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Socio-economic Consequences of Climate Change

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Socio-economic Consequences of Climate Change

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DEDICATION

In ever loving memory of my father, my biggest cheerleader.

To my loving mother.

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DECLARATION

I hereby declare that I am the author of this thesis. All references cited have been consulted, unless otherwise stated. All the work of which this thesis is a record has been done by myself. This thesis has not been previously accepted for a higher degree.

Mehdi Shiva

PhD Candidate

Date 14/08/2018

CERTIFICATION

I certify that Mr. Mehdi Shiva conducted his research under my supervision in the Department of Economic Studies, University of Dundee. Mr. Shiva, has fulfilled all the conditions of the relevant Ordinances and Regulations of the University of Dundee for obtaining the Degree of Doctor of Philosophy.

Andrzej Kwiatkowski

Principal Supervisor

Date 14/08/2018

ABSTRACT

Extreme weather events, armed conflicts and migration are considered as the most likely, and most substantial, risk factors of 2015, 2016 and 2017 in the latest Global Risk Report by World Economic Forum (World Economic Forum, 2017). That these factors are in turn influenced by climatic conditions is also a well-documented consensus. As global warming become an unescapable reality (IPCC, 2014), my thesis attempts to make a contribution to understanding of its consequences by quantifying the magnitude and significance of the influence of climatic factors on conflict and migration.

An overview of the thesis is provided in the first chapter.

The main aim of the second chapter is to provide a comprehensive empirical study of the impact of climatic factors on the onset of internal armed conflicts. There is no firm consensus in the literature regarding a coherent set of factors that cause armed conflicts. In particular, while there are new studies emerging which examine this issue, conclusions about the role of climatic factors remain rather ambiguous. The contribution of this chapter is to carry out a systematic econometric study of the role of variables commonly used in the literature in order to establish a robust empirical specification which could aid quantifying the contribution of climatic factors. We find that (i) climate warming is instrumental in raising the probability of onset of armed conflicts, and (ii) there is an interdependency in the way temperature and precipitation affect the onset of conflicts: dryness (low precipitation) increases the effect of temperature growth.

High levels of political and economic development are widely regarded as important factors that contribute to sustained civil peace. However, repeated occurrences of conflicts in democratic regimes and their complete absence in some rich countries with non-democratic regimes are counter examples that cannot be simply regarded as exceptions. Given this anomaly, the third chapter examines whether the influence of development and democracy are contingent on each other. Using a robust empirical specification that takes account of climatic factors, we find that economic development per se reduces the probability of conflicts but its impact is contingent on the extent of political development and that the latter might in fact reverse the overall impact of former.

Demographic projections suggest that climate change will be responsible for a large displacement of population worldwide (Gemenne et al., 2012). Evidence shows that a major part of such displacements primarily take place within national borders in the first instance. The fourth chapter investigates the nature of internal migration within Iran which has experienced substantial internal migration and is also subject to significant climatic variations. We find that even though climatic variables are not the leading factors of internal migration in Iran, their role, especially as push factors, is eminent: It appears people tend to leave warmer and/or drier regions, and select nearby destinations which offer better economic opportunities and welfare provision.

Chapter 1

An overview of the thesis

1.1. Introduction

Extreme weather events, mass migration, and armed conflicts were respectively ranked as the most likely and impactful risks of 2017, 2016, and 2015 (World Economic Forum, 2017). The contribution of this thesis consists of three chapters which attempt to enhance our understanding of the links that are thought to exist between these natural, social and political phenomena. In Section 1.2 we first examine each of these separately and then briefly discus their potential associations. In Section 1.3 we present an overview of the next three chapters in which we have constructed relevant datasets and used them to empirically examine the underlying relationships.

1.2. Climate change, armed conflict, and migration: background

1.2.1. Climate change

There is now robust evidence that the average temperature of Earth is steadily rising – see Intergovernmental Panel on Climate Change (IPCC) 2014 Assessment Report – and that this warming up of the planet affects our surrounding environment and reconditions our behaviour as human beings. The Report considers anthropogenic factors as the most likely cause of more than half of the observed increase in the average global surface temperature over the last 60 years. IPCC also predicts an average rise of 1.1°C to 6.4°C in global temperature by the end of this century. There have already been multiple episodes of extreme weather events that are, at least partially, linked with this change in the Earth atmosphere and it is very likely that we will see increases in the length and severity of heat waves and extreme storm events in the future. The World Economic Forum 2017 agreed that the world is now more likely to be ravaged by environmental rather than economic catastrophes. The number of natural disasters has more than doubled over the last two decades, and statistics show that only in 2008 more than 20 million people have been displaced by sudden onset of climate related natural disasters and extreme weather events – see United Nations Office for the Coordination of Humanitarian Affairs and the Internal Displacement Monitoring Centre reports (OCHA-IDMC, 2009). The World Bank warns that *"... without rapid action, climate change could push more than 100 million people into poverty by 2030*" (World Bank, 2016: pp. 17).

Despite the geographically heterogeneous impact of climate change, eventually most countries will experience its adverse effects. Inevitably, some nations are likely to be affected more severely at the earlier stages – e.g. some of the Least Developed Countries (LDCs) due to their poverty, weak infrastructure and unstable governments (IPCC, 2007), or countries with low altitude. However, in the long run, there will be worldwide consequences either via direct effects of climate change or indirectly by the repercussions of the severely affected regions.

Awareness of and concerns for the effects of climate change have stimulated high profile policy actions. Jim Yong Kim, the president of the World Bank, optimistically stated that "*we are the first generation in human history that can end extreme poverty*" (World Bank, 2016: pp. 3). This statement was made in connection with the recent World Bank projection which claimed that for the first time in history the number of people living in extreme poverty has fallen below 10 percent of the global population. While such news show that policies can be implemented to improve the overall living standards, they should be considered together with the news that warn us that such achievements become more difficult as the Earth climate warms up: World Bank (2014b) indicates that achieving many of the Sustainable Development Goals (SDGs)[1] will be much harder with 2°C warming up, but there is serious doubt whether these goals can be achieved at all if this becomes 4°C.

One of the main challenges that climate change presents is to better understand its socio-economic and political consequences.

1.2.2. Armed conflict

Prolonged and widespread armed conflicts are causing major ongoing human tragedies which we continually witness. While their coverage by mass media gives an indication of the extent of devastation these conflicts are capable of causing, academic scholars from different disciplines have been studying the reasons for and consequences of these conflicts. In particular, considerable research has been carried out by political scientists, sociologists and economists to identify the factors which contribute to the onset of conflicts and to use data to quantify the extent of their contribution.

Like the study of any social phenomenon, studies of conflict begin with identifying the underlying motives and reasons with the aim of understanding the policies that could help reduce their costs and prevent their recurrence. Some studies focus on understanding the role of some clearly identified motive such as 'grievance' – which reflect

[1] Set of goals to end poverty, protect the planet and ensure prosperity for all. Each goal has specific targets to be achieved by 2030.

opportunities for rebels, or rebellion leaders, to take stand against perceived social, political or economic injustice – while others analyse the 'feasibility hypothesis' – which is based on the self-fulfilling prophesy that where rebellion is possible it will occur regardless of the motives. The latter put the emphasis on evidence-based, be it case studies or statistical analysis, of the determining effects and stress the importance of careful and robust empirical analysis that help unravel the explanatory role of the potential contributing factors.

1.2.3. Migration

Human migration has attracted the attention from most social science disciplines: geographers, demographers, anthropologists, sociologists and economists have studied the phenomenon from different points of view. Historically, economists' interest in the subject goes as far back as a century, with especial focus on features such as rural-urban balance, social costs of intensive movements, e.g. 'brain-drain', etc. In addition, put within the context of human capital mobility, migration has been seen as one of the main stimulants of economic and social development: while often resulting from regional imbalances in economic or political development in one part, it has fuelled the engine of development in another.

More recently, one of the most prevalent themes of migration research has been concerned with a specific type known as *human displacements* which are caused by the so called push factors which render one's home unliveable. The scale and frequency with which these have been occurring in recent years have led them to be classified as one of the most severe human tragedies and multinational efforts are sought to contain them. In such circumstances, one of the main challenges facing social scientists is to identify the role and impact of factors that lead migrants to move from one location to another in the hope that such understanding could contribute to formulating more effective policies that could prevent forced migration and reduce its undesirable consequences.

1.2.4. Factor linking climate change, armed conflicts, and migration

The potential links between climate change, migration, are now more widely discussed in the literature and are also taking increasingly higher priorities in national and internal policy makers' agendas (IPCC, 2014; CNA, 2014; World Bank 2014b; World Economic Forum, 2017). While different views are on the whole converging to a consensus that regards climate change as one of the main factors contributing to both migration and conflicts, substantial research is still required to determine the appropriate form of climate change and to unravel the nature and strength of its impact.

Climate change is seen as a threat multiplier in that it stimulates political instability via severely affecting the maintenance of production for survival – Centre for Naval Analyses (CNA) 2007 and 2014 reports, and Joe Bryan (2017).[2] It propels sudden disasters like floods and storms and gradually shapes catastrophes such as droughts and desertification. These in turn contribute to failed crops, famine and which overcrowds urban centres; these lead to crises that inflame political unrest and a vicious circle sets in. Since there is no official, internationally recognised, category as 'climate refugees' – i.e. those who leave their original habitat to avoid the harsh consequences of severe weather induced disasters – it is not possible to have an accurate measure of climate induced migrants. However, to have an idea of the measure involved we can rely on a 2010 Gallup World Poll in which about 12% of respondents, from a total of 500 million adults, anticipated that severe environmental problems would require them to move within the next five years.

There is a vast literature on the role of climate change in inducing conflicts and/or migration (Burke et al., 2009; Anderson and DeLisi, 2011; Salehyan and Hendrix, 2014; Joseph and Wodon, 2013), and on the causal relationship between conflicts and migration (Homer-Dixon, 1999; Reuveny, 2007). Gleditsch et al. (2007) observe that climate-induced migration appears as a direct consequence of many episodes of climate-induced violences. Reuveny (2007) carries out a non-quantitative empirical study on climate, conflict, and migration on Hirschman's (1970) economic framework of people's response to an unpleasant change. Having classified residents' response to climate change, based on 38 cases studies of environmental migration, as one of

(i) staying put and accepting the costs,

(ii) staying put and mitigate changes, or

(iii) leaving the affected areas,

the study finds that environmental migration plays a role in initiating a conflict. Reuveny (2007) also finds that while developed countries tend to mitigate problems through technological innovation and institutional redesign, in less developed countries the solution is often one of mass emigration from the affected areas.

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[2] http://www.atlanticcouncil.org/blogs/new-atlanticist/climate-change-as-a-threat-multiplier

A careful scrutiny of the literature, however, reveals a number of issues that motivate further exploring of the links described above. In particular, there seem to be no consensus yet, especially in the empirical literature, regarding the factors that influence armed conflicts. Generally, the academic discipline of researchers govern their choice of these variables and there is a lack of systematic selection based on the available statistical techniques whose application could improve robustness of the results – e.g. by reducing the omitted variable bias. It is therefore not surprising that the existing studies on the role of climatic arrive at mixed, and somewhat conflicting, conclusions: some considering climatic conditions as the most important factors causing armed conflicts or human displacement while others completely dismiss them. In Chapters 2 and 4 of the thesis we shall attempt to provide a more coherent empirical study of the impact of climate on armed conflicts and migration. While emphasising the role of climatic factors, the study of causes of armed conflicts also reveal the crucial role of extent economic and political development. Therefore, having studied the role of climatic factors in conjunction with other determining variables of armed conflicts in Chapter 2, in Chapter 3 we investigate the nature of the empirical link between the onset of armed conflicts and economic and political development. Below we provide a brief explanation of contribution of these chapters.

