylum seeking flows due to data availability at the global level, case studies that would be able to quantify forced migration flows in a more detailed manner would also be important in order to advance our knowledge on the causalities underlying the climate-conflict-migration trinity.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.gloenvcha.2018.12.003.

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