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# What Drives Migratory Pressure at the Southern EU Borders?

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**Abstract**

In the wake of the "migration crisis" of 2015 in the Mediterranean region, environmental factors (e.g. droughts) have re-emerged as a possible major driver of emigration. In this paper, I make use of a novel data set for the study of migration drivers: illegal border-crossings (IBCs) into the Schengen Area in Europe. They are correlated with another measure of distress-driven migration, applications for asylum (into the European Union), and respond in the expected direction to known drivers of migration (e.g. income at origin). They have the unique merits over other measures of migration of quantifying the *inflow* of immigrants at a high frequency (monthly), and of being immune to some of the typical concerns that plague administrative data in the study of international migration to Europe, namely lack of cross-country comparability and inability to capture illegal migration. I examine the response of this new measure of distress-migration to weather shocks in the origin country of migration. While these weather shocks indeed influence the number of illegal crossings detected, the clear nonlinear relationship in temperature established in previous work on asylum seekers is not robust anymore. I discuss potential explanations and implications for future research.

**Keywords:** international migration, illegal migration, asylum-seekers, European Union.

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# 1 Introduction

Migration and the place of foreigners in a society have always been a salient, and often defining issue for nations. Research, through the lens various disciplines, has tried to shed light on the where, the why, the who, the how (and the then what) of human migrations. The more recent awakening to global changes and their consequences has, however, brought forth a new set of preoccupations regarding migration, namely, are environmental degradations, and in particular climate change, likely to affect current and future migration flows?[1]

In its most recent annual report, the European Border and Coast Guard Agency estimated that

> "In 2015, Member States reported more than 1 820 000 detections of illegal border-crossing along the external borders. This never-before-seen figure was more than six times the number of detections reported in 2014, which was itself an unprecedented year, with record monthly averages observed since April 2014." [Frontex, 2016]

The sheer magnitude of migrant inflow was such that that episode was dubbed "the migration crisis". As a point of comparison, the latest events of mass-migration in the 20th century saw the displacement of about 20 million Europeans following the Potsdam Agreement (1945), and of some 14 million people in the cross-exodus that took place around the partition of the British Indian Empire into India and Pakistan.[2] The nearly 2 million detections mentioned in the above quote, on the other hand, occurred over 12 months, and resulted not from a single war or geopolitical event, but from several concomitant conflicts or crises.

This particular episode gave rise not only to a recrudescence of febrility on migratory questions in the public debate and to migration fear-mongering, but also to heightened concern over climate change's effects on migration, in the public debate as well as in scientific communities.[3]

Better understanding migration has become a more pressing policy need and a more intricate academic undertaking. On the one hand, both the touchiness of the subject and the possible changes in the scale and nature of migration, make it necessary for policymakers to get a better grasp at it ("*gouverner c'est prévoir*,"[4] governing means anticipating). Coast guards and other public authorities have been taken aback by the magnitude and the suddenness of recent migration flows across the Mediterranean Sea, and were therefore unable to provide for adequate oversight and support where and when needed, and the emergency adjustments came at a high cost and caused much distress. Being able to plan ahead is key to managing migration waves such as the one experienced in Europe, and this requires a better understanding of migration drivers, in particular if they are affected by climate change. Mishandling migration is a political and existential risk for nations.

On the other hand, human migration is a complicated, multifactorial social phenomenon on which a complex phenomenon – climate change – is now suspected to have an effect. The discourses on migration, and their social and political implications, add yet another layer of complexity. At the national scale, for instance, the past "crisis" has given rise to an escalation in populist and nationalist claims and in xenophilic manifestations in response, and has been looming over this election season in many OECD countries. At the international scale, the term "climate refugees" (or "environmental refugee"), although insubstantial as far as international law is concerned,[5] and ill-defined in general [Bates, 2002, Maertens, 2015], has gained ground in international institutions and in particular in negotiations on climate change, so much so that they are now part and parcel of the diplomatic process. Over the past few years, the scholarly study of migrations has required the inclusion of more disciplines; it has in parallel pervaded the agendas of more advocacy and political groups (e.g. thanks to the connexions made with climate change), requesting from the researchers much wariness and scrutiny with both the inputs and outputs of their academic endeavours.

[1] As reported by Piguet et al. [2011], however, environmental factors as migration drivers isn't a new research topic for migration scholars.

[2] Source: UNHCR, *The State of The World's Refugees 2000: Fifty Years of Humanitarian Action*, retrieved from unhcr.org and http://www.unhcr.org/3ebf9bab0.pdf

[3] While the latter isn't new and has been traced by Piguet et al. [2011] and others as dating back to the 1980s-90s, the former (i.e. the public's interest), is quite recent, and is made manifest by the publication of articles in the popular press and the release of the 2017 documentary *The Age of Consequences*.

[4] Attributed to Émile de Girardin.

[5] The term "refugee" refers *stricto sensu* to people granted international protection on grounds of political oppression in their home country, but is very often misused, especially in the phrase "climate [resp. environmental] refugee". For a more precise definition, see glossary in annex, section A.1.

In an effort to contribute to the advances in our understanding of migrations and to the better anticipation of their evolutions, I propose to consider an unconventional measure of migratory pressure as a way to get a better grasp of migration drivers, in particular as regards distress-driven migration, and the effect of weather shocks thereon. This particular measure comes from the border and coast guard agency of the European Union, Frontex, and pertains to attempts at entering illegally into the European Union, which constitutes the visible part of the 2015 migratory crisis. I'll start (in section §2) by brushing the landscape of economic research on human migrations so as to position the present work in it, with a particular emphasis on the data challenges faced by this type of studies. The ensuing section will be devoted to a description of the various data sets used in the present study, and most importantly of the one to which this paper is devoted, Frontex's illegal border-crossings between border-crossing points, 2009-2016. The analyses conducted on these data sets will be briefly laid out in section 3.3, whose results will be detailed and discussed in section §4; illegal border-crossings will be compared to other migration measures, directly and in their response to "usual" migration drivers, and finally their response to weather shocks in the origin country will be explored. I will then conclude on the progress made in our understanding of the Frontex data and what it taught us on migrations, and its potential for furthering our understanding of distress-driven migration.

# 2 Studying migration: current knowledge and data shortcomings

This study seeks to uncover the drivers of illegal border crossings into the European Union, and in particular to assess the potential role of weather shocks. It therefore builds on two overlapping literatures: the economics of migration, and environmental migration.

## 2.1 The economics of migration

*Why do people migrate? Where do they migrate? What are the consequences of migration?* are the three main aspects of migration tackled in the literature.

### Drivers

The decision to emigrate is most often multifactorial; determining, among the drivers at play, the importance of economic conditions, and modelling their role in an utilitarian framework, is still an open research field. Drivers may be of economic (is migration counter- or pro-cyclical? who gets to migrate?), humanitarian, environmental nature, or an expression of preferences over lifestyle (e.g., Albouy et al. [2016]).

The *response of migration to income* (levels or variations) at origin and destination has been extensively studied; although focussed on selection into migration (see below), the Roy model provides the theoretical framework within which the problem has been posed and answered empirically – the difference in expected incomes at origin and destination, and the relative cost of migration should matter, and it follows that a higher income level renders one more likely to be able afford migration costs but also weakens the income gradient that fuels migration. The hypothetical gradual shift from one regime to the other has been called "mobility transition" (migration intensifies, and then weakens, as income increases, in the cross-section and/or in the time series), of which Clemens [2014] reviews the empirical evidence; he indeed reports findings of a transition at the micro (household) level (as Bazzi [2017] very neatly finds in Indonesia), and mixed evidence thereof at the macro (national) level (cross-sections find such a transition, time series usually do not, likely because such transitions occur on a timespan larger than that of the time series at hand). Income and wealth differentials are also central to the (panel) analysis of "push" and "pull" factors in Mayda [2010] where she finds that "pull" factors (proxies of expected income at destination) are stronger than "push" factors (income at origin), and that the latter, when significant, could be characteristic of an early stage in the mobility transition (i.e., as income increases, liquidity constraints get lifted and emigration increases); Ortega and Peri [2013] follow her steps, confirm the strong effect of income at destination, and also find that immigration policies are critical (when a 1 % increase in income at destination corresponds to a 0.76 % increase in immigration into a given country, a tightening of immigration policies results in a 6 % decrease in immigration). The study of *self-selection into migration* takes into account the heterogeneity of the population considered, and acknowledges that the fraction that migrates is not random: while subjected to the same macro-scale drivers (e.g. GDP differentials), each household or individual has to factor in constraints

of their own (e.g. skill level, credit constraint, subjective discount rate). The Roy model, in addition to setting the theoretical frame for migration flows that would be driven by income differentials, models self-selection based on skill (or income) level: by comparing incomes and skills at origin and destination, it makes falsifiable claims as to when emigrants should be drawn from the higher or lower tail of the national income or skill distribution [Borjas, 1987] (it depends on the strength of the correlation any given worker can expect between her earnings at home and abroad, the skewness of the income distribution at home and abroad). The issue has been further explored empirically since then; e.g., Abramitzky et al. [2013] find that during the "Age of Mass Migration" the poorer Norwegians were more likely to move to the United States than the richer.

Among the non-economic drivers of migration, *humanitarian drivers*, i.e. emigration because of conflict and persecution, have been shown to still play a significant role in recent times, alongside economic factors [e.g., Neumayer, 2005a, on asylum migration]. *Environmental factors* such as climate change, weather shocks [Kniveton et al., 2012, Gray and Wise, 2016, Cai et al., 2014, Mueller et al., 2014, Marchiori et al., 2012], natural disasters [Gray and Mueller, 2012], have been shown to have contrasting effects on migration – its existence, type (local, international), and duration (temporary as with floods, or permanent), in relation with the type of damage incurred. The literature on environmental migration is presented in more detail below, in section 2.2.

#### Choice of destination/target country

Once the decision is made to migrate, where do migrants go? Is the destination picked on considerations such as pre-existence of migrant networks (people of the same national or ethnic origin), cultural (*sensu lato*) and geographic proximity (cultural/colonial proximity including language, e.g. Pedersen et al. [2008], Adserà and Pytliková [2015]), locational fundamentals including climate amenities [Albouy et al., 2016], information on economic conditions and migration policies? Interestingly, in a case-study of Ecuadorian emigration, Bertoli et al. [2013] find that income *variations* in destination countries, irrespective of level, change migration rates to these countries (e.g. Spain *vs.* the United States), but not overall emigration.

#### Effects of migration

They have been studied both on the destination (most importantly on labour outcomes, again in relation to the Roy model – most importantly in Borjas [1987], Abramitzky et al. [2012]) and source (remittances: Yang and Choi [2007] find for instance that they work as insurance against income shocks in the origin country (Philippines) and see Poston and Micklin [2005] for a review, brain-drain: Massey et al (1998) on doctors, migration-induced technological change: Hornbeck and Naidu [2014]) countries or regions.

The present study fits in the first category, as it is concerned with the drivers of (illegal) migration flows into the European Union, chiefly environmental ones (but socio-economic drivers will be explored too, as a means of comparison to other migration data sets).

The Frontex data set described here isn't suited to address the choice of the destination country (since it is not specified, and the route taken is at best a very noisy proxy for that), but it could be used in future work to quantify the short-term effects of migration on socio-economic conditions at destination.

## 2.2 Environmental migration

As stressed in several recent reviews, the environment as a leading driver of human migrations isn't a new phenomenon, nor is it a new research subject [e.g., Laczko and Aghazarm, 2009, Piguet et al., 2011, Piguet, 2013]. Environmental factors (droughts, floods, better growing conditions, etc.) have been the first causes of migration in human history, and the first to have been studied as well; yet, the recent changes in magnitude of both environmental changes and migration, concerns over the former's influence on the latter, in addition to the emergence on the climate change negotiation agenda of "climate refugees" (e.g. from small island-states), have led to renewed interest in the environment as a driver of migration.

Most of the literature on environmental migration is non-economic (in geography, sociology, political science). The contribution of economics is to analyse those migrations in terms of income and prices, as transductors of the effect of the environment on human migration. Conversely, environmental shocks lend themselves well (when exogenous) to identifying the effect of migration on economic outcomes (e.g. of

migration and subsequent change in labor supply on technological change [Hornbeck and Naidu, 2014]), and vice versa (e.g. of exogenous income shocks on migration [Bazzi, 2017, Nunn et al., 2017]) – this particular strand of the literature will not be discussed further here.

The literature on environmental migration addresses a vast range of population displacements, that can be broadly classified according to three axes [Piguet et al., 2011]:[6] duration (temporary, short-, medium- or long-term?), distance (internal or international migration?), extent to which the migration is forced or voluntary. While this typology can describe any population move, it is particularly relevant to *environmental* migration, as individual environmental drivers will tend to be associated with specific types of migration (as they bear a consistent economic signature). For instance, Boustan et al. [2012] find that in the United States, the nature of the disaster (e.g., tornado or flood) determines the migration response (reduced immigration into, and emigration from tornado-hit areas, immigration into flooded zones), and suggest that this may be in part attributable to the differing share of the risk assumed by individuals and the government, at least in perception, with the construction of government-commissioned infrastructure (levees, sea walls, flood retention basins) transferring some of the risk previously borne by individuals to the government, thus discouraging self-protection ("crowding out") and encouraging people to move into or stay in flood-prone areas (and not tornado-prone areas). Such differences between the migratory effect of natural disasters may also be due to the spatio-temporal profiles of the damage incurred (severity, frequency, aggregate/idiosyncratic nature of the shock) as, for example, Yang [2008] finds that in rural El Salvador, shocks (earthquakes) affecting an entire community ("aggregate") tended to decrease emigration, whereas shocks affecting only a household ("idiosyncratic") increased it, due to their opposed effects on credit constraints;[7] likewise, Gray and Mueller [2012] find that floods and crop failures in Bangladesh have markedly different effects on migration, flooding causing short-distance and short-term displacement while crop failures cause permanent and longer-distance migration, which they attribute to the better adaptation to recurrent (yearly) events like floods, resulting in the lesser magnitude of the negative shock on household income they observe for floods.

The particular type of environmental migration with which this paper is concerned is that produced by weather shocks (temperature and rainfall anomalies); these tend to be long-term and medium- to long-range migrations. Most studies find no relationship between rainfall anomalies and migration (with the possible exception of Henry et al. [2004], in rural Burkina Faso[8]), but often find an association with temperature anomalies [Gray and Wise, 2016, Mueller et al., 2014, Cai et al., 2016, Marchiori et al., 2012]. Further, Cai et al. [2016] *hints* at the importance of the agricultural channel in the relationship between temperature and migration, which they find to be significant only for those countries that rely the most on agriculture (as indicated by the share of agriculture in their GDP). And Nunn et al. [2017] use that relationship in "the age of mass migration" to instrument for migration.

## 2.3 Some data challenges for the empirical study of the drivers of international migration

Empirical studies on migration have been growing on the confined medium of existing data and field experiments.