1.3. Climate change, armed conflict, and migration: the contribution of thesis

Chapter 2. Climate change and armed conflicts: an empirical investigation

"*Although it would be overly simplistic to blame the bloody conflicts in Africa and Asia during the latter part of twentieth and the first decade of the twenty-first century on climate change and environmental disasters, it also would be incorrect to ignore the role played by the economic hardships (including starvation) wrought by the prolonged droughts and resulting resource shortages*" (Anderson and DeLisi, 2011, p. 259).

There is a well-established literature which proposes and analyses a complex causal process that links climate change to conflict. Briefly, the deterioration of agricultural productivity leads to food shortages and water scarcity, which result in rivalry over the natural resources and migration. The socio-economic features of the community are thought to be affected by these changes as well as being shaped directly by heat factor. Many US military reports, such as the ones conducted by CNA in 2007 and 2014, conclude that climate change not only acts as a threat multiplier for instability in volatile regions, but it would also add tension to the stable regions of the world (e.g., by decreasing food production and freshwater). A glance through the wider literature reveals that armed conflicts are associated with a number of factors of which climate change is merely one: other, economic, sociological and geographical factors such as 'availability of natural resources', 'existence of rough terrain', 'historical grievance', 'ethnic dominancy' and similar factors are also thought to play prominent roles. The majority of studies on the nexus between climate and conflict agree with the neo-Malthusian interpretation that sees conflicts arising as a result of scarcity brought about by climatic changes (e.g. Fischer et al., 2002; Hertel and Rosch, 2010). A point of view has also emerged which considers conflicts as the outcome of the collaborative aggressive behaviour of individuals – and which could throw new insights on the questions being considered.

Based on the above background, in Chapter 2 we use a categorisation for climatic factors – similar to that employed by Anderson and DeLisi (2011) – to examine the explanatory role of (i) the short-run, year-to-year, change in the weather, as well as (ii) the long-run or historical trend in the weather. Our results, based on intensive econometric scrutiny of regression equations that explain the probability of onset internal armed conflicts, suggest that both temperature and precipitation play significant explanatory roles once the contribution of other relevant factors is accounted for. In addition, we find that the nature of climate matters: change in climatic factors are likely to have a different impact – in terms of magnitude and sign – in different climates; in particular, change in climatic factors in hot regions is found to be more effective.

Chapter 3. Internal armed conflicts: contribution of economic and political development

A major contribution of Chapter 2 is in its application of a systematic econometric procedure to select the relevant subset of the commonly used variables in the literature as the control variables on which the relationship between onset of conflict and climatic factors could be conditioned. While this helped to specify and estimate the impact variables that represent climatic factors more accurately, it also revealed the existence of a complex relationship between per capita income, political regime characteristics and the onset of armed conflict: per capita income only possesses a significant coefficient when it is interacted with *Regime Instability*. In other words, the impact of a change in per capita income is contingent on political factors. This finding, together with the discussion in the literature on the role of economic and political development motivated the research question for Chapter 3. Using *per capita GDP* as an indicator of economic development and capturing the level of political development by various interpretations of the *Polity Score*, we focus on the robust specification of the joint contribution of these after all other relevant factors are accounted for. Building on the work of Collier and Rohner (2008), we re-examine the empirical determination of probability of onset of internal armed conflicts we find that while more well-off autocracies seem to be less prone to conflict, this does not hold for democracies. We also find that major political disruptions could escalate the chances of armed conflicts regardless of the regime type, and that their impact is larger the higher is per capita income. Our findings highlight the importance of political stability in keeping peace and emphasise the role of stable democracy.

Chapter 4. Climate change and internal migration: a case study of Iran

Mass migration is one of the main features of humanity throughout its history. Civil conflicts, religious intolerance, and economic opportunities are amongst its recent causes (UNEP, 2012). More recently, climate-induced migration has been featuring as one of the focus topics: for instance, Intergovernmental Panel on Climate Change's (IPCC) first assessment report (IPCC, 1990) identified human migration as the greatest single impact of climate change; the International Organization for Migration (IOM, 1992) raised concerns regarding the dramatic increase in mass displacements and predicted a substantial rise in their numbers when larger areas of the earth would become uninhabitable due to climate change. Projections suggest 25 million to 1 billion displacements by 2050 due to climate change, with 200 million being the most widely cited estimate (Gemenne et al., 2012).

Given the importance of this phenomenon, in Chapter 4 we use econometric analysis of migration data to understand the nature of the process that governs migration flows. However, since there are no data on climate-induced migrants, we base our empirical investigation on inter-province migration in Iran. This choice is justified on the following grounds: (i) Iran provides a good example of a country affected by severe climate change; (ii) the recent history of the country shows a relatively high rate of migration stimulated by political reasons, by the prolonged war with the neighbouring country Iraq, as well as by weather conditions; and (iii) there is some evidence that, due to the high cost of cross border relocation and benefits of community networks in familiar and nearby locations, most of the displacements caused by climate change primarily take place within national borders (Beyani, 2014).

Our main aim in Chapter 4 is to understand whether climate factors, measured by temperature and precipitation levels, perform as push and/or pull factors that encourage individuals to migrate. We use two waves of national census data to construct an inter-province dataset consisting of migration flows and the relevant province-level socio-economic variables, as well as data on temperature and precipitation levels, and use this dataset to estimate the impact of the latter on migration flows in the context of a generalised gravity model. Our findings suggest that although climatic factors are not amongst the most important determinants of internal migration in Iran, their role as push factors is eminent and remain so after rigorous robustness checks. More specifically, our results indicate that: (i) while people tend to leave warmer and/or drier regions, there is not sufficient evidence to ascertain whether the choice of destination also depends on climatic factors, since the latter do not appear to act as pull factors; and (ii) distance, economic and wellbeing factors rank highest respectively: neighbouring regions are more frequently targeted, followed by locations that offer better opportunities.

Chapter 2

Climate and Armed Conflict

2.1. Introduction

This chapter examines the role of climatic factors in affecting the likelihood of onset of armed conflicts. A glance through the wider literature reveals that armed conflicts are associated with a number of factors of which climate change is merely one: other, economic, sociological and geographical factors such as 'availability of natural resources', 'existence of rough terrain', 'historical grievance', 'ethnic dominancy' and similar factors are also thought to play prominent roles. The majority of studies on the nexus between climate and conflict agree with neo-Malthusian interpretation that sees conflicts arising as a result of scarcity brought about by climatic changes (e.g. Fischer et al., 2002; Hertel and Rosch, 2010). A good share of the literature emphasises the role of natural resources where studies have sought to explain the riddle of insurgency by linking the motivation of the rebels with their claims on such resources. Amongst the studies which examine the role of sociological and geographical factors, grievance is considered as one of the main causes of civil war: it is claimed that grievance is rooted in a behavioural paradigm which emphasises relative deprivation, social exclusion and inequality (Gurr, 1971; Scott, 1977; Muller, 1985; Connor, 1994). Collier and Hoeffler (2004) propose ethnic dominancy[3] as a factor in influencing the start of a civil war. However, they also argue that the ability to loot natural resources has a stronger effect on rebellion. Fearon and Laitin (2003) emphasise the facilitating role of rough terrain[4], which was previously introduced by Collier et al. (2001) as an effective factor.

Regarding the role of historic events, the end of the cold war and decolonisation are commonly known as the greatest destabilising events of the past century. We should keep in mind that accounting for historical events might be difficult at times when conducting quantitative studies. Based on the literature, although such events proceeded with new conflicts, their direct role in triggering conflicts is widely disputed (Fearon and Laitin, 2003; Collier, 2007). Presumably the correlation between these events and prevalence of conflict exists because of the new independent, but financially, bureaucratically, and militarily weak states that are created as the result (Fearon and Laitin, 2003). For instance, collapse of the Soviet Union created a number of new unstable states prone to new conflicts. Alternatively, collier (2007) did "… *find no relationship between the subsequent risk of civil war and either the country that had been the colonial power or how long the country had been decolonised*" (p. 113).

[3] This is defines as a situation in which one ethnic group makes up to 45-90% of the population.
[4] This is defined as the proportion of the country that is mountainous.

A point of view has also emerged which considers conflicts as the outcome of the collaborative aggressive behaviour of individuals – and which could throw new insights on the questions being considered. In this particular context, evidence exists on (i) both direct and indirect psychological effects of climate (long-run) and weather (short-run) on violence and conflicts (Anderson, 2001; Anderson and DeLisi, 2011; Hsiang et al., 2013; Prediger et al. 2014); and (ii) emergence of conflict as a collective aggressive act based on crowd behaviour where individual feelings spread to groups (Muller and Opp, 1986; Stott and Reicher, 1998). Such studies however attempt to understand the role of factors that influence individual-level violence and conflict and therefore lie beyond the interest of this chapter whose focus is on the role of climate factors amongst the determinants of armed conflicts which are defined as collaborative acts fuelled by political or economic motives.

Our specific interest in the role of climatic factors is motivated by the global political efforts to influence (i) the consequences of climate change, and (ii) reduce the onset of armed conflicts. The main aim of this chapter is to address a number of issues that have not been considered in the existing literature on the determinants of the onset of conflicts. In particular, there is no consensus regarding a coherent set of factors that cause armed conflicts and, while there are new studies emerging which examine this issue, conclusions about the role of climatic factors remain rather mixed and vary between regarding them as the most important and disregarding them completely. The contribution of this chapter is to carry out a systematic econometric study of the role of variables commonly used in the literature in order to improve the robustness of conclusions regarding the specific role of climatic factors.

In our empirical analysis we have used a categorisation for climatic factors similar to that employed by Anderson and DeLisi (2011) and examine the explanatory role of both (i) the short-run, year-to-year, change in the weather, as well as (ii) the long-run, historical, trend in the weather. Our results, based on intensive econometric scrutiny of regression equations that which explain intra-state armed conflicts, suggest that both temperature and precipitation play significant explanatory roles once the contribution of other relevant factors are accounted for. As Homer-Dixon (1999) suggests, *"environmental scarcity is never a sole or sufficient cause of large migrations, poverty, or violence; it always joins with other economic, political, and social factors to produce its effects*" (p. 16). In a similar fashion, we wish to emphasise at the outset that our aim in this chapter is not to single out climatic factors as the important determinant of conflicts. Instead, we wish to establish whether or not they feature robustly amongst the explanatory variables that determine conflict and to measure the extent of its contribution. By doing so, we hope to provide additional support for placing climate change issues on the global policy agenda.

The rest of this chapter is organised as follows. Section 2.2 reviews the literature. Section 2.3 describes the data and methodology employed in the empirical analysis. Section 2.4 provides and discusses the evidence and Section 2.5 concludes the chapter.

2.2. Literature review

There is an ongoing disagreement on the motives of rebels: looting, religious reforms, nationalist and/or economic grievances, and pursuit of more favourable conditions are the main reasons highlighted in Collier and Hoeffler (2004), Gurr (1971), and Fearon and Laitin (2003). Collier et al. (2009) conclude that for the incidence of civil war is to be reduced it will need to be made more difficult to start one. This is an implication of the feasibility hypothesis which proposes rebellion will inevitably occur if there are grounds for it. For instance, it has been argued in the literature on the 'resource curse' that resource wealth (especially oil) increases the probability of civil war since the resource-rich areas have an incentive to form a separate state (Le Billon, 2001; Fearon, 2005) or to seek a high level of autonomy which weakens the state's bureaucratic capacity and influence (Fearon and Laitin, 2003). In this context, Ross (2004) distinguishes between the resource types and finds, in the cases that he considers, that while 'richness' in fuel and nonfuel minerals and illicit drugs appears to influence conflicts other types of resource wealth – especially agricultural commodities – seem to be unrelated to civil war.[5]

As far as the role of climate is concerned, the influencing channels in the literature are usually separated in terms of time horizon and the actual mechanism. In particular, there are:

(i) long-term indirect effects of climate changes that affect the risk factors involved;
(ii) short-term shocks that raise the survival pressure;
(iii) direct effects of extreme temperature on violence.

[5] Ross (2004) also states gemstones, opium, coca, and cannabis do not seem to be linked to the initiation of conflict, but they do seem to lengthen pre-existing wars. Timber's role remains untested.

Gleditsch (2012) acknowledges the importance of recognising the separate role of each type and stresses the importance of considering the role of long-term and short-term factors separately. Various studies have examined the indirect effects of climatic factors which are exerted through food scarcity, malnutrition, economic poverty and geographical conditions. Prediger et al. (2014) use experimental methods on Namibians and suggest long-term exposure to food scarcity could increase anti-social behaviour and aggression. Liu et al. (2004) examine the relationship between malnutrition and subsequent antisocial behaviour using a birth cohort of children from the island of Mauritius, and conclude that malnourished children show symptoms of more aggressive behaviour. Huston and Bentley (2010) and Chen et al. (2010) examine how growing up in poverty affects children's future behaviour. White et al. (2013) show that a greener habitat – e.g. larger park and recreation areas in cities – reduces the incidence of aggression by raising the happiness levels. Fearon and Laitin (2003), Collier and Hoeffler (2004), Buhaug and Gates (2002) and Fearon and Laitin (2003) all examine how the topological characteristics of a territory (formed or affected by long-term climate change) play a role in facilitating or preventing an uprising.

A number of emerging studies examine the impact of short-term weather changes: notable amongst these are Hendrix and Glaser (2007) and Fjelde and Uexkull (2012) who study the role of precipitation; Burke et al. (2009), Buhaug (2010) and Hsiang et al. (2013) who consider the effect of temperature shocks; Raleigh and Urdal (2007) and Salehyan and Hendrix (2014) who examine the impact of water resources and arable lands; and last but not least, Bergholt and Lujala (2012) and Slettebak (2012) who analyse the influence of natural disasters. However, the evidence presented in these studies does not lead to a clear conclusion about the size and significance of the estimated impact of climatic factors on conflicts. For instance, Hendrix and Glaser (2007) and Fjelde and Uexkull (2012) report a positive effect on probability of armed conflicts, Bergholt and Lujala (2012) and Raleigh and Urdal (2007) find the effect to be rather small or negligible, while Salehyan and Hendrix (2014) and Slettebak (2012) suggest negative effects.

One of the main criticisms levelled at some of the recent studies concerns their tendency to neglect the role of political and economic related factors (see, e.g., Burke et al. 2009 and Hsiang et al. 2013 limit the set of controls of their study – on conflict – to only country and year fixed effects, arguing all other effects could get captured by them) and their use of national-level aggregate data. A novel study by Hsiang and Burke (2014) examines 50 rigorous quantitative studies on the association between (i) violent conflict, and (ii) socio-political stability and deviations of temperature and precipitation from their norm. They use meta-analysis methodology and a broad range of aggressive behaviour from individual-level violence to country-level political instability and civil war and conclude "… *the majority of studies suggest that conflict increases and social stability decreases when temperatures are hot and precipitation is extreme…*" (p. 52). Buhaug et al. (2014) criticise this methodology arguing that "… *the notable discrepancy in views between Hsiang and Burke and the larger scholarly community can be traced back to problems related to the accompanying meta-analysis*" (p. 393), and state that their study "*suffers from shortcomings with respect to sample selection and analytical coherence*" (p. 392). We note in passing that pooling all types of conflicts together is likely to lead to inaccurate estimates since the same explanatory variables cannot be used to predict, for example, an armed political conflict and a violent act such as murder, rape or other similar civil crimes. Buhaug et al. (2014) argue that statistical analysis which pool different types of aggressive behaviour "*from non-violent land grabbing via urban riots to major civil war*" that have occurred in "*a wide range of spatial scales, from municipalities via countries to the entire world*" and use as explanatory variables "*a wide range of climatic events, from heat waves via excess rainfall to global ENSO* [El Niño–Southern Oscillation] *cycles*" (p. 393) are bound to result in inaccurate and biased estimates.

The link between temperature levels and incidence of individual-level aggression – which been examined by other social scientists, especially psychologists – is worthwhile mentioning. This is because, although this link is not directly related to the focus of this chapter which considers the onset of armed conflicts, the evidence provides a strong indication of why this factor may play a significant role in providing a fertile environment for invoking conflicts. Anderson (1989, 2001) and Baron and Bell (1976) argue that high temperature increase aggressive motives and tendencies (the heat hypothesis). Anderson (1989) finds that on average there is evidence of a higher level of individual-level aggressive behaviour and crime (e.g. murder, rape, assault, riot, wife beatings, etc.) being committed in the hotter regions of the world. Anderson et al. (2000) estimate the effect of temperature on violent-crime rates in different cities while controlling for the geographical location (*southness*), population size and socioeconomic status of the cities using meta-analysis of the compiled knowledge of previous studies and several different lab experiments. They find that temperature has a large (compared with other factors) and statistically significant effect on violent crime and conclude that there is a higher level of violence level likely to be committed in hotter cities even after other city characteristics are accounted for. Anderson (2001), in fact, goes on to claim that "*An accidental bump in a hot and crowded bar can lead to the trading of insults, punches, and (eventually) bullets*" (p. 36). Evidence on the effect of high temperature on individual behaviour is also found in studies that examine the direct effect of heat on aggression. Kenrick and MacFarlan (1986) find that aggressive horn honking is increased in hotter temperatures only by drivers who do not have air-conditioned cars. Vrij et al. (1994) conducted a field experiment in which Dutch police officers performed in a simulated burglary scenario under different conditions. They found that officers were reported to be more aggressive and less likely to draw their weapons and shoot the suspect when they operated under cooler temperature conditions. Finally, while it is acknowledged that, in general, people living in extreme temperature conditions – hot or cold – are more likely to experience aggression and violence (see, e.g., C. Anderson and K. Anderson, 1998 for evidence on low temperature effects), low temperature is found to be less effective. This is explained by the fact that it is easier to overcome the environmental aspects of low temperature and is also supported by medical research which finds that the level of tritiated paroxetine platelet in body, which is negatively correlated with impulsivity and aggression, is reduced in higher temperatures (see Tiihonen et al. 1997).

To conclude this section, we note that the evidence provided by studies which attempt to explain the incidence of aggression and violence in general, and armed conflicts in particular, together with the fact grievances felt at the individual levels are known to spread to group actions[6], provides sufficient grounds for postulating an empirical relationship the onset of a specific type of conflict and a core set of explanatory variables that are thought to cause such a conflict. In the rest of this chapter therefore we provide a systematic empirical study of the relationship between the onset of 'internal armed conflicts' – whose curtailment is a desirable international objective – and their determining factors. In addition, given the importance of climatic factors, whose control

[6] For instance, Muller and Opp (1986) and Stott and Reicher (1998) who study crowd behaviour report how the origin of some group conflicts and collective aggressive acts lie in individual grievances.

features on international policy agenda, we narrow our focus on obtaining robust estimates of their impact.[7]

2.3. Data and methodology

The Uppsala Conflict Data Program (UCDP) defines conflict as: "*a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths*". We use the conflict data provided by UCDP and the Peace Research Institute Oslo (PRIO) where the following four types of conflicts are identified:[8]

(i) 'Extra systemic armed conflicts' which occur between a state and a non-state group outside its own territory;

(ii) 'Interstate armed conflicts' which occur between two or more states;

(iii) 'Internal armed conflicts' which occur between the government of a state and one or more internal opposition group(s) without intervention from other states;

(iv) 'Internationalised internal armed conflicts' which occurs between the government of a state and one or more internal opposition group(s) with intervention from other states (secondary parties) on one or both sides.

In this chapter we shall use 'internal armed conflicts' as the dependent variable to be explained[9] for which there are two main measures available in the dataset: 'the onset' and 'the incidence'. The former measure is based on the occurrence or starting of a new conflict – or when there is more than one year since the last observation of an old one – within a country in a given year, while the latter accounts for the existence of an active conflict in a country in a specific year. The full list of all the conflicts can be found in Table A2.1 in the Appendix, followed by Table A2.2 which provides the summary information and Table A2.3 that gives the occurrence of missing values. We shall use the onset data as our dependent variable, covering 139 countries over the time period 1961-2011. This amounts to 229 occurrences, which count for 4.15% of the total observations.

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[7] Although this factor appears in some form in most of the existing studies, the reported results of its impact vary substantially.

[8] The actual data can be found at http://www.ucdp.uu.se/gpdatabase/search.php and Gleditsch et al. (2002) and Harbom and Wallensteen (2012) provide further detail.

[9] The estimates are tested against including 'internationalised internal armed conflicts' in the dependent variable along with 'internal armed conflicts' in robustness checks.

We note at the outset that our dependent variable is dichotomous categorical variable taking the value of 1 if a new conflict happened in a given year-country combination. Therefore the ongoing conflicts in the sample are treated as 'missing' so as to avoid the confusion that would arise from the similarity between observations corresponding to (i) a country-year where there is a continuing that had started before, and (ii) a country-year where there is no conflict. Acknowledging the potential risk of truncating our sample, we believe this is the right procedure to avoid counting observations with an active conflict as 'no-conflict'.[10] Also, in order to avoid confusion in terminology, hereafter the word 'conflict' is used interchangeably with "the onset of an armed conflict".

Turning our attention to the choice of variables that determine a conflict, the existing studies provide helpful information about the relevance of different variables but there is no consensus in the literature regarding a common core set which could be used to predict conflict; different studies have used different explanatory variables and the overlapping subset is not indicative. Noting this problem, Hegre and Sambanis (2006) identify 88 variables that are frequently used in the literature to explain civil wars. They group these under 18 'concept' categories and to narrow down the number of regressors used in regression analysis to a parsimonious set they first select a core subset of the variables which they regard as the variables of interest, and then choose the final subset of conditioning regressors from the rest of the variables by applying a specification procedure on the basis of systematically including plausible combinations from the rest of the variables and testing their joint significance and the way they affect the coefficients of variables of interest.[11] They report their results in each case. We have used the information they additionally provide in the appendix on the relevance of these variables with respect to statistical robustness of parameter estimates, as well as data availability as the main guide in selecting the set of regressors which we have used in our analysis; Table 2.1 below provides the list and definition of the variables we have chosen. However, we enhance our set of regressors by inclusion of additional variables (which do not feature in the above mentioned dataset) which we list in Table 2.2. These variables are found, in studies which examine development issues, to play a pertinent role mainly in reflecting different aspects of climatic effects. Brunnschweiler and Bulte (2008) and

[10] This method has been widely used in the literature by some of the most established scholars such as Collier and Hoeffler (2004) and Hegre and Sambanis (2006). The alternative, treating ongoing conflicts as 'no conflict', has been tested in robustness checks.

[11] Their approach is based on the methodology proposed by Levine and Renelt (1992) and implemented in Sala-i-Martin (1997).

Boschini et al. (2013) find that a country's latitude captures the quality of its institutions;[12] Gallup et al. (1999) argue that health quality and agricultural productivity are adversely affected by tropical climatic conditions; Masters and McMillan (2001) stress the positive role winter frost on agricultural productivity; Acemoglu et al. (2001) claim that a heavy burden of infectious disease in some regions was exploited by colonising powers and in most cases these regions subsequently failed to achieve a sustained level of development.

Finally, there are the direct climatic factors whose impact on conflicts forms the focus our study. The list of variables which are typically used as a measure of climatic factor is given in Table 2.3. In the rest of this chapter we shall provide an in depth statistical analysis of their explanatory role in order to form a better understanding of the impact of climate. We therefore conclude this section by anticipating the possible relevance of climate in Figure 2.1 which plots, for the countries included in the sample and over the sample period: (i) deviations in average annual temperature from its last 30 years' moving average (a.k.a. climate[13]); (ii) total number of onsets of conflicts; and (iii) total incidences of conflicts. A number of points are worth noting.

The first point concerns the existence of a long-run pattern in climatic evolution. There is clear evidence from data that the temperature deviation series is not stationary: a linear trend regression yields a mild but highly significant trend (0.024 with t-ratio of 9.20) and the unit root tests cannot reject the null hypothesis that series is I(1). To support this evidence further, we also estimated the autocorrelation coefficients of the annual temperature deviations using

$$r_{t,t-s} = \frac{\sum_{i=1}^{N}\left(TD_{i,t} - \overline{TD}_t\right)\left(TD_{i,t-s} - \overline{TD}_{i,t-s}\right)}{\sqrt{\sum_{i=1}^{N}\left(TD_{i,t} - \overline{TD}_t\right)^2 \sum_{i=1}^{N}\left(TD_{i,t-s} - \overline{TD}_{i,t-s}\right)^2}}$$

where $TD_{i,t}$ is the annual temperature deviation from climate in country i in year t as defined in Table 2.3. As shown in Figure 2.2, although $r_{t,t-s}$ reduces with s, the estimates remain positive and significantly different from zero. As a result, we cannot rule out a systematic pattern in temperature that is indicative of global warming, typically

[12] This was initially suggested by Hall and Jones (1999) who argued that the distance to the equator reflects exposure to 'western influence' which in turn is correlated with quality of institutions.
[13] IPCC defines climate as the 'average weather'. World Meteorological Organization (WMO) suggest the average should be taken over 30 years. We follow the latter method.

stated to be ‘a gradual increase in the overall temperature of the Earth’s atmosphere’. Table A2.4 in the Appendix reports the autocorrelation coefficients for annual average temperature series.

Figure 2.1. Number of conflicts and temperature deviation from climate

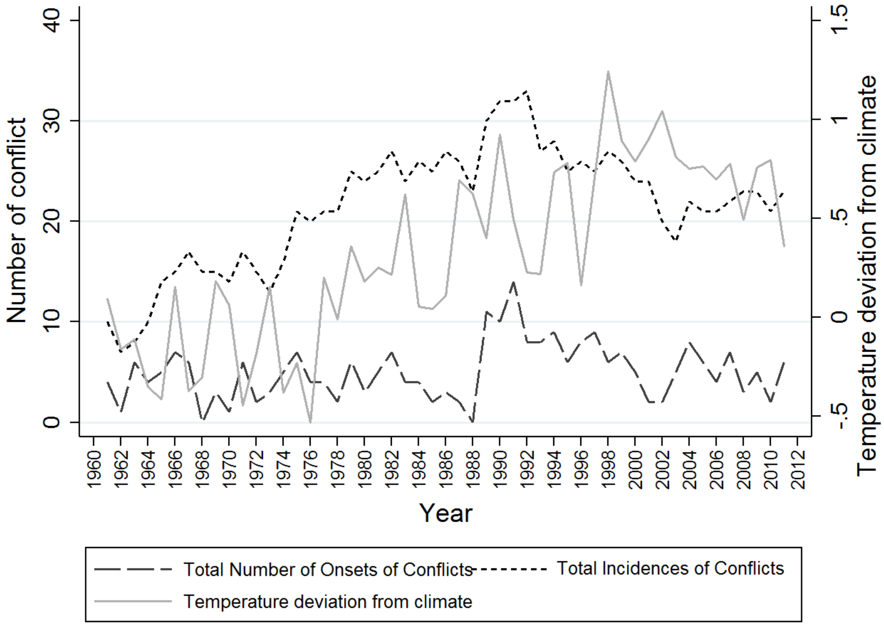


Figure 2.2. Sample autocorrelation coefficients with 90% CIs for $TD_{i,t}$

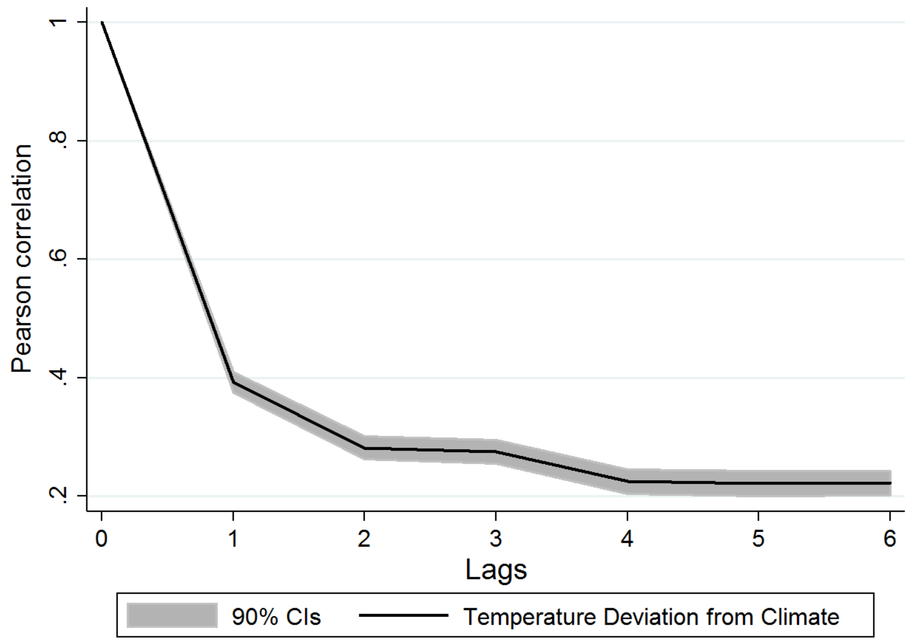


Table 2.1. List of country-specific explanatory variables

Variable	Description	Source
Regime Instability	Number of years since the most recent regime change (defined by a three-point change in the Polity score over a period of three years or less). This variable is measured in the decaying form $2^{-RD/0.5}$ where RD is the *Regime Instability*. See Hegre and Sambanis (2006) and Gurr and Jaggers (2000) for details of advantages in using this transformation.	Author's coding based on Polity IV data
Per Capita GDP	Annual gross domestic product in constant 2005 US$ prices divided by population	World Bank (2014a)
Peace Duration	Number of years since that last active conflict during which there were no new conflicts. This variable is measured in the decaying form $2^{-PD/8}$ where PD is the *Peace Duration*. See Hegre and Sambanis (2006) for details of advantages in using this transformation.	Author's coding based on conflict data
Ethnic Heterogeneity Index	Based on sub-indices of racial, linguistic, and religious divisions and ranging between 0 (fully homogeneous) and 144 (most heterogeneous)	Vanhanen (1999)
Rough Terrain	Proportion of the country that is mountainous	Fearon and Laitin (2003)
Population	Mid-year Population estimates	World Bank (2014a)
GDP Growth	Annual percentage growth rate of real GDP	World Bank (2014a)
Military Personnel	Number of armed forces personnel per 1000 people	World Bank (2014a)
Regulation of Political Participation Index	Takes the following values: 0, if there is an interregnum or transition; 1, if participation is unregulated; 2, if multiple identity; 3, if sectarian; 4, if restricted; 5, if regulated; and 'missing' when foreign interruption	Marshall and Gurr (2013)
Anocracy	If the Polity score[14] lies inside [-5, 5] range and/or if one of the special situation coded as -77 (interregnum) and -88 (transition), missing for foreign interruption (-66)	Author's coding based on Polity IV data
Cold War	A year dummy accounting for the period of disruption resulting from the ending of the cold war and breaking up of the Soviet Union	Author's coding
Oil Exporter	A country-year dummy when fuel exports revenue exceeding a third of value of exports	Author's coding
Neighbouring Conflict	A country-year dummy which assumes the value of unity if there is a conflict in one of the neighbouring countries	Hegre et al. (2013)
Region	A set of dummies, each representing one of the following six political regions,: 'Western Europe and the US', 'Eastern Europe and Central Asia', 'South and East Asia and Oceania', 'Central and South America', 'Sub-Saharan Africa' and 'Middle East and North Africa'	Hegre and Sambanis (2006)

[14] The Polity Score is a weighted average score that captures the 'regime authority spectrum' on a 21-point scale ranging from -10 (*hereditary monarchy*) to +10 (*consolidated democracy*) as well as the three special cases of '*interregnum*' regimes, regimes in '*transition*' and those having a '*foreign interruption*' which are respectively assigned the score -77, -88 and -66. See http://www.systemicpeace.org/polityproject.html for details

Table 2.2. Additional explanatory variables

Variable	Description	Source
Latitude	Absolut value of capital city's latitude over 90	La Porta et al. (1999)
Malaria	Share of 1995 population living in the area with risk of Malaria	Gallup et al. (1999)
Soil Quality	Share of areas with suitable soil for crop production	Gallup et al. (1999)
Tropical Area	Share of 1995 population living in the tropics or subtropics areas	Mellinger et al. (2000)
Crop Production Index	Annual agricultural production index, 2004-2006 = 100	World Bank (2014a)
Tropics	A regional dummy which assumes unity if the country is in a tropical zone with latitudes within an interval of 23.26^o from the equator	Author's coding

Table 2.3. Measures of climatic factors used as the explanatory variable of interest[1]

Variables	Notation and Description[2]
Temperature	$T_{i,t}$: Annual average temperature in Fahrenheit
Precipitation	P_{it}: Annual total precipitation in mm
Climate Temperature	$CT_{i,t}$: Moving averages of $T_{i,t}$ of over the last 30 years
Climate Precipitation	CP_{it}: Moving averages of $P_{i,t}$ of over the last 30 years
Temperature Deviation from Climate	$TD_{i,t} = T_{i,t} - CT_{i,t}$
Precipitation Deviation from Climate	$PD_{i,t} = P_{i,t} - CP_{i,t}$
Change in Temperature	$\Delta T_{i,t} = T_{i,t} - T_{i,t-1}$
Change in Precipitation	$\Delta P_{i,t} = P_{i,t} - P_{i,t-1}$
Growth Rate of Temperature	$\%\Delta T_{i,t} = \Delta T_{i,t}/T_{i,t-1}$
Growth Rate of Precipitation	$\%\Delta P_{i,t} = \Delta P_{i,t}/P_{i,t-1}$
Humidity Index[3]	$Humidex_{i,t} = T_{i,t} + 0.5555\left[6.11e^{5417.7530\left(\frac{1}{273.16}-\frac{1}{Dew_{i,t}}\right)} - 10\right]$

[1] The raw data were obtained from the Climatic Research Unit (Harris et al. 2014); all measures were constructed by the author.

[2] Subscripts i and t refer to country and year respectively.

[3] $Dew_{i,t} = \frac{5}{9} \times (T_{i,t} + 459.67) - \frac{9}{25}(100 - RH_{i,t})$ and RH_{it} is the annual average percentage air humidity.

The second point relates to the evolving pattern of conflicts: while we cannot reject the stationarity of the onset series, the incidence series too exhibit very similar characteristics to temperature deviations with a linear trend regression yielding a coefficient of 0.253 with t-ratio of 5.46) and the unit root tests strongly rejecting the series being I(0).

Our third point highlights the way conflict and climate are related: the simple static cointegration regression of incidence of conflicts on temperature deviations yields a highly significant CI coefficient (t-ratio of 4.3) with D-W statistic of 0.5 and we cannot reject the hypothesis that the CI residuals series is stationary.

Together, these points provide sufficient evidence to justify a thorough scrutiny of the statistical relationship between conflict and climatic factors once the relationship is conditioned on other relevant determinants of conflict outlined above. Our challenge in this chapter is to focus on explaining the onset of conflicts whose total annual number we found to exhibit a stationary behaviour over the sample period. However, since our main sample has a panel structure and the dependent variable is dichotomised, this issue should not cause a serious concern.

2.4. Estimating the impact of climate on the onset of conflicts

In this section we conduct an in depth study of the role of climatic factors in affecting the onset of conflicts. The explanatory role of a climatic factor is, in general, justified in the literature by noting that, ceteris paribus, a persistence climate change is expected to affect 'conflict' via, say, its impact on the associated risks; e.g. a rise in temperature facilitates aggressive behaviour, etc. While a number of studies have examined this phenomenon empirically, the accumulated evidence is, as argued before, somewhat controversial and unsatisfactory (mostly due to issues surrounding the measurement of climatic factor being used and the choice of statistical approach underlying the estimation techniques, which have led to an ambiguity in effect of climate change). Given the importance of the question being addressed, our contribution aims to provide a systematic examination of the impact of climate by applying robust econometric techniques to estimate a clearly specified regression equation which includes a well-defined climate measure as our explanatory variable of interest. In particular, we shall estimate different versions of the regression equation

$$y_{i,t} = \alpha + \mu_r + \theta_t + z'_{i,t}\beta_z + \beta_x x_{i,t} + u_{i,t}, \; t \in [1, T], \; i \in [1, N], \tag{2.1}$$

where $y_{i,t} = 1$ if there is an onset of conflict in country i in year t and $y_{i,t} = 0$ otherwise (see Tables A2.1 and A2.2 in the Appendix for details), $x_{i,t}$ is the corresponding climatic factor (one of the variables in Table 2.3) to be further clarified below, $z_{i,t}$ is the vector of the conditioning explanatory variables listed in Tables 2.1, μ_r is the region fixed effect where each country in the sample is associated with a specific geo-political region denoted by the subscript $r \in [1, R]$[15], θ_t is the year fixed effect, and $u_{i,t}$ is the appropriate disturbance term. At this stage we do not include country fixed effects but allow for within country correlations by means of clustered errors.[16]

As far as the choice of $x_{i,t}$ is concerned, it is believed that the appropriate measure should adequately reflect both the long-run trend in climate change as well as the short-run climatic volatility. This is because these characteristics capture the resilience building phenomenon linked to the adaptation strategies (see Bloomfield and Nychka, 1992; Rea et al., 2011; and Koubi et al. 2012). Therefore, while we shall experiment with all the variables listed in Table 2.4, using each as an alternative explanatory variable to represent the role of climate change, it might be argued that $CT_{i,t}$ or $T_{i,t}$ – or, $CP_{i,t}$ or $P_{i,t}$ – capture the long-run pattern while $TD_{i,t}$, $\Delta T_{i,t}$ or $\%\Delta T_{i,t}$ – or, $PD_{i,t}$, $\Delta P_{i,t}$ or $\%\Delta P_{i,t}$ – better embody the short-run volatility in climate. In addition, the humidity index, $Humidex_{i,t}$, which adjusts $T_{i,t}$ for the impact of humidity so as to provide a more accurate measure of 'how hot the weather feels to the average person' is used as an alternative to $T_{i,t}$ and is expected to have a similar effect.

Our choice of elements of the vector of conditioning variables $z_{i,t}$ was explained in detail in the previous section, listed in Tables 2.1, and here we state the expected explanatory role of the main variables of interest and provide a brief explanation of how they have featured in other studies:

- *Regime Instability*, also known as *Regime Durability*, is a decay function of the Polity *Durable* variable which measures the number of years since the most recent regime change (defined by a three-point change in the Polity score over a period of three

[15] See Table 2.1 for the regions. The proposed categorisation is intended to reflect the tendency towards conflict in regions. Table A2.5 in the Appendix provides further details of the relevant data.

[16] It is more sensible to cluster errors on countries rather than on regions, of which there are only six in the current sample, to reduce the bias in standard errors. See Nichols and Schaffer (2007) and Wooldridge (2003) for details.

years or less). We use Polity IV (Marshall and Jaggers, 2002; Marshall and Gurr, 2013) data to construct this variable, following the instructions in Hegre and Sambanis (2006). Political instability has been measured in different forms, e.g. Fearon and Laitin (2003) and Collier and Rohner (2008) use a dummy variable to capture the contribution of political instability. In general, political instability could influence conflict directly or indirectly via its impact on economic performance (see Alesina et al., 1996).

- *Peace Duration* is related to a measure of the period in which a country has not experienced any conflicts. Starting from 1946 (corresponding to the first observation in our dataset), we approximate this period by the number of days from the end of the last conflict up to two years before the beginning of the next conflict so as to avoid endogeneity and to allow for the reconstruction time, etc. – we follow the definition suggested in Sambanis (2004) and Hegre and Sambanis (2006). *Peace Duration* is then measured in decay form and is therefore expected to have a positive contribution. The peace period, measured in one form or another, is considered as one of the main influencing factors (Collier and Hoeffler, 2004; Fearon, 2005; Hegre et al., 2013). Collier (2008) explains this with the concept of 'conflict trap' which is based on the evidence that a country has a higher risk of starting another conflict in the post-conflict period and Collier and Hoeffler (2004) highlight the positive role of conflict-free years in keeping peace in long run.

- *Ethnic Heterogeneity Index* ranges from 0 (perfect homogeneity) to 144 (perfect heterogeneity), combining the racial, linguistic and religious diversity indices. These were introduced by Vanhanen (1999) and were later combined into one index representing overall diversity, usually labelled as *ethnic heterogeneity* or *ethnic fragmentation* index. *Ethnic Heterogeneity* is thought to contribute positively to the starting of conflicts. The ideas was originally introduced by Gurr (1971) using grievance motives provoked by social exclusion and was further developed later by Fearon and Laitin (2003) and Collier and Hoeffler (2004) who studied the role of ethnic dispersion or diversity. Others, e.g. Hegre and Sambanis (2006), Collier and Rohner (2008) and Slettebak (2012), have investigated the contribution of different measures of ethnic diversity.

- *Rough Terrain* measures the proportion of the area of the country that is mountainous and is considered as important since rough terrains are usually poorly served by roads and happen to be located farther away from the centre of state power. Therefore, it is expected to have a positive impact since it facilitates insurgency. The idea was first introduced conceptually by Fearon and Laitin (1999) and Buhaug and Gates (2002), and was later quantified in the study conflict by Fearon and Laitin (2003) to capture the hide-out opportunity for rebels. Since then, this variable features as one of the important control factors and used in later studies, e.g. Collier and Hoeffler (2004) and Collier and Rohner (2008).

- *Population* is expected to have a positive impact. The main reason for this is based on the way a conflict is defined, which requires a certain threshold of deaths in order for it to be classified as an armed violence against the state; the higher is the population, the higher are the casualties and the easier to reach the threshold. (Hegre and Sambanis, 2006). Also, Fearon and Laitin (2003) further justify the positive effect of population on conflict on two other grounds, namely: (i) higher cost of government surveillance and tracking people in populated countries, and (ii) better recruitment opportunities of insurgents for a given level of income. To avoid endogeneity issues and allow for the time required for it to exert its impact, we use the lagged value of this variable.

- *Per Capita GDP* is measured as GDP in constant 2005 U.S. dollars divided by the midyear population. This variable is thought to reflect the economic opportunity cost of the conflict (Collier and Hoeffler, 2004) as well as the state's sovereignty, and therefore government's military capabilities (Fearon and Laitin 2003). In addition, it is thought to provide a measure of the level of development. The latter feature forms the focus of the next chapter. In all cases one would expect to find a negative relationship between per capita GDP and conflict. To avoid endogeneity issues and allow for the time required for it to exert its impact, we use the lagged value of this variable.

- *GDP Growth* is measured as the percentage change in GDP in constant 2005 U.S. dollars. Its effect does not appear to be unambiguously determined in the literature. For instance, Collier and Hoeffler (2004) find a negative effect and interpret growth as reflecting the 'opportunity cost' of conflict; ceteris paribus, the higher is growth the more costly is conflict and hence the lower is the probability of starting a conflict. However, as Heston (1994) and Hendrix and Glaser (2007) among others have noted, data availability and measurement problems together with relatively high volatility of growth across the countries involved can undermine the accuracy of such interpretations as well as reducing robustness of the estimated effect. To avoid endogeneity issues and allow for the time required for it to exert its impact, we use the lagged value for this variable. It is worth noting at this stage that an additional econometric specification problem exists that can affect the sign and significance of the coefficient of this variable and which results from the link between logarithm of *Population,* logarithm of *Per Capita GDP* and the change in logarithm of *GDP* which approximates *GDP Growth*. In other words, including $\log(Population_{-1})$, $\log(GDP_{-1}/Population_{-1})$ and $\log(GDP_{-1}/GDP_{-2})$ as three explanatory variables is equivalent to including $\log(Population_{-1})$, $\log(GDP_{-1})$ and $\log(GDP_{-2})$, since the latter is simply the unrestricted version of the former. This shows that if the underlying restriction does not hold we might find unexpected signs and significance levels for coefficients of one or more of the regressors involved. We shall therefore keep these issues in mind but include the restricted form since the impact of each variable involved is directly interpretable and can be seen in the context of the evidence available in the literature.

- *Military Personnel* features frequently amongst the variables used in the literature but there is substantial ambiguity associated with its explanatory role. As Collier (2008, p. 132) explains "… *governments that spend the most are likely to be those that face the biggest risk.*" and "…*because causality runs from risk to spending, it is hard to distinguish any causality from spending to risk.*" Even disregarding the reverse causality problem and treating it as an exogenous explanatory variable, data on 'military personnel' is poor and there is a substantial number of missing values which reduce the sample considerably. We therefore have decided to exclude this variable from our set of regressors.

Table 2.4. Explanatory variables based on a sample of 139 countries[*] over 51 years, 1961-2011

Variable	Number of Observation	Mean	Std. Dev.	Min	Max
Regime Instability [decaying]	6330	0.107695	0.289747	0	1
GDP Per Capita [real, log]	5719	7.694141	1.588392	3.912867	11.31383
Peace Duration [decaying]	6380	0.431231	0.376947	0.003582	1
Ethnic Heterogeneity Index [Index]	6380	45.56105	34.07222	0	144
Rough Terrain [% in Total]	6380	2.057542	1.441827	0	4.55703
Population [log]	6377	16.00166	1.512535	12.30505	21.01901
GDP Growth [real, %]	5712	3.996665	6.83548	-64.0471	189.8299
Military Personnel [log]	3027	1.742921	0.756337	0	4.386381
Regulation of Political Participation Index	6297	3.466254	1.224555	0	5
Anocracy [dummy]	6297	0.23408	0.423456	0	1
Cold War [dummy]	6380	0.214263	0.410343	0	1
Oil Exporter [dummy]	6380	0.171317	0.376815	0	1
Neighbouring Conflict [dummy]	6380	0.600627	0.489808	0	1
Latitude	6380	0.280213	0.185997	0.011111	0.711111
Malaria [% in Total]	6297	38.23458	43.4708	0	100
Soil Quality [% in Total]	6206	12.78507	9.148625	0	55.0726
Tropical Area [% in Total]	6297	38.86282	42.86875	0	100
Crop Production Index	6311	78.65377	46.32625	1.35	962.57
Tropics [dummy]	6380	0.515047	0.499812	0	1
Temperature [Fahrenheit]	6380	66.15404	14.69043	18.68	85.64
Precipitation [log]	6380	6.650115	.9733427	2.595255	8.209498
Climate Temperature [Fahrenheit]	6380	65.8012	14.72825	22.082	83.84
Climate Precipitation [log]	6380	1093.597	758.2622	37.38333	3164.58
Temperature Deviation from Climate [Fahrenheit]	6380	0.352836	0.867792	-3.48	4.356003
Precipitation Deviation from Climate [millimetre]	6380	-0.202109	163.2015	-919.58	1340.117
Change in Temperature [Fahrenheit]	6380	0.019552	0.975245	-5.4	5.220001
Change in Precipitation [millimetre]	6380	0.018903	221.8989	-1864.2	1745.2
Growth Rate of Temperature [%]	6380	0.055140	2.060326	-20.8655	26.01713
Growth Rate of Precipitation [%]	6380	3.010396	28.18621	-82.5723	471.371
Humidex Index	6380	22.45607	11.90481	-11.6894	40.57645

[*] The full list of countries with a conflict can be found in Table A2.1 in the Appendix. However, the sample is not balanced as not all the countries existed throughout the years, e.g. the countries formed after the collapse of the Soviet Union.

Finally, on the basis of the evidence presented in the literature, we approximate the impact of a number of explanatory variables by a quadratic from and therefore include both the level and the squared values, e.g. the effect of temperature is captured by $\beta_{1T}T_{i,t} + \beta_{2T}T_{i,t}^2$.

Moving on to estimation issues, given the binary form of the dependent variable, our regression equation in (2.1) is modified to reflect the assumption that its right-hand-side determines the conditional probability of onset subject to an unpredictable random error, namely,

$$Prob\left(y_{i,t} = 1\middle|\left(x_{i,t}, z_{i,t}'\right)\right) = F\left(\alpha + \mu_r + \theta_t + z_{i,t}'\beta_z + \beta_x x_{i,t}\right) + u_{i,t}$$

We therefore estimate our regressions using the logit model[17] and present and discuss estimates of marginal effects of the variables of interest while the actual parameter estimates are reported in Table A2.6 in the Appendix.

2.4.1. Evidence

Table 2.5 reports our estimates of the average marginal effects (AMEs) of the main explanatory variables (the actual parameter estimates are reported in Table A2.6 in the Appendix) where each column corresponds to capturing the climate effect with one of the variables defined in Table 2.3; column A does not include any climate factor as explanatory variable and provides a benchmark with which the estimates reported in the other columns can be compared. Columns B and C show the impact of long-run climatic factors captured by the quadratic forms of $CT_{i,t}$ and $CP_{i,t}$ respectively: the AMEs have the correct sign – consistent with the role of climate in contributing to onset of conflict – but only temperature exerts a significant impact: a one s.d. rise in climate-level temperature (in Fahrenheit) raises the probability of conflict by 3.1 percentage points. Similar results are obtained when we use the average annual temperature to capture the long-run impact of climate – see columns D and E. Thus, precipitation does not seem to be a significant proxy for the long-term effect of climate. However, this changes when we focus on the short-term effect and use the deviation in climate: as shown in columns

[17] While both logit and probit models are appropriate in these circumstances, the former performs better in statistical tests and is more relaxed regarding the assumptions on the distribution function representing the conditional probability.

Table 2.5. Logit estimates of equation (2.1) with different climatic factors: average marginal effects of selected explanatory variables

Dependent: conflict onset	A	B	C	D	E	F	G	H	I	J	K	L
Regressors $x_{i,t}$:	--	$CT_{i,t}$	$CP_{i,t}$	$T_{i,t}$	$P_{i,t}$	$TD_{i,t}$	$PD_{i,t}$	$\Delta T_{i,t}$	$\Delta P_{i,t}$	$\%\Delta T_{i,t}$	$\%\Delta P_{i,t}$	$Humidex_{i,t}$
Regime Instability [decaying]	0.0115***	0.0122***	0.0115***	0.0121***	0.0116***	0.0114***	0.0116***	0.0115***	0.0116***	0.0115***	0.0116***	0.0117***
GDP Per Capita [real, log, lagged]	-0.00772	-0.00648	-0.00771	-0.00647	-0.00780	-0.00776	-0.00786	-0.00783	-0.00772	-0.00792	-0.00773	-0.00733
Peace Duration [decaying]	0.0300***	0.0289***	0.0300***	0.0288***	0.0298***	0.0301***	0.0300***	0.0302***	0.0300***	0.0301***	0.0300***	0.0290***
Ethnic Heterogeneity [Index]	0.0147***	0.0112***	0.0147***	0.0111***	0.0149***	0.0147***	0.0146***	0.0147***	0.0147***	0.0147***	0.0147***	0.0127***
Rough Terrain [% in Total]	0.00657	0.0154***	0.00649	0.0157***	0.00489	0.00686*	0.00654	0.00660	0.00651	0.00659	0.00658	0.0118**
Population [log, lagged]	0.0197***	0.0222***	0.0195***	0.0222***	0.0182***	0.0194***	0.0197***	0.0196***	0.0197***	0.0195***	0.0197***	0.0219***
GDP Growth [real, lagged]	0.00258	0.00244	0.00257	0.00240	0.00257	0.00253	0.00259	0.00249	0.00257	0.00249	0.00259*	0.00240
Climate: $\beta_{1x}x_{i,t} + \beta_{2x}x_{i,t}^2$		0.0307***	-0.00041	0.0317***	-0.00283	--	--	--	--	--	--	--
Climate: $\beta_{1x}x_{i,t}$		--	--	--	--	0.00677*	-0.0042**	0.00551*	-0.00261	0.00707**	0.000476	0.0150**
MENA [Region dummy]	0.0212	0.0332*	0.0209	0.0334*	0.0273*	0.0229	0.0217	0.0218	0.0214	0.0219	0.0211	0.0285*
R^2	0.2746	0.2814	0.2747	0.2819	0.2760	0.2780	0.2757	0.2760	0.2751	0.2765	0.2747	0.2781
L	-603.29	-597.66	-603.29	-597.23	-602.14	-600.52	-602.39	-602.19	-602.94	-601.76	-603.28	-600.46

- The dependent variable 'onset of conflict', is set to unity if there is onset of conflict and to zero otherwise.
- This table only presents the estimates of explanatory variables which had a statistically significant effect in atleast one of the regressions.
- In order to facilitate comparison, all non-dummy explanatory variables are standardised so that the marginal effects reflect the impact of a one s.d. change in the value of the variables.
- The sample size in all regressions is 4463, consisting an unbalanced combination of 139 countries over the period 1961-2011.
- '*', '**' and '***' respectively denote significance at 10%, 5% and 1% critical values based on standard errors clustered at the country level. R^2 and L are the pseudo R^2 and log pseudo likelihood values respectively.
- We only report the fixed effect of *MENA* region where the base line region is Sub-Saharan Africa.

F and G, the AMEs associated with both $TD_{i,t}$ and $PD_{i,t}$ are statistically significant with correct signs. But replacing deviations with changes or growth rates to capture the short-term effect reverts to only temperature effect being significant as shown in columns H to J. In particular, a 1% rise in the current temperature increases the probability of onset of conflict by 0.7 percentage points. Finally, in the last column we report the role of humidity index whose effect turns out to be positive and significant but, as expected, its impact is lower than that of $T_{i,t}$, i.e. 0.015 < 0.032, since the former adjusts the latter for the impact of humidity. To summarise, as far as the impact of climate is concerned measures which are based on temperature levels always play a positive and statistically significant role; while precipitation effect too always has the correct sign, it is only find to be significant when its deviation from the long-run climate level is used to proxy the short-run effect.

Turning to the effects of other determining factors we find that most have the expected signs and feature mostly significantly. The exceptions are *Per Capita GDP* whose coefficients have the correct sign but are statistically insignificant and *GDP Growth* which exerts statistically significant but positive effect. This anomaly was, to some extent, anticipated above where we discussed the issues related to GDP variables. While this is not fully satisfactory, we shall leave this set of explanatory variables intact on the understanding that together they remove the omitted variable effect and allow a more robust estimation of the climatic effect which is the primary focus of this chapter. However, it is worth mentioning at this stage that the coefficient of *Per Capita GDP* is always significant when it is interacted with variables that reflect the political feature of a country – e.g., *Regime Instability* as reported in Table A2.6 in the Appendix. The role of *Per Capita GDP* is explored in detail in Chapter 3 in the context of development and conflict.

Amongst the fixed effects, we only report the coefficient capturing the MENA region effect because it is one of the most troubled regions. The estimated effect is always positive and is statistically significant in columns B and D where temperature is used to capture the climate effect.

In order to compare the quantitative impact of the variables, in Table 2.6 we provide a comparative illustration of the AMEs where we also show the corresponding 90% confidence interval for each effect. Two observations are worth highlighting:

(i) The pattern of predictive margins, calculated at different sample values of the relevant climate factor, suggest a clear positive association between climate warming and the probability of onset of conflicts; the hotter is the climate, the larger is the associated probability.

(ii) Based on the estimates of AMEs, *Peace Duration* has the highest impact followed by Annual Average Temperature, *T*, and then *Population*.

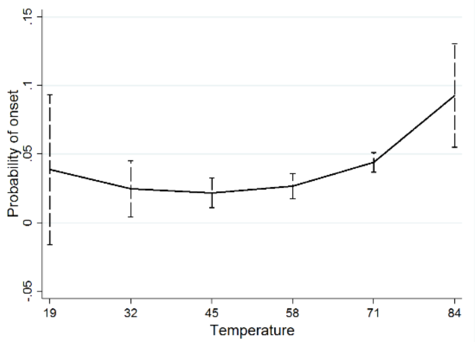
These results are worth emphasising since they convey a clear message for international peace agenda since they imply that promoting peace and controlling climate and population growth are the most effective factors in contributing to a reduction in the onset of armed conflicts. It is also important to consider at this stage that policies that aiming to affect these are not necessarily target specific. For instance, Collier (2008) interprets the prominent role of Peace Durability in the context of 'conflict trap' theory and it is believed that properly targeted foreign aid and direct external intervention can be effective in breaking the vicious circle by enhancing peace durability. However, there is no reason why such policies should not target both Peace Durability and climate control.

We conclude our discussion of the evidence by examining two further questions regarding the effect of climate factor we have considered. First, we ask: which one of the measures used as a proxy for climate is more effective? In Table 2.7 we report the AMEs based on using the actual data (rather than standardised data) for the climatic factor whose effect we found to be significant as reported in Table 2.5. The results are revealing in that they stress the particular effectiveness of climate control policies that target reducing the deviation of current temperature from the long-run: a 1^{o} F increase above the climate average increases the probability of conflict by 0.8 percentage point.

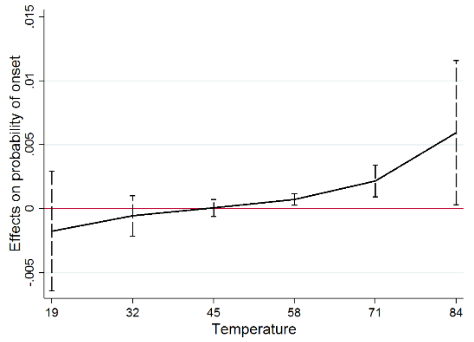
Next, we ask whether there is an interaction between the two main climate factors, temperature and precipitation. So far, we have used these as alternative indicators. We now examine if they play a joint role in capturing the effect of climate on the grounds that while only one of these – and on the basis of the above evidence, a temperature-based measure – is more likely to capture the direct effect of climate, the direct effect is bound to be influence by the extent to which the other factor varies. As argued by Lilleør and Van den Broeck (2011), the impact of temperature is likely to be higher in drought-prone areas. We therefore experimented with different specifications by keeping the

Table 2.6. Selected summary results based on the estimates reported in Table 2.5

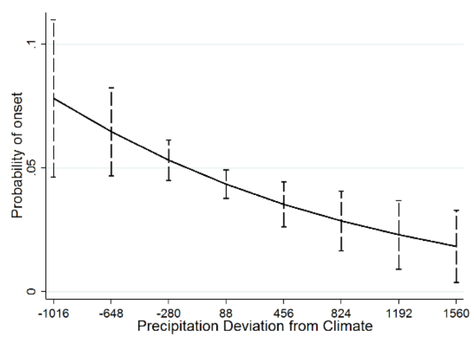
Predictive Margins with 90% CIs (Column D)



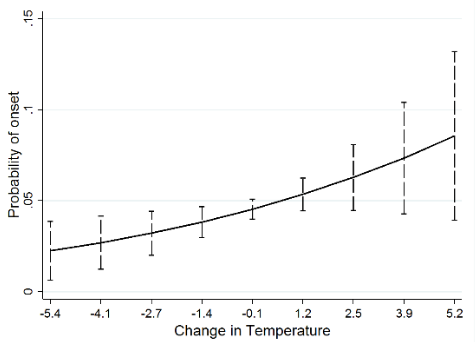
AMEs with 90% CIs (Column D)



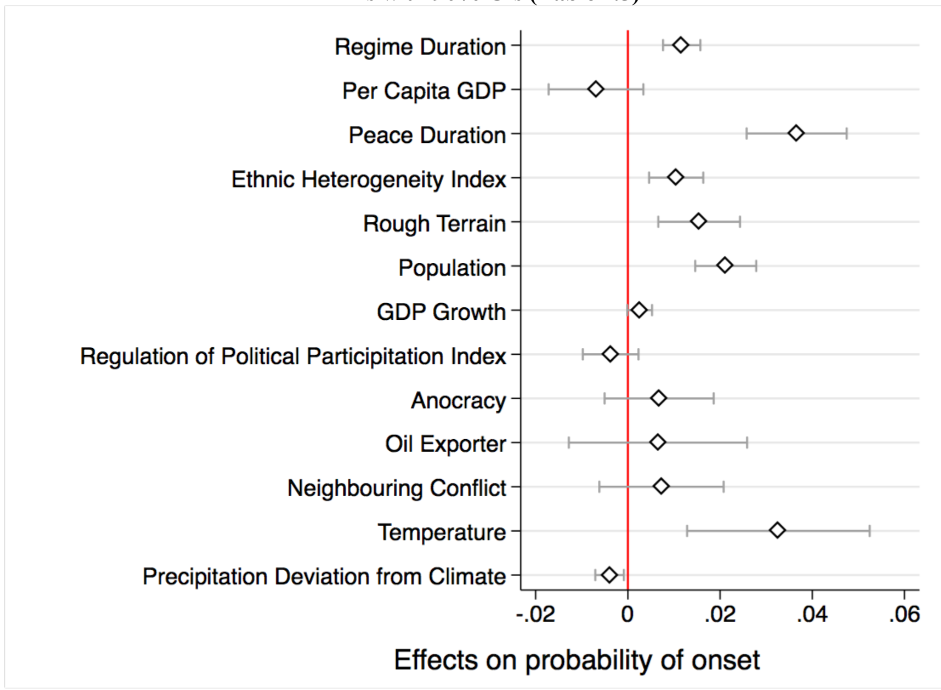
Predictive Margins with 90% CIs (Column G)



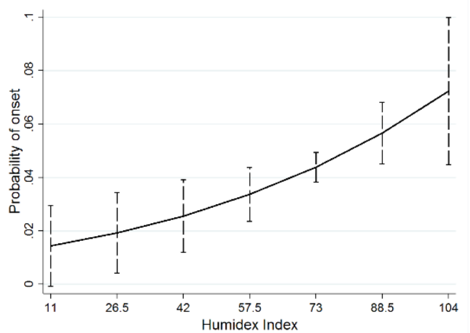
Predictive Margins with 90% CIs (Column H)



AMEs with 90% CIs (Table 2.5)



Predictive Margins with 90% CIs (Column L)



sample and all other control variables intact and using different combinations of temperature and precipitation measures and found that data supports the following model where we also report the estimated values of parameters of interest (t-ratio in parentheses):

$$y_{i,t} = \alpha + \mu_r + \theta_t + z'_{i,t}\beta_z + \beta_{\%\Delta T}(\%\Delta T_{i,t}) + \beta_P P_{i,t} + \beta_{\%\Delta T,P}(\%\Delta T_{i,t} \times P_{i,t}) + v_{i,t}, \quad (2.2)$$

$$\hat{\beta}_{\%\Delta T} = 0.166\ (2.60);\ \ \hat{\beta}_P = -0.00006\ (0.46);\ \ \hat{\beta}_{\%\Delta T,P} = -0.00013\ (1.72),$$

$$\frac{\partial y_{i,t}}{\partial \%\Delta T_{i,t}} = \beta_{\%\Delta T} + \beta_{\%\Delta T,P} P_{i,t}$$

The choice of this specification was justified on the grounds that while together $\%\Delta T_{i,t}$ and $P_{i,t}$ capture the short-run and long-run impacts, they are less correlated and their interaction provides a better reflection of the hypothesis put forward by Lilleør and Van den Broeck (2011) in measuring how the impact of temperature fluctuations is enhanced in dryer climates. As expected, we find the direct effect of $P_{i,t}$ to remain insignificant but to impact upon the effect exerted by $\%\Delta T_{i,t}$: a rise in precipitation moderates the impact of growing temperature. In Figure 2.3 we illustrate this quantitatively by plotting the evolution of AMEs of $\%\Delta T_{i,t}$ as $P_{i,t}$ rises.

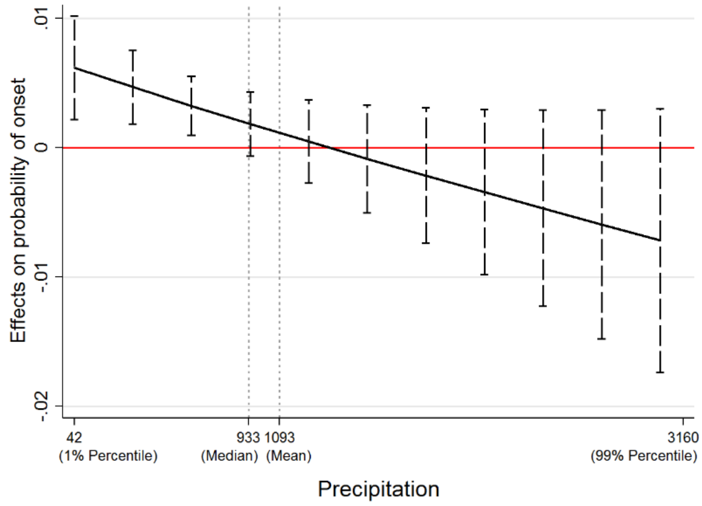
Table 2.7. AMEs for different climatic factors[1]

Climatic Factor	$CT_{i,t}$[3] Climate Temperature	$T_{i,t}$[3] Temperature	$\Delta T_{i,t}$ Change in Temperature	$\%\Delta T_{i,t}$ Growth Rate of Temperature	$TD_{i,t}$ Temperature Deviation from Climate	$PD_{i,t}$ Precipitation Deviation from Climate
AME[2]	0.21	0.22	0.6	0.4	0.8	-0.3

[1] See the note below Table 2.5. The difference between these estimates and those reported in Table 2.5 is due to use of raw rather than standardised data.
[2] These measure the impact of 1°F or 100mm rise in temperature or precipitation on the probability of onset of conflict.
[3] These variables appear in quadratic form as in Table 2.3.

Figure 2.3. Impact of temperature growth on probability of onset of conflict

at different levels of precipitation – estimates of equation (2.2)



2.4.2. Robustness of evidence on the climate effects

Our evidence already supports the hypothesis that, ceteris paribus, the warming of climate raises the probability of onset of conflicts. In order to further strengthen this support, we now address a number of questions that could weaken our evidence if they are left unanswered. There is no particular order in which one should consider these questions. We therefore examine them in order of their importance and relevance.

The first question is whether the effectiveness of the climate factor significantly diminishes over time. To answer this, we re-estimated the regression equations corresponding to columns D and E in Table 2.5 over the shorter period of 1967-2011 where we used the current and lagged climate factors, $T_{i,t-s}$ and $P_{i,t-s}$, in order to check if their impact is reduced as s rises. We present the results in Table 2.8 where, given that all regressions are estimated using an identical sample, the evidence suggest the passage of time does not significantly erode the climate effect.

The next issue concerns the fact that our evidence is based on the whole sample and imposes the restriction that the impact of climate is homogeneous across different climatic conditions. We therefore examine if this restriction is supported by dividing our observations into three groups in terms of climate, namely *cold*, *mild* and *hot*, where the *mild* climate is assumed to prevail when the temperature is within one s.d. of mean; the *cold* and *hot* climates then correspond to temperatures below and above the lower and the upper bounds of the interval.

Table 2.8. Comparing the AMEs of current and past temperature

s: Climate Factor	0	1	2	3	4	5	6
Temperature: $\beta_{1T}T_{i,t-s}+\beta_{2T}T_{i,t-s}^2$	0.0305 (2.40)	0.0291 (2.35)	0.0296 (2.40)	0.0301 (2.38)	0.0292 (2.35)	0.0286 (2.29)	0.0275 (2.27)
R^2	0.295	0.294	0.294	0.294	0.294	0.294	0.293
AIC	1228	1229	1229	1229	1229	1230	1230
Precipitation: $\beta_{1P}P_{i,t-s}+\beta_{2P}P_{i,t-s}^2$	-0.00363 (0.78)	-0.00237 (0.52)	-0.00351 (0.77)	-0.00433 (0.92)	-0.00207 (0.43)	-0.00394 (0.83)	-0.00215 (0.47)
R^2	0.290	0.289	0.289	0.289	0.288	0.290	0.288
AIC	1236	1237	1238	1237	1238	1236	1238

- See the notes below Table 2.5. The dependent variable and the set of regressors are identical to that used in Table 2.5, but the sample size is reduced to 4212 since we have dropped the observations for 1961-1966 to allow for maximum of 6 lags. The numbers in parentheses are the corresponding t-ratios (standard errors are clustered at the country level).

Respectively, *cold*, *mild* and *hot* climate occur in 22.6%, 66.83% and 10.56% of observations in the sample. Accordingly, we constructed three dummy variables, denoted by $DC_{i,t}$, $DM_{i,t}$ and $DH_{i,t}$ and assigned the value of unity if the observation corresponds to a *cold*, *mild* and *hot* climate respectively and zero otherwise. Using these, we examined estimates based on the following regression equation which augments equation (2.1) with the dummies and their interactions with the climate variable, $x_{i,t}$,

$$y_{i,t}=\alpha+\mu_r+\theta_t+z_{i,t}'\beta_z+\beta_x x_{i,t}+\gamma_m DM_{i,t}+\gamma_h DH_{i,t}$$
$$+\beta_{xm}DM_{i,t}x_{i,t}+\beta_{xh}DH_{i,t}x_{i,t}+u_{i,t}. \quad (2.3)$$

In Table 2.9 we only report estimates of γ coefficients and the interaction effects when $x_{i,t}$ is set to $TD_{i,t}$, $\%\Delta T_{i,t}$, $PD_{i,t}$ and $\%\Delta P_{i,t}$ and the *cold* climate is treated as baseline and in Figures 2.4-2.7 we provide an illustration of how the impact of climate is likely to evolve in each case.

Table 2.9. Effect of climatic factors in different climates based on estimates of equation (2.3)

$x_{i,t}$:	$TD_{i,t}$	$\%\Delta T_{i,t}$	$PD_{i,t}$	$\%\Delta P_{i,t}$
γ_m	0.955**	1.011**	0.977**	0.978**
γ_h	1.788***	1.920***	1.891***	1.881***
β_x	0.0780	0.110**	0.00497*	0.00858
β_{xm}	0.0512	-0.0124	-0.00590**	-0.00903
β_{xh}	0.176	0.103	-0.00590**	-0.00719
Constant	-11.85	-11.70	-11.96	-11.87
R^2	0.2857	0.2873	0.2883	0.2852
L	-594.08	-592.78	-591.96	-594.50

- See the notes below Table 2.5. The dependent variable, the set of regressors and the sample are identical to that used in Table 2.5. The '*cold*' case is used as the baseline.
- This table exceptionally reports Log odds, as interpreting joint role and interaction terms separately, is not possible having just marginal effects.

Figure 2.4. Predictive Margins of temperature conditions in different $\%\Delta T_{i,t}$ based on estimates of equation (2.3)

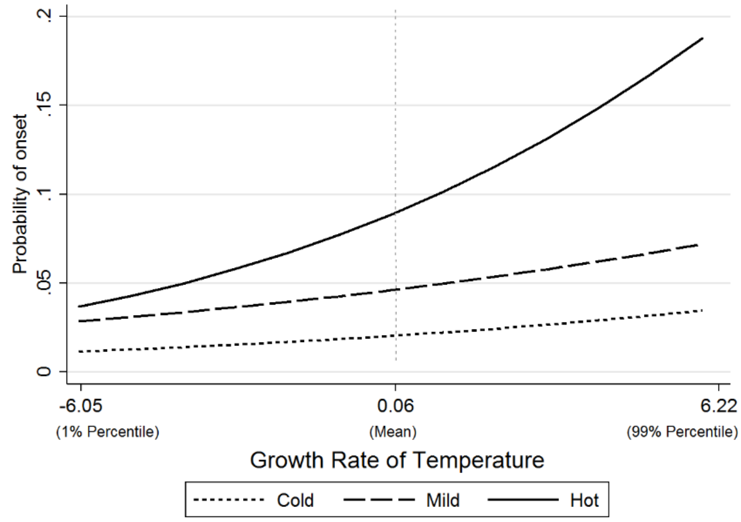


Figure 2.5. Predictive Margins of temperature conditions in different $PD_{i,t}$ based on estimates of equation (2.3)

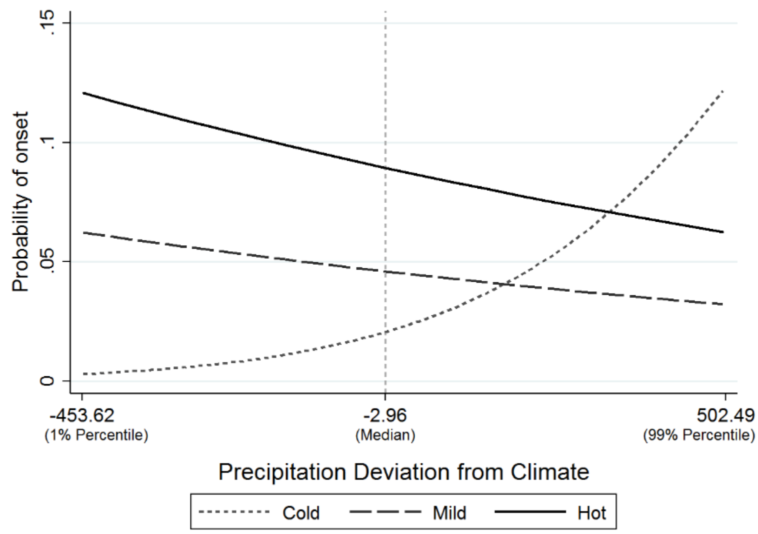


Figure 2.6. AMEs of temperature conditions in different $\%\Delta T_{i,t}$ with 90% CI based on estimates of equation (2.3)

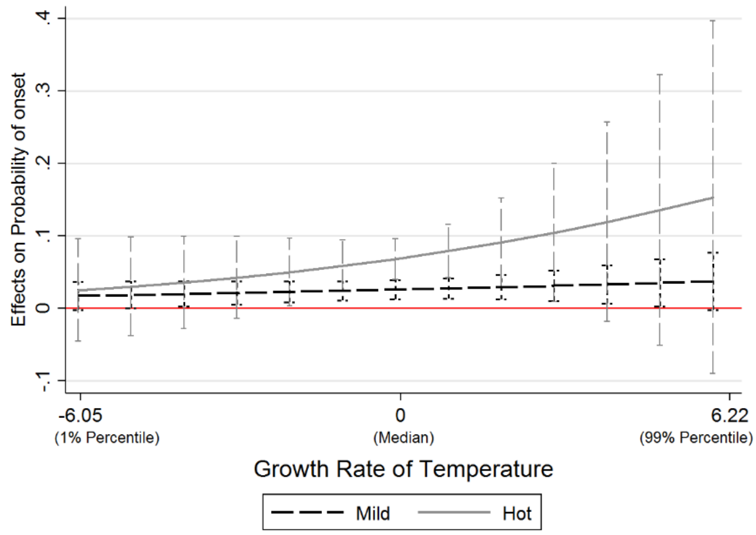
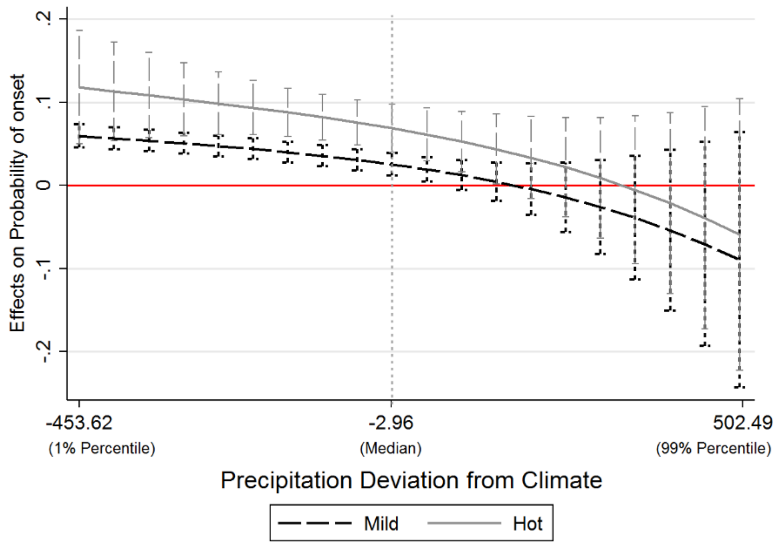


Figure 2.7. AMEs of temperature conditions in different $PD_{i,t}$ with 90% CI based on estimates of equation (2.3)



As expected, including the interaction term improves the predictive power and fit of the model. This is mainly results from separating observations by their climate condition, as evidently the effect of climatic factors is somewhat sensitive to the designated climates as the magnitudes and even signs of the effects differ. From Figures 2.4 and 2.5 it is apparent that the effect of a rise in temperature is less substantial in *cold* climates compared to *mild* and *hot* climates. This is in line with our expectations that *hot* climates are more vulnerable to warming (Anderson, 1989; Lilleør and Van den Broeck, 2011);

the same argument applies to *hot* climates which are likely to be more drought-prone. Lilleør and Van den Broeck (2011) state "*Areas which are close to the upper threshold of, say, temperature for agricultural production are likely to suffer more* [from global warming] *than similar cooler areas. Likewise, already drought-prone areas will suffer more from further lack of rain than very wet areas, which may even benefit from such a change*" (p. 77).

In an attempt to examine the impact of climate on violence (not necessary armed conflicts), a number of recent studies which use cross country data (e.g. Burke et al., 2009; Hsiang, 2013) have argued in favour of estimating a restricted version of equation (2.1) which replaces the effect off country characteristics, captured by $\mu_r + z'_{i,t}\beta_z$ in (2.1), with a country fixed effect, namely

$$y_{i,t} = \alpha + c_i + \theta_t + \beta_x x_{i,t} + \epsilon_{i,t}, \tag{2.4}$$

where c_i is the country fixed effect. This approach is worth considering when assessing the robustness of our evidence: if country fixed effects provide a better way of capturing country-specific characteristics embodied in variables listed in Table 2.1 and used in our approach, then clearly one ought to at least provide estimates on the basis of both. However, estimation of the specification in (2.4) restricts the sample since all the observations pertaining to countries that did not experience any conflict will drop out. In addition to reducing the sample considerably (limiting the number of countries to 75 out of original 139), and eliminating the possibility of distinguishing between countries on the basis of a specific characteristic, this approach also raises the likelihood of introducing a sample selection problem since those countries which have experienced a conflict tend to have some common characteristics. Before comparing our estimate based on this approach with those discussed above, reported in Table 2.10, we note that the sample mean and median of 'risks of onset' for countries with a history of conflict are respective 11.3% and 5%, which are noticeably larger than the corresponding values for the whole sample of 7.3% and 1.8% – see Table A2.7 in the Appendix for a comparison of sample statistics between the two sets of countries. In Table 2.10, the set of estimates entitled (A) are our original estimates which can be compared with those entitled (B); climatic factors retain their sign and significance but, as expected, their effects are considerably larger. To make direct comparison between the two specifications possible, the corresponding estimates based on identical samples are also reported in the table entitled (C) and (D) respectively. These results too support our original conclusions regarding the sign of the impacts. While there are certain drawbacks in using this method – which stem from eliminating important observations from the sample and hence over-estimating the effects and introducing sample selection bias – it should be noted that this approach could be more appropriate in situations where the focus is on countries with a history of conflict and/or there are data availability issues regarding the country-specific characteristics.

The next question concerns the adequacy of our sample. In this connection we consider three main issues:

(i) ***the rare event characteristic of the dependent variable*****:** King and Zeng (2001) and Tomz et al. (2003) discuss the rare event problem and propose using an adjusted logit model specifically designed for estimating regression equations where data exhibits the so called rare-events characteristic. In particular, the results presented in King and Zeng (2001) suggest that standard logit estimates may under predict the probability of an event occurring when the events are rare and Tomz et al. (2003) show how their modified estimator yields lower mean squared errors when applied to rare events data such as wars, political activism or epidemiological infections. Given that our dependent variable could be classified as rare-event since $y_{i,t} = 1$ only for less than 5% of the observations, we re-estimated equation (2.1) for $x_{i,t} = \beta_{1T}T_{i,t} + \beta_{2T}T_{i,t}^2$ using the modified logit estimator and found support for our original conclusion, with $\hat{\beta}_{1T} = 0.262$, $\hat{\beta}_{2T} = 0.269$ and both statistically significant at 5%.[18]

(ii) ***treatment of the observation corresponding to on-going conflicts*****:** Our sample so far only includes the observations in which at least one new conflict has started but all the on-going conflicts (defined as an active conflict that started before that observation) are excluded. An alternative would be to include the latter but treat them as if there were no new conflict starting. Although this modification skews the sample (since observations with an active conflict are not distinguished from those with no conflict), it is worthwhile checking if it affects the estimated impact of climatic effect. We therefore re-estimated equation (2.1) for $x_{i,t} = \beta_{1T}T_{i,t} +$

[18] The software is made available for Stata by Tomz et al. (2003) and can be downloaded from https://gking.harvard.edu/relogit.

$\beta_{2T}T_{i,t}^2$ using the modified sample and found that the results support our original conclusion with the estimated AME of $T_{i,t}$ 0.0211 being statistically significant at 5%.

(iii) ***inclusion of 'internationalised internal armed conflicts':*** There is a clear distinction between *internal* and *internationalised* internal armed conflicts based on the definition introduced earlier: there is evident involvement of a foreign state in the later. The foreign intervention might be obscure at times, but it is assumed that internal armed conflicts with an apparent third-party support and involvement being fundamentally different from the rest of internal conflicts. We tested our findings by accounting for *internationalised* conflicts in our dependent variable and did not find any noticeable change in our main findings.

(iv) ***exclusion of the observations corresponding to high leverage cases*:** Since there are a number observations within the sample which could be described as 'outliers' and/or 'influential', due to the country-specific characteristics, it is important to ensure that their inclusion does not skew the estimates. We therefore used (i) the approach recommended in Pregibon (1981) to eliminate observations with high leverage from the sample, and (ii) the method advocated by Hosmer and Lemeshow (1989) and Hosmer et al. (2013) to omit observations with large residuals – based on Pearson and Deviance Residuals. Re-estimating (2.1) with after excluding such outliers did not alter the general conclusions and as far as the AME of $x_{i,t} = \beