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Developments along the route

The role of transit countries in shaping mixed-migration flows to Europe

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Executive Summary

Push and pull factors shaping migration flows have been extensively covered in empirical research. However, while international migration can be largely thought of as a phenomenon involving only two countries (one of origin and one of destination), developments in countries along the migration routes (i.e. transit countries) can have an important role in affecting migration flows. Mixed-migration flows encompassing people with different reasons to move but without a valid permit to do so often entail long journeys across several transit countries. For instance, asylum seekers do not always have the opportunity to seek protection in neighbouring countries or via resettlement, and therefore they may opt to reach the EU and directly lodge their application there. Similarly, jobseekers without a permit may attempt to cross into the EU irregularly to then find a way to regularisation. Given both the vulnerability of people embarking on long journeys to the EU and the precarious stability of several countries along the migration routes, it is important to account for the role played by transit countries in affecting mixed-migration flows to the EU.

While qualitative or case studies focusing on specific dyads of transit and origin countries exist, empirical and quantitative data-driven assessments of the factors along the route that can affect mixed-migration flows are scarce. In this sense, the present study tries to expand the literature by taking a quantitative and general approach covering all major origin countries of mixed-migration flows to the EU, as well as the main migration routes.

This analysis relies on a multidimensional longitudinal dataset providing information on the number of crossings by nationality and migration route for each month between 2009 and 2019. In other words, the dataset allows not only the country of origin of people attempting to cross irregularly into the EU to be identified, but also the route and thereby the countries of transit that were likely crossed to reach a specific external EU border. Figures on mixed-migration flows are complemented by indicators covering several dimensions, such as political stability, peace, natural disasters and changing weather conditions, as well as socioeconomic factors. These dimensions are captured for both origin countries and transit countries along the migration routes.

Across several specifications tested, findings show how some factors are more significant than others in affecting the number of crossings. Violent events due to conflict, and mass disasters due to natural events, are always found to increase mixed-migration flows. More importantly, their effect is larger when they take place along the route than at origin; for instance, one violent event due to conflict recorded at origin leads to an increase of 0.2% in the mean number of crossings in the same month compared to a 2.5% increase if the event took place along the transit route. However, violent events in the months prior to crossing have an additional significant effect if they take place at the origin: **the more the violence of conflicts intensifies the higher the number of people deciding to leave their country of origin.** For other dimensions, effects between origin and transit countries can differ not only in terms of impact or duration but also in their signs. For instance, while prolonged periods with significantly low precipitations at origin increase mixed-migration flows, their effect is negative if they concern the countries along the routes.

Findings show how different dimensions along the route can affect the mixed-migration flows, and that their effect can differ in terms of direction, size and duration depending on whether the origin or the transit countries are concerned. These findings are crucial for the development of the models that will feed the EUMigraTool (EMT) within ITFLOWS. Monitoring of these developments can inform about sudden and/or growing movements of migrants along the main routes to the EU. Future research could investigate other types of data (e.g. surveys, big data) to monitor for changing intentions and length of stay in transit countries.

Keywords: Mixed-migration flows, transit and origin countries, migration routes, political stability, conflict and natural events

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Abbreviations

CMR: Central Mediterranean Route

EM-DAT: Emergency Events Database

EMR: Eastern Mediterranean Route

EMT: EUMigraTool

EU: European Union

PPML: Poisson pseudo-maximum likelihood regression

REIGN: Rulers, Elections, and Irregular Governance

SPI: Standard Precipitation Index

TCNs: Third Country Nationals

UCDP: Uppsala conflict Data Program

UN: United Nations

WAR: Western African Route

WBR: Western Balkan Route

WDI: World Development Indicators

WMR: Western Mediterranean Route

1 Introduction

International migration is often seen as a simple decision-making process based on incentives and reasons to migrate deriving from a mix of 'push' and 'pull' factors between countries of origin and destination. Nevertheless, the mixed-migration flows[1] that periodically have reached the EU borders in the past decades most often entail long journeys across several countries and borders. Therefore, countries along the main migration routes could play an important role in affecting the dynamics of mixed-migration flows to the EU.

Firstly, conditions along the migration routes can affect the likelihood of successfully reaching the EU borders. For instance, growing political instability or worsening weather conditions might hamper the practicability of routes. Secondly, several transit countries along the main migration routes to the EU can be, in the first place, destination countries for migrants of major origin countries of mixed-migration flows to the EU. Libya, for instance, has usually been a country of destination for sub-Saharan African citizens (Bredeloup, 2012; Collyer and de Hass, 2012; Duvel, 2012; Duvel et al., 2014). Therefore, worsening conditions in transit countries to the EU could affect the decision-making process of third-country nationals (TCNs) and spur 'unplanned' migration towards destinations unforeseen in the pre-departure phase.

The role of transit countries has been usually neglected in empirical exercises, while different qualitative analyses and case studies exist for specific transit countries and their role on a given migration route. In addition, there is no clear definition of what defines a country of transit, as countries can be at the same time origin, transit and destination, depending on the different points of view.

The main contribution of this report is twofold: first, it explores empirically the effect of changes in conditions in transit countries on the size of mixed-migration flows to the EU; second, it takes a comprehensive approach by studying monthly

[1] Complex migratory population movements including refugees, asylum seekers, economic migrants and other types of migrants, as opposed to migratory population movements that consist entirely of one category of migrants, European Migration Network (EMN) Glossary (https://ec.europa.eu/home-affairs/what-we-do/networks/european_migration_network/glossary_search/mixed-migration-flow_en).

irregular crossings to the EU for the five main migration routes – and their transit countries – identified in the literature.

Specific attention is paid to conflict and political instability, and natural disasters (e.g. extreme climate events and epidemiological outbreaks), for two main reasons:

- these events are likely to affect several countries in a specific area and to have long-lasting effects, thus highlighting the need to account for the situation in transit countries to better understand developments of migration flows and routes; and
- because of their nature, these events have the potential to create the conditions not only for short-term displacement but also to affect individuals' migration decisions by progressively worsening living conditions.

The next section reviews, first, the concept of transit migration and its interplay with other aspects such as intentions to migrate and length of migration; and second, the main migration routes of mixed-migration flows to the EU as identified in the literature. Section 3 explains the types and characteristics of data used in the analysis and reports their data sources, while section 4 lays down the methodologies used for the data preparation and for the empirical exercise. Results are shown in section 5 and main conclusions in section 6.

2 Literature review

The starting point of the analysis is to better understand the concept of 'transit' migration and its declinations, and to then identify the countries of interest along the main routes to Europe.

2.1 Transit: a blurred concept

The concept of transit migration emerged firstly within a UN conference in 1993, and then gained continuous relevance in the policy debate over the following years. Yet there is no clear and commonly agreed-upon definition of what transit migration is (Duvell, 2012). In fact, several definitions have been provided over the years, based on the migrants' intentions as well as the temporal and spatial dimensions of the migration. The current one from the European Migration Network (EMN) is: "passage through a country of transit of a TCN travelling from their country of origin to an EU Member State",[2] which resembles the one given by the UN in 1993: "migration in one country with the intention of seeking the possibility there to emigrate to another country as the country of final destination" (Duvell, 2012).

However, to different extents, all these definitions fail to: 1) determine how long a person should stay in a given country to define that stay as 'transit' migration; and 2) account for the fact that migrants' intentions can change depending on contextual factors. In other words, the main limitations of such definitions are the unclear temporal boundaries between transit and temporary or permanent migration, and the assumption that migrants' intentions are fixed through time (Collyer and de Hass, 2012; Duvel et al., 2014).

In addition, labelling a country as 'transit' fails to account for the multidimensionality of international migration, and its interpretation intrinsically depends on the point of view of different stakeholders: Libya is seen as a key transit country for the EU, yet it has always been a key destination for several sub-Saharan nationals (Bredeloup, 2012; Collyer and de Hass, 2012, Duvel, 2012, Duvel et al., 2014). This also affects the definition of transit migrants, as people who

[2] EMN Glossary. https://ec.europa.eu/home-affairs/what-we-do/networks/european_migration_network/glossary_search/transit_en

initially intended to reach the EU may have to settle - perhaps temporarily - if, for instance, conditions along the route worsen. In the same way, migrants residing in transit countries along the route might decide to leave if conditions become unfavourable and move onward along the migration route towards the EU. Developments along the route in transit countries can thus affect migrants' intentions to move and, therefore, their spatial outcome in terms of final country of destination.

Last but not least, due to the low – and in some cases non-existent – level of recognition of the migrant status in several of the transit countries along the main migration routes, migrants passing through or residing in these countries are often in precarious conditions and rely on the informal economy; this is why transit migration is usually defined as 'mixed-flows' of economic migrants and refugees (Duvel et al., 2014). Thus, transit migrants are usually among the most exposed to sudden shifts in the political and economic stability of already fragile transit countries (Duvel et al., 2014; Bredeloup, 2012).

2.2 Migration routes

Migration routes are far from being set in stone, and their path and relevance can change significantly depending on political and policy developments as well as on people's knowledge of the network along the route (Natter, 2020). From the literature (Idemudia and Boehnke, 2020) the main five routes identified are:

- The Central Mediterranean Route (CMR)
- The Western Mediterranean Route (WMR)
- The Western African Route (WAR)
- The Eastern Mediterranean Route (EMR)
- The Western Balkan Route (WBR)[3]

The CMR main entry point is Italy (occasionally Malta), and migrants depart mostly from Libya and Tunisia. Migrants originate from all countries in Africa but transit

[3] Drivers, trajectories and dynamics of mixed-migration flows along these routes are also analysed from a qualitative perspective in Deliverable 3.2, focusing on the key transit countries also considered here, as, for instance, Niger, Libya and Turkey.

through different countries. Migrants from West Africa[4] (e.g. Senegal, Ivory Coast, Gambia, Guinea) usually go through Mali and then Niger into Libya, with an alternative path going through Mali, Algeria and then Tunisia or Libya.[5] For Eastern African nationals (e.g. Eritreans, Ethiopians, Somalians), the CMR route goes instead through Sudan and Libya (passing through Chad occasionally before entering Libya - see Kuschminder, de Bresser & Siegel, 2015). To avoid tensions in Sudan, these migrants often go through Egypt, from which they could depart towards the EU as well (Marchand, Reinold and Dias e Silva, 2017). The CMR is also (and has been) used by nationals of Maghreb countries and by Syrians.

Migrants along the WMR, instead, cross through Spain (Ceuta and Melilla) from Morocco and they mostly originate from the Maghreb and Western African countries. As for the CMR, West African nationals go through Mali or Niger, and then into Algeria and Morocco (instead of Libya).

The WAR's entry point is the Canary Islands, passing from Mauritania, Western Sahara/Morocco, as well as from other countries along the coast; this route is mostly used by Western African migrants who travel along the coast through Senegal.

The EMR's country of crossing is Greece, from Turkey, with main origin countries being Middle East and South Asians countries (e.g. Syria, Iraq, Iran, Afghanistan, and Pakistan). Afghans and Pakistanis transit through Iran before entering Turkey. Some migrants from Eastern African countries, Egypt and Maghreb countries also fly into Turkey to take this route (Crawley, Düvell, Jones, McMahon and Sigona, 2016).

From Greece, migrants can also use the WBR, which goes through North Macedonia/Bulgaria to Serbia and Hungary. Because of its connection to the EMR, migrants originate mostly from the Middle East but Europeans (e.g. Serbians, Albanians) can also use this route.

[4] Note that all migrants from countries that are part of the Economic Community of West African States (ECOWAS): Benin, Burkina Faso, Cabo Verde, Côte D'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo, can move without any restrictions between these countries.

[5] Nigerians and Cameroonians mostly pass by Niger into Libya.

These five routes correspond to the main ones[6] identified by Frontex, which provides data on people intercepted while trying to cross into the EU. These routes are therefore used to define the transit countries for each country of origin and assess how developments along the route can impact migration flows (see section 4.2). Moreover, since Frontex data is broken down by nationality and migration route, this analysis can exploit additional sources of variations in conditions/developments along the routes and their effects on migration flows. More precisely, migrants from different origin countries using the same route will cross different countries (e.g. Western Africans, and Eastern Africans using the CMR) providing some within-route variations that will help identify the effects of varying conditions more precisely (see section 4.2).

[6] Frontex defines additional routes which are, however, considerably less significant and that are more relevant for specific situations (e.g. a circular route from Albania to Greece mostly used by Albanians).

3 Data

Given the multidimensional nature of transit migration, the focus of this report is on mixed-migration flows reaching the EU for different motives (e.g. protection, work, family reunification) and duration of migration. Moreover, since the main interest is in explaining how conditions (and their development) in transit countries can trigger and affect the movement of people along the main migration routes, the date of arrival in the EU is another important dimension to account for.

3.1 Mixed-migration flows

The two main categories of data that can capture mixed-migration to the EU are (1) the **number of people intercepted crossing into the EU**, and (2) the **number of people applying for asylum**.

Data on border crossings in the EU is incomplete since, by definition, only *intercepted* crossings can be reported. Furthermore, a person can be intercepted attempting to cross a border more than once, thereby leading to a possible overestimation of the number of individual crossings. On the contrary, the number of asylum applications lodged within EU territory underestimates the number of people crossing, as not everyone applies for international protection, thus failing to cover the different reasons for migrating under mixed-migration flows. For instance, people crossing into the EU irregularly for work purposes might decide not to apply for asylum and thus would not be recorded under asylum statistics.

Moreover, asylum applications are not always lodged in the first country of arrival in the EU (i.e. secondary movements within the EU), which adds another layer of uncertainty in terms of timing, since the date of arrival would differ from that of the application. Detected crossings, instead, do not suffer from this limitation.

Last but not least, another key value added of Frontex data is that figures are broken down not only by nationality, but also by migration routes and, therefore, borders likely crossed. These migration routes reflect those identified in the literature, which implies that we can identify the main transit countries and control for changes over time of their importance for each nationality. For all these reasons, the main data used in the analysis to capture migration flows is the **number of crossings detected by Frontex**.

In terms of limitations, one issue with Frontex data is that nationality is not always available, which leads to two large groups of unidentified nationals crossing the border irregularly: *unspecified* and *unspecified sub-Saharan nationals*. Hence, the analysis will test different specifications using, first, figures by nationality as provided by Frontex and, second, by distributing the number of crossings of unknown nationals to known nationalities. These figures are allotted following the share of each nationality in each specific combination of year-month and route. Moreover, for the category of unspecified sub-Saharan nationals, figures are redistributed only among sub-Saharan nationals, following their share in total crossing from sub-Saharan Africa.

3.2 Conflict events and mass disasters

To capture conditions along the route, the explanatory variables focus on stability, which encompasses peace, as well as living, weather, and political conditions.

The first set of regressors is extracted from event-based datasets capturing violent events due to conflict,[7] and mass disasters (either natural or technological) that impacted the population (e.g. floods, earthquakes). **The Georeferenced Event Dataset from the Uppsala Conflict Data Program (UCDP) and the Emergency Events Database (EM-DAT) from the Centre for Research on the Epidemiology of Disasters (CRED)** are the two main data sources used for conflict and disasters events respectively.

The majority of events detected have a short duration, mostly within one day.[8] Yet there are cases of events that can unfold over several months, as for instance with some mass disasters, e.g. drought or epidemic events. Therefore, it is important to count these events not only in their starting month, but in all the months they lasted for.[9]

[7] More specifically, violent events deriving from conflict are events that recorded casualties.

[8] UCDP events are recorded daily. The only events lasting more than one day are those for which precise starting and/or ending dates are not available.

[9] Since these are event-based datasets, starting and ending dates are provided, which therefore allow computing the duration in days of an event. Start and end date are complete for most observations; yet, in a few cases, only year and month are available for the end date, in which cases the first day of the month is imputed.

3.3 Political stability and weather conditions

In addition to event-based data, other variables are used to capture the level of political stability. The **Rulers, Elections, and Irregular Governance (REIGN)** dataset provides monthly information on several political dimensions, focusing not only on the leader of each country but also on the overall political system: e.g. type of government, risk of coup d'état, or number of months since an irregular election took place.

In terms of weather conditions, instead, both precipitations and temperatures are considered in the analysis. The REIGN dataset also provides the Standard Precipitation Index (SPI), while Temperature Change is taken from FAO. Both indicators are expressed as deviations from the (long-term) average computed by country and month, and where zero values reflect no change from the baseline.[10]

3.4 Socioeconomic conditions

Besides variables capturing stability over the main dimensions (e.g. peace, political, weather), other control variables are included to account for socioeconomic dimensions both at origin and in transit. These are sourced from the **World Development Indicators of the World Bank** and include population, GDP per capita in PPP (constant 2017 international $), and unemployment rate, as well as other controls, such as the share of agriculture in total GDP or government expenditure in health. However, given serious limitations in terms of data availability for important origin countries, the main specification includes only population, GDP per capita and unemployment rates to avoid losing key observations.[11] Finally, missing values for 2019 have been extrapolated using the country's historical trend since 2008.

[10] The SPI can be interpreted as a Z-score on the historically expected values, while Temperature Change is expressed in °C degrees with respect to the baseline period 1951-1980.

[11] In fact, population, GDP per capita and unemployment rate were the statistics most widely available for all countries, especially, those relevant in terms of mixed-migration flows to the EU. Nevertheless, missing information also concerned these variables in some cases. As concerns missing series for GDP per capita, these have been estimated using the average of the region to which the country belongs (e.g. East Africa for Eritrea). Countries concerned are Eritrea, Syria, South Sudan, Venezuela, and Yemen. Population figures, instead, were missing only for Eritrea and only in some years; missing data have been estimated applying the growth rate of the East African region to the existing Eritrean trend.

4 Methodology

4.1 Mixed frequency and temporal disaggregation

The collected types of data vary in terms of time frequency, going from daily dates for event-based data, to monthly for the number of crossings, political stability, and weather conditions, and yearly for socioeconomic control variables. **Monthly** is, therefore, the preferred choice for the time frequency of the dataset since the main variables of interest (both dependent and independent) are originally provided at this frequency. Event-based figures on conflicts and mass disasters have a start and an end date and can thus be easily aggregated at the monthly level. On the contrary, control variables sourced from WDI are available only with an annual frequency and monthly observations are estimated via temporal disaggregation.

Temporal disaggregation is the process of deriving high frequency time series from low frequency ones (also known as target series). It is widely used in official national statistics (Sax, 2013) when only low frequency series are observed, the collection of high frequency data is costly and difficult or when high frequency indicators are not consistent with low frequency ones over time (Eurostat, 2018).

The literature provides several methods for the conversion of low frequency series to higher frequency. However, there is no single method that systematically outperforms the others across all the possible cases. Broadly speaking, two alternative approaches are possible: methods that rely on purely mathematical criteria to derive smooth paths for the unobserved series, and methods that rely on regressions.[12] Moreover, depending on the type of variable disaggregated, both the underlying estimation process and conversion type differ. Temporal disaggregation of stock variables is closely related to interpolation, because stock series are measured at a particular moment in time; flow indicators, indexes and averages of stock variables instead require that temporal additivity is observed, meaning that the sum or average of higher frequency data should be consistent with the lower frequency (Chamberlin, 2010).

[12] While the mathematical methods can be sub-grouped into (i) methods that do not involve any related high frequency series to inform on short-term movements, and (ii) methods that make use of information obtained from related to high frequency indicators, regression-based models make use of related high frequency indicators by construction.

In this study, temporal disaggregation has been performed using the *tempdisagg* R package (Sax, 2013), which provides a collection of mathematical-based and regression-based methods. Among the methods provided within the package, the Denton-Cholette mathematical-based method was used to interpolate or distribute monthly data, using the sum and the last conversion type for flow and stock variables respectively.[13]

4.2 Aggregating at route level

For each regressor included in the analysis at the origin country level, another indicator is computed to capture the same dimension along the migration route. Depending on the type of variable, the route values are computed either by averaging (e.g. GDP per capita)[14] or summing (e.g. number of conflict events) figures across countries identified and (potentially) crossed along the route. In other words, the route value captures the conditions faced by migrants in transit: for instance, the total number of conflict events registered, in a given month, in all of the transit countries along a specific route.

Countries selected to compute route values are those identified in the literature for the five main migration routes (see section 2.2). As explained above, Frontex data provide figures disaggregated by route and nationality, thus allowing route values to be defined at a more granular level depending on the combination of country of origin and route. All details on routes and regions are reported in Appendix 1.

Taking the Central Mediterranean Route as an example, nationals from West and East African countries will have different route values since they need to cross different countries, as identified by the literature (Figure 1).

[13] For each of the disaggregation methods, a conversion type can be chosen to ensure that either the sum, the average, the first or the last value of the resulting high frequency series is consistent with the low frequency series. The main idea behind the conversion type is that the high frequency data resulting from temporal disaggregation must be consistent both with the low frequency target series and the aggregation method. For example, flow monthly data disaggregated from annual data should add up to the total annual value for each year. For stock or index variables, the last figure of the monthly disaggregated series should match that of the annual target series.

[14] We also explored the possibility of computing transit countries' variables as (population) weighted averages, but this had only marginal effects on the results.

Figure 1 Transit countries along the Central Mediterranean Route by main region of origin

Note: Countries in the South African region have the same countries selected for the Central African region with the addition of the Democratic Republic of the Congo (DRC) and the Central African Republic. Nationals from North African countries and from other countries included in the analysis take the values of the main disembarkation countries for the CMR, namely Libya and Tunisia.

Moreover, countries identified as being of transit along a route can also be countries of origin, having then a different route value. For instance, West African nationals along the CMR will have route values based on figures for Mali, Niger, Algeria, Tunisia, and Libya, but Malians will have route values based only on Niger, Algeria, Tunisia, and Libya. Similarly, Afghanis and Pakistanis crossing through the EMR will have route values accounting for Iran as well since they transit through it before entering Turkey.[15] In sum, route values take into consideration not only the combination between nationality and route, but also, to the extent possible, the geographical position of the country in the region.[16]

4.3 Model

The dataset provides information for each country of origin in relation to each of the five migration routes and each month between 2009 and 2019. In other words, five observations are recorded for each country of origin in every month. The

[15] In Appendix 4, we further disentangle departure countries from transit countries. Variables for departure countries are computed as the average/sum of Tunisia and Libya for the CMR, Morocco for the WMR, Turkey for the EMR, Morocco and Mauritania for the WAR, and North Macedonia/Serbia for the WBR. The transit countries' variables are then obtained by taking the average/sum of the variables excluding these departure countries. Results are displayed in Table 15.

[16] See Appendix 1 for details on both routes and regions.

multidimensionality of the data, therefore, allows us to define the level of the analysis at the country-route pair rather than simply at the country or route level.

The multidimensionality of the panel is coupled with a high-time frequency (i.e. monthly) to ensure a considerable number of observations and hence a certain degree of flexibility in testing several regressors and refining the sample. Yet a high frequency and detailed figures by route also implies a higher likelihood of observing several zeros in the dependent variable. In other words, it might happen that for several months there were no crossings from nationality A on route B, but some were recorded on route C and even more on route D.

In order to deal with the zeros present in the dependent variable, first of all, the country-route pairs for which crossings reported were always zero, are dropped. Secondly, cases where very few crossings were reported are also dropped, applying a threshold to the number of crossings relative to the overall population of the country of origin. More specifically, country-route pairs with less than five crossings per 100,000 inhabitants (across the entire period of 2009-2019) are dropped. Finally, the regions of origin countries covered are all those in Africa, the Middle East, and South Asia, in addition to the countries of origin selected at the project level.[17]

From a modelling approach, instead, Poisson-based models are the preferred option to deal with zeros in the dependent variable; they can handle positive count-dependent variables, which, if estimated in the log form, would otherwise lead to inconsistent estimates in the presence of heteroskedasticity (Santos Silva and Tenreyro, 2006) and force to either drop zero-outcomes values or transform the dependent variable by adding a constant (i.e. 1).[18] Moreover, given the multidimensionality of the panel identifier composed by country of origin and transit route, the intention is to control for multiple levels of fixed effects, therefore accounting for pairwise combinations of different dimensions.

The Stata command *ppmlhdfe* is used to fit a Poisson pseudo-maximum likelihood regression (PPML) with multiple high-dimensional fixed effects (HDFE) to absorb

[17] See details in Appendix 1.

[18] Nevertheless, we explore the linear-log model in Appendix 3 as a robustness check for the PPML results.

the pairwise fixed effects at the country of origin and route level, at the year and month level, as well as at the month and route level. By absorbing these pairs, the regressions account for specific effects driven by a combination of: country of origin and routes that might, for instance, enjoy stronger networks and/or be closer to the EU; years and months that might have recorded exceptionally high irregular crossing; and, finally, seasonality in relation to each route as some periods might be preferred than others to cross in a route as well as differ among routes.[19] In brief, the multilevel fixed effects allow us to account for any specific characteristic of the routes as well as exceptional periods that could affect the estimate of the impact of transit countries on mixed-migration flows. In this respect, our model thus provides overall estimates across the major routes to the EU, controlling for cyclical changes in their relative importance.

Last but not least, the *ppmlhdfe* command permits the computation of clustered standard errors at the origin country-route level to account for uncertainty driven by possible unobserved part of the population crossing, additional effects at the route level, and potential serial (auto) correlation.

The baseline specification, therefore, fits a fixed-effect pseudo-Poisson model defined as:

$$Crs_{c,r,t} = e^{(x_{c,r,t}\boldsymbol{\beta})} + \varepsilon_{c,r,t}, \quad \varepsilon_{c,r,t} \sim \mathcal{N}(0, \sigma^2)$$

$$x_{c,r,t}\boldsymbol{\beta} = \beta_0 + \beta_1 Crs_{c,r,t-1} + PolStab_{c,t}\boldsymbol{\beta_2} + PolStab_{r,t}\boldsymbol{\beta_3} + Climate_{c,t}\boldsymbol{\beta_4} + Climate_{r,t}\boldsymbol{\beta_5} + X_{c,t}\boldsymbol{\beta_6} + X_{r,t}\boldsymbol{\beta_7} + \gamma_t + \delta_{c,r} + \mu_{r,t}$$

where Crs_{crt} denotes the number of crossings of nationals from country *c* through route *r* in month *t.* The number of crossings at lag one also enters the right-hand side of the equation to account for the possible persistence of irregular crossing through time. Given the high frequency of observations, the number of periods is large (T=131 with one lag) and we should not be too concerned with the bias coming from the fixed-effect estimation.

PolStab are (row) vectors of variables capturing the political stability at time *t* in the country of origin *c*, as well as on the migration route *r*. The vectors include the

[19] For instance, the number of irregular crossings along the CMR decreases substantially during winter since this route entails crossing the Mediterranean Sea.

risk of coup d'état and the number of violent events due to conflicts. Different regressors are tested in other specifications, for instance the type of governmental system (democratic, interim, non-democratic), and the extent of political violence (see section 5.2)

Similarly, the *Climate* vectors capture the development in weather conditions including change in temperature, precipitation index, and the number of mass disasters in the country of origin, *c*, and on the migration route *r*.

Xs are vectors of control variables for both country *c* and route *r* in month *t,* which includes GPD per capita in PPP (current 2017 international $), unemployment rate for the young (15-24), and population for the country of origin only. The square of GDP per capita is also included to account for the potential non-linear relationship between economic development and emigration (i.e. 'migration-hump' theory). Other regressors, such as domestic expenditure on health and value added of agriculture in GDP, are tested in other specifications with subsets of the dataset (see section 5.2)

Finally, γ, δ and μ account for fixed effects at year-month, country-route and month-route, while ε is the error term.

5 Results

While most regressors in the model are either count or continuous positive variables, precipitation and temperature can take both negative and positive values since they record a change with respect to a baseline period (long-term average) at the country-month level. To capture the effect of exceptional changes in weather on crossing, the model includes indicator variables that record whether a specific month was significantly below or above the baseline value. Table 1 shows results taking a 90% significance for the SPI (i.e. z-score of at least 1.645) and ranges of ± 1.5, 1.75 and 2 °C of temperature change. Additional models have been tested lowering the confidence level of the Precipitation Index to 80% and 50%, reporting similar results (see section 5.2).

The lagged term of the dependent variable is, as expected, positively correlated with crossing at time *t*, even if with a small magnitude. This indicates a certain degree of persistence in irregular crossings through time. A 10% increase in the previous month's crossings increases the mean number of crossings in *t* by only 0.02%.

In terms of political stability and conflict, the log of risk of coup d'état is negative and significant for the route, but not for the origin country; a 1% increase of the risk of coup d'état along the migratory route, therefore, seems to significantly decrease the mean number of crossings by around 0.43% in the same month.

In terms of conflict events, instead, both origin and route regressors are positively related to crossing. However, the magnitude is significantly different: one event at origin leads to an increase of 0.2% in the mean number of crossings in the same month compared to a 2.5% increase if the event takes place along the transit route. This can be explained by the precariousness of living and economic conditions migrants in transit experience and that violence along the route would only make worse. Hence, violence along the route can act as a powerful incentive to move further, both if the initial intention was to reach the EU or not (i.e. migrants living in a country along the route deciding to leave). This difference in coefficients could also result from a difference in timing. More precisely, a violent event in month *t* in a given origin country could affect crossings with a certain lag, since it should take

some time for migrants to reach the departure country and illegally cross an EU border.[20]

Similarly, mass natural disasters are also positively correlated with the number of crossings and the effects of those along the route are higher than for those at the origin: one disaster at origin leads, on average, to an 8.5% increase in crossing compared to a 21.5% increase if the disaster takes place along the route. Compared to violent events caused by conflicts, mass disasters have a significantly larger impact, which might be due to their more extended coverage of the population affected and their longer duration than conflict events.

For what concerns precipitation, results are not significant for changes at origin, while both a drop and rise along the route seem to significantly affect crossing. Results compare months during which precipitations were either below or above the average baseline for that country-month at a significance level of 90%.[21] In other words, coefficients capture whether exceptional values of precipitation (at either sides of the distribution) have a significant effect on the number of crossings in comparison to a 'standard' month (i.e. long-term average). A month recording significantly lower precipitations than usual along the transit route leads, on average, to a number of crossings 58% lower than in a standard month. On the contrary, a month with precipitation along the transit route significantly higher than usual leads to a number of crossings around 110% higher than in a standard month. These large effects indeed capture the exceptionality in terms of weather conditions of specific months. Moreover, the fact that coefficients at time *t* are significant only along the route and not at origin seems to indicate a short-term effect on the practicability of the routes, which seems to be hindered (facilitated) by decreased (increased) precipitation.

[20] The results displayed in Appendix 4 and Table 15 for the case where departure countries are separated from transit countries tend to confirm this hypothesis. We can see that the coefficient on violent events is greater for departure countries, followed by transit countries and origin countries. The coefficients are statistically significant for all three variables.

[21] It is important to keep in mind that months with higher-than-normal precipitations are rather rare in our sample. This results from the geography of origin countries, which are mostly located in Africa and the Middle East. The semi-elasticity associated with this variable is therefore estimated on few observations. The same applies for temperature below our selected thresholds.

While changes in precipitations are captured by a z-score that allows us to identify months with precipitations statistically significantly below or above the baseline value (e.g. at 90%), change in temperatures are reported in °C degrees; therefore, three specifications are tested at 1.5, 1.75 and 2 °C change either below or above the long-term average.

For temperature changes at origin, a drop with respect to the baseline value is found to have a significant and negative effect on the number of crossings compared to a 'standard' month. Moreover, both the significance level and the magnitude of the coefficients increase along with the change tested, from 10% significance level if the temperature dropped by 1.5 °C at origin, to 1% significance level if it dropped by at least 2 °C. Furthermore, a rise in temperature at origin is also found to decrease crossings in comparison to a standard month. However, the effects are about one third of those reported with a drop in temperature and are significant only when the temperature is 1.75 °C above its long-term average. As concerns temperature changes along the route, instead, higher temperatures are found to increase the number of crossings compared to a standard month, if the rise is of at least 1.75 °C, while lower temperatures do not seem to have a significant effect.

Finally, as concern control variables, GDP per capita is significant for the country of origin, for which crossing increases as GDP rises until a turning point when crossings start decreasing with increasing levels of GDP (i.e. inverted U-shaped relationship). The unemployment rate of the young cohort (i.e. 15-24) shows a positive sign both at origin and along the transit route, yet is significant only for the route.

Table 1 Precipitation above or below average at 90% significance, and temperature below or above average at 1.5, 1.75 and 2 °C

	(1)	(2)	(3)
Crossing	1.5 °C	1.75 °C	2.0 °C
Crossing (t-1)	0.00001***	0.00002***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.09364	-0.08160	-0.09401
	(0.08287)	(0.07833)	(0.08414)
Log risk coup d'état (route)	-0.42840***	-0.44602***	-0.43333***

	(0.13812)	(0.14264)	(0.14039)
Conflict events (org)	0.00196***	0.00196***	0.00192***
	(0.00036)	(0.00035)	(0.00036)
Conflict events (route)	0.02572***	0.02626***	0.02578***
	(0.00593)	(0.00583)	(0.00594)
Precipitation below (org)	-0.16325	-0.14166	-0.15064
	(0.27185)	(0.25881)	(0.25865)
Precipitation above (org)	-0.39568	-0.36688	-0.37791
	(0.49027)	(0.49080)	(0.48208)
Precipitation below (route)	-0.85794**	-0.90071**	-0.89300**
	(0.41892)	(0.41731)	(0.41481)
Precipitation above (route)	0.74317**	0.76406**	0.72502**
	(0.35147)	(0.33585)	(0.33552)
Temperature below (org)	-0.40734*	-0.51911**	-0.81944***
	(0.21991)	(0.21272)	(0.24895)
Temperature above (org)	-0.05682	-0.13080**	-0.20926***
	(0.06860)	(0.05187)	(0.06239)
Temperature below (route)	0.29194	0.33432	0.29873
	(0.20346)	(0.21622)	(0.20927)
Temperature above (route)	0.01236	0.22466**	0.18528**
	(0.09726)	(0.09846)	(0.07933)
Mass disasters (org)	0.08231**	0.08041**	0.08274**
	(0.03778)	(0.04064)	(0.03937)
Mass disasters (route)	0.19922***	0.19260***	0.18683***
	(0.03637)	(0.03540)	(0.03505)
Log GDP pc PPP (org)	19.92245**	20.12318**	20.25273**
	(10.02380)	(9.98855)	(9.88968)
Log GDP pc PPP ^2 (org)	-1.64518*	-1.66269*	-1.67840**
	(0.85320)	(0.84931)	(0.83899)
Unemployment rate (15-24) (org)	0.02850	0.02832	0.02995
	(0.03704)	(0.03669)	(0.03652)
Log GDP pc PPP (route)	-13.69989	-12.89371	-13.20097
	(14.33656)	(14.57459)	(14.36427)
Log GDP pc PPP ^2 (route)	0.93941	0.88766	0.90795
	(1.04916)	(1.06724)	(1.05094)
Unemployment rate (15-24) (route)	0.08611**	0.08789**	0.08380**
	(0.03528)	(0.03423)	(0.03393)
Log population (org)	-1.73572	-1.71650	-1.69217
	(1.55285)	(1.53191)	(1.50505)
Constant	21.18124	17.05059	17.76471
	(57.00412)	(56.30685)	(56.61138)
Obs	14,325	14,325	14,325
Pseudo Rsq	0.860	0.861	0.861
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster	Country-route	Country-route	Country-route

5.1 Prolonged disruption

Besides investigating the immediate impact of changes in weather conditions and destabilising events, the analysis tests for the effect of the sustained worsening of conditions too, both at origin and along the transit route, in the months prior to crossings. Table 2 reports the specifications, including the running sum of the previous six months of the main variables of interest. Besides the counting of both conflict events and mass disasters, the model includes the count of exceptional months in terms of precipitation and temperature change in the six-month period antecedent to crossing.

This specification reports the same trends observed when including regressors only at time *t,* with, overall, smaller coefficients.

When looking at the cumulative number of violent events due to conflict in the antecedent six-month period, the coefficient is positive and significant when it comes to events taking place in the origin country. Even if the coefficient of the running sum is smaller than the one at time *t*, a positive sign still implies that conflict events not only have an immediate but also a long-lasting impact on crossing: the more the violence of conflicts intensifies the higher the number of people leaving the country. This long-lasting effect, however, is not found along the route, while the coefficient is still highly significant for events in the current month. Thus, this points to a more pronounced short-term effect of violence from conflict along the route on displacement. In terms of mass disasters, instead, there is not a significant long-lasting effect reported for the country of origin, while the coefficient is significant, even if only at 10% level, for the transit route. Once again, the differences in terms of types and duration between conflict and mass disasters might drive intentions to migrate differently.

When looking at sustained worsening weather conditions in the antecedent six-month period instead, these can show opposite trends in comparison with conditions in the current month.

Starting with precipitation at origin, a sustained period with below average precipitation increases number of crossings, while there is not a significant effect for a change in the same month, as reported also in the standard specification. In other words, only long period of droughts in the origin countries seem to lead to

more crossings, with each additional month recording lower precipitation in the previous six months, leading to an increase of 12% in crossings. Moreover, this effect is found to be significant at 1% level.

On the contrary, when looking at the situation along the transit route, long-lasting droughts negatively affect crossing, while sustained periods with precipitation above increase crossing. These results once again point to the different interplays between these factors and migration, depending on whether they concern the country of origin or the situation along the transit route. Periods of drought, for instance, can be seen as potentially creating incentives for people to leave their country because of worsening of living conditions and possibly disruption of source of income, while they can potentially hamper the practicability of migration routes and thus limit crossings.

In terms of temperature change for origin countries in the previous six-month period, there is no clear trend emerging, as only some of the specifications tested across different levels of temperature change report significant results. Along the route, instead, periods with sustained higher temperatures are found to have a significant and negative effect on crossings, the opposite of what happens when considering only the increase in the same month. This might imply that while a sudden change pushes people to cross in the same month, ongoing increasing temperatures might hinder the situation along the route and slow down the entire journey. It is in fact important to remember that these effects might change also depending on the location along the journey of migrants, as an increase in temperature might facilitate crossing conditions in the Mediterranean, but hotter periods might make the journey through the Sahara Desert impossible.

Table 2 Running sum of six months previous crossing

Crossing	(1) 1.5 °C	(2) 1.75 °C	(3) 2.0 °C
Crossing (t-1)	0.00001***	0.00001***	0.00001***
	(0.00001)	(0.00001)	(0.00001)
Log risk coup d'état (org)	-0.08007	-0.08131	-0.06834
	(0.06717)	(0.06775)	(0.06960)
Log risk coup d'état (route)	-0.36066***	-0.37166***	-0.39128***
	(0.13755)	(0.13933)	(0.13390)
Conflict events (org)	0.00084***	0.00073**	0.00066***
	(0.00030)	(0.00030)	(0.00024)

RSum Conflict events (org)	0.00022**	0.00022**	0.00024***
	(0.00009)	(0.00009)	(0.00009)
Conflict events (route)	0.02240***	0.02433***	0.02312***
	(0.00483)	(0.00480)	(0.00464)
RSum Conflict events (route)	-0.00115	-0.00163	-0.00083
	(0.00185)	(0.00182)	(0.00182)
Precipitation below (org)	-0.29790*	-0.27875	-0.17387
	(0.16676)	(0.18509)	(0.16967)
Precipitation above (org)	-0.20111	-0.23860	-0.31202
	(0.32723)	(0.35428)	(0.36781)
RSum months Precipitation below (org)	0.11419***	0.11395***	0.11398***
	(0.04283)	(0.04156)	(0.03658)
RSum months Precipitation above (org)	-0.05538	-0.02683	-0.04803
	(0.15218)	(0.14096)	(0.14600)
Precipitation below (route)	-0.01362	-0.03662	-0.04654
	(0.28516)	(0.28639)	(0.33287)
Precipitation above (route)	0.55410*	0.47197*	0.36108
	(0.29537)	(0.26909)	(0.25009)
RSum months Precipitation below (route)	-0.24996***	-0.22942***	-0.22535***
	(0.05924)	(0.06028)	(0.05802)
RSum months Precipitation above (route)	0.80007***	0.72906***	0.67246***
	(0.25741)	(0.24947)	(0.23459)
Temperature below (org)	-0.62813***	-0.62725**	-0.98721***
	(0.20320)	(0.24871)	(0.25309)
Temperature above (org)	-0.05755	-0.12676**	-0.21877***
	(0.06727)	(0.06095)	(0.05687)
RSum months Temperature below (org)	-0.22702	-0.27844	-0.48746**
	(0.19488)	(0.20220)	(0.23752)
RSum months Temperature above (org)	0.07288*	-0.00291	-0.06670
	(0.04285)	(0.05428)	(0.06191)
Temperature below (route)	0.49168**	0.40879**	0.29137
	(0.19538)	(0.18930)	(0.19509)
Temperature above (route)	-0.02587	0.20139***	0.18606***
	(0.06839)	(0.07548)	(0.04896)
RSum months Temperature below (route)	0.08952	0.06254	0.05928
	(0.23793)	(0.23897)	(0.22844)
RSum months Temperature above (route)	-0.12831***	-0.11043*	-0.17212***
	(0.04380)	(0.06673)	(0.06027)
Mass disasters (org)	0.06291**	0.07294**	0.08243***
	(0.02965)	(0.03087)	(0.02979)
RSum Mass disasters (org)	-0.00801	-0.01204	-0.01004
	(0.01667)	(0.01653)	(0.01735)
Mass disasters (route)	0.17110***	0.15546***	0.13967***
	(0.03396)	(0.03388)	(0.03086)
RSum Mass disasters (route)	0.03887*	0.03575*	0.03274
	(0.02052)	(0.02161)	(0.02109)
Log GDP pc PPP (org)	19.31772**	19.99125**	18.36505*
	(8.87738)	(9.10496)	(9.37621)
Log GDP pc PPP ^2 (org)	-1.56356**	-1.62740**	-1.48933*
	(0.75119)	(0.77181)	(0.79181)
Unemployment rate (15-24) (org)	0.03773	0.03268	0.03084
	(0.03752)	(0.03835)	(0.04038)
Log GDP pc PPP (route)	-17.62914	-17.45287	-19.76005
	(14.66698)	(14.63410)	(14.47060)
Log GDP pc PPP ^2 (route)	1.16595	1.15089	1.32567
	(1.06389)	(1.06414)	(1.04554)
Unemployment rate (15-24) (route)	0.07152	0.06998	0.06842
	(0.04862)	(0.04494)	(0.04530)
Log population (org)	-1.87090	-1.71384	-1.86802
	(1.68772)	(1.69604)	(1.76991)

Constant	41.14025 (56.94691)	36.46436 (59.20720)	51.35145 (59.59483)
Obs	14325	14325	14325
Pseudo Rsq	0.868	0.868	0.870
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster var	Country-route	Country-route	Country-route

5.2 Robustness checks

Further tests have been carried out with different specifications to check the robustness of results and better disentangle the role of specific dimensions. For instance, different regressors capturing political stability and violence have been added to the baseline specification, or several lags of the risk of coups d'état have been tested to investigate possible delayed effects on a crossing. Other additional specifications check, for example, for different levels of precipitation, number of crossings with unknown nationality, and further control variables. The tables with complete results are reported in Appendix 2.

5.2.a Political stability and violence

Other variables from the REIGN dataset are added to the baseline specification for both origin and transit countries: the type of government regime, a categorical variable taking the value 1 for democracy (our reference category in Table 3), 2 for an interim period and 3 for non-democratic regimes; and a standardised series capturing political violence with positive values indicating months of excessive violence with respect to the long-term average.

Table 3 only displays political stability estimates, including the risk of coup d'état and the number of conflict events (see Table 5 in Appendix 2 for the full set of results).

Regarding the type of government, it appears that crossings are not significantly different between democratic (i.e. reference category) and non-democratic origin countries. This result does not imply that the number of irregular crossings for democratic and non-democratic regimes is the same, since non-democratic countries tend to be characterised by a greater number of conflict events, for instance. On the other hand, routes going through non-democratic countries tend to have a greater number of irregular crossings. When the journey of migrants

involves crossing mostly interim period regimes, crossings increase by around 33% compared to routes going through (mostly) democratic regimes. For non-democratic regimes, this figure rises to more than 80%. These results could be understood from the fact that smuggling networks and human trafficking activities are more easily set up in non-democratic regimes, as national authorities are probably more lenient towards such activities. Therefore, the type of government regime along the migration route is an important dimension to explain mixed-migration flows.

As concerns political violence, this variable has a positive and significant effect in origin countries, which reflects similar findings related to violence due to conflict events. Finally, the probability of coups d'état in origin countries has now a significant and negative effect compared to the baseline scenario. A 1% increase in the probability of coup d'état lowers the number of irregular crossings by around 0.18%. The coefficient for the transit countries variable is again negative and its magnitude is similar to the one reported in Table 3 for the baseline specification. Overall, these results suggest that higher uncertainty on the political stability in countries of origin and transit (as captured by an increase in the probability of coups d'état) have negative effects on the number of crossings.

Table 3 Additional political stability and violence variables

Political Stability		Specifications tested by levels of Temperature change		
		1.5	1.75	2
Log risk coup d'état	origin	-0.209***	-0.197***	-0.211***
	transit	-0.496***	-0.510***	-0.499***
Conflict events	origin	0.002***	0.002***	0.002***
	transit	0.024***	0.025***	0.024***
Gov. Type: Interim Period	origin	0.168	0.170	0.188
	transit	1.486***	1.455***	1.456***
Gov. Type: Non-	origin	-0.101	-0.105	-0.096

Democracy	transit	2.275***	2.204***	2.209***
Political violence	origin	0.045**	0.045**	0.046**
	transit	-0.004	-0.015	-0.019

In order to further understand the possible delayed effect of growing political instability, a final test includes twelve lags (i.e. one-year time span) of the risk of coup d'état both at origin and along the route (see Table 6 in Appendix 2). For both origin and transit values, a positive and significant relationship is found in the very last months tested. In fact, an increase in the risk of coup d'état at origin is found to still have a negative effect on crossing six months after, but this relation reverses after twelve months. The trend is more marked for the risk of coup d'état along the route, with a negative and significant effect in the four to six months after an increase, but with a positive effect after eleven and twelve months. This result shows a delayed positive effect of increased political instability on number of crossing vis-à-vis the short-term negative effect reported at time *t*.

However, while an increase in the risk of coup d'état captures a growing political instability in a given country, it does not necessarily imply a change in the balance of power or type of government. In fact, the risk of a coup d'état can increase without a coup ever taking place, and, in the event that a coup takes place, this can also fail in the objective of taking power. Moreover, risk of coup d'état mostly focuses on internal political pressure and unrest, failing to capture external interferences.

Hence, a further specification tests for actual changes in type of government (i.e. democratic, interim period, and non-democratic) both at origin and along the route: results are shown for any type of change (i.e. the type of government has changed since the previous month) as well as changes that specifically led to less democratic regimes.

A change in the type of government in the country of origin is not found to significantly affect the number crossing in the same month; however, a positive and significant coefficient at 10% level is found for a change towards a less democratic regime (see **Table 7** in Appendix 2). No significant effects are instead found for changes of type of governments in the transit countries along the routes.

When including twelve lags (see **Table 8** in Appendix 2), the coefficient for any type of change at origin also becomes significant at time *t,* even if the coefficient is about half the one for a change towards less democratic types of government. Besides for the effect at time *t,* a change in government at origin is found to have a significant and positive effect on the number of crossings for between one and three months, with both coefficient and significance level being the highest in the first and second lag tested. If only changes towards less democratic regimes are considered, the coefficient at time *t* remains the largest, but positive and significant effects are found also for lag 6, 11 and 12. It appears therefore that, while any type of change in the type of government at origin can lead to an increase in crossing one to three months afterwards, a change towards a less democratic government always has an immediate impact on crossing as well as a delayed one of several months. As concerns delayed effects of changes along the route, most of the lags tested are significant for any type of change or changes towards less democratic governments. However, while the first lag for any type of change is found positively related to number of crossings at time *t,* all the others report a negative effect on the number of crossings.

This strongly significant negative trend could capture the importance of political stability in transit countries along the route for smuggling networks to remain unaffected and continue to operate. In fact, while it is easier for smuggling networks to operate in less democratic regimes, it does not mean that a change in the type of government, even towards an even less democratic one, will necessarily lead to better business. A change in the type of government, in fact, implies significant shifts not only of leaders in power but also of political systems and reorganisation of powers among different entities and governmental level. Such significant changes would therefore likely affect smuggling networks, which rely on established connections and corruption activities (UNODC, 2011; Europol-Interpol, 2016).

In comparison to the findings related to an increase in the risk of coup d'état, the change in type of government seems therefore to capture a more significant and long-lasting negative effect on crossing. As mentioned above, this could be explained by the fact that while a change in type of government captures an event that has materialised, an increase in the risk of coup d'état does not necessarily.

5.2.b Additional specifications and variables

As reported in section 3.1, one of the main limitations of Frontex data is that information on the nationality of crossing is not always available, thus leading to two undefined groups: 'Unknown' and 'Unknown sub-Saharan'. Therefore, an additional test is carried out using the baseline specification, but with figures on a number of crossings of unknown nationals redistributed across known nationalities. The share of each nationality in known number of crossings by route and month is used to redistribute unknown figures; for 'Unknown sub-Saharan', figures are redistributed only among sub-Saharan countries. Overall, the main results obtained with known figures are confirmed, with slight changes in magnitudes (see Table 9 in Appendix 2). One coefficient worth mentioning concerns the change in precipitation vis-à-vis a baseline month. Precipitation below the standard level along the migration route is still found to lower the number of crossings with a significance level of 5%; however, no significant effect is reported any more for precipitation being above the standard level. This result confirms the main expectation that changes in precipitation would be more relevant in affecting crossings when they entail a drop rather than an increase, as migration routes to Europe, especially those in Africa, cross already very arid environments. Moreover, given the ongoing effects of climate change, changes in precipitation are more likely to be recorded in the left rather than the right hand of the distribution.

In order to further investigate the role of changes in precipitation, two additional tests use the baseline specification but with lower thresholds (i.e. 80% and 50%) applied to define an exceptional month in terms of precipitation. Results are in line with the baseline model using a 90% significance level for the SPI (see Table 10, Table 11, and Table 12 in Appendix 2 for full sets of results). Moreover, a comparison across the different levels shows again that drops in precipitation along the route are always found to significantly decrease crossings, while the coefficient for a rise becomes significant only for extremely exceptional months (i.e. at least 80% significance of the SPI) (Table 4).

Table 4 Additional specifications for changes in precipitation: focus on route values

Precipitation change by significance level (50%, 80% and 90%)		Specifications tested by levels of Temperature change		
		1.5	1.75	2
50%	Below std month	-0.61927***	-0.61335***	-0.62720***
	Above std month	0.26979	0.35734	0.34699
80%	Below std month	-0.96385**	-0.98430**	-0.97745**
	Above std month	0.35342*	0.36341*	0.36387*
90%	Below std month	-0.85794**	-0.90071**	-0.89300**
	Above std month	0.74317**	0.76406**	0.72502**

Finally, a last specification includes other control variables that can capture additional socioeconomic dimensions, both at origin and in transit. In fact, the baseline model includes on purpose only GDP per capita and unemployment rate to limit the loss of observations from key origin countries of mixed-migration flows to the EU.[22]

First of all, the coefficient for general government per capita expenditure on health reports a negative sign for both the origin and the route value. However, only the latter is found to be statistically significant at 1%. In other words, this suggests that the more countries along the migration route spend on health (and therefore commit more in terms of welfare support), the more conditions for population are improved and the less people will attempt to cross into the EU. It is in fact important to remember that while countries along the migration route to the EU are, of course, seen as being of 'transit' to the EU, they still play a key role as destination countries for a lot of nationals attempting crossing into the EU. Thus, their stability as well as the level of services they provide can be an important factor shaping incentives to move. On the contrary, the share of people using the internet is found to significantly increase number of crossings, but only when this refers to the share in origin country and not along the route. This indicates a potential information channel linked to internet access, as the more people can get

[22] The inclusion of three additional variables to the baseline in fact reduces the number of observations from 14,325 to 12,538. See Table 13 in Appendix 2.

informed about, for example, the situation in destination countries or along the route, the more they can prepare for an eventual journey. Finally, the contribution of agriculture to overall value added in % of GDP does not report any significant coefficients, neither for origin nor route values.

6 Conclusions

Mixed-migration flows are often characterised by long journeys crossing different countries before reaching the EU. Moreover, they encompass not only people embarking on the journey with an EU country as intended final destination, but also those who decide to attempt crossing into the EU in a second stage. In fact, countries defined as being of transit to the EU can be important countries of destination for several people in search of better opportunities. Libya, for instance, has always attracted foreign workers, mostly from sub-Saharan countries in both the east and west of Africa.

Conditions in transit countries, and their development, can therefore affect the number of people ultimately attempting to reach the EU for several reasons. By accounting for the five main migration routes to the EU and the main regions of origin of mixed-migration flows, the analysis has tried to contribute to the literature on the role of transit countries by taking a quantitative and general approach. This empirical analysis, in fact, relies on a longitudinal dataset covering monthly number of crossings by nationality and route between 2009 and 2019, thus providing a considerable number of observations and therefore flexibility to test several regressors and control for multiple levels of fixed (unobserved) effects. Within the broad objective of ITFLOWS, this empirical analysis complements the qualitative one based on different case studies of dyads of origin and transit countries within WP3, which will both help develop the models of the EMT on the role of transit countries.

Among the regressors tested, the number of violent events due to conflict and the number of mass disasters due to natural events are among the most relevant, given their possible implications on intentions to move both in the short and long term. Both types of events are found to increase mixed-migration flows, with mass disaster having a larger effect. Moreover, these events appear to have larger effects when they take place along the route than at origin. This difference could be explained by the precariousness of living and economic conditions of migrants in transit: disruption along the route, due to either conflict or natural disasters, would further worsen their situation and therefore acts as a powerful incentive to migrate, independently from whether the EU was the initial intended destination.

In addition, closer proximity to the EU along the route than at origin might also explain the larger magnitude observed for the value in transit countries.

The previous mechanism is indirectly supported when testing also for the number of events occurring in the six months prior to crossing. For instance, violent events due to conflict in the country of origin report an additional positive effect on the number of crossings. This implies that this type of event not only has an immediate impact on crossing, but also a long-lasting effect that possibly shapes intentions to move: the more the violence of conflicts intensifies the higher the number of people deciding to leave their country of origin. The same cannot be said, however, for mass disaster due to natural events occurring at origin. Furthermore, results were not significant for violent events due to conflicts along the route in the six previous months before crossing, and only at 10% for the mass disasters.

Beside violent events due to conflicts, the analysis tested other indicators capturing overall political stability in both origin and transit countries. An increase in the risk of coups d'état in countries along the route has been found to decrease the number of crossings, while no significant effect is found for the origin country. Testing for different lags, however, reveals that an increase of the risk of coup d'état leads to more people leaving their country of origin only after several months. Similarly, the negative effect on number of crossings of a rise in the probability along the route is balanced by a positive delayed effect. Additional variables on the types of governments and the level of political violence were also added to our baseline specification: interim (provisional period) and non-democratic governments along the route lead to higher crossings compared to democratic governments and increases in political violence at origin also have a positive impact on the number of crossings.

The analysis also tested for changes in weather conditions, both in terms of precipitations and temperatures. Results show that exceptional months can affect the mean number of crossings in comparison to those reported during a 'standard' month. More specifically, months with precipitations along the route below the baseline value are found to significantly decrease the mean number of crossings compared to a 'standard' month across all specifications tested. On the other hand, an increase in precipitations along the route is found to increase crossings only for

higher deviations in precipitation, which are less common by far for rises than for drops in precipitations.

Further tests using information on the six-month period before crossing, however, show how changing weather conditions can have a different impact depending on their duration. For instance, a sustained period with below average precipitation at origin increases the number of crossings, while there is no significant effect for a change in the same month. In other words, only sustained periods of drought in the origin countries seem to create more incentives to move and therefore more crossings. On the contrary, long-lasting droughts along the route negatively affect crossing: once again, these findings point to the different interplays between these factors and development of mixed-migration flows depending on whether they concern the country of origin or the situation along the route.

For temperatures, significant results are recorded mostly for changes along the route: periods prior to crossing with sustained higher temperatures are found to have a significant and negative effect. However, when considering only contemporaneous (at time t) effects, higher temperature along the route leads to more crossings in the same month. This could imply that while a sudden change might push people to cross in the same month, ongoing increasing temperatures might hinder the situation along the route and slow down the entire journey.

Results have shown how the development of several dimensions both in origin and transit countries can affect the number of crossings into the EU, and how their effect can differ in terms of direction and magnitude depending on whether the origin or the transit countries are concerned. The use of high frequency data and the granular definition of transit countries based on both origin and route taken are two values added of the research. Event-based data and monthly indicators gave flexibility to test for both short to medium term effects of developments and investigate how extended disruption of conditions, due for instance to changing weather or increasing number of violent and natural events, can lead to additional effect on the number of crossings. **Monitoring of such granular indicators on both origin and main transit countries can therefore be helpful to understand when to expect a possible rise in mixed-migration flows to the EU.** Yet, further research could investigate the use of micro-data based on, for example surveys collecting the experiences of migrants in the EU, or of big data, for

example internet searches and social media, to better understand how people's intentions are affected by changing conditions in transit as well as to control for the length of stay in each country transited prior to entering the EU.

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FRONTEX

Detections of illegal border-crossings statistics, see https://frontex.europa.eu/we-know/migratory-map/.

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Sundberg, Ralph and Erik Melander (2013), Introducing the UCDP Georeferenced Event Dataset, *Journal of Peace Research*, 50(4), see https://ucdp.uu.se/downloads/index.html#ged_global.

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EM-DAT, CRED / UCLouvain, Brussels, Belgium – (D. Guha-Sapir), see https://www.emdat.be/

Rulers, Elections, and Irregular Governance (REIGN) dataset

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Appendix 1. Regions and routes

As explained in the methodology, the main regions of origin included are all those in Africa, the Middle East and South Asia. Further to that, the final sample is restricted to those country-route pairs for which there were at least five crossings detected every 100,000 inhabitants across the 11 years' timespan selected (i.e. 2009-2019). No country in the Southern African region overcame the threshold. Finally, being key countries of origin at project level, both Venezuela and South Sudan are included despite not overcoming the threshold.

Central Africa	At least 5 crossing per 100,000 inhabitants (route level)
Burundi	
Cameroon	x
Central African Republic	x
Chad	x
Congo, Dem Rep	x
Congo, Rep	x
Equatorial Guinea	x
Gabon	x

East Africa	At least 5 crossing per 100,000 inhabitants (route level)
Comoros	x
Eritrea	x
Ethiopia	x
Kenya	
Madagascar	
Mauritius	
Rwanda	
Seychelles	
Somalia	x
South Sudan	*
Sudan	x

Tanzania	
Uganda	

** Included as key country of origin at project level*

North Africa	At least 5 crossing per 100,000 inhabitants (route level)
Algeria	x
Egypt, Arab Rep	x
Libya	x
Morocco	x
Tunisia	x

West Africa	At least 5 crossing per 100,000 inhabitants (route level)
Benin	x
Burkina Faso	x
Cabo Verde	
Cote d'Ivoire	x
Gambia, The	x
Ghana	x
Guinea	x
Guinea-Bissau	x
Liberia	x
Mali	x
Mauritania	x
Niger	x
Nigeria	x
Senegal	x
Sierra Leone	x
Togo	x

Middle East	At least 5 crossing per 100,000 inhabitants (route level)
Djibouti	
Iran, Islamic Rep	x
Iraq	x
Israel	
Jordan	x
Kuwait	x
Lebanon	x
Oman	
Saudi Arabia	
Syrian Arab Republic	x
United Arab Emirates	
West Bank and Gaza	x
Yemen, Rep	x

South Asia	At least 5 crossing per 100,000 inhabitants (route level)
Afghanistan	x
Bangladesh	x
Bhutan	
India	
Maldives	
Nepal	
Pakistan	x
Sri Lanka	x

The countries used to compute route values are the transit countries identified by the literature. Depending on the region of origin, some transit countries change within the same route (e.g. West versus East Africans using the CMR). Further to that, countries that are defined as transit can also be origin: Mali is a transit country for West Africans but also one of the main countries of origin of crossing to the EU. Hence, origin countries that are also transit countries identified in the

literature will have their route variables based only on the 'remaining' transit countries along the route.

Last but not least, while the literature identifies 'main' transit countries along each route, it is also true that there are alternatives that might be used and increasingly become relevant over time. The same holds for transit countries at the end of the route, i.e. disembarkation. For instance, while Niger and Libya represent the main countries of transit and disembarkation for the CMR, both Algeria and Tunisia are important countries for this route, especially for specific regions of origin, for example, West Africa.

Therefore, the computation takes into consideration the main transit countries and the possible alternatives reported by the literature and, at the same time, accounts, to the extent possible, for the geographical position of the different origin and transit countries along the routes.

Transit countries selected by route and region of origin are reported below. For countries of origin in the South African region, countries selected are always those for the Central African region with the addition of the DRC and Central African Republic. Finally, each route has some key disembarkation countries selected. In the case of nationals detected in a route that is not identified by the literature as being the main one for their region of origin, or if they belong to the same region of disembarkation countries, then the transit value takes into consideration only the disembarkation country/ies. For instance, South Asian citizens crossing through the CMR will have transit values based only on Libya and Tunisia, as East Africans crossing through the EMR will have transit values based only on Turkey.

Figure 2 Central Mediterranean Route (CMR)

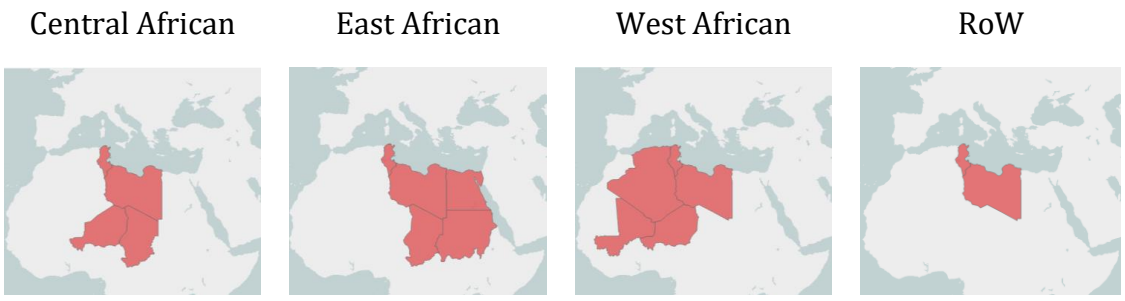


Figure 3 Western Mediterranean Route (WMR)

Figure 4 Western African Route (WAR)

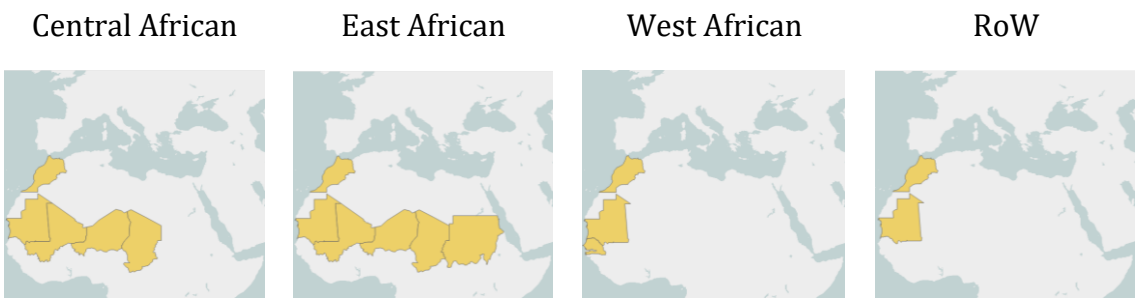


Figure 5 Eastern Mediterranean Route (EMR)

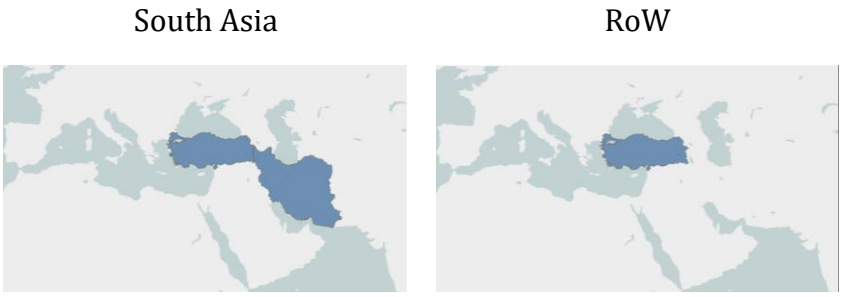
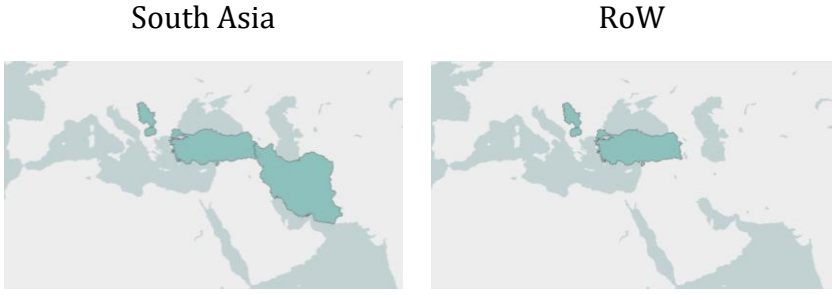


Figure 6 Western Balkan Route (WBR)



Appendix 2. Additional results

Table 5 Baseline model including additional political stability variables

VARIABLES	(1) 1.5 °C	(2) 1.75 °C	(3) 2.0 °C
Crossing (t-1)	0.00001***	0.00001***	0.00001***
	(0.00000)	(0.00000)	(0.00000)
Gov. Type: Interim Period (org)	0.16768	0.16966	0.18770
	(0.26891)	(0.26436)	(0.26392)
Gov. Type: Non-Democracy (org)	-0.10106	-0.10534	-0.09619
	(0.41337)	(0.41081)	(0.41761)
Gov. Type: Interim Period (route)	1.48636***	1.45466***	1.45634***
	(0.41835)	(0.41194)	(0.41048)
Gov. Type: Non-Democracy (route)	2.27469***	2.20411***	2.20925***
	(0.52413)	(0.50063)	(0.50782)
Political violence (org)	0.04502**	0.04529**	0.04633**
	(0.01802)	(0.01817)	(0.01822)
Political violence (route)	-0.00385	-0.01526	-0.01911
	(0.07539)	(0.07360)	(0.07446)
Log risk coup d'état (org)	-0.20894***	-0.19656***	-0.21134***
	(0.05885)	(0.05597)	(0.06044)
Log risk coup d'état (route)	-0.49610***	-0.51014***	-0.49910***
	(0.13349)	(0.13857)	(0.13629)
Conflict events (org)	0.00175***	0.00174***	0.00169***
	(0.00036)	(0.00036)	(0.00037)
Conflict events (route)	0.02434***	0.02475***	0.02431***
	(0.00456)	(0.00451)	(0.00449)
Precipitation below (org)	-0.04321	-0.03165	-0.03879
	(0.21672)	(0.20525)	(0.20388)
Precipitation above (org)	-0.23893	-0.22335	-0.22455
	(0.53936)	(0.53563)	(0.52635)
Precipitation below (route)	-0.63903*	-0.67605*	-0.67074*
	(0.36825)	(0.37225)	(0.36837)
Precipitation above (route)	0.71515**	0.73529**	0.69842**
	(0.30772)	(0.29060)	(0.28735)
Temperature below (org)	-0.34123	-0.47784*	-0.80336**
	(0.22288)	(0.24929)	(0.31616)
Temperature above (org)	-0.06535	-0.13245**	-0.22535***
	(0.07184)	(0.05778)	(0.05693)
Temperature below (route)	0.29286	0.32918	0.30072
	(0.20595)	(0.21900)	(0.21307)
Temperature above (route)	-0.00347	0.20494***	0.20718***
	(0.08765)	(0.07885)	(0.06421)
Mass disasters (org)	0.08977***	0.08817***	0.08959***
	(0.03048)	(0.03295)	(0.03141)
Mass disasters (route)	0.18182***	0.17513***	0.16672***
	(0.03567)	(0.03394)	(0.03238)
Log GDP pc PPP (org)	20.85973**	21.16620**	21.30609**
	(9.59074)	(9.51955)	(9.41410)
Log GDP pc PPP ^2 (org)	-1.69784**	-1.72463**	-1.74334**

	(0.80694)	(0.79980)	(0.78894)
Unemployment rate (15-24) (org)	0.04492	0.04417	0.04581
	(0.03826)	(0.03793)	(0.03774)
Log GDP pc PPP (route)	3.04576	2.95037	2.85607
	(14.88475)	(14.92709)	(14.78118)
Log GDP pc PPP ^2 (route)	-0.32885	-0.31240	-0.30710
	(1.08658)	(1.08842)	(1.07786)
Unemployment rate (15-24) (route)	0.03547	0.04019	0.03625
	(0.03547)	(0.03430)	(0.03473)
Log population (org)	-1.06434	-1.03844	-0.96526
	(1.66101)	(1.63703)	(1.60957)
Constant	-48.35235	-49.90660	-50.73809
	(55.00417)	(54.36125)	(54.34070)
Obs	14325	14325	14325
Pseudo Rsq	0.869	0.870	0.870
Dep. var	Crossing	Crossing	Crossing
Std. errors	Clustered	Clustered	Clustered
Cluster Variable	Country-route	Country-route	Country-route

Table 6 Baseline model including lags of the risk of coup d'état

VARIABLES	(1) 1.5 °C	(2) 1.75 °C	(3) 2.0 °C
Crossing (t-1)	0.00002***	0.00002***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.12234***	-0.11279***	-0.12631***
	(0.04296)	(0.03840)	(0.04356)
Lag1	0.03290	0.02869	0.03752
	(0.06467)	(0.06766)	(0.06468)
Lag2	0.06437	0.05818	0.05394
	(0.04700)	(0.04644)	(0.04570)
Lag3	0.03952	0.03794	0.04826
	(0.04524)	(0.04396)	(0.04355)
Lag4	0.06723	0.06604	0.07063
	(0.05023)	(0.05215)	(0.05485)
Lag5	-0.12124	-0.09048	-0.09998
	(0.07908)	(0.07107)	(0.07277)
Lag6	-0.11218*	-0.11787**	-0.11532**
	(0.05896)	(0.05689)	(0.05564)
Lag7	0.04418	0.03740	0.04385
	(0.06544)	(0.06373)	(0.06308)
Lag8	-0.01929	-0.02054	-0.02924
	(0.04869)	(0.04650)	(0.05110)
Lag9	-0.04857	-0.04737	-0.04634
	(0.06623)	(0.06466)	(0.06777)
Lag10	0.07733	0.07725	0.07888
	(0.05977)	(0.05848)	(0.06106)
Lag11	0.05450	0.05863	0.04829
	(0.04315)	(0.04826)	(0.04321)
Lag12	0.13115**	0.12225**	0.11860**
	(0.05301)	(0.04883)	(0.04958)
Log risk coup d'état (route)	0.03632	0.01419	0.02405
	(0.07185)	(0.07057)	(0.07241)
Lag1	0.00827	0.03508	0.02395
	(0.08386)	(0.08549)	(0.08358)
Lag2	-0.09885	-0.10146	-0.10756
	(0.07512)	(0.07393)	(0.07377)

Lag3	-0.11118	-0.13925*	-0.11703
	(0.07418)	(0.08331)	(0.08315)
Lag4	-0.34091***	-0.34124***	-0.34024***
	(0.06787)	(0.07012)	(0.07033)
Lag5	-0.25575***	-0.25860***	-0.27439***
	(0.06945)	(0.06963)	(0.06973)
Lag6	-0.20382***	-0.19285***	-0.19682***
	(0.06903)	(0.06531)	(0.06485)
Lag7	-0.04713	-0.03308	-0.03679
	(0.08193)	(0.07412)	(0.07390)
Lag8	0.13908**	0.13879**	0.15143**
	(0.06284)	(0.06528)	(0.06195)
Lag9	-0.10757*	-0.11387**	-0.11879**
	(0.05878)	(0.05808)	(0.05806)
Lag10	-0.00866	-0.01672	-0.00389
	(0.06642)	(0.06552)	(0.06391)
Lag11	0.18267***	0.18927***	0.18723***
	(0.05700)	(0.05901)	(0.05956)
Lag12	0.30066***	0.28284***	0.28049***
	(0.08007)	(0.07639)	(0.07571)
Conflict events (org)	0.00194***	0.00194***	0.00192***
	(0.00035)	(0.00034)	(0.00034)
Conflict events (route)	0.02429***	0.02461***	0.02467***
	(0.00488)	(0.00495)	(0.00498)
Precipitation below (org)	-0.04504	-0.03529	-0.04978
	(0.24982)	(0.23804)	(0.23556)
Precipitation above (org)	-0.35768	-0.33722	-0.34229
	(0.55017)	(0.54948)	(0.54486)
Precipitation below (route)	-0.95142**	-1.00943**	-1.00856**
	(0.40943)	(0.40318)	(0.40381)
Precipitation above (route)	0.46676	0.47267	0.45373
	(0.33981)	(0.32778)	(0.32067)
Temperature below (org)	-0.34031	-0.44417*	-0.72999***
	(0.21880)	(0.24379)	(0.28274)
Temperature above (org)	-0.04621	-0.10678**	-0.16961***
	(0.06742)	(0.05276)	(0.04728)
Temperature below (route)	0.07880	0.09828	0.05578
	(0.20910)	(0.22986)	(0.22035)
Temperature above (route)	0.04154	0.21420**	0.19433**
	(0.10071)	(0.08682)	(0.08080)
Mass disasters (org)	0.07651**	0.07543*	0.07684**
	(0.03610)	(0.03868)	(0.03768)
Mass disasters (route)	0.16805***	0.16201***	0.15771***
	(0.03442)	(0.03407)	(0.03378)
Log GDP pc PPP (org)	20.31249**	20.53553**	20.55224**
	(9.33211)	(9.33241)	(9.18374)
Log GDP pc PPP ^2 (org)	-1.62836**	-1.64977**	-1.65643**
	(0.79019)	(0.78886)	(0.77464)
Unemployment rate (15-24) (org)	0.02584	0.02613	0.02802
	(0.03698)	(0.03660)	(0.03653)
Log GDP pc PPP (route)	-17.53157	-17.42462	-17.60353
	(17.36817)	(17.57726)	(17.36788)
Log GDP pc PPP ^2 (route)	1.19009	1.18758	1.20089
	(1.26237)	(1.27736)	(1.26265)
Unemployment rate (15-24) (route)	0.08716**	0.08960**	0.08634**
	(0.03671)	(0.03599)	(0.03555)
Log population (org)	-2.05771	-2.04590	-2.01436
	(1.61827)	(1.59994)	(1.57622)
Constant	38.66801	37.05877	37.34651
	(65.46474)	(65.45306)	(64.79480)
Obs	14253	14253	14253
Pseudo Rsq	0.869	0.870	0.870
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered

Cluster var		Country-route	Country-route	Country-route	

Table 7 Baseline model including change in type of government and additional political variables

VARIABLES	(1) 1.5 °C		(2) 1.75 °C		(3) 2.0 °C	
	Any change	Change to less democratic	Any change	Change to less democratic	Any change	Change to less democratic
Crossing (t-1)	0.00001***	0.00001***	0.00001***	0.00001***	0.00001***	0.00001***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Gov. Type: Interim Period (org)	0.21094	0.20077	0.21225	0.20175	0.23038	0.21875
	(0.24741)	(0.24648)	(0.24419)	(0.24439)	(0.24241)	(0.24342)
Gov. Type: Non-Democracy (org)	-0.15750	-0.16421	-0.15784	-0.16637	-0.14821	-0.15810
	(0.44246)	(0.44266)	(0.43796)	(0.43909)	(0.44431)	(0.44599)
Change in gov. type (org)	0.22837	1.03230*	0.30403	1.01786*	0.38319	1.01168*
	(0.26227)	(0.54468)	(0.24165)	(0.55010)	(0.24271)	(0.54660)
Gov. Type: Interim Period (route)	1.48730***	1.49665***	1.46192***	1.47289***	1.46776***	1.47696***
	(0.42616)	(0.42410)	(0.41819)	(0.41646)	(0.41730)	(0.41541)
Gov. Type: Non-Democracy (route)	2.23654***	2.25219***	2.16766***	2.18794***	2.17713***	2.19513***
	(0.48344)	(0.48601)	(0.45967)	(0.46238)	(0.46664)	(0.46878)
Change in gov. type (route)	0.05417	-0.31684	0.00907	-0.49013	-0.00486	-0.45539
	(0.21638)	(0.30650)	(0.21333)	(0.36518)	(0.21278)	(0.34050)
Political violence (org)	0.04535**	0.04535**	0.04564**	0.04566**	0.04661**	0.04659**
	(0.01825)	(0.01820)	(0.01838)	(0.01832)	(0.01842)	(0.01837)
Political violence (route)	-0.01923	-0.01906	-0.03120	-0.03085	-0.03469	-0.03421
	(0.07963)	(0.07967)	(0.07744)	(0.07754)	(0.07817)	(0.07826)
Log risk coup d'état (org)	-	-	-	-	-	-
	0.19302***	0.19009***	0.18285***	0.17908***	0.19741***	0.19270***
	(0.07283)	(0.07169)	(0.06973)	(0.06817)	(0.07471)	(0.07265)
Log risk coup d'état (route)	-	-	-	-	-	-
	0.47086***	0.47301***	0.48076***	0.48437***	0.46989***	0.47356***
	(0.14232)	(0.14143)	(0.14681)	(0.14629)	(0.14387)	(0.14333)
Conflict events (org)	0.00177***	0.00177***	0.00176***	0.00176***	0.00171***	0.00171***
	(0.00036)	(0.00036)	(0.00036)	(0.00036)	(0.00037)	(0.00037)
Conflict events (route)	0.02349***	0.02341***	0.02398***	0.02384***	0.02353***	0.02338***
	(0.00455)	(0.00453)	(0.00450)	(0.00448)	(0.00447)	(0.00444)
Precipitation below (org)	-0.06612	-0.05662	-0.05621	-0.04494	-0.06486	-0.05106
	(0.23625)	(0.23120)	(0.22539)	(0.22072)	(0.22475)	(0.22011)
Precipitation above (org)	-0.29383	-0.29359	-0.27122	-0.26964	-0.27543	-0.27368
	(0.53749)	(0.53502)	(0.53394)	(0.53206)	(0.52333)	(0.52135)
Precipitation below (route)	-0.61554	-0.62592*	-0.64967*	-0.66192*	-0.64062*	-0.65514*
	(0.38291)	(0.37622)	(0.38785)	(0.38108)	(0.38411)	(0.37656)
Precipitation above (route)	0.66551**	0.66835**	0.68691**	0.68875**	0.65071**	0.65355**
	(0.31187)	(0.31128)	(0.29596)	(0.29513)	(0.29207)	(0.29084)
Temperature below (org)	-0.30170	-0.30010	-0.42871*	-0.43112	-0.74913**	-0.74407**
	(0.23017)	(0.23176)	(0.26036)	(0.26337)	(0.32948)	(0.32942)
Temperature above (org)	-0.05164	-0.05064	-0.12518**	-0.12377**	-	-
					0.22156***	0.21765***
	(0.07161)	(0.07147)	(0.05630)	(0.05675)	(0.05692)	(0.05621)
Temperature below (route)	0.29591	0.29763	0.33330	0.33496	0.30200	0.30465
	(0.20039)	(0.20104)	(0.21217)	(0.21290)	(0.20538)	(0.20670)
Temperature above (route)	-0.00571	-0.00377	0.20161***	0.20233***	0.20005***	0.19916***
	(0.08960)	(0.08867)	(0.07818)	(0.07752)	(0.06737)	(0.06619)

Mass disasters (org)	0.08452***	0.08340***	0.08332**	0.08205**	0.08500***	0.08350**
	(0.03182)	(0.03162)	(0.03395)	(0.03402)	(0.03242)	(0.03254)
Mass disasters (route)	0.19200***	0.19067***	0.18491***	0.18338***	0.17648***	0.17507***
	(0.03776)	(0.03713)	(0.03585)	(0.03515)	(0.03421)	(0.03361)
Log GDP pc PPP (org)	20.12490**	20.14146**	20.45721**	20.46931**	20.47184**	20.49186**
	(9.38336)	(9.37464)	(9.31450)	(9.30248)	(9.22662)	(9.20601)
Log GDP pc PPP ^2 (org)	-1.65122**	-1.65238**	-1.67917**	-1.68023**	-1.68653**	-1.68803**
	(0.79144)	(0.79061)	(0.78447)	(0.78334)	(0.77517)	(0.77351)
Unemployment rate (15-24) (org)	0.04686	0.04745	0.04617	0.04677	0.04773	0.04833
	(0.03795)	(0.03795)	(0.03774)	(0.03779)	(0.03741)	(0.03750)
Log GDP pc PPP (route)	4.70631	4.70202	4.68411	4.63878	4.50366	4.47424
	(14.54027)	(14.50242)	(14.64381)	(14.60601)	(14.41432)	(14.37012)
Log GDP pc PPP ^2 (route)	-0.47355	-0.47465	-0.46195	-0.46028	-0.45039	-0.44990
	(1.06262)	(1.05989)	(1.06919)	(1.06644)	(1.05244)	(1.04932)
Unemployment rate (15-24) (route)	0.04581	0.04516	0.05008	0.04934	0.04639	0.04558
	(0.03669)	(0.03695)	(0.03548)	(0.03582)	(0.03567)	(0.03606)
Log population (org)	-0.91794	-0.95313	-0.88955	-0.92921	-0.80940	-0.85459
	(1.66473)	(1.66401)	(1.63452)	(1.63652)	(1.60276)	(1.60850)
Constant	-54.40070	-53.75813	-56.41517	-55.52053	-56.78532	-55.87115
	(55.69389)	(55.67140)	(54.80747)	(54.84015)	(54.73143)	(54.70688)
Obs	14319	14319	14319	14319	14319	14319
Pseudo Rsq	0.868	0.868	0.869	0.869	0.869	0.869
Dep. var	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing
Std. errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Cluster Variable	Country-route	Country-route	Country-route	Country-route	Country-route	Country-route

Table 8 Baseline model including 12 lags of the change in type of government and additional political variables

VARIABLES	(1) 1.5 °C		(2) 1.75 °C		(3) 2.0 °C	
	Any change	Change to less democratic	Any change	Change to less democratic	Any change	Change to less democratic
Crossing (t-1)	0.00001**	0.00001***	0.00001**	0.00001***	0.00001**	0.00001***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Gov. Type: Interim Period (org)	0.23365	0.17466	0.24594	0.17825	0.24499	0.19439
	(0.20687)	(0.23086)	(0.20506)	(0.23113)	(0.20867)	(0.22970)
Gov. Type: Non-Democracy (org)	0.26523	-0.06218	0.26235	-0.07236	0.25543	-0.05865
	(0.47896)	(0.42555)	(0.47246)	(0.42553)	(0.48236)	(0.42919)
Change in gov. type (org)	0.42143*	1.11938*	0.49052**	1.10442*	0.53596**	1.09588*
	(0.23855)	(0.63119)	(0.23149)	(0.63665)	(0.22834)	(0.63475)
Lag1	1.34429***	0.85048	1.32092***	0.88551	1.29297***	0.85633
	(0.38614)	(0.59172)	(0.38833)	(0.61160)	(0.38577)	(0.60157)
Lag2	1.54086***	-0.17319	1.55513***	-0.22715	1.52165***	-0.21675
	(0.48248)	(0.64741)	(0.48493)	(0.58730)	(0.46909)	(0.60324)
Lag3	0.69993*	-0.29871	0.66527*	-0.33975	0.67336*	-0.35866
	(0.36633)	(0.53752)	(0.37755)	(0.52810)	(0.38194)	(0.54224)
Lag4	0.12529	-0.37052	0.08869	-0.36363	0.09641	-0.48105
	(0.34471)	(0.44277)	(0.35388)	(0.47594)	(0.34641)	(0.45365)
Lag5	0.05477	-0.12011	0.05081	-0.15855	0.03914	-0.16929
	(0.36137)	(0.43071)	(0.37231)	(0.38989)	(0.37007)	(0.38330)
Lag6	-0.02679	0.87354**	0.02606	0.94456**	-0.00716	0.88275**
	(0.41129)	(0.38824)	(0.40351)	(0.39525)	(0.40284)	(0.38918)
Lag7	-0.13009	0.40853	-0.12528	0.34225	-0.14113	0.38562
	(0.27660)	(0.71120)	(0.26251)	(0.72409)	(0.26320)	(0.71167)

Lag8	0.10952	0.27219	0.06801	0.26964	0.10885	0.22518
	(0.34919)	(0.31066)	(0.38592)	(0.34562)	(0.36657)	(0.32726)
Lag9	0.39006	0.84278	0.42794*	0.93591*	0.39014	0.81693
	(0.28035)	(0.53560)	(0.25972)	(0.55367)	(0.28110)	(0.55598)
Lag10	0.04585	0.28855	0.06141	0.35640	0.02610	0.36697
	(0.35091)	(0.43278)	(0.33795)	(0.44585)	(0.34382)	(0.44596)
Lag11	-0.20191	0.95704**	-0.16481	0.97565**	-0.21363	0.98221**
	(0.26430)	(0.42433)	(0.23970)	(0.41110)	(0.25598)	(0.40824)
Lag12	-0.23124	0.59750*	-0.23729	0.52246	-0.30931	0.63333**
	(0.26354)	(0.32677)	(0.25038)	(0.31833)	(0.29072)	(0.31934)
Gov. Type: Interim Period (route)	1.79220***	1.86471***	1.76008***	1.80725***	1.77367***	1.81775***
	(0.40105)	(0.45065)	(0.39272)	(0.44707)	(0.39262)	(0.43992)
Gov. Type: Non-Democracy (route)	2.36449***	2.89225***	2.28672***	2.77547***	2.31542***	2.79586***
	(0.46734)	(0.54202)	(0.44358)	(0.52286)	(0.44971)	(0.52438)
Change in gov. type (route)	-0.22317	-0.78442	-0.28546	-0.91283*	-0.29686	-0.89832*
	(0.23337)	(0.48358)	(0.22502)	(0.51578)	(0.22493)	(0.49741)
Lag1	0.52784*	-1.38755**	0.52886*	-1.30678**	0.55173*	-1.32425**
	(0.29562)	(0.54608)	(0.29193)	(0.53643)	(0.29313)	(0.52541)
Lag2	-0.36575	-1.83933***	-0.37662	-1.61244***	-0.35537	-1.63919***
	(0.27202)	(0.59363)	(0.27797)	(0.56426)	(0.27646)	(0.56457)
Lag3	-0.76477***	-0.97593*	-0.73778***	-0.92872*	-0.71028***	-0.88943*
	(0.27395)	(0.52411)	(0.26318)	(0.54191)	(0.26079)	(0.51926)
Lag4	-0.99164***	-1.11939***	-0.93009***	-0.95305**	-0.93953***	-0.95165**
	(0.30563)	(0.42289)	(0.30459)	(0.42013)	(0.29679)	(0.43306)
Lag5	-1.53902***	-1.51309***	-1.55115***	-1.51598***	-1.54817***	-1.58834***
	(0.25694)	(0.39957)	(0.25434)	(0.40573)	(0.25721)	(0.41223)
Lag6	-1.66528***	-0.62349*	-1.62053***	-0.49557	-1.60426***	-0.59058
	(0.21963)	(0.35135)	(0.20837)	(0.36357)	(0.21995)	(0.36326)
Lag7	-1.16773***	-0.01532	-1.28047***	0.05827	-1.19976***	-0.01870
	(0.24404)	(0.39735)	(0.25008)	(0.39852)	(0.22573)	(0.39666)
Lag8	-1.48494***	-1.82168***	-1.43269***	-1.74752***	-1.31227***	-1.82523***
	(0.28869)	(0.40767)	(0.27378)	(0.40526)	(0.25624)	(0.40411)
Lag9	-1.98849***	-1.34502***	-1.99810***	-1.33399***	-2.04659***	-1.34016***
	(0.38886)	(0.40972)	(0.36622)	(0.40918)	(0.37927)	(0.41319)
Lag10	-1.95133***	-1.13556**	-1.86281***	-1.04036**	-1.85004***	-1.08396**
	(0.37228)	(0.51813)	(0.35425)	(0.51085)	(0.34584)	(0.51686)
Lag11	-0.68488**	-0.59159	-0.72083**	-0.53307	-0.61549**	-0.56779
	(0.31893)	(0.60475)	(0.31930)	(0.61129)	(0.31164)	(0.61403)
Lag12	-1.47920***	-2.04580**	-1.54624***	-2.04675**	-1.55068***	-2.03386**
	(0.39602)	(0.94158)	(0.40136)	(0.92276)	(0.40449)	(0.92545)
Political violence (org)	0.04860***	0.04807***	0.04885***	0.04800***	0.04954***	0.04903***
	(0.01667)	(0.01799)	(0.01682)	(0.01822)	(0.01688)	(0.01822)
Political violence (route)	-0.05048	-0.01197	-0.06486	-0.02425	-0.06336	-0.02694
	(0.08874)	(0.07993)	(0.08602)	(0.07720)	(0.08677)	(0.07857)
Log risk coup d'état (org)	-0.22740***	-0.19345***	-0.22098***	-0.18304***	-0.23410***	-0.19551***
	(0.07670)	(0.07264)	(0.07508)	(0.06920)	(0.07856)	(0.07347)
Log risk coup d'état (route)	-0.19835	-0.50677***	-0.20681	-0.51523***	-0.20893	-0.50465***
	(0.12850)	(0.14176)	(0.12956)	(0.14629)	(0.12930)	(0.14372)
Conflict events (org)	0.00203***	0.00187***	0.00202***	0.00185***	0.00197***	0.00180***
	(0.00034)	(0.00036)	(0.00034)	(0.00037)	(0.00034)	(0.00037)
Conflict events (route)	0.01900***	0.02231***	0.01899***	0.02278***	0.01941***	0.02231***
	(0.00427)	(0.00438)	(0.00419)	(0.00436)	(0.00422)	(0.00432)

Precipitation below (org)	-0.15092	-0.08969	-0.14450	-0.07771	-0.15076	-0.08344
	(0.19350)	(0.21589)	(0.18745)	(0.20745)	(0.19001)	(0.20619)
Precipitation above (org)	-0.29413	-0.27708	-0.26948	-0.25712	-0.27378	-0.25941
	(0.54394)	(0.52994)	(0.53926)	(0.52773)	(0.53186)	(0.51667)
Precipitation below (route)	-0.48877	-0.56924	-0.52542	-0.60398	-0.52626	-0.59615
	(0.35579)	(0.36745)	(0.36788)	(0.37301)	(0.36512)	(0.36889)
Precipitation above (route)	0.54047	0.64069**	0.56915*	0.66281**	0.54649*	0.62971**
	(0.33515)	(0.31150)	(0.32278)	(0.29490)	(0.32092)	(0.29030)
Temperature below (org)	-0.35029	-0.25623	-0.46837	-0.37424	-0.76732**	-0.67692*
	(0.25303)	(0.23247)	(0.28516)	(0.27775)	(0.34992)	(0.34905)
Temperature above (org)	-0.02141	-0.04811	-0.08057*	-0.11580**	-0.17926***	-0.21190***
	(0.05517)	(0.07365)	(0.04586)	(0.05843)	(0.06698)	(0.05754)
Temperature below (route)	0.10068	0.27813	0.12508	0.31292	0.08716	0.28480
	(0.19495)	(0.19896)	(0.21249)	(0.21105)	(0.20604)	(0.20404)
Temperature above (route)	-0.00119	-0.01974	0.19662***	0.17985**	0.19544***	0.17973***
	(0.08954)	(0.09019)	(0.06725)	(0.07716)	(0.06746)	(0.06937)
Mass disasters (org)	0.07354**	0.08075**	0.07172**	0.07967**	0.07149**	0.08089**
	(0.03312)	(0.03280)	(0.03515)	(0.03494)	(0.03513)	(0.03360)
Mass disasters (route)	0.13806***	0.18400***	0.13194***	0.17853***	0.12845***	0.17021***
	(0.04208)	(0.03631)	(0.04008)	(0.03484)	(0.03960)	(0.03317)
Log GDP pc PPP (org)	18.86608**	18.91335**	19.21791**	19.26884**	19.28681**	19.28290**
	(8.93530)	(9.19576)	(8.93794)	(9.11789)	(8.82121)	(9.02929)
Log GDP pc PPP ^2 (org)	-1.52630**	-1.56003**	-1.55693**	-1.58843**	-1.56969**	-1.59583**
	(0.74930)	(0.77432)	(0.74822)	(0.76746)	(0.73652)	(0.75792)
Unemployment rate (15-24) (org)	0.04557	0.05377	0.04414	0.05231	0.04633	0.05399
	(0.03339)	(0.03665)	(0.03310)	(0.03644)	(0.03315)	(0.03621)
Log GDP pc PPP (route)	-14.99869	3.38497	-15.27092	3.27578	-14.40693	3.19558
	(15.20336)	(14.86695)	(15.27271)	(14.95630)	(15.20877)	(14.72968)
Log GDP pc PPP ^2 (route)	0.79942	-0.40883	0.82941	-0.39042	0.76958	-0.38617
	(1.10449)	(1.08085)	(1.10832)	(1.08621)	(1.10365)	(1.06999)
Unemployment rate (15-24) (route)	0.04447	0.03255	0.04932	0.03713	0.04610	0.03318
	(0.03801)	(0.03765)	(0.03695)	(0.03606)	(0.03706)	(0.03660)
Log population (org)	-0.67908	-1.10058	-0.62473	-1.06224	-0.59675	-0.98961
	(1.61244)	(1.55094)	(1.59327)	(1.52818)	(1.58002)	(1.50116)
Constant	21.36014	-41.53170	19.73574	-43.52894	16.22634	-44.09956
	(59.63604)	(56.49707)	(59.39563)	(55.81624)	(58.83914)	(55.61575)
Obs	14247	14247	14247	14247	14247	14247
Pseudo Rsq	0.880	0.870	0.881	0.871	0.881	0.871
Dep. var	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing
Std. errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Cluster Variable	Country-route	Country-route	Country-route	Country-route	Country-route	Country-route

Table 9 Baseline model including figures on crossing from 'Unknown' and 'Unknown sub-Saharan' nationals

VARIABLES	(1) 1.5 °C	(2) 1.75 °C	(3) 2.0 °C
Crossing (t-1)	0.00001***	0.00001***	0.00001***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.08062	-0.07337	-0.08107
	(0.07081)	(0.06822)	(0.07252)
Log risk coup d'état (route)	-0.40522***	-0.41966***	-0.41317***
	(0.13584)	(0.13896)	(0.13789)
Conflict events (org)	0.00204***	0.00204***	0.00201***

	(0.00035)	(0.00035)	(0.00035)
Conflict events (route)	0.03097***	0.03157***	0.03127***
	(0.00569)	(0.00565)	(0.00575)
Precipitation below (org)	-0.29120	-0.27489	-0.27684
	(0.33457)	(0.32314)	(0.32177)
Precipitation above (org)	-0.31847	-0.28192	-0.29104
	(0.49866)	(0.49224)	(0.48745)
Precipitation below (route)	-0.92980**	-0.97237**	-0.97083**
	(0.47012)	(0.46996)	(0.46819)
Precipitation above (route)	0.26463	0.26256	0.24450
	(0.47150)	(0.45903)	(0.46376)
Temperature below (org)	-0.47090**	-0.56558***	-0.86834***
	(0.20113)	(0.20282)	(0.24573)
Temperature above (org)	-0.00493	-0.07362	-0.10474
	(0.08072)	(0.06548)	(0.07866)
Temperature below (route)	0.25787	0.31548	0.28614
	(0.21935)	(0.21945)	(0.21518)
Temperature above (route)	-0.04189	0.19316**	0.16373*
	(0.09336)	(0.07932)	(0.08689)
Mass disasters (org)	0.12555***	0.12477**	0.12586***
	(0.04849)	(0.05016)	(0.04877)
Mass disasters (route)	0.21293***	0.20749***	0.20172***
	(0.03108)	(0.03171)	(0.03231)
Log GDP pc PPP (org)	22.29720**	22.66498**	22.79539**
	(10.03410)	(10.03396)	(9.95187)
Log GDP pc PPP ^2 (org)	-1.82019**	-1.85192**	-1.86490**
	(0.85203)	(0.85128)	(0.84323)
Unemployment rate (15-24) (org)	0.03757	0.03712	0.03838
	(0.03846)	(0.03812)	(0.03791)
Log GDP pc PPP (route)	-10.64632	-9.56326	-9.70962
	(14.41632)	(14.52788)	(14.46022)
Log GDP pc PPP ^2 (route)	0.72767	0.65638	0.66506
	(1.05398)	(1.06261)	(1.05637)
Unemployment rate (15-24) (route)	0.06505**	0.06847***	0.06472***
	(0.02598)	(0.02466)	(0.02485)
Log population (org)	-1.86211	-1.82822	-1.83265
	(1.59758)	(1.58029)	(1.55603)
Constant	5.05747	-0.83072	-0.32106
	(59.58407)	(58.62828)	(58.92169)
Obs	14325	14325	14325
Pseudo Rsq	0.859	0.860	0.860
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster var	Country-route	Country-route	Country-route

Table 10 Precipitation changes at 50%, 80% and 90% significance level compared to a standard month. Specification with ± 1.5 °C

VARIABLES	(1) Precip. 50%	(2) Precip.80%	(3) Precip. 90%
Crossing (t-1)	0.00001***	0.00001***	0.00001***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.09462	-0.08870	-0.09364
	(0.06914)	(0.07674)	(0.08287)
Log risk coup d'état (route)	-0.39842***	-0.43295***	-0.42840***
	(0.14319)	(0.13552)	(0.13812)
Conflict events (org)	0.00197***	0.00193***	0.00196***
	(0.00038)	(0.00035)	(0.00036)
Conflict events (route)	0.02478***	0.02582***	0.02572***

	(0.00572)	(0.00589)	(0.00593)
Precipitation below (org)	-0.38773**	-0.07994	-0.16325
	(0.16209)	(0.19278)	(0.27185)
Precipitation above (org)	-0.18095	0.00859	-0.39568
	(0.16230)	(0.24860)	(0.49027)
Precipitation below (route)	-0.61927***	-0.96385**	-0.85794**
	(0.15418)	(0.39352)	(0.41892)
Precipitation above (route)	0.26979	0.35342*	0.74317**
	(0.28688)	(0.20859)	(0.35147)
Temperature below (org)	-0.27145	-0.28426	-0.40734*
	(0.22702)	(0.20726)	(0.21991)
Temperature above (org)	-0.04505	-0.05544	-0.05682
	(0.07512)	(0.07112)	(0.06860)
Temperature below (route)	0.10555	0.29349	0.29194
	(0.25599)	(0.20698)	(0.20346)
Temperature above (route)	0.02701	0.01442	0.01236
	(0.09390)	(0.09698)	(0.09726)
Mass disasters (org)	0.08656**	0.08006**	0.08231**
	(0.03825)	(0.03790)	(0.03778)
Mass disasters (route)	0.19070***	0.19715***	0.19922***
	(0.03677)	(0.03589)	(0.03637)
Log GDP pc PPP (org)	20.31887**	19.95128**	19.92245**
	(9.64375)	(9.89742)	(10.02380)
Log GDP pc PPP ^2 (org)	-1.69084**	-1.64594*	-1.64518*
	(0.82507)	(0.84547)	(0.85320)
Unemployment rate (15-24) (org)	0.02538	0.02980	0.02850
	(0.03686)	(0.03750)	(0.03704)
Log GDP pc PPP (route)	-9.51387	-13.29719	-13.69989
	(13.82481)	(14.42158)	(14.33656)
Log GDP pc PPP ^2 (route)	0.63196	0.90871	0.93941
	(1.00691)	(1.05571)	(1.04916)
Unemployment rate (15-24) (route)	0.09919**	0.08503**	0.08611**
	(0.04066)	(0.03560)	(0.03528)
Log population (org)	-2.32577	-1.83074	-1.73572
	(1.68719)	(1.55913)	(1.55285)
Constant	16.52435	21.36206	21.18124
	(55.10903)	(56.20190)	(57.00412)
Obs	14325	14325	14325
Pseudo Rsq	0.863	0.860	0.860
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster var	Country-route	Country-route	Country-route

Table 11 Precipitation changes at 50%, 80% and 90% significance level compared to a standard month. Specification with ± 1.75 °C

VARIABLES	(1) Precip. 50%	(2) Precip. 80%	(3) Precip. 90%
Crossing (t-1)	0.00001***	0.00002***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.08324	-0.07831	-0.08160
	(0.06734)	(0.07375)	(0.07833)
Log risk coup d'état (route)	-0.41251***	-0.44944***	-0.44602***
	(0.14605)	(0.14026)	(0.14264)
Conflict events (org)	0.00198***	0.00193***	0.00196***
	(0.00039)	(0.00035)	(0.00035)
Conflict events (route)	0.02577***	0.02635***	0.02626***

	(0.00560)	(0.00582)	(0.00583)
Precipitation below (org)	-0.37083**	-0.06423	-0.14166
	(0.15638)	(0.18597)	(0.25881)
Precipitation above (org)	-0.17914	0.01534	-0.36688
	(0.16110)	(0.25245)	(0.49080)
Precipitation below (route)	-0.61335***	-0.98430**	-0.90071**
	(0.15796)	(0.39967)	(0.41731)
Precipitation above (route)	0.35734	0.36341*	0.76406**
	(0.24620)	(0.20845)	(0.33585)
Temperature below (org)	-0.34569	-0.37314*	-0.51911**
	(0.23114)	(0.21080)	(0.21272)
Temperature above (org)	-0.11003*	-0.13097**	-0.13080**
	(0.05686)	(0.05520)	(0.05187)
Temperature below (route)	0.08076	0.33504	0.33432
	(0.24894)	(0.22090)	(0.21622)
Temperature above (route)	0.26251***	0.21758**	0.22466**
	(0.08382)	(0.09681)	(0.09846)
Mass disasters (org)	0.08576**	0.07837*	0.08041**
	(0.03974)	(0.04037)	(0.04064)
Mass disasters (route)	0.18557***	0.19111***	0.19260***
	(0.03593)	(0.03513)	(0.03540)
Log GDP pc PPP (org)	20.20204**	20.10252**	20.12318**
	(9.78018)	(9.88523)	(9.98855)
Log GDP pc PPP ^2 (org)	-1.68066**	-1.65939**	-1.66269*
	(0.83654)	(0.84319)	(0.84931)
Unemployment rate (15-24) (org)	0.02574	0.02960	0.02832
	(0.03680)	(0.03713)	(0.03669)
Log GDP pc PPP (route)	-8.04461	-12.55134	-12.89371
	(13.86774)	(14.66142)	(14.57459)
Log GDP pc PPP ^2 (route)	0.53394	0.86137	0.88766
	(1.01162)	(1.07387)	(1.06724)
Unemployment rate (15-24) (route)	0.10299***	0.08750**	0.08789**
	(0.03956)	(0.03436)	(0.03423)
Log population (org)	-2.30658	-1.79923	-1.71650
	(1.66446)	(1.53512)	(1.53191)
Constant	10.82321	17.35507	17.05059
	(53.98835)	(55.52453)	(56.30685)
Obs	14325	14325	14325
Pseudo Rsq	Crossing	Crossing	Crossing
Dep var	Clustered	Clustered	Clustered
St. errors	Country-route	Country-route	Country-route
Cluster var	Crossing	Crossing	Crossing

Table 12 Precipitation changes at 50%, 80% and 90% significance level compared to a standard month. Specification with ± 2 °C

VARIABLES	(1) Precip. 50%	(2) Precip. 80%	(3) Precip. 90%
Crossing (t-1)	0.00001***	0.00002***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'état (org)	-0.09673	-0.09072	-0.09401
	(0.07319)	(0.07949)	(0.08414)
Log risk coup d'état (route)	-0.40083***	-0.43742***	-0.43333***
	(0.14367)	(0.13802)	(0.14039)
Conflict events (org)	0.00194***	0.00190***	0.00192***
	(0.00039)	(0.00035)	(0.00036)
Conflict events (route)	0.02525***	0.02591***	0.02578***

	(0.00570)	(0.00593)	(0.00594)
Precipitation below (org)	-0.37367**	-0.06843	-0.15064
	(0.15499)	(0.18790)	(0.25865)
Precipitation above (org)	-0.17762	0.02260	-0.37791
	(0.16112)	(0.25175)	(0.48208)
Precipitation below (route)	-0.62720***	-0.97745**	-0.89300**
	(0.16042)	(0.39623)	(0.41481)
Precipitation above (route)	0.34699	0.36387*	0.72502**
	(0.26537)	(0.21521)	(0.33552)
Temperature below (org)	-0.56228**	-0.57526**	-0.81944***
	(0.24908)	(0.24609)	(0.24895)
Temperature above (org)	-0.21412***	-0.20725***	-0.20926***
	(0.06248)	(0.06080)	(0.06239)
Temperature below (route)	0.04773	0.30178	0.29873
	(0.26008)	(0.21346)	(0.20927)
Temperature above (route)	0.23285***	0.18322**	0.18528**
	(0.06706)	(0.08280)	(0.07933)
Mass disasters (org)	0.08908**	0.08063**	0.08274**
	(0.03930)	(0.03924)	(0.03937)
Mass disasters (route)	0.17732***	0.18566***	0.18683***
	(0.03555)	(0.03495)	(0.03505)
Log GDP pc PPP (org)	20.35743**	20.18667**	20.25273**
	(9.59663)	(9.80379)	(9.88968)
Log GDP pc PPP ^2 (org)	-1.69990**	-1.67124**	-1.67840**
	(0.81803)	(0.83426)	(0.83899)
Unemployment rate (15-24) (org)	0.02700	0.03128	0.02995
	(0.03638)	(0.03696)	(0.03652)
Log GDP pc PPP (route)	-8.47982	-12.80352	-13.20097
	(13.79015)	(14.44475)	(14.36427)
Log GDP pc PPP ^2 (route)	0.56338	0.87797	0.90795
	(1.00461)	(1.05704)	(1.05094)
Unemployment rate (15-24) (route)	0.09848**	0.08363**	0.08380**
	(0.03911)	(0.03407)	(0.03393)
Log population (org)	-2.28391	-1.77747	-1.69217
	(1.63573)	(1.51075)	(1.50505)
Constant	12.01265	18.02242	17.76471
	(54.65897)	(55.77164)	(56.61138)
Obs	14325	14325	14325
Pseudo Rsq	0.864	0.861	0.861
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster var	Country-route	Country-route	Country-route

Table 13 Additional socioeconomic control variables

VARIABLES	(1) 1.5 °C	(2) 1.75 °C	(3) 2.0 °C
Crossing (t-1)	0.00004***	0.00004***	0.00004***
	(0.00001)	(0.00001)	(0.00001)
Gov. exp. on health pc PPP (org)	-0.02118	-0.02158	-0.02137
	(0.01466)	(0.01481)	(0.01474)
Gov. exp. on health pc PPP (route)	-0.09529***	-0.09413***	-0.09153***
	(0.02693)	(0.02638)	(0.02620)
Individuals using internet % (org)	0.02861**	0.02924**	0.02939**
	(0.01185)	(0.01211)	(0.01226)
Individuals using internet % (org)	0.04097	0.04040	0.03965
	(0.03546)	(0.03496)	(0.03481)
Agriculture value added % GDP (org)	-0.02254	-0.02256	-0.02065

	(0.02990)	(0.02993)	(0.02989)
Agriculture value added % GDP (route)	-0.06813	-0.06929	-0.06973
	(0.09581)	(0.09511)	(0.09529)
Log risk coup d'état (org)	-0.09385	-0.08761	-0.09221
	(0.08644)	(0.08511)	(0.08811)
Log risk coup d'état (route)	-0.25971**	-0.28296**	-0.27939**
	(0.12145)	(0.12617)	(0.12547)
Conflict events (org)	0.00175**	0.00186**	0.00180**
	(0.00084)	(0.00086)	(0.00086)
Conflict events (route)	0.02087***	0.02194***	0.02144***
	(0.00553)	(0.00561)	(0.00563)
Precipitation below (org)	-0.24049	-0.23839	-0.24408
	(0.17971)	(0.17416)	(0.17335)
Precipitation above (org)	-0.52041	-0.52257	-0.53173
	(0.48093)	(0.48612)	(0.48100)
Precipitation below (route)	-1.12618***	-1.12543***	-1.12777***
	(0.39940)	(0.40427)	(0.40104)
Precipitation above (route)	0.54163	0.57682	0.53203
	(0.45142)	(0.44435)	(0.45896)
Temperature below (org)	-0.49602*	-0.46933	-0.59389
	(0.28632)	(0.35637)	(0.47760)
Temperature above (org)	-0.09265	-0.08135	-0.11845***
	(0.05640)	(0.05458)	(0.04159)
Temperature below (route)	-0.60243***	-0.66124***	-0.71283***
	(0.14458)	(0.17574)	(0.16197)
Temperature above (route)	0.15301*	0.18233**	0.12408
	(0.08909)	(0.08622)	(0.08358)
Mass disasters (org)	0.02633	0.03360	0.03311
	(0.05855)	(0.05642)	(0.05667)
Mass disasters (route)	0.15665***	0.15758***	0.15657***
	(0.03464)	(0.03478)	(0.03508)
Log GDP pc PPP (org)	25.73669***	26.17208***	26.20623***
	(6.87221)	(6.80684)	(6.79146)
Log GDP pc PPP ^2 (org)	-2.16891***	-2.21024***	-2.21585***
	(0.56559)	(0.56046)	(0.55926)
Unemployment rate (15-24) (org)	-0.00648	-0.00607	-0.00447
	(0.02934)	(0.02916)	(0.02934)
Log GDP pc PPP (route)	-17.72414	-17.66217	-17.58850
	(13.78026)	(13.70898)	(13.71252)
Log GDP pc PPP ^2 (route)	1.20778	1.20721	1.19701
	(1.00731)	(1.00206)	(1.00268)
Unemployment rate (15-24) (route)	0.02246	0.02406	0.02176
	(0.03357)	(0.03317)	(0.03334)
Log population (org)	2.34979	2.30419	2.33258
	(3.50565)	(3.50081)	(3.49566)
Constant	-44.74540	-45.68197	-46.24397
	(83.82338)	(83.75184)	(83.78378)
Obs	12538	12538	12538
Pseudo Rsq	0.826	0.826	0.826
Dep var	Crossing	Crossing	Crossing
St. errors	Clustered	Clustered	Clustered
Cluster var	Country-route	Country-route	Country-route

Appendix 3. The linear-log model

As explained in section 4.3, we estimate a more standard linear model with the dependent variable equal to the log of irregular crossings, to which we add one to account for zero values. The specification of the model is otherwise similar to the PPML model with the set of explanatory variables containing one lag of the dependent variable and the same control variables displayed in Table 1.

To compute standard errors, we first estimate the model and test the estimated residuals for serial (using the Bias-corrected Born and Breitung (2016) Q(p)-test) and cross-correlation using a Pesaran (2004) test. For the Q(p) test, we reject the null of no serial correlation (up to lag 12) and the Pesaran test indicates the presence of cross-correlation in the errors. Therefore, we calculate Driscoll/Kray standard errors with a Moving Average (MA) of order 12, which allows for the computations of standard errors corrected for serial and cross correlation as well as heteroskedasticity (Hoechle2007). Results are displayed below.

Table 14 Linear-log model

	(1)	(2)	(3)
VARIABLES	1.5C	1.75C	2C
Crossing (t-1)	0.65487***	0.65479***	0.65463***
	(0.01371)	(0.01372)	(0.01363)
Log risk coup d'etat (org)	0.01393	0.01406	0.01440
	(0.01702)	(0.01716)	(0.01720)
Log risk coup d'etat (route)	0.03189	0.03242	0.03158
	(0.04375)	(0.04334)	(0.04367)
Conflict events (org)	0.00104***	0.00104***	0.00104***
	(0.00019)	(0.00019)	(0.00019)
Conflict events (route)	-0.00294	-0.00296	-0.00300*
	(0.00183)	(0.00183)	(0.00179)
Precipitation below (org)	0.00928	0.01096	0.01007
	(0.10761)	(0.10784)	(0.10820)
Precipitation above (org)	-0.06701	-0.06441	-0.06314
	(0.08611)	(0.08597)	(0.08614)
Precipitation below (route)	-0.22492***	-0.23427***	-0.23722***
	(0.07969)	(0.08347)	(0.08601)
Precipitation above (route)	0.45542***	0.46012***	0.46746***
	(0.17365)	(0.17340)	(0.17662)
Temperature below (org)	-0.04592	-0.00424	-0.10342
	(0.14716)	(0.15426)	(0.22433)
Temperature above (org)	0.01264	0.02368	0.03774

	(0.01918)	(0.02084)	(0.03040)
Temperature below (route)	-0.05820	-0.01458	-0.02142
	(0.08754)	(0.09127)	(0.10157)
Temperature above (route)	-0.01137	-0.00095	0.02487
	(0.03000)	(0.02269)	(0.02689)
Mass disasters (org)	0.00746	0.00736	0.00755
	(0.01715)	(0.01732)	(0.01745)
Mass disasters (route)	0.01786	0.01759	0.01708
	(0.02037)	(0.02040)	(0.02032)
Log GDP pc PPP (org)	2.27643***	2.28991***	2.29977***
	(0.66237)	(0.66976)	(0.66871)
Log GDP pc PPP ^2 (org)	-0.18154***	-0.18250***	-0.18314***
	(0.05528)	(0.05598)	(0.05587)
Unemployment rate (15-24) (org)	0.00199	0.00195	0.00187
	(0.00384)	(0.00386)	(0.00384)
Log GDP pc PPP (route)	-12.72223**	-12.70387**	-12.61448**
	(5.87697)	(5.84399)	(5.85713)
Log GDP pc PPP ^2 (route)	0.92471**	0.92353**	0.91547**
	(0.41863)	(0.41686)	(0.41792)
Unemployment rate (15-24) (route)	0.03209	0.03156	0.03085
	(0.02829)	(0.02830)	(0.02812)
Log population (org)	-0.48595**	-0.48857**	-0.48421**
	(0.24112)	(0.24300)	(0.24341)
Constant	44.61533**	44.57057**	44.24386**
	(22.30366)	(22.21201)	(22.28844)
Dep. var	log crossing	log crossing	log crossing
Std. errors	Drisc/Kraay	Drisc/Kraay	Drisc/Kraay
Cluster Variable	Country route	Country route	Country route
Obs	14325	14325	14325
Within Rsq	0.644	0.644	0.644
number of MA lags	12	12	12

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Results vary substantially when compared to those reported in Table 1. However, this is not really surprising, given the high prevalence of zero values in the sample and the evidence reported by Silva and Tenreyro (2006).

We can note that the coefficient on the lag value of crossing is large and statistically significant, which suggests a certain degree of persistence in irregular crossings. Furthermore, the only statistically significant effects for political and climate variables are the ones associated to conflict events in the origin country, precipitation below 90% along the route and temperature above 2°C in transit

countries. The effect of the origin country GDP is also consistent with the hump-shaped migration theory.

Compared to the results in Table 1, the coefficient associated to risk of coup d'état is positive in origin country but has no effect in transit countries. Everything else being equal, a 1% increase in the risk of coup d'état in the origin country leads to an increase of approximately 0.03% in irregular crossings. This effect is only statistically significant at the 10% level. Finally, the log of population is found to have positive and significant effect on irregular crossings.

Appendix 4. Departure countries

Table 15 Departure and transit countries

VARIABLES	(1) 1.5C	(2) 1.75C	(3) 2C
Crossing (t-1)	0.00001***	0.00001***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
Log risk coup d'etat (org)	-0.11053	-0.10780	-0.11118
	(0.07797)	(0.07811)	(0.07994)
Log risk coup d'etat (route)	-0.33479***	-0.33963***	-0.33914***
	(0.11646)	(0.11700)	(0.11673)
Log risk coup d'etat (dep)	-0.10179	-0.11271	-0.10468
	(0.13499)	(0.13641)	(0.13544)
Conflict events (org)	0.00211***	0.00208***	0.00204***
	(0.00027)	(0.00027)	(0.00027)
Conflict events (route)	0.01397***	0.01400***	0.01379***
	(0.00502)	(0.00514)	(0.00508)
Conflict events (dep)	0.03054***	0.03027***	0.02978***
	(0.00658)	(0.00682)	(0.00714)
Precipitation below (org)	0.15142	0.16146	0.15690
	(0.21252)	(0.21556)	(0.21239)
Precipitation above (org)	-0.24002	-0.28133	-0.28228
	(0.49009)	(0.48483)	(0.47560)
Precipitation below (route)	-2.02391***	-2.13185***	-2.12157***
	(0.29567)	(0.31097)	(0.32204)
Precipitation above (route) = o,	-	-	-
Precipitation below (dep)	-1.32221***	-1.31674***	-1.29995***
	(0.27460)	(0.27581)	(0.27910)
Precipitation above (dep)	0.29051	0.23426	0.22162
	(0.30109)	(0.30891)	(0.31185)
Temperature below (org)	-0.28359	-0.44346**	-0.70591***
	(0.24283)	(0.20840)	(0.25222)
Temperature above (org)	-0.06838	-0.10572**	-0.20938***
	(0.06699)	(0.05273)	(0.06727)
Temperature below (route)	0.55940	0.57594	0.57442
	(0.37062)	(0.36081)	(0.34984)
Temperature above (route)	0.07730	0.06415	0.13172
	(0.11591)	(0.08926)	(0.11753)
Temperature below (dep)	0.49615*	0.36948	0.35401
	(0.25576)	(0.26871)	(0.28302)
Temperature above (dep)	0.19600**	0.02304	0.03688
	(0.08516)	(0.09730)	(0.08618)
Mass disasters (org)	0.07611**	0.07824**	0.07945**
	(0.03850)	(0.03889)	(0.03888)
Mass disasters (route)	0.19332***	0.19383***	0.18809***
	(0.04155)	(0.04151)	(0.04046)
Mass disasters (dep)	0.14685***	0.15551***	0.15592***
	(0.04417)	(0.04552)	(0.04808)

Log GDP pc PPP (org)	24.71717**	24.51175**	24.36997**
	(9.77651)	(9.68443)	(9.63063)
Log GDP pc PPP ^2 (org)	-2.05675**	-2.04196**	-2.03204**
	(0.84337)	(0.83383)	(0.82758)
Unemployment rate (15-24) (org)	0.02619	0.02516	0.02613
	(0.03956)	(0.03949)	(0.03958)
Log GDP pc PPP (route)	4.54261	5.03278	5.09597
	(14.52624)	(14.59959)	(14.44778)
Log GDP pc PPP ^2 (route)	-0.19195	-0.22183	-0.21276
	(1.06933)	(1.07174)	(1.05972)
Unemployment rate (15-24) (route)	-0.03718	-0.04040	-0.04019
	(0.07796)	(0.07642)	(0.07526)
Log GDP pc PPP (dep)	19.71083	17.75066	17.48381
	(19.21162)	(19.21215)	(18.82144)
Log GDP pc PPP ^2 (dep)	-1.49659	-1.36020	-1.34186
	(1.38747)	(1.38823)	(1.36058)
Unemployment rate (15-24) (dep)	0.03257	0.03281	0.03338
	(0.02327)	(0.02368)	(0.02313)
Log population (org)	-1.66857	-1.64609	-1.59935
	(1.57855)	(1.57154)	(1.55629)
Constant	-115.48768	-109.04275	-108.78880
	(77.72877)	(77.42208)	(76.68514)
Dep. var	Crossing	Crossing	Crossing
Std. errors	Clustered	Clustered	Clustered
Cluster Variable	Country-route	Country-route	Country-route
Obs	14325	14325	14325
Pseudo Rsq	0.865	0.864	0.865

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1