[6] Bates [2002] proposes another typology, perhaps more adapted to the sociology and political science of environmental migration, depending on: the origin of the "disruption" (anthropogenic/natural), its duration (acute/gradual), the intentional/unintentional nature of the migration, and the type of "disruption" (natural/technological disaster, expropriation due to infrastructure development or ecocide, or gradual deterioration).

[7] Gray and Mueller [2012] find an opposite effect taking place in Bangladesh in response to crop failure – aggregate shocks lead to *decreased* migration, idiosyncratic (household-specific) shocks lead to *increased* migration – but the hypothesis they venture to explain their findings *also* relies on credit availability at the local level ("risk-sharing networks"): their undermining by aggregate shocks is a *motivation* for emigration. Idiosyncratic shocks, on the other hand, take away the resources necessary for emigration (which apparently, there, cannot be overcome thanks to the unscathed local risk-sharing networks).

[8] In the aggregate, neither average rainfall nor deviations from year to year affect men's nor women's likelihood to migrate (measured as an odds ratio). However, when disaggregating by destination type (rural/urban/abroad) and/or duration (short-/long-term), then authors find significant relationships: with (usual) rainfall conditions (thought they correlate with other geographic factors such as distance to the border with Côte d'Ivoire) and with deviations, such that, for instance, people living in water-scare areas are more likely to engage in short-term ($\leq$ 2 years) migrations (as a means of income diversification, the authors hypothesise), negative rainfall shocks hinder long-range migrations. Also note that Mueller et al. [2014] conjecture that emigration didn't occur in response to floods in their case-study (Pakistan, 1991-2012) because floods systematically attracted relief (via national programs or international donors) when temperature shocks did not, thus reducing the attractiveness of migration as an adaptation strategy in the case of floods, not in the case of heat stresses.

Many of the studies cited above rely on RCTs [Bryan et al., 2014] or on survey data from the origin country [e.g., Yang, 2006, Mueller et al., 2014, Angelucci, 2015, Gray and Wise, 2016] (using national surveys in the Philippines, Pakistan, Mexico, and the World Bank's ARMS,[9] respectively), which provide rich insight into the emigration dynamics of a particular country. They fall short, however, when seeking more general, systematic patterns.

Data on international migration with global coverage is hard to come by; the OECD provides a partial solution by centralising various measures of migration for its member states (e.g. migration from, migration to, a given OECD country). But it misses the South-South migrations, and is very heterogenous (across destination countries), chiefly because of varying reporting practices across countries (frequencies, definitions, scopes, vary, which makes comparing national statistics in general challenging).[10] Besides, most migration data sets (produced by authorities at destination) record the "stock" of immigrants legally present in the country, and are therefore ill-suited to capture variations in the in- and out-flows of immigrants (or foreigners) into and out of a given country; the Eurostat data base[11] is one exception to the rule, but suffers from the same issues of heterogenous reporting practices, short time series. Finally, measures made at the national level are usually a snapshot of one particular step of the migration process, most often, when migration is already far advanced (i.e. people have crossed the border, and possibly entered in contact with the local authorities to get a work permit or residency card).[12] In addition, because of this reliance on data derived from interactions with the local authorities, these data sets lump together all sorts of migrants of varied situations, while others are left out (e.g. because in an irregular situation); it is particularly problematic for the study of distress-driven migration and illegal migration with which we're concerned here, as for the former, they are indiscernible from the rest, and for the latter, immigrants may lack the resources (institutional knowledge or other) or the willingness (for fear of being deported) to engage in such administrative proceedings. In any case, it is very hard to get a consistent picture across countries for a region of destination or origin, despite harmonisation efforts on reporting (e.g. in the European Union).

One workaround is, as exemplified by Neumayer [2005a], Missirian and Schlenker [2017a,b], to exploit data assembled by the UNHCR (UN's High Commissariat for Refugees) on asylum-seekers. While more comprehensive in terms of geographical scope and of a bilateral (dyadic) nature, asylum-seekers cover a small (yet meaningful), share of migration flows, or even of the populations the UNHCR is concerned with, as is made obvious by the following observation by Frontex:

> "Upon arrival [*via the Central Mediterranean route*], less than half of the migrants who were rescued subsequently claimed asylum. [...] The decisions to apply for asylum upon arrival is largely dependent on nationality."[13] [Frontex, 2016, p. 20]

This self-selection into asylum procedures isn't concerning if, as in the studies cited above, asylum applications are in and of themselves the object of interest; should they be considered a proxy for some category of migration flow, the bias underlined in the quote would be concerning.

Here I describe a data set that I don't think has ever been used to study the drivers of distress-driven migration nor in any other quantitative study of migration, and has the excellent feature of dealing only with illegal migration (by construction). It not only is a rare insight into a key stage of migration (border-crossing), but also a very proximate measure of the phenomenon of interest here (in time and in scope), distress-driven migration.

[9] African Remittances and Migration Surveys, microdata.worldbank.org.

[10] Mayda [2010] also reports large discrepancies between total immigration into a given OECD country and the sum of the flows into that country from all reported source countries, which results from the rounding of small flows to zero (as she explains), but may also denote an issue of incomplete reporting of member states to the OECD in that database.

[11] See the `migr_immi` series on ec.europa.eu/eurostat/data/database.

[12] While there exists polls surveying people's intention to migrate in some countries, their representativity (as always) is questionable, as is declared intent a valid measure of intention/propension to migrate, and they certainly aren't available worldwide nor comparable across countries.

[13] The report further explains: "The majority of migrants from Nigeria, the Gambia, Senegal, Bangladesh, Mali, Ghana and Côte d'Ivoire make an asylum application upon arrival. [...] The remaining half (mostly from Eritrea, Somalia, Sudan, Syria and Ethiopia) who do not often apply for asylum upon arrival will either stay illegally in Italy, or continue towards other EU Member States, where they will apply for asylum."

# 3 Methods

## 3.1 Foreword on "distress-driven migration"

"Distress-driven migration" isn't an official denomination, doesn't correspond to a particular visa nor status; it is likely not captured by a single data set. It is however, I argue, a policy-relevant category, especially as far as climate change impacts are concerned.

The distinction is often made between "economic migrants" and "refugees" (e.g., see Neumayer [2005a] and his undertaking of disentangling the two subgroups in the population of asylum-seekers) as they attempt to cross the border into the EU or the United States. The divide isn't in fact that clear, as they may partake in the same flows, and belong to the two categories at the same time (as conflict or persecution may create an economic necessity to migrate). Both groups undertake a very costly and risky migration to save their lives, from degraded economic conditions or oppression (or both).

From a policy standpoint, however, what matters is that both of these theoretically delineated groups partake in the same (very real) migration flows, that both drivers may reinforce one another when a "crisis" (similar to that of 2014 and thereafter in Europe) occurs, and that both drivers may be affected by climate change (and more broadly, global environmental change). There is indeed a growing literature on the effects of climate (and weather shocks) on conflict, and on rural livelihoods (crop yields) [Schlenker and Roberts, 2009, Burke et al., 2009], and Kelley et al. [2015] have hinted at the relationship between rural livelihoods and conflict and its possibly instrumental role in the case of the onset of the Syrian civil war.[14]

The number of applications for asylum (reported by the UNHCR, discussed above) and illegal border-crossings of migrants (discussed below) are two complementary ways of getting at "distress-driven migration."

## 3.2 Data

### 3.2.1 Illegal Border-Crossing (IBC) detections by Frontex

It is worth taking some time to better understand this data set I propose to use, as its scope, object and collection, are unusual.

Frontex is the European Border and Coast Guard Agency, responsible for a harmonious border-keeping at the external borders of the European Union (more background information on Frontex is provided in A.2, and Tables S3 and S4 recap the successive expansion phases of the European Union and the Schengen area, none of which interferes with our data set). It participates in the border-keeping effort and coordinates operations between national border control forces, and produces and centralises data. In particular, illegal border-crossings (IBCs) detected by any border enforcement service are reported and compiled on a monthly basis by Frontex (see time series on Figure 1).

Therefore, by construction, IBCs as reported by Frontex concern individual attempts at entering the European Union,[15] by land or sea (see map in Figure S1), regardless of the success of the attempted crossing, and regardless of the intended destination – in most cases the country of entry *isn't* the intended destination, all the more so given that movement of people within the Schengen area is theoretically free (some internal borders were reinstated following the "crisis"), and that the southern countries of the area tend to be less affluent than their northern counterparts. These IBCs are provided by month and year (2009-present[16]), nationality of the trespasser, border type (land or sea), and route (Black Sea, Central Mediterranean, Circular route from Albania to Greece, Eastern Land Borders, Eastern Mediterranean, Western African, Western Balkans,Western Mediterranean, Other – see Figure S1). The data is freely available online,[17] and updated

[14] They argue that an exceptional series of droughts, attributable to climate change, whose effects were worsened by political neglect, forced people living in hard-hit areas to migrate *en masse* to urban areas, where food supplies were already low due to the drought, and where there were already large refugee populations due to the war in Iraq; this new inflow put an additional strain on the resources and the social fabric. In the absence of political intervention to alleviate the crisis, the situation further degraded into civil unrest, and ultimately civil war.

[15] Associated countries likely make a negligible, if positive, share of IBC detections – Switzerland, Liechtenstein, Norway, and Iceland are either too far inland (i.e. enclaved in the EU), or too far North, to be of concern, or as much of a concern, for illegal border-crossing at the *external* borders of the Schengen area (Schengen area: see Table S4).

[16] Data exist for earlier dates, but Frontex is unwilling to share them.

[17] frontex.europa.eu

every month; contrary to other data sets involving individuals, no data is redacted (e.g. to protect sensitive populations, the UNHCR redacts data when 5 or fewer individuals are to be reported in a given category). Data dimensions are summarised below in Table 1; data for all illegal border crossings (between BCPs) is mapped for year 2016 in Figure 2. Figures S6–S7 plot the time series by route (for the most travelled routes).

Table 1: Data dimensions

| Variable | Values |
|---|---|
| Date | monthly $\rightarrow$ here, 96 obs. |
| Route | 9 (see Figure S1 & Table S5) |
| Border | 2 (land, sea) |
| Nationality | 137 (+ 2 "unknown" categories) |
| IBC detections | $\in \mathbb{N} \rightarrow$ here, $\in [\![0, 204\,286]\!]$ |

*Notes:* "Nationality" isn't necessarily in accordance with international conventions and UN statuses – for instance, people from Taiwan, Kosovo, or Western Sahara, are reported separately from people from (mainland) China, Serbia, or Morocco (resp.). These are precisions on one's origin that the UNHCR cannot afford to give. "Unknown" categories are dropped when data is analysed at the level of the origin country (and not in the aggregate).
"Border" takes only two values ("land", "sea") because illegal border crossings at an "air" border typically happen *at* a border-crossing point (passport check and immigration control at the airport), not *between*.

The relationship between IBC detections and applications for asylum in the European Union isn't *a priori* straightforward. Not all asylum-seekers had to cross a border of the European Union between BCPs: they may be in a legal situation, have arrived in a legal situation and overstayed their visa, or crossed illegally *at* a border-crossing point. Likewise, not all IBCs between BCPs translate into an application for asylum in a country of the European Union: beside the issue of multiple crossings (see below), not all migrants reported by Frontex request asylum, and if they do, they may do so outside the European Union (e.g., in Switzerland). Once registered by Frontex, migrants are to be sent back to their country of origin, unless they are applying for asylum (especially true for those arriving on Greek islands as migrants are not permitted to leave, hence most apply for asylum); however, given that detention facilities are very limited (especially true in Italy), migrants are often left to their own devices after their registration with Frontex, and given that in addition the return decision (after an unsuccessful application, or no attempt to apply) usually takes time to be issued by the local authorities, it is sometimes hard to find the migrants concerned to enforce the return order. Readmission agreements have been passed with some countries (e.g., Tunisia, Turkey) that help expedite the process, in which case the return may occur within one or two weeks; it takes longer for other countries of origin.[18] The fate of immigrants intercepted and registered by Frontex can therefore take varied turns: they may stay, move to another country, eventually apply for asylum, or never enter the refugee recognition process.

Given the extent of both source and destination areas, the information on migration provided there is extremely detailed. It is nevertheless not a perfect measure of immigration into the European Union, nor even of illegal migration. The issues pertaining to these data are inherent to the data collection process.

Frontex only reports the illegal border-crossings its agents *see*. It therefore misses all the successful (and more or less furtive) illegal border-crossings. The exactitude of the counts may thus depend on the border-policing effort; while this is *prima facie* concerning, it is likely that states and Frontex deploy as required by the migratory pressures (and respond fast, illegal migration being an inflammatory topic in national politics), and therefore, increases or spikes in IBC detections are likely to reflect actual increases and spikes in IBC attempts (*idem* with decreases). Nonetheless, in some episodes of unexpected surges in interceptions, the data collection couldn't be as thorough as it normally is, and while the IBC detection counts seem not to have been affected,[19] information on nationality went unreported (e.g., individuals whose nationality is "Not specified" indeed make the bulk of the spike pictured in Figure S7 for the Western Balkans route). However, such episodes are rare in the study period[20] and IBC counts missing information on origin are

[18] Source: Ewa Moncure (by telephone), spokesperson, Frontex (20/07/2017).

[19] If agents were making rough count, one would expect larger frequencies of counts ending in "0", which we do not observe – see Figure S9.

[20] The episode mentioned above is the only case where no nationality could be reported for a $month \times route \times border$ combination. Overall, nationality data was only missing in 354 instances, out of 16,770 non-zero data points ($\simeq$2%) ($month \times$

probably a side-effect of the rigorous process undertaken by Frontex to establish nationality: experts are deployed on-site to register and screen migrants, which involves an interview with the help of an interpreter, and possibly with a document expert if there are documents to be authenticated, followed by a search of the profile thus obtained against Frontex databases (again, to authenticate the information provided), and finally the photographing and fingerprinting of the interviewee.[21] Frontex observes that "*fraudulent declarations of nationality are rife*" [Frontex, 2016] (as some nationalities are more likely than others to be granted asylum given the geopolitical situation); this also applies to asylum-seeker (UNHCR) data. This problem seems to be recurrent with illegal migration data, but given the amount of resources and expertise deployed by Frontex to verify the narratives, and in particular, the nationality, of the intercepted migrants, it seems reasonably small, if existant at all, as regards the IBC detection data.

When using Frontex data on IBCs, one also has to keep in mind that these are IBCs and not *persons*: one person may indeed attempt to cross several times if unsuccessful (or in trying to travel between two non-contiguous parts of the Schengen area). As mentioned above, Frontex has undertaken fingerprinting migrants, but deplores that "*fingerprinting of all persons detected crossing illegally the border is not possible or of poor quality, and in any case, is often not transmitted promptly to the Eurodac central database*" [Frontex, 2016]. Multiple crossings are an issue in estimating migration *volume* (the number of migrants); they are not as far as the present study is concerned, since I use IBC data to quantify migratory *pressure* or the urge to migrate into the European Union, which is precisely what IBCs are.

Another limitation is that this particular data set misses other forms of illegal migration, e.g. attempts to enter *at* border-crossing points (BCPs)[22] without proper documents (the data set described here considers only illegal border-crossings *between* BCPs), or visa overstay. Frontex collects data on both; the magnitudes seem to be quite different (with IBCs between BCPs dwarfing the rest – see Figure S2), and while the three measures are of interest, the measurement methods as well as the underlying phenomena at play (e.g. who migrates, when, and why) are quite different, therefore, in addition to those flows being of a lesser quantitative importance and political salience, this discrepancy makes it preferable to consider the IBCs between BCPs data set only (at least for now). For example, attempting an IBC at an airport involves a very different type of demographic, motivation to migrate, and cost of migration;[23] overstaying a visa pertains to a migration that occurred months ago at least, whereas IBC is contemporaneous to migration.

Finally, those migrations are also immensely dangerous, as people-smugglers tend to cram migrants on unsafe embarcations (if crossing a sea border), and casualties are many. Frontex does not report on that issue, but mentions that dead bodies are recovered during joint operations with coast guards (470 in 2015 [Frontex, 2016]), and amount to about a tenth of the number missing persons reported by the International Office for Migrations (IOM), though both are likely underestimates of the death toll. This constitutes a further hindrance in characterising *e*migration (how many people leave), but does not bear on the analysis of *im*migration into the European Union (how many people enter) – except to keep in mind the extremely high cost, monetary and otherwise, borne by the migrant and their family, of these migration flows we are considering here.

### 3.2.2 Applications for asylum, UNHCR

Asylum-seeker data are an equally rich source of information on the type of migration on which we focus here (distress-driven).

An asylum-seeker is someone who has sought the international protection conferred by the refugee status but whose claim has neither been denied nor granted; a refugee "is someone who is unable or unwilling to return to their country of origin owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion".[24] The data are collected in part, and assembled, by the office of the UN High Commissioner for Refugees (UNHCR – "the UN refugee agency"), and available on the UNHCR's website.[25] They have been used as a proxy for distress-driven

$route \times border \times nationality$), totalling 706,365 IBC detections out of 2,439,628 ($\simeq$3%).

[21] Source: Ewa Moncure (by telephone), spokesperson, Frontex (20/07/2017).

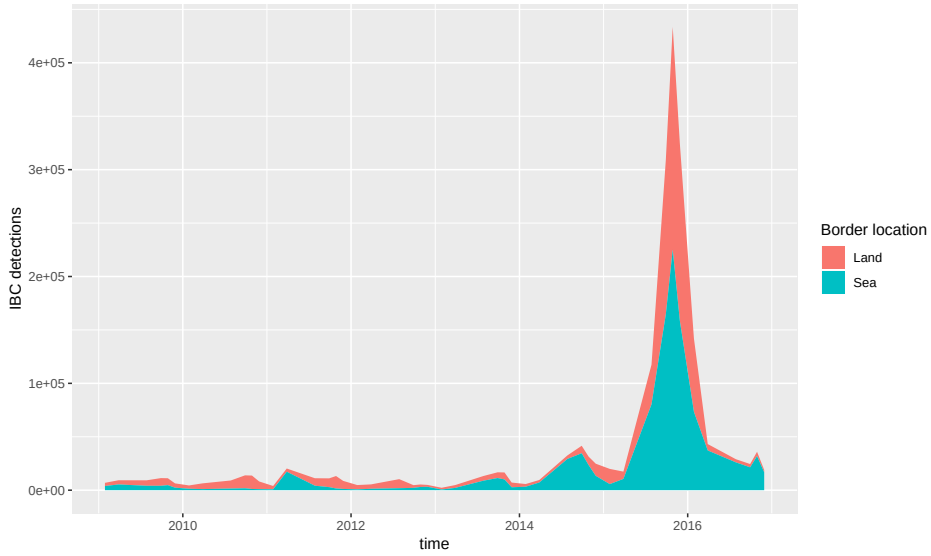
[22] Definitions are provided in Annex A.1.

[23] See also Figure S12 for a comparison of yearly air IBCs (Eurostat data) and sea IBCs between BCPs (this data set).

[24] See UNHCR [2010], p. 3.

[25] popstats.unhcr.org.

Figure 1: IBC detections, 2009-2016




*Notes:* Shows monthly totals for IBC detections (between BCPs) at land and sea borders for all routes, stacked. Source: Frontex (data).

migration by Missirian and Schlenker [2017a,b], and for the sake of asylum-seekers themselves by Neumayer [2004], Hatton [2009, 2004], Neumayer [2005b], Vogler and Rotte [2000], Neumayer [2005a], UNHCR [2016].

This data set stands out by its global coverage (contrasting the Europe-centricity encountered with Frontex), long time series (at a yearly resolution 1951-2015, monthly January 1999-January 2017), and dyadic nature (i.e. at $t$, how many country $X$ nationals applied for asylum in country $Y$). In addition, it lends itself much more to cross-country comparisons than most migration data sets: the status of refugee is defined by an international convention,[26] and is determined following a standardised procedure (which leaves a paper trail). Therefore, while different countries typically account for the migrants they host in inconsistent ways (definition of an immigrant, monitoring effort, definition of "origin") and measure stocks rather than gross flows, applications for asylum offer a much more consistent measure (of a specific type of migration), and provide insights on (in)flows ($\sim$ an application is filed) rather than stocks.

One of the limitations pertains precisely to the fact that this is an administrative process, rather than a direct measure of migration. The UNHCR and Frontex both report that only a fraction of the migrants washing on the shores of the European Union subsequently make a claim for asylum (about half or less).[27] Besides, as mentioned earlier, entering in contact with local authorities to start the asylum process may be fraught with the fear of getting deported as a result, and thus asylum applications likely grossly underestimate the population we are concerned with (that undertakes distress-driven migration). In addition, contrary to IBC detections, asylum applications occur once the person has crossed the country borders, and may occur quite some time after (green) border-crossing has occurred.[28]

Asylum-seekers making a claim in the European Union are nonetheless not a subset of illegal border-crossing detections between BCPs: they also comprise people who crossed the borders legally and then made a claim for asylum, and those who entered illegally *via* a BCP (e.g. at an airport, or in merchandise trucks), and are therefore not covered in our Frontex data set.[29]

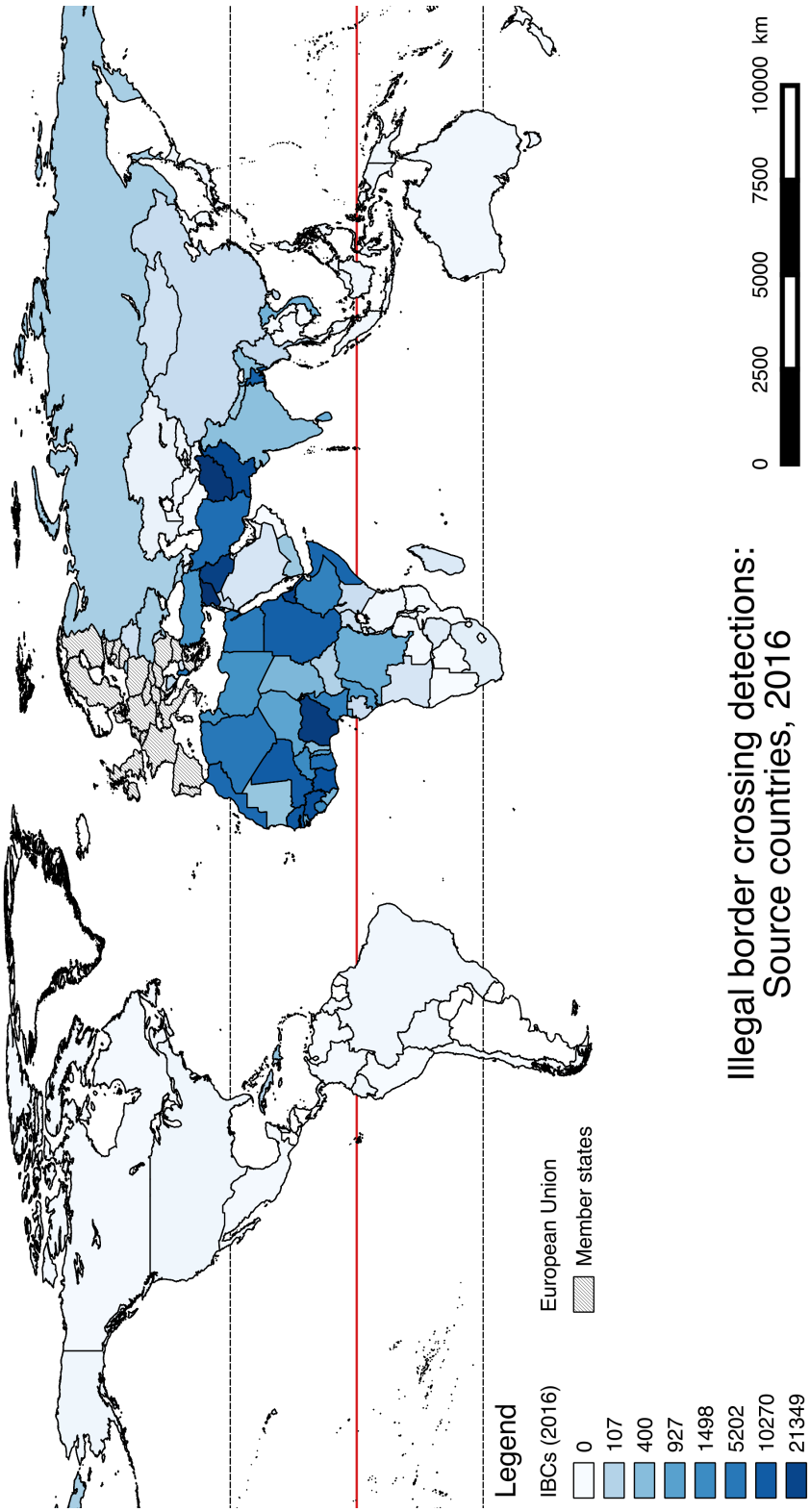
[26] The 1951 Convention Relating to the Status of Refugees and its amendement by the 1967 Protocol.

[27] Frontex mentions that on the Central Mediterranean route, "*less than half* of the migrants who were rescued subsequently claimed asylum," and this decision to apply is strongly associated with the nationality of the migrant [Frontex, 2016, p. 20, emphasis added]), whereas on the Eastern Mediterranean route, "a vast majority of migrants do not apply for asylum in Greece" (p. 18), though they may -or may not- do it later upon reaching EU countries further to the West.

[28] The green border refers to that delineating the Schengen area.

[29] Besides, while rare, there are instances of asylum claims from an EU country to another EU country, e.g., in 2015 and 2016, one person from Sweden asked for asylum in Belgium – a type of asylum migration that is way beyond the scope of Frontex's activities.

Figure 2: The Geography of Illegal Border Crossings




*Notes:* The color scale corresponds to the number of IBC detections from the source country, as reported by Frontex for the year 2016. The hatched area corresponds to the member states of the European Union as of 2015.

### 3.2.3 Other data sets

**World Bank indicators** Following Neumayer [2005a], I seek to identify some political and macroeconomic drivers (at the country level) of the particular type of migration captured in the Frontex data, and to that end, downloaded the time series for a selection of the World Bank's World Development Indicators,[30] spanning 2000-2015, and covering matters such as agricultural production, income, conflict. There is no data posterior to 2015, and some gaps exist for some countries and indicators during 2000-2015 (2015 in particular is very incomplete).

The selected indicators of food production, conflict, and economic activity are listed in Table S1; summary statistics are provided in Table S2.

**Weather data** The weather data used in the analyses presented here consists in monthly average temperatures and total precipitations as provided by the University of Delaware (version 4), covering our study period until 2014, on a 0.5x0.5 degree grid. Following Missirian and Schlenker [2017b], these temperatures and precipitations are averaged at the country level either by giving equal weight to all grid cells within a given country, or by weighting each data point by a maize weather exposure index. The latter averaging method acknowledges that rural (cropped) areas are particularly sensitive to temperature and precipitation fluctuations during the growing season, and that maize is a staple crop that constitutes the largest source of calories for human nutrition and is grown ubiquitously worldwide [Roberts and Schlenker, 2013]. Weather data are thus averaged at the country-year level over the maize growing season and area by using the fraction of each grid cell that grows maize as weights (data set described in Monfreda et al. [2008] – see Figures S13-S14), and using only those (monthly) temperature and precipitation data points that fall within the maize growing season. For the nonlinear transformations of temperature and precipitation considered below in section 3.3, the nonlinear transformations are applied at the grid cell level, and then averaged at the country-year level.

## 3.3 Models

The objective of this study is to describe this new data set obtained from Frontex, in relation to existing comparable migration data sets, and in its response to suspected drivers. Note that due to the lack of information on the intended destination, we cannot test for cultural affinity or existing networks or other factors as explanations for the choice of the destination.

### 3.3.1 How do illegal border-crossings compare with asylum data?

I examine how the time series of IBCs $y_{it}$ (aggregated at the year level and over all routes and borders) and the time series of asylum applications $AS_{it}$ (aggregated over all EU destinations) covary. Given that the asylum procedure – except in very rare cases[31] – starts after the migration has taken place, it is likely that the AS series will be lagging behind the IBC series, hence the inclusion lags in the specification:

$$y_{it} = \alpha_0 + \sum_{k=0}^{l} \beta_k IBC_{i(t-k)} + \lambda_t + \varepsilon_{it} \qquad \text{with } l \in [\![0, 5]\!] \tag{1}$$

$i$ indexes the origin country, $t$ the year (2009-2016). $\lambda_t$ are year fixed-effects. Other specifications include origin country fixed effects or country-specific time trends. $y_{it}$ corresponds either to $AS_{it}$ (i.e. the number of new asylum applications of country $i$ nationals in year $t$) or to $\ln AS_{it}$ (and then $IBC_{it}$ is changed to $\ln IBC_{it}$), given the very skewed distributions of the asylum-seeker and IBC data.[32]

A graphical indication of the relationship between the two series over 2009-2016 is provided in Figure S4.

[30] data.worldbank.org, accessed on March 29th, 2017.

[31] The standard procedure requires the applicant to have left their country; most countries apply the standard procedure, and the applicant needs to be in the "country of asylum" to make a claim. A few countries, however, have procedures in place to help oppressed individuals claim the refugee status and get extradited.

[32] E.g. see Figure S10.

### 3.3.2 Are IBCs correlated with social and political conditions in the origin country?

I follow Neumayer [2005a]'s correlatory approach (non-causal), and seek correlations (or lack thereof) between suspected drivers of migration and IBCs. I test the "push" factors listed in Table S1 with the specification in equation $(2)$, where $\mathrm{IBC}_{it}$ is the number of illegal border-crossings by nationals of country $i$ in year $t$, and $\mathrm{WBDI}_{it}$ is the value taken by a given Word Bank Development Indicator in year $t$ for country $i$.

$$\mathrm{IBC}_{it} = \alpha_0 + \alpha_1 \mathrm{WBDI}_{it} + \lambda_i + \lambda_i + \varepsilon_{it} \tag{2}$$

I also further disaggregate results by type of border crossed (land, sea), to see whether, when a variable is significant, the result is driven mostly by land or sea border-crossings, in other words, whether a particular type of migration channel is attached to a given "push" factor (or vice versa).

### 3.3.3 Do IBCs respond to weather shocks in the origin country?

To get at the response of IBCs to weather shocks in the origin country, I follow Missirian and Schlenker [2017b] in using a fixed-effects model of the type:

$$y_{it} = \alpha_i + \beta \mathbf{W}_{it} + f(t) + \varepsilon_{it} \tag{3}$$

Log IBC detections $y_{it}$ of country $i$ nationals in year $t$ are regressed on the weather $\mathbf{W}_{it}$ in origin country $i$ in year $t$ as well as origin country fixed-effects $\alpha_i$; time controls $f(t)$ are included in some specifications (to absorb global shocks affecting all (origin) countries in a given year, or to allow for delayed effects of the weather by adding lags of the independent variables); the error term $\varepsilon_{it}$ uses is computed using White's correction (heteroskedasticity-robust standard errors).

Given that studies examining the effect of weather shocks on agricultural output, or migration and conflict, tend to find that temperature has a stronger effect than precipitation, and that the effects are nonlinear (conflict: see Burke et al. [2015], agricultural output: see Schlenker and Roberts [2009]), $\mathbf{W}_{it}$ consists, in the main specification, of a quadratic in temperature averaged over the maize growing season and area as described in 3.2.3. Alternative specifications use precipitation averages, lags of the weather variables, or weather variables averaged over the whole country and year (i.e. giving equal weight to all grid cells, throughout the year).

# 4 Results and discussion

The present section details the results of the analyses outlined in section §3. Note that in general, we are limited by the shallowness of the time series in the Frontex data, which is aggravated when combined to time series that end in 2014 (weather) or 2015 (World Bank Development Indicators), and by the use of lags.

## 4.1 Asylum applications track IBC detections fairly closely

As shown in Table 2 and on Figure S10, asylum applications and IBC detections between BCPs are tightly related: in all the specifications considered, the relationship between the two variables is highly significant (an increase of the number of detections by 1 % is associated with a contemporaneous increase in asylum applications by about 0.1-0.6 %). Lags of IBC detections (up to two here) are also significant,[33] though with attenuated coefficients. Two non-mutually exclusive explanations can be proposed: claims for asylum filed at $t$ come mostly from IBCs at $t$, but also from earlier IBCs, or IBCs at $t$ and $t-1$ are correlated, and thus both *appear* to influence asylum applications at $t$ when the underlying process concerns only applications at $t$ and IBCs at $t$.[34]

Regression results are robust to leaving out the "crisis" years (2015 onwards, or 2014 onwards – not shown); the regressions in levels provide similar results, as shown in annex Table S6.

**Dependent Variable: Applications for asylum in year *t* (logged)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| log IBC in year t | 0.554*** | 0.213*** | 0.169*** | 0.108** | 0.169*** | 0.156*** |
| | (0.017) | (0.022) | (0.029) | (0.044) | (0.029) | (0.030) |
| log IBC in t-1 | | | 0.093*** | 0.116*** | 0.093*** | 0.076*** |
| | | | (0.029) | (0.043) | (0.029) | (0.028) |
| log IBC in t-2 | | | 0.073** | -0.001 | 0.073** | 0.073** |
| | | | (0.029) | (0.049) | (0.029) | (0.030) |
| log IBC in t-3 | | | | 0.015 | | |
| | | | | (0.055) | | |
| log IBC in t-4 | | | | -0.139*** | | |
| | | | | (0.051) | | |
| log IBC in t-5 | | | | -0.011 | | |
| | | | | (0.042) | | |
| Origin FEs | | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y | Y |
| Country-specific time trends | | | | | | Y |
| Combined effect of log IBC | 0.554 | 0.213 | 0.334 | 0.087 | 0.334 | 0.305 |
| | (0.017) | (0.022) | (0.043) | (0.132) | (0.043) | (0.065) |
| N | 800 | 800 | 504 | 231 | 504 | 504 |
| $R^2$ | 0.576 | 0.285 | 0.396 | 0.425 | 0.396 | 0.766 |

Table 2

Notes: $*p < 0.1, **p < 0.05, ***p < 0.01$ Column (5) replicates column (3) with the same sample as in column (4). "Combined effect of log IBC" corresponds to the sum of annual effects of log IBC on the dependent variable. Standard errors in parentheses.

[33] Despite the structural impossibility of asylum-seekers at time $t$ influencing the number of IBC detections at $t+1$, some leads are significant as well – but less so, and are of a smaller magnitude and less robust. My interpretation is that IBC detections stemming from a given country at $t$ are related both to asylum applications at $t$ and to IBC detections at $t+1$, given that the illegal migration networks, and reasons to migrate are sticky.

[34] The lesser relevance of IBCs at $t-1$ is indicated by the lesser coefficient of the lagged variable, and its persistence at this level when the contemporaneous variable is omitted.

## 4.2 IBC detections covary with (some) food security, economic, and conflict indicators

The single-factor approach confirms (again, in a non-causal way) the importance of economic conditions, food security and conflict as drivers of distress-driven migration (as measured by IBC detections or asylum applications), broadly.

Table 3: Single-factor analysis results

| | IBC total | IBC Sea | IBC Land | AS | Avg. value |
|---|---|---|---|---|---|
| Agriculture, value added | -0.01 | -0.02 | -0.04 | 0.01 | |
| Land under cereal production | 0.00 | 0.00 | 0.00 | 0.00 | |
| Agricultural land | -0.01 | -0.03 | -0.01 | -0.02 | |
| Cereal production | -1.58E-08 | -2.24E-08 | 0.00 | 0.00 | 1.81E+07 |
| Cereal yield | -2.26E-05 | -6.49E-04 | 2.01E-05 | -3.00E-05 | 3,106 |
| Crop production index | -0.007 | -0.017 | -0.003 | -0.006 | 117.65 |
| Food production index | -0.006 | -0.017 | -0.002 | -0.008 | 117.73 |
| Forest area | 0.03 | -0.09 | 0.04 | 0.05 | |
| ln GDP | 0.17 | 0.45 | -0.36 | -1.17 | 24.23 |
| GDP growth | -0.017 | -0.017 | -0.019 | -0.010 | 3.75 % |
| ln GDP per capita | -0.30 | 0.01 | -0.77 | -1.31 | 8.07 |
| GDP per capita growth | -0.016 | -0.016 | -0.019 | -0.009 | 1.91 % |
| ln GDP per capita, PPP | -2.51 | -1.95 | -2.83 | -2.44 | 8.81 |
| Inflation, consumer prices | -1.10E-02 | -3.80E-03 | -6.95E-03 | 1.50E-02 | 6.00 % |
| Gini index | -0.06 | -0.16 | 0.00 | 0.01 | |
| ln Population | 5.79 | 4.98 | 4.27 | 0.71 | 16.12 |
| Armed forces personnel | 0.06 | 0.04 | 0.09 | -0.05 | |
| Military expenditure | 2.85E-03 | 8.80E-03 | 5.14E-03 | -5.51E-04 | |
| Arms imports | 0.00 | 0.00 | 0.00 | 0.00 | |
| Presence of peacekeepers | -8.73E-05 | -1.52E-04 | 8.84E-05 | 1.09E-04 | 4,999 |
| ln IDPs (high estimate) | -0.04 | 0.03 | -0.13 | 0.00 | 9.78 |
| ln IDPs (low estimate) | 0.45 | 0.14 | 0.18 | 0.16 | 12.37 |

*Notes*: Table shows the estimates ($\alpha_1$) of the simple fixed-effects model outlined above; coefficients in black are significant at least at the 10 % level, those in grey are not. The last column to the right shows the average of the independent variable $\text{WBDI}_{it}$ (for the set of countries concerned) over the period covered by both IBC and WB data sets (2009-2015). All dependent variables are logged. "AS" stands for asylum-seeker.
The average *high* estimate of IDPs is lower than the average *low* estimate of IDPs, but note the sample size difference.

In particular, Table 3 points at income (per capita or national) *growth* as an important migration inhibitor (i.e. income growth is associated with less emigration); per capita income at purchasing power parity was also significantly negatively associated with all four measures of distress-driven migration. Levels, however, are otherwise not significant, nor are inflation and income inequality in the source country (cf. the lack of significance of the Gini index[35]). Allowing for more flexibility in the specification helps clarify the relationship to income (regression results not shown): quadratic functions yield a much better fit (almost as good as lowess), as shown on Figures S8a-S8b (in annex), which could be expected from the theory narrated above (section §2 – emigration increases as income at origin gets larger and credit constraints are overcome, up to a certain point after which emigration decreases as income, and hence the opportunity cost of moving, increase).

And while surface-based measures of the size of the agricultural sector seem not to matter for any of

[35] While I found this somewhat surprising, it may also be due to the fact that Gini index data as provided by the World Bank is very lacunary – cf. Table S2 for sample sizes; while there are 1080 observations for IBC detections at the country-year level, there are only 194 for corresponding Gini indices; most countries only have one observation over 2009-2015, and there is in fact no observation for year 2015 for any of the countries in the sample. Mayda [2010] uses total migration into OECD countries and "high-quality" Gini index observations from a different data set than the one I'm using here (the "Deininger and Squire (1996) dataset"), and extrapolates the rest; she finds that relative inequality (between source and origin countries) plays a significant role in explaining emigration rates.

the emigration variables, production-based measures (cereal production, crop and food production indices, cereal yield) do. Unsurprisingly, higher food (or crop) production is associated with less emigration (and this shouldn't be attributable to the size of the country or its population given that the specification includes country fixed-effects); but this may only hold up to some quantity of food (cereals) produced, as a quadratic relationship –similar to that observed for per capita income– seems to offer a better fit between cereal production (the physical measure, in tonnes) and IBC detections (both in logs), as can be seen on Figure S8c (regression results not shown).

Finally, conflict-related measures yield a somewhat confusing picture due to the dearth of observations (and likely the measurement errors surrounding reports of military expenditure, arms imports, IDPs[36]). It seems anecdotal and likely calls for a deeper investigation, that the various estimates of IDPs should be significantly negatively associated with IBCs at land and total, alternatively positively (total) and negatively (land); it may say something of the mechanics through which internal displacement eventually translates into (illegal) international migration (regarding timeline and route), or may just reflect that the sets of countries that send migrants across the sea, or across land borders, are distinct, and differ by some deep characteristics (yet to be determined). More interestingly, the share of the labor force enrolled in the army becomes a significant factor when lagged (thus likely indicating that the changes, rather than the levels, matter); looking at yearly changes, it seems that increases in that variable are associated with larger IBC detections (i.e. the fact that the armed forces –whether governmental or not– should take a larger share of the labor force signals future emigration). An increase in the size of armed forces could indeed denote mounting tensions or be associated with more exactions against civilians.

Despite the data challenges –short and lacunary time series, unbalanced panel, measurement error– the IBC detection data seems to respond to suspected migration drivers. The urge to migrate (illegally) would be accrued by: low food production, low GDP (per capita or national) growth, increased army size (the relationship to IDPs is unclear). This points at a counter-cyclical form of migration, i.e. people emigrate when conditions at home are bad or deteriorate.[37]

While the asylum application response to those drivers differs, their behaviours are generally similar and consistent. Therefore, while the two series capture different aspects of distress-driven migration, the underlying push factors are homologous.

### 4.3 Weather shocks and migration: an intriguing or null result

The present section discusses the relationship between IBC detections and weather over the maize growing area and season in the origin country, as shown in Table 4; regression results for weather variable averaged over the entire country and year are consigned in annex, Table S7.

Contrary to what was previously found with asylum-seeker data (Missirian and Schlenker [2017b]), no clear and stable relationship of any kind (linear or otherwise) emerges between IBC detections and weather in the origin country.

Precipitation clearly has no effect whatsoever on the dependent variable (neither "natural," nor lagged, squared, splined, averaged over the maize growing season or not).

Temperature, however, shows a more complex effect. There appears to be a response to a quadratic in (contemporaneous) temperature (column (1) of Table 4) as long as no controls other than country fixed-effects are included; it disappears when year fixed-effects are added (as in column (2)), where they seem to absorb most of the identifying the variation. Adding lags and precipitations (columns (3) and (4)) further restricts the sample and increases the model's degrees of freedom, it is therefore not surprising that the coefficients for contemporaneous temperature and squared temperature should not be significant; the signs and size of the estimates remain unscathed, however, and are quite close to those found in Missirian and Schlenker

[36] Note for instance that there are 34 country-year pairs of observations where the low estimate for IDPs is larger than the high estimate, out of 140 instances where both figures are available. Regarding arms imports, also note that those only concern heavy equipment such as aircrafts and tanks; light weapons and light military vehicles, for instance, are not included.

[37] The opposite would be pro-cyclical migration, whereby people emigrate when conditions are better or improve at home, as it enables them to afford the cost of the move (as long as the income (or other measure of welfare) gradient remains strong enough); this can be detected at higher income levels in our sample, thus reproducing the inverted-U shape predicted by theory and sometimes found empirically between income and emigration.

[2017b] with the asylum-seeker data.[38] More puzzling are the facts that the first lag in temperature (and the first lag only) should become significant, and that in Table S7 the second lag in temperature and squared temperature (*averaged over the entire country*) should be significant.[39] This may indicate something as to the mechanism through which temperature shocks influence migration (e.g. country-wide shocks matter, and take two years to translate into migration across the Mediterranean; shocks on the rural sector take one year), but may also indicate that the contemporaneous temperature effects picked up in Table 4 are spurious.

Note that the results *cannot* be driven (nor rendered null) by the spike in IBCs 2015, since the Delaware weather data doesn't cover 2015 onwards. Note also that there are at best only 4 observations per origin country when the model comprises two lags, because the time series is extremely short, which certainly doesn't facilitate the identification of a pattern concerning the relationship between migration and weather shocks.

[38] In that paper, the model using a quadratic in temperature, no precipitations, and no lags found -0.556 for the temperature coefficient and 0.012 for the squared temperature coefficient, both significant at the 1% level.

[39] The signs remain in line with what would be expected, i.e. a convex parabola when squared temperature matters, and else, a positive relationship between temperature and IBC detections as for the lagged (t-1) coefficients in columns (3)-(4) – i.e., the hotter in the origin country, the more IBC detections.

Table 4: Illegal Border Crossings and Temperature Shocks in Origin Countries

| | Illegal Border Crossings | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Average Temperature in t | -0.673** | -0.480 | -0.459 | -0.468 |
| | (0.296) | (0.321) | (0.465) | (0.481) |
| Average Temperature in t-1 | | | 0.630** | 0.640** |
| | | | (0.312) | (0.300) |
| Average Temperature in t-2 | | | 0.728 | 0.725 |
| | | | (0.491) | (0.510) |
| Avg. Temp. Squared in t | 0.014* | 0.011 | 0.016 | 0.018 |
| | (0.007) | (0.008) | (0.011) | (0.012) |
| Avg. Temp. Squared in t-1 | | | -0.010 | -0.010 |
| | | | (0.007) | (0.007) |
| Avg. Temp. Squared in t-2 | | | -0.015 | -0.014 |
| | | | (0.011) | (0.012) |
| Precipitation in t | | | | 0.001 |
| | | | | (0.001) |
| Precipitation in t-1 | | | | 0.001 |
| | | | | (0.001) |
| Precipitation in t-2 | | | | 0.001 |
| | | | | (0.001) |
| Prec. Squared in t | | | | -0.000 |
| | | | | (0.000) |
| Prec. Squared in t-1 | | | | -0.000 |
| | | | | (0.000) |
| Prec. Squared in t-2 | | | | -0.000 |
| | | | | (0.000) |
| Country FEs | Y | Y | Y | Y |
| Year FEs | | Y | Y | Y |
| Lags (2) | | | Y | Y |
| $R^2$ | 0.006 | 0.095 | 0.152 | 0.170 |
| N | 552 | 552 | 368 | 368 |
| p-value Temperature | 0.025 | 0.294 | 0.136 | 0.070 |

Notes: $*p < 0.1, **p < 0.05, ***p < 0.01$. Robust standard errors in parentheses. *p-value Temperature* corresponds to the joint significance of the temperature variables included.

## 4.4 Discussion and some caveats

The results presented in the first two sections (4.1 and 4.2) confirm IBC data as a measure of distress-driven migration, as it bears a close relationship to asylum-seeker data and responds well-documented "push-factors," while distinguishing itself from more traditional sources by its finer time scale, direct policy relevance, and harbouring a behaviour of its own.

Those presented in section 4.3 are somewhat less clear. Migration as measured by IBC detections seems not to respond *at all* to precipitation over the origin country, but *may* respond to temperature over the maize growing area and season, although the relationship is weak and unstable.

These analyses are hampered by the small overlap of the various time series they rely on, and the gaps that exist in some of the data sets.

Even the positive results presented here are to be taken with caution and circumspection. IBC detections between BCPs measure, as their name indicates, illegal border-*crossings*, hence overlooks other forms of illegal migration (e.g. overstaying one's visa), and may overstate or understate the actual number of illegal *migrants* (i.e. individuals) crossing the border, as Frontex doesn't guarantee a watertight border, and migrants are known to attempt to cross several times on average, or may have to cross the green border several times on their journey to their intended destination – Frontex estimates that there might have been about 1,000,000 *people* in 2015 who crossed the borders into the EU illegally, and reports 1,820,000 IBC detections between BCPs for that period.[40] But as argued in the Data section, they remain a good and useful measure of migratory pressure.

[40] Frontex even notes that getting their "customers" to have to cross (rather, attempt to do so) several times is part of some smugglers' business strategy, as they "purposely s[i]nk their boats" in order to get paid for several trips [Frontex, 2016].

# 5 Conclusion

In this paper I have described a data set that hasn't to my knowledge been used before in scholarly research to analyse migration, and could be exploited to some profit to gain insights on human migration and its drivers, in particular as far as distress-driven migration is concerned.

Illegal border-crossings (IBCs) between border-crossing points (BCPs) are a good and highly policy-relevant measure of migratory pressure at the EU external borders; they correspond to a counter-cyclical type of migration, and seem to respond to changes in domestic income, food production and level of tension, and may also respond to weather (temperature) shocks (on the maize growing area and season). At the country-year level, they provide a complementary picture to that obtained with asylum-seekers data.

The country-year level, however, loses a wealth of information contained in the Frontex data, which in my view offers a fruitful alley for future research and is a unique feature to this data set. Indeed, in all that precedes, it's the data collection process characterising the Frontex data set that has made its specificity. The potential lying in the other dimensions over which the data has been aggregated (border type, route, month) has so far remained untapped.

Beyond the effect of seasonality or weather at sea on border type choice (land, sea) which has been widely covered in news pieces,[41] the monthly resolution and information on the route taken could be exploited. For instance, both dimensions could be used to assess the effect of public statements and policies – e.g., was Chancellor Angela Merkel's declaration that "there is no upper limit to the right for asylum"[42] followed by a surge in migration? did the EU-Turkey agreement (or all the joint declarations that preceded) indeed reduce the flow coming from Turkey-controlled routes (Figure S6 seems to indicate so), did smugglers transfer the flow to other routes?

Although data collected by Frontex only concerns *illegal* migration solely into the *European Union*, it promises to offer insights into international migration in general, distress-driven, and South-North, in particular, all the more so as the time series deepens thanks to the publication of data collected by the agency priori to 2009, or to the addition of new years of data as the series ages.

[41] *La Croix* (France), 28/05/2017: "*Les traversées et les naufrages de migrants ont repris avec l'arrivée des beaux jours, où la Méditerranée est plus clémente*," crossings [of the Mediterranean] and shipwrecks have resumed as the weather got nicer, and the Mediterranean more clement (www.la-croix.com). *Le Soir* (Belgium), 29/05/2016: "*Migrants: avec les beaux jours, le carnage reprend en Méditerranée*" (title), Migrants: the carnage resumes in the Mediterranean as summer weather settles in (www.lesoir.be). *CNN* (USA), 26/05/2017: "This week, Italy received 4,513 migrants to the country. It was a 576 % increase from the previous week, according to the International Organization for Migration. It could suggest that more migrants are attempting to cross the Mediterranean as the weather gets warmer – a pattern seen in previous years." (www.cnn.com).

[42] Frontex [2016] p. 19, and *The Guardian* 08/11/2015, theguardian.com.

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# Appendix

# A Supplementary information

## A.1 Definitions

**asylum-seeker** Individual who has sought international protection and whose claims for refugee status have not yet been determined. (Source: UNHCR [2016])

**border crossing** The physical act of crossing a border either at a border crossing point or another point along the border.[43] (Source: EMN, Asylum and Migration Glossary, version 3.0.[44])

**border crossing point** Any crossing point authorised by the competent authorities for the crossing of external EU borders. (Source: EMN, *ibid*.)

**FRAN Member States** The 28 EU Member States and the three Schengen Associated Countries (Iceland, Norway and Switzerland). [Frontex, 2016]

**internally displaced person** Individual who has been forced to leave their home or place of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalised violence, violations of human rights, or natural or man-made disasters, and who have not crossed an international border. (For the purposes of UNHCR's statistics, this population includes only conflict-generated IDPs to whom the Office extends protection and/or assistance. The IDP population also includes people in an IDP-like situation, i.e. groups of persons who are inside their country of nationality or habitual residence and who face protection risks similar to IDPs but who, for practical or other reasons, could not be reported as such.) (Source: UNHCR [2016].)

**refugee** "Any person who owing to well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence, is unable or, owing to such fear, is unwilling to return to it." (1963 Protocol Art. I.2, UNHCR [2010])

## A.2 On Frontex

As explained by the European Commission (ec.europa.eu), "Operational cooperation between EU States is coordinated by the European Agency for the Management of Operational Cooperation at the External Borders ("FRONTEX"). The major task of the Frontex Agency is to coordinate joint operations to assist EU States in managing migratory flows at their external borders. The joint operations coordinated by the Frontex Agency at sea are governed by Regulation 656/2014, which establishes rules on interception, rescue and disembarkation to be applied in the context of such joint operations. The Agency also manages a pool of border guards called European Border Guard Teams for deployment as guest officers during Frontex joint operations and pilot projects, and during Rapid interventions in States facing urgent and exceptional pressures at their external borders."

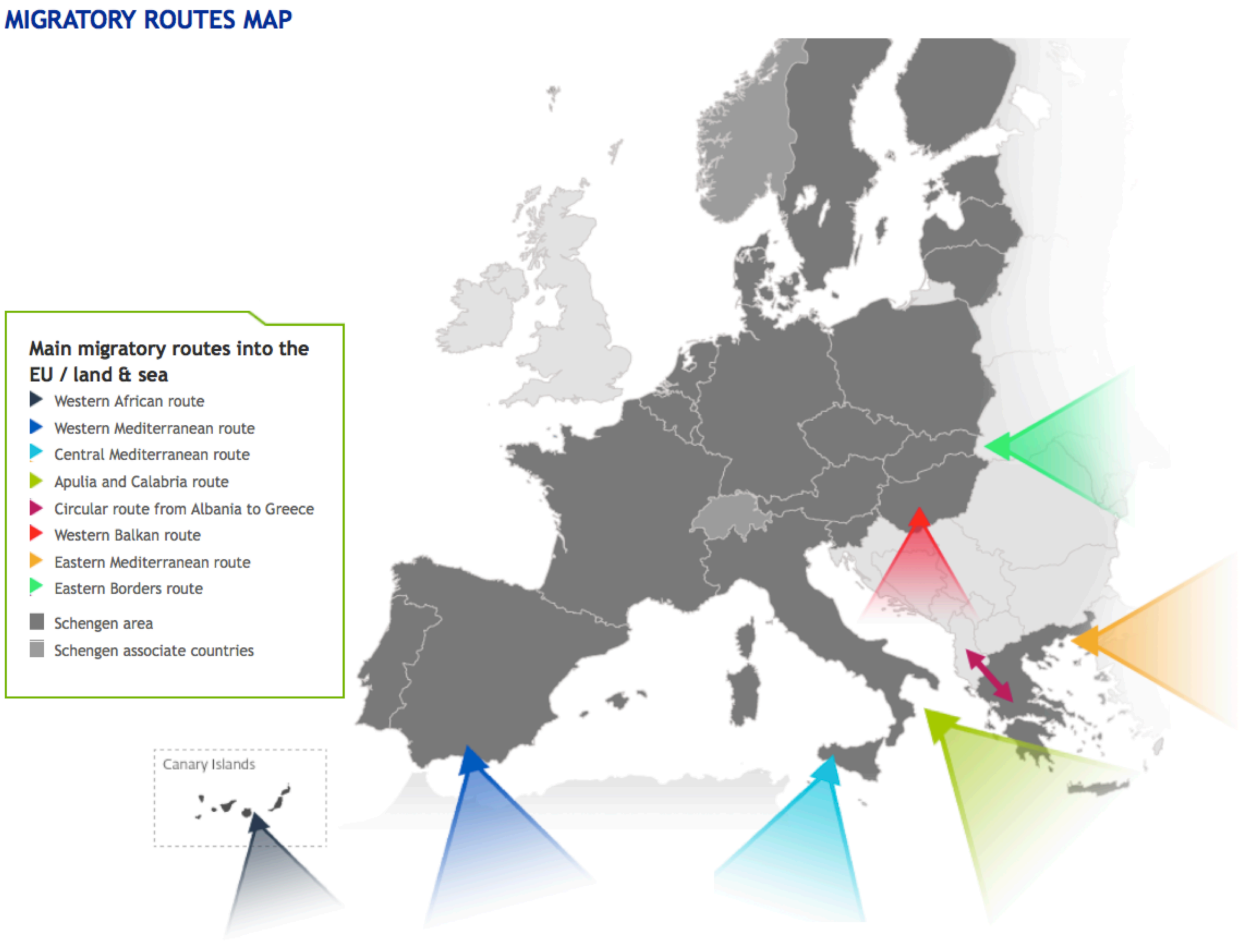
Frontex also collects and analyses the data pertaining to its operations, in order to produce intelligence and policy guidance for its own needs as well as for European policymakers.

[43] The latter appear in Frontex statistics as IBC detections *between* BCPs, as opposed to *at* BCP.

[44] The European Migration Network was established in 2008 by the European Council, and its mission is to provide "up-to-date, objective, reliable and comparable information on migration and asylum topics to policy makers (at EU and Member State level) and the general public".

# B Supplementary figures

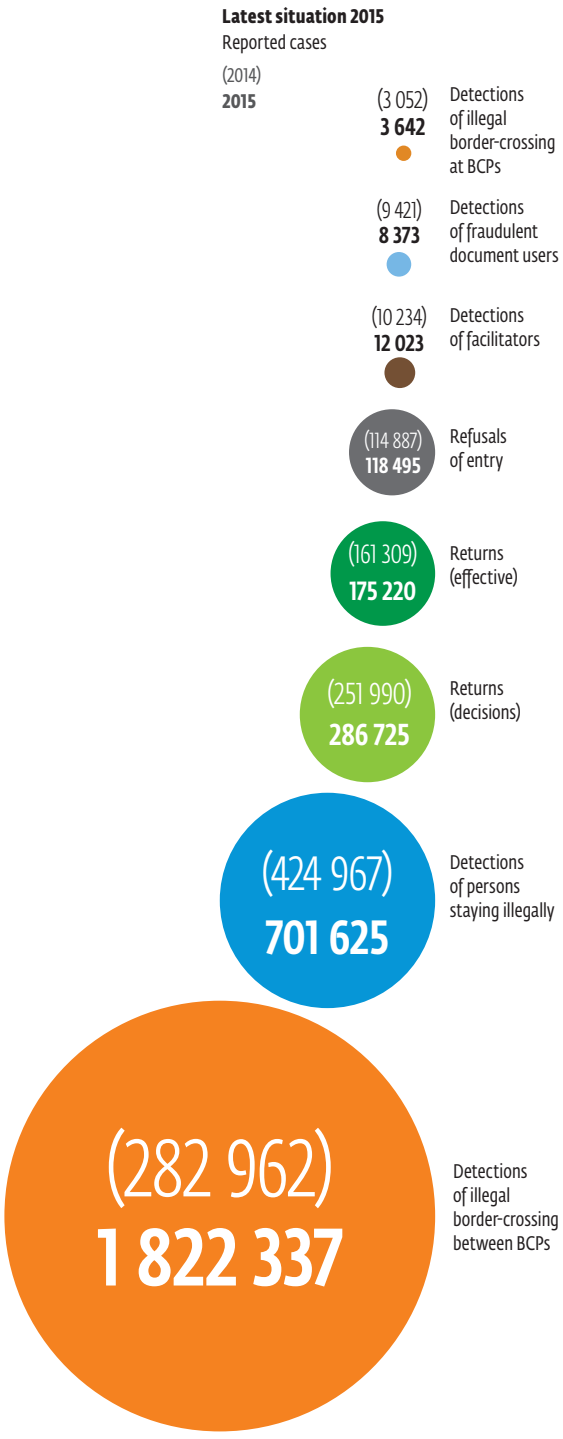
Figure S1: Main migratory routes into the European Union, according to Frontex




| Route | Zones included |
|---|---|
| Black Sea | Bulgaria and Romania sea borders. |
| Central Mediterranean | Italy and Malta sea borders. |
| Circular route from Albania to Greece | Greece land border with Albania. |
| Eastern Land Borders | Romania, Hungary, Slovakia, Poland, Lithuania, Latvia, Estonia, Finland and Norway land borders with Moldova, Ukraine, Belarus and Russia. |
| Eastern Mediterranean | Cyprus, Greece sea border, Greece and Bulgaria land borders with Turkey. |
| Other | Areas not included in the other routes. E.g.: Baltic Sea, North sea. |
| Western African | Canary Islands. |
| Western Balkans | Greece, Bulgaria, Romania, Hungary and Croatia at the land borders with countries from the Western Balkan region. |
| Western Mediterranean | Spain land and sea borders without the Canary Islands. |

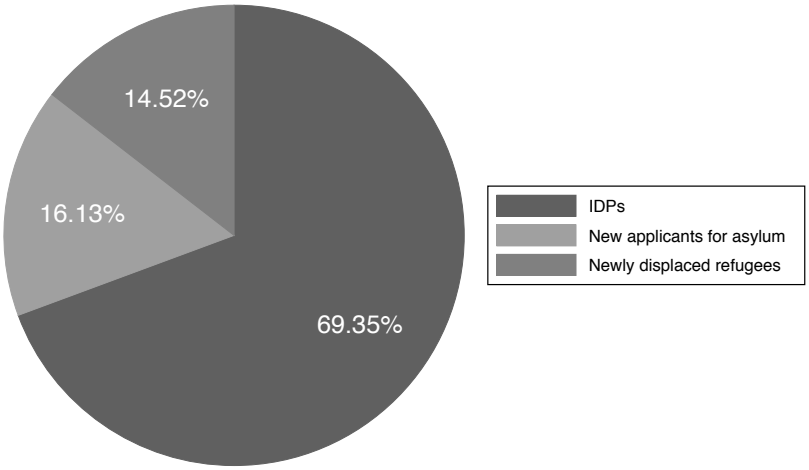
*Notes:* Source: Frontex, frontex.europa.eu.

Figure S2: Orders of magnitude



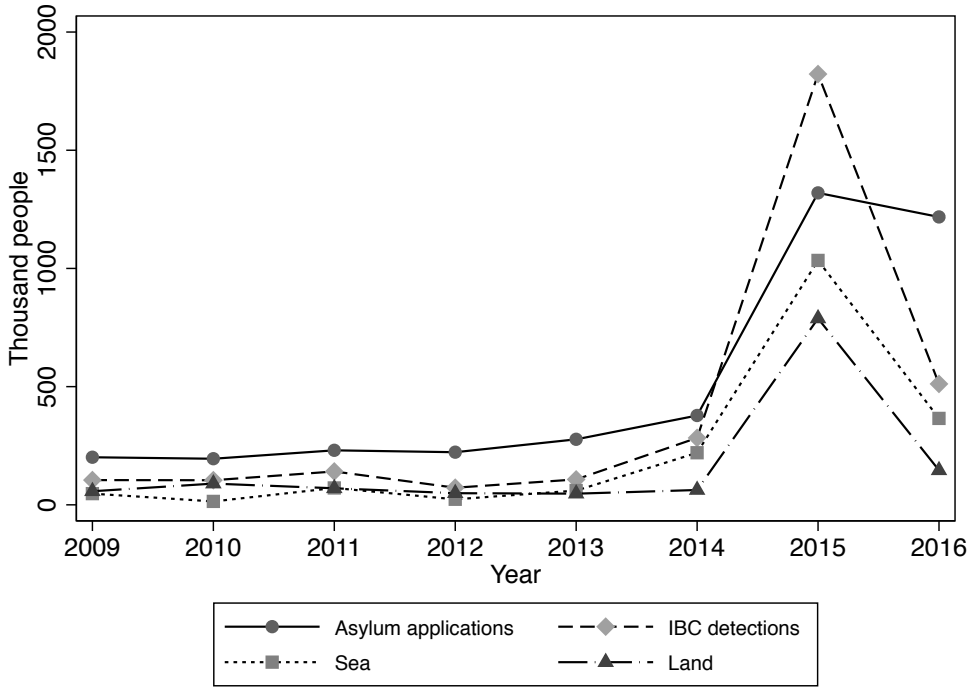

*Notes:* Shows magnitude of IBCs compared to other Frontex migration-related indicators. Notice rank change over 2015-16 between IBC detections between BCPs and detections of persons staying illegally, and *lack* thereof between IBC detections *between* BCPs and IBC detections *at* BCP. Source: Frontex [2016], p. 14.

Figure S3: Newly displaced people in 2015 (total: 12.4 millions)



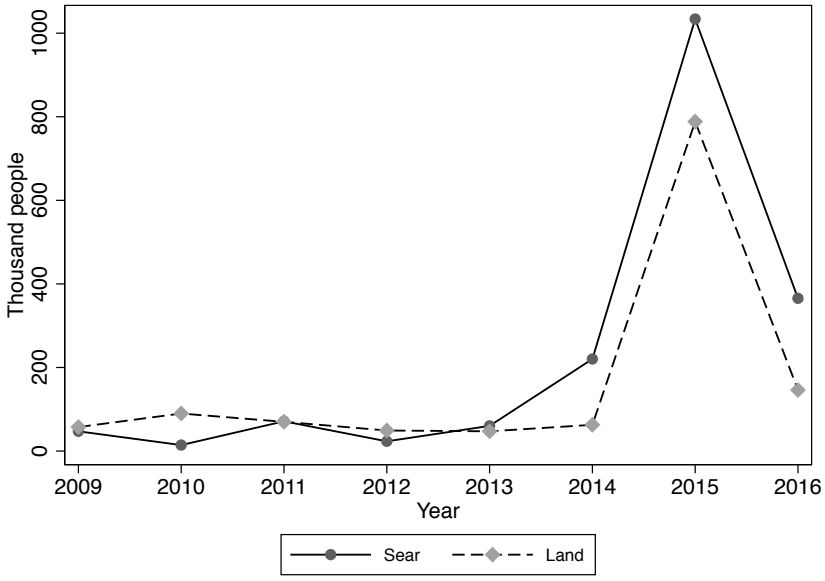

*Notes:* Shows magnitude and relative importance of three categories of displaced populations of concern to the UNHCR, *newly* displaced during the year 2015 (worldwide). IDPs stands for Internally Displaced Persons. Source: UNHCR [2016], p. 2 (data).

Figure S4: Comparison of the UNHCR and Frontex time series, 2009-2016



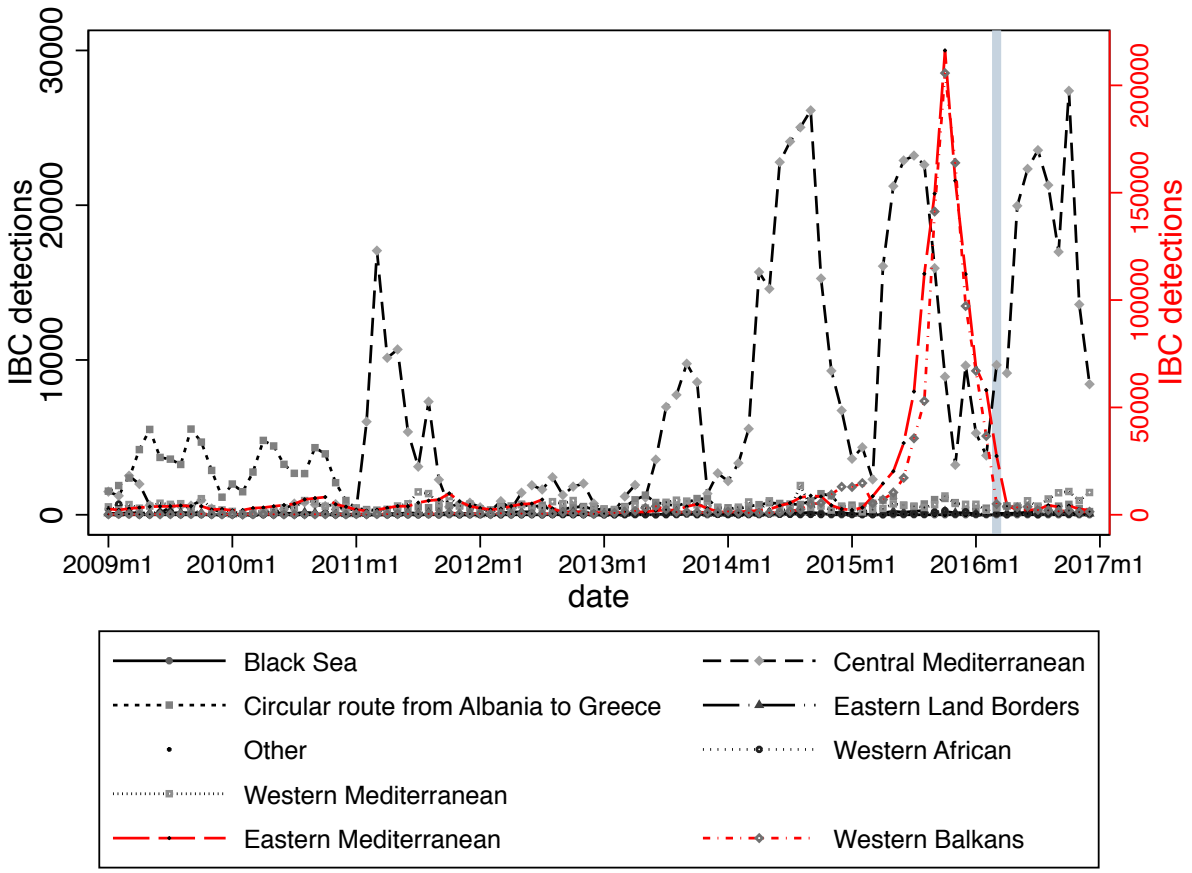

*Notes:* The figure presents the aggregate numbers of new asylum applications filed, and illegal border crossings detected (total, land border, or sea border), all origins included, by year and over the period for which Frontex data is available. Correlation of the two aggregate time series (IBCs and asylum applications) is 0.8417 ($N = 8$), when disaggregated by country, 0.6498 ($N = 1,104$).

Figure S5: Comparison of border crossing routes, 2009-2016



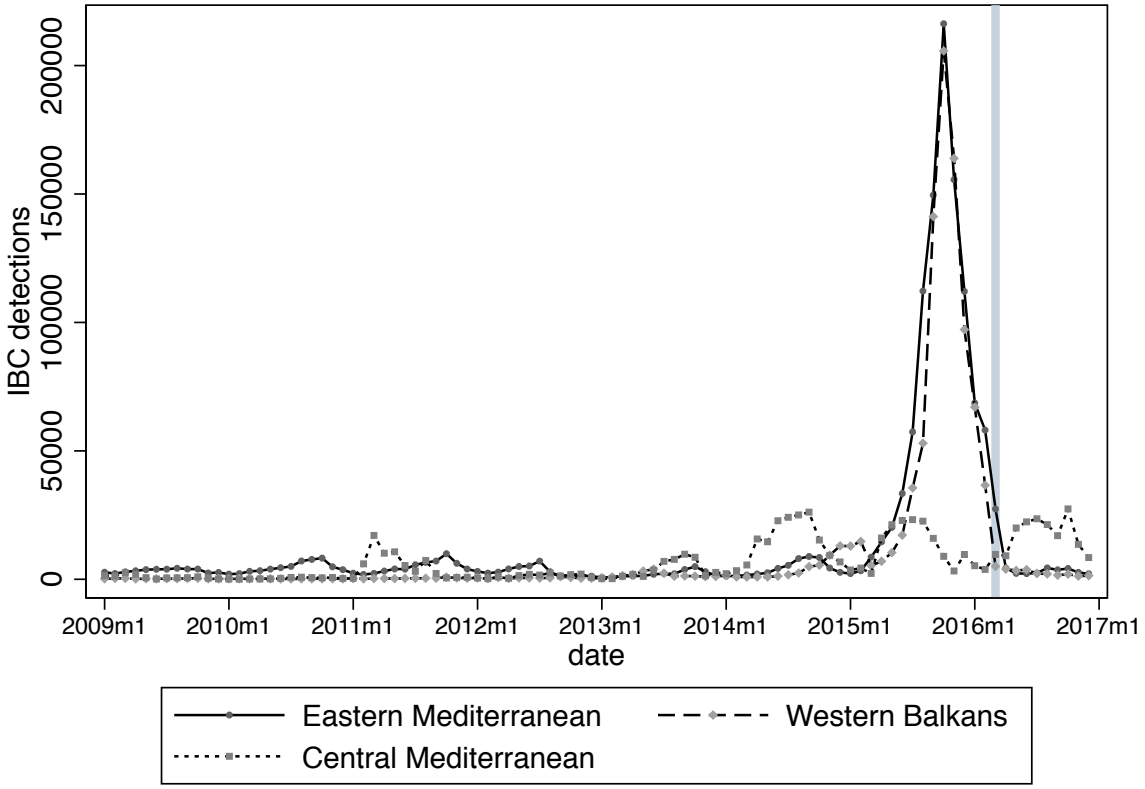

*Notes:* The figure presents the aggregate numbers of illegal border crossings detected (land or sea border), all origins included, by year and over the period for which Frontex data is available. Correlation of the two aggregate time series is 0.9587 ($N = 8$), when disaggregated by country, 0.1896 ($N = 1,120$).

Figure S6: Migratory routes, 2009-2016




*Notes:* Note that *Eastern Mediterranean* and *Western Balkans* routes are represented on a separate scale (right axis); see Figure S7 for a better sense of magnitudes. Shaded area (March 2016) marks the publication of the first draft (March 7th), the signature (March 18th), and the enforcement start date (March 20th) of the EU-Turkey agreement (technically, a "statement"), whereby any migrant crossing from Turkey into Greek islands will be returned to Turkey. This measure is declared to be "extraordinary and temporary" measure, and closes effectively the Eastern Mediterranean route (and perhaps the Western Balkan route?). This agreement comes after the "EU-Turkey Joint Action Plan activated on 29 November" (sources: EU-Turkey statement and press release by the Commission on europa.eu).

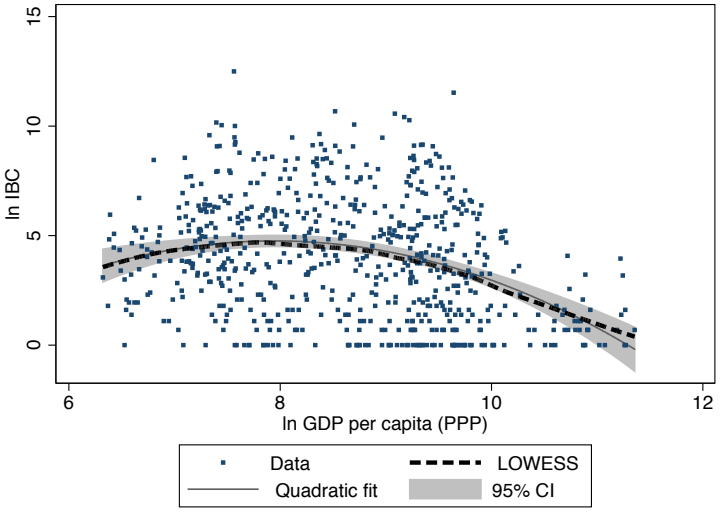
Figure S7: Migratory routes (selected), 2009-2016



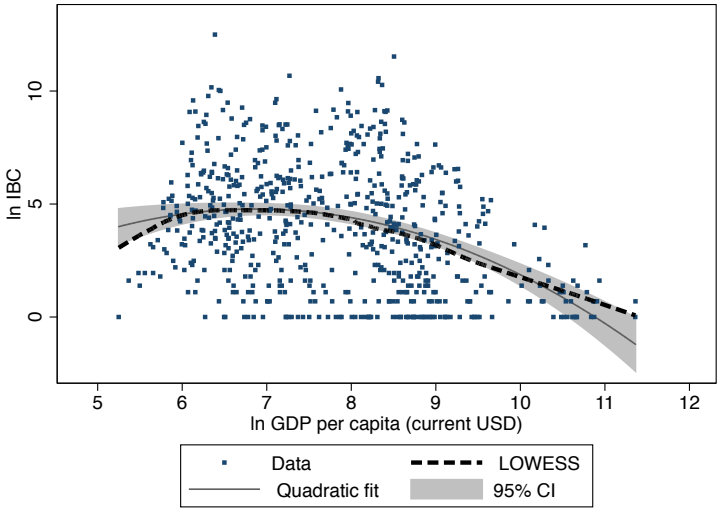

*Notes:* Shaded area (March 2016) marks the publication of the first draft (March 7th), the signature (March 18th), and the enforcement start date (March 20th) of the EU-Turkey agreement on illegal migration stemming from Turkey into the EU. Other migratory routes are of incommensurably smaller importance.

Figure S8: IBC detections: Non-linear relationships to migration drivers

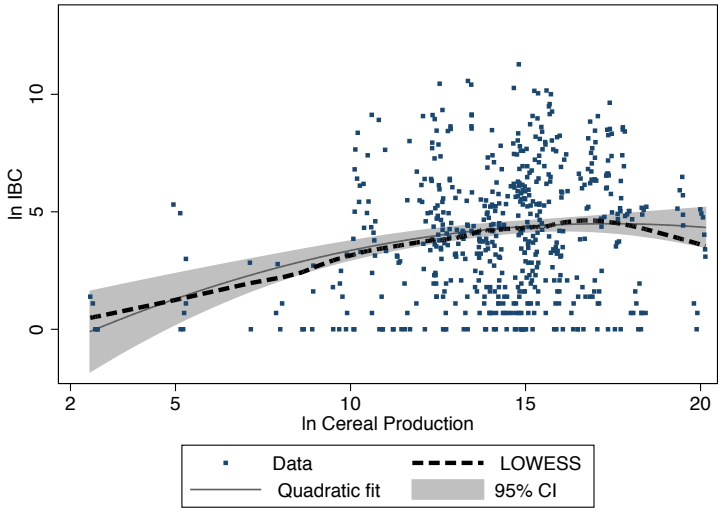
(a) Per capita GDP (PPP)




(b) Per capita GDP (current USD)



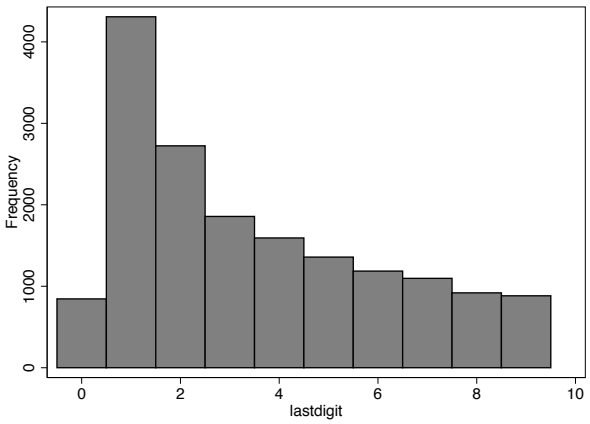

(c) Cereal production



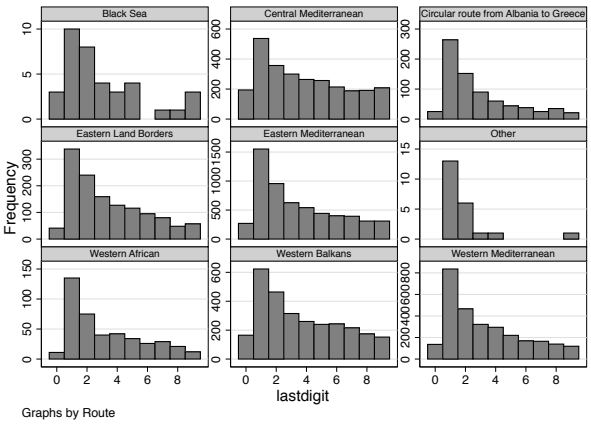

*Notes:* Figure presents instances of non-linear relationships between migration drivers explored in section 4.2, by means of LOWESS and quadratic fits.

Figure S9: Excess zeros? Examining the last digit of IBC detection figures

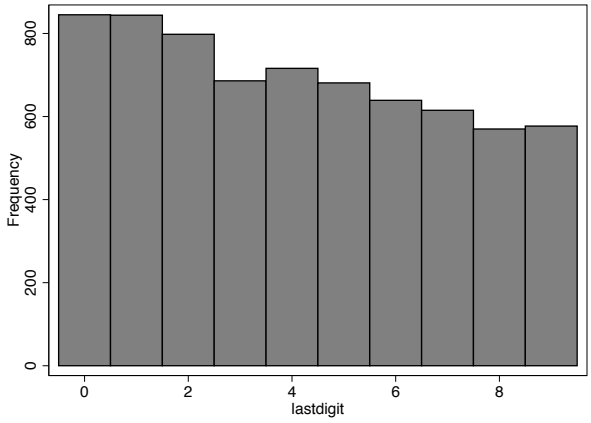
(a) Full sample




(b) Full sample, by route

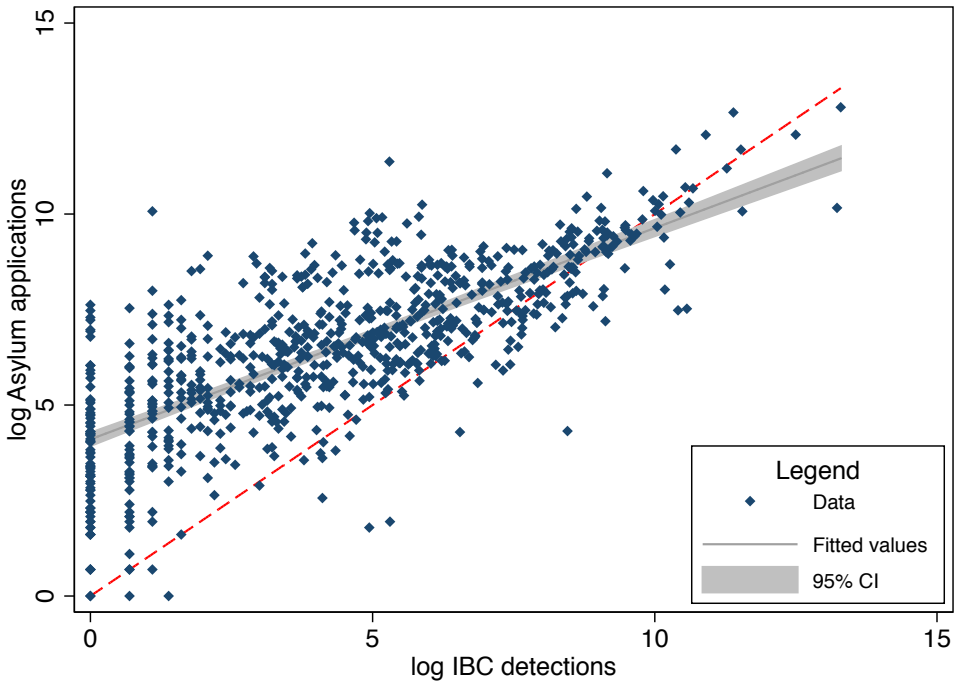



(c) Sample such that $n \geq 10$



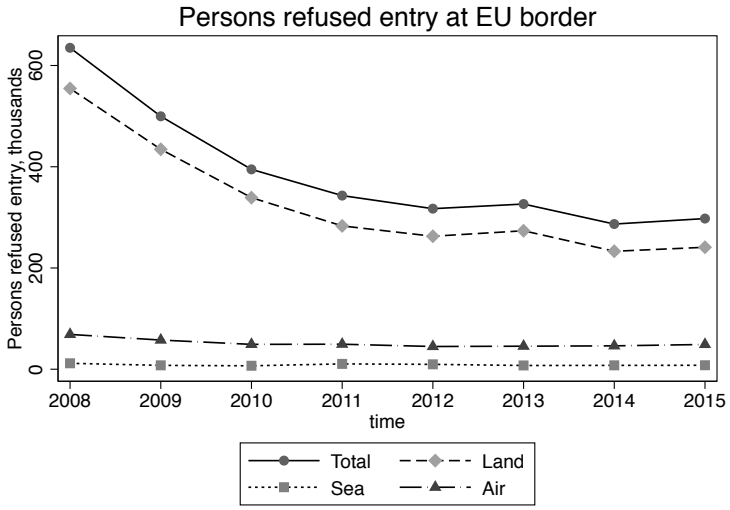

*Notes:* The figures present the frequencies of integers $0 - 9$ as last digits in the raw monthly IBC detection figures as reported by Frontex. Entries reported as "0" are ignored. The excess of "1"s seems to be entirely attributable to detections of a single IBC in a given month for a given route (not shown); patterns do not change much when considering or excluding a particular route (see Figure S9b), vaguely specified ("Unspecified sub-Saharan nationals") or unspecified ("Not specified") nationalities (not shown).

Figure S10: Log asylum applications into the EU vs. log IBC detections, 2009-2016



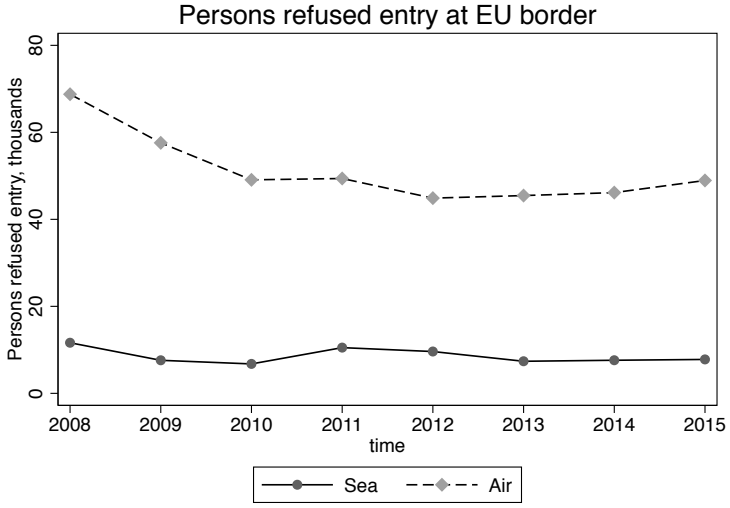

*Notes:* The figure presents presents the log asylum applications filed in a given year from a given country into the European Union, against the illegal border-crossing detections of nationals of that same country and in that same year. The red dashed line corresponds to the 45° line (where IBC detections = asylum applications), and the solid grey line corresponds to the best linear fit between the two series – see column (1) of Table 2.

Figure S11: Persons refused entry into EU territory



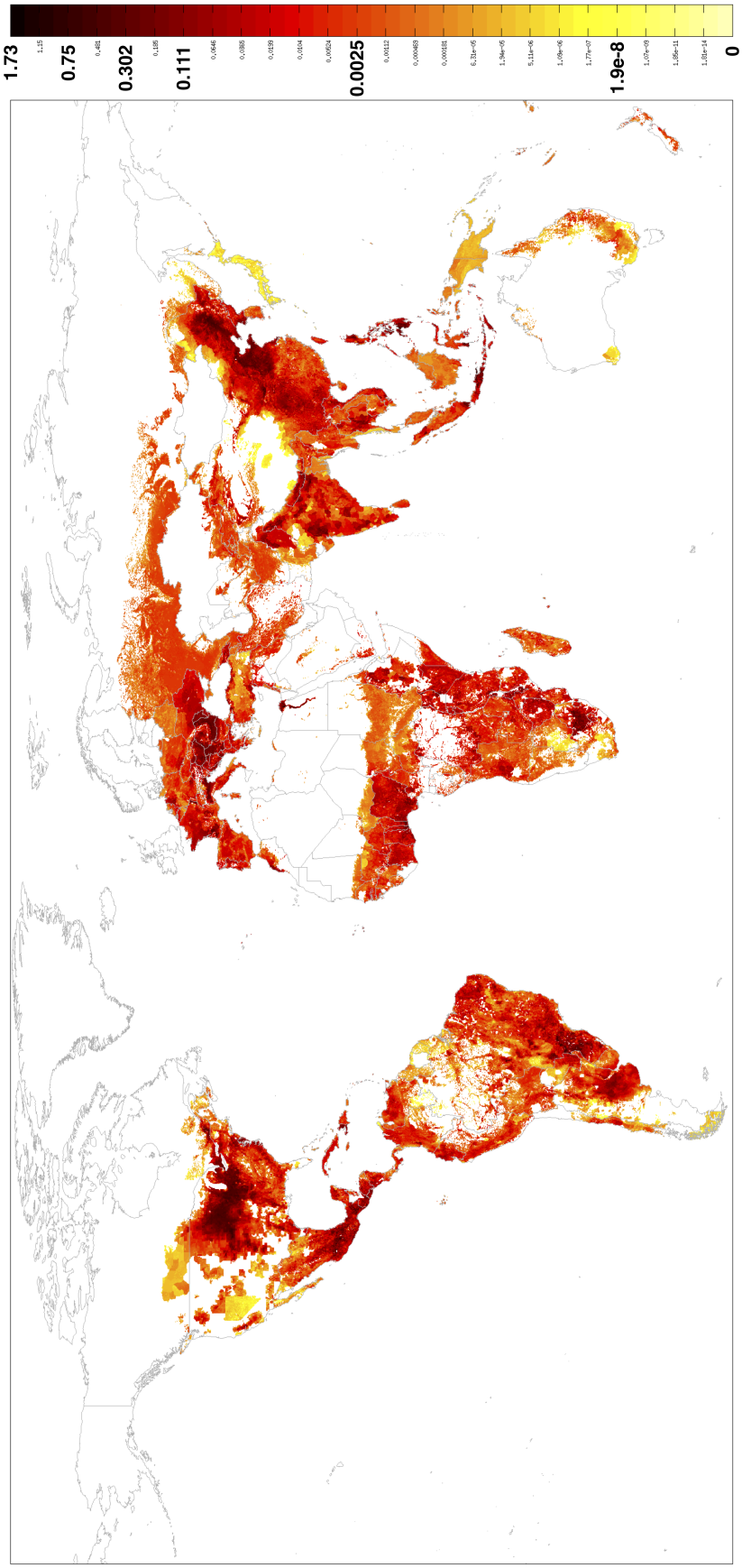

*Notes:* The figure presents Eurostat data on the numbers of people denied entry into the European Union (i.e. at external borders), in its EU28 configuration.
Data source: Eurostat (series migr_eirfs ("Third country nationals refused entry at the external borders - annual data (rounded)" – which also contains data for non-member associated states (e.g. Switzerland)).

Figure S12: Persons refused entry into EU territory, zooming in on air and sea BCPs




*Notes:* The figure presents Eurostat data on the numbers of people denied entry into the European Union (i.e. at external borders), in its EU28 configuration, at air and sea border crossing points (BCPs) only.
Data source: Eurostat (series migr_eirfs).

Figure S13: Maize Growing Area




*Notes:* Figure displays the fraction of each grid cell in Monfreda et al. [2008] used to grow maize (note the nonlinear scale on the right). Numbers greater than 1 indicate double cropping.

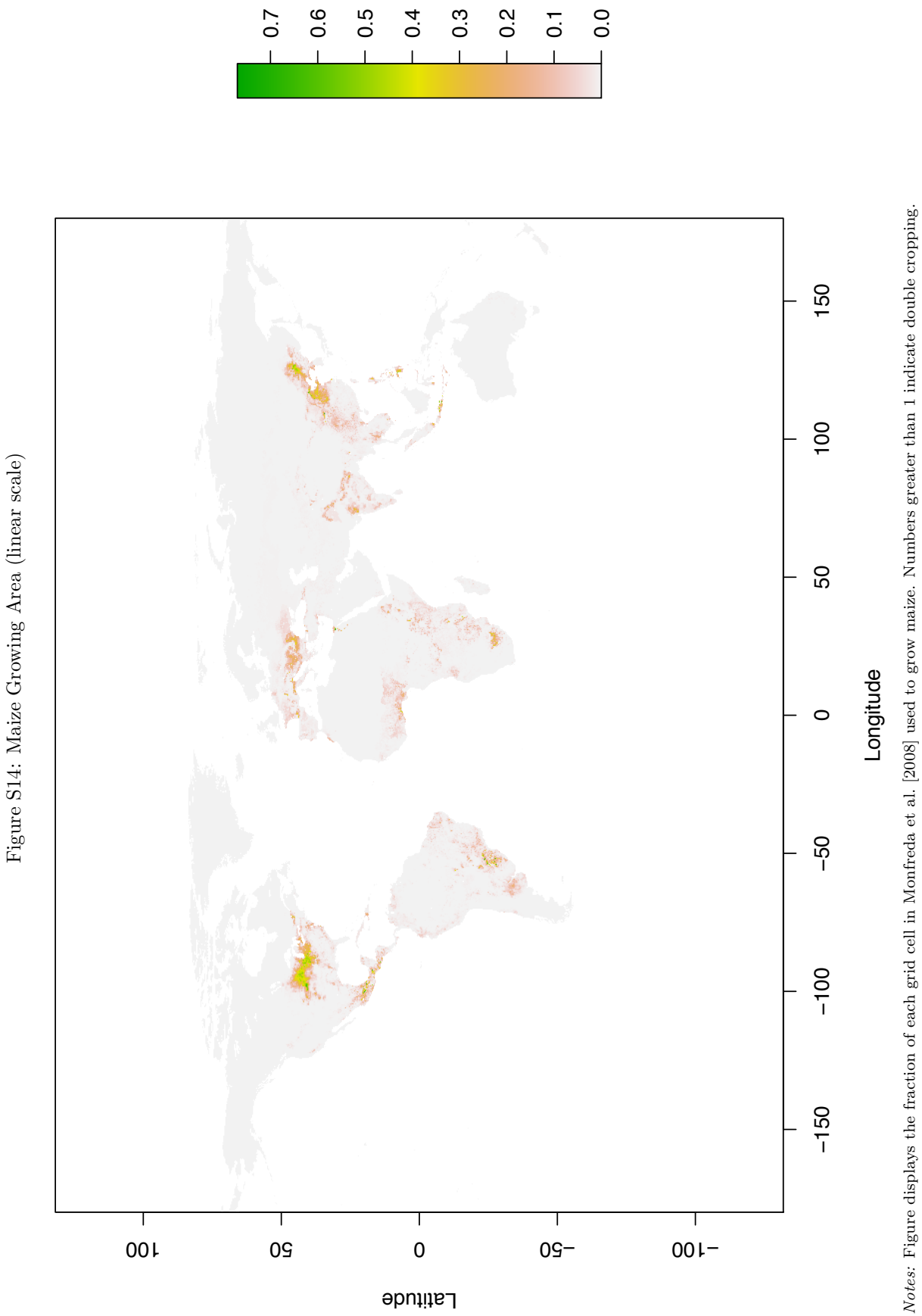



Figure S14: Maize Growing Area (linear scale)

*Notes:* Figure displays the fraction of each grid cell in Monfreda et al. [2008] used to grow maize. Numbers greater than 1 indicate double cropping.

# C Supplementary tables

## C.1 World Bank Development indicators

Table S1: Selected World Bank Development Indicators

| |
|---|
| **food production** |
| agricultural GDP |
| surface of agricultural land |
| surface of agricultural land in cereal |
| cereal production |
| cereal yield |
| food production index |
| forest land |
| **conflict** |
| armed forces personnel (% of total labor force) |
| arms import |
| military expenditure |
| internally displaced people (IDPs), lower estimate |
| internally displaced people (IDPs), higher estimate |
| number of UN peacekeepers present |
| **national economy** |
| GDP (current USD) |
| GDP growth (annual) |
| GDP per capita (current USD) |
| GDP per capita (at PPP) |
| GDP per capita growth (annual) |
| inflation (consumer prices, annual % change) |
| Gini coefficient |
| population |

Table S2: Summary statistics of the World Bank Development Indicators, for the IBC detection sample

| Variable | n Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Agricultural land | 774 | 40.7214 | 22.19422 | .9308886 | 80.77779 |
| Land under cereal production | 747 | 5099723 | 1.37e+07 | 0 | 1.01e+08 |
| Forest area | 903 | 29.00784 | 23.50354 | 0 | 89.26146 |
| Cereal production | 747 | 1.81e+07 | 6.50e+07 | 0 | 5.57e+08 |
| Crop production index | 650 | 117.6539 | 25.48487 | 40.16 | 291.48 |
| Food production index | 650 | 117.7261 | 20.3258 | 55.15 | 213.39 |
| Cereal yield | 747 | 3106.252 | 5076.963 | 177.8 | 74205.6 |
| Inflation | 813 | 6.003837 | 8.072509 | -8.283078 | 121.7381 |
| Arms imports | 566 | 2.93e+08 | 5.64e+08 | 0 | 5.29e+09 |
| Armed forces personnel | 711 | 1.48129 | 1.796753 | 0 | 10.64489 |
| Military expenditure | 424 | 11.35655 | 22.18982 | .0124862 | 297.3008 |
| Agriculture, value added | 773 | 16.04788 | 13.06971 | 0 | 61.33473 |
| GDP | 882 | 4.08e+11 | 1.71e+12 | 1.30e+08 | 1.80e+13 |
| GDP growth | 880 | 3.746906 | 5.323919 | -62.07592 | 25.26386 |
| GDP per capita | 882 | 8472.992 | 14640.11 | 190.3942 | 96074.84 |
| GDP per capita growth | 880 | 1.915462 | 5.233444 | -62.21435 | 22.16616 |
| GDP per capita, PPP | 880 | 13228.52 | 17860.29 | 556.7281 | 141947 |
| Gini index | 194 | 39.3818 | 9.023438 | 24.09 | 63.38 |
| Population | 920 | 4.90e+07 | 1.64e+08 | 30407 | 1.37e+09 |
| IDPs (high estimate) | 417 | 352409.1 | 1351480 | 6 | 1.59e+07 |
| IDPs (low estimate) | 69 | 748943.5 | 1118647 | 1200 | 4900000 |
| Presence of peace keepers | 90 | 4998.633 | 6206.523 | 1 | 21198 |

## C.2 On European Borders

Table S3: Enlargements of the European Union

| Date | State |
|---|---|
| 1957 | Belgium, Luxembourg, the Netherlands, France, West Germany Italy |
| 1973 | United Kingdom, Ireland, Denmark |
| 1981 | Greece |
| 1986 | Portugal, Spain |
| 1995 | Austria, Sweden, Finland |
| 2004 | Cyprus, Malta, Hungary, Poland, Slovakia, Slovenia, Czech Republic, Estonia, Latvia, Lithuania |
| 2007 | Romania, Bulgaria |
| 2013 | Croatia (EU28) |

*Note:* East Germany (GDR) joined in 1990, at the reunification. Only Croatia joined the European Union in the period covered by our Frontex data set.

Table S4: The Schengen Area

| Date | State |
|---|---|
| 1995 | Belgium, France, Germany, Luxembourg, Netherlands, Portugal, Spain |
| 1997 | Italy, Austria |
| 2000 | Greece |
| 2001 | Denmark, Finland, Iceland*, Norway*, Sweden |
| 2007 | Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia |
| 2008 | Switzerland* |
| 2011 | Liechtenstein* |

*Note:* At present, the Schengen area comprises 26 countries (4 of which non EU member states, "Associated Countries" – Iceland, Norway, Switzerland, Liechtenstein, denoted with an asterisk), which corresponds to "44,000 km of external sea borders and almost 9,000 km of land borders" (Source: frontex.europa.eu).
The Schengen Area excludes Monaco, Vatican City, San Marino and most overseas territories (e.g., Sint Marteen and other Dutch overseas territories, French DOM-COM, Svalbard, Greenland, the Faroe Islands; Ceuta and Melilla are included but under special provisions).

Table S5: Route summary statistics (2009-2016)

| Var: IBC (monthly) | N Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Black Sea | 96 | 6.791667 | 22.13448 | 0 | 154 |
| Central Mediterranean | 96 | 6732 | 8010.098 | 0 | 27390 |
| Circular route from Albania to Greece | 96 | 1228.542 | 1315.296 | 140 | 5535 |
| Eastern Land Borders | 96 | 113.5417 | 50.38774 | 25 | 275 |
| Eastern Mediterranean | 96 | 13887.58 | 34840.7 | 712 | 216260 |
| Other | 96 | .4270833 | 1.237525 | 0 | 9 |
| Western African | 96 | 52.6875 | 101.4824 | 0 | 685 |
| Western Balkans | 96 | 10147.04 | 32428.7 | 146 | 205704 |
| Western Mediterranean | 96 | 602.1458 | 332.7256 | 66 | 1887 |

*Note:* See map of the routes, Figure S1. Source (raw data): Frontex.

## C.3 Alternative specifications

### C.3.1 Asylum-seekers and IBC detections (absolute values)

**Dependent Variable: Applications for asylum in year *t***

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| IBC in year t | 0.432*** | 0.359*** | 0.324*** | 0.293*** | 0.298*** | 0.312*** |
| | (0.015) | (0.016) | (0.014) | (0.019) | (0.019) | (0.013) |
| IBC in t-1 | | | 0.212*** | 0.176*** | 0.180*** | 0.221*** |
| | | | (0.016) | (0.021) | (0.021) | (0.015) |
| IBC in t-2 | | | 0.991*** | 1.585*** | 1.206*** | 0.294** |
| | | | (0.130) | (0.238) | (0.211) | (0.118) |
| IBC in t-3 | | | | -1.100** | | |
| | | | | (0.433) | | |
| IBC in t-4 | | | | -1.135*** | | |
| | | | | (0.306) | | |
| IBC in t-5 | | | | 0.116 | | |
| | | | | (0.310) | | |
| Origin FEs | | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y | Y |
| Country-specific time trends | | | | | | Y |
| $R^2$ | 0.434 | 0.390 | 0.627 | 0.620 | 0.593 | 0.875 |
| N | 1104 | 1104 | 828 | 414 | 414 | 828 |

Table S6

Notes: $*p < 0.1, **p < 0.05, ***p < 0.01$
Table replicates Table 2 with non-logged IBC detections and asylum applications.

### C.3.2 Average temperature over the whole country area

**Dependent Variable: Illegal Border Crossings**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Average Temperature in t | 0.190 | 0.194 | -0.007 | -0.095 |
| | (0.210) | (0.248) | (0.385) | (0.360) |
| Average Temperature in t-1 | | | -0.072 | -0.182 |
| | | | (0.273) | (0.251) |
| Average Temperature in t-2 | | | 0.625** | 0.541* |
| | | | (0.276) | (0.275) |
| Avg. Temp. Squared in t | -0.008 | -0.005 | 0.006 | 0.008 |
| | (0.006) | (0.007) | (0.010) | (0.010) |
| Avg. Temp. Squared in t-1 | | | 0.006 | 0.008 |
| | | | (0.008) | (0.007) |
| Avg. Temp. Squared in t-2 | | | -0.014* | -0.013 |
| | | | (0.008) | (0.008) |
| Precipitation in t | | | | 0.000 |
| | | | | (0.001) |
| Precipitation in t-1 | | | | 0.000 |
| | | | | (0.001) |
| Precipitation in t-2 | | | | -0.000 |
| | | | | (0.001) |
| Prec. Squared in t | | | | -0.000 |
| | | | | (0.000) |
| Prec. Squared in t-1 | | | | -0.000 |
| | | | | (0.000) |
| Prec. Squared in t-2 | | | | 0.000 |
| | | | | (0.000) |
| Country FEs | Y | Y | Y | Y |
| Year FEs | | Y | Y | Y |
| Lags (2) | | | Y | Y |
| $R^2$ | 0.007 | 0.095 | 0.151 | 0.171 |
| N | 573 | 573 | 384 | 384 |

Table S7

Notes: $*p < 0.1, **p < 0.05, ***p < 0.01$
Table replicates Table 4 with temperature and precipitation variables averaged over the entire country area and the entire calendar year.
Robust standard errors in parentheses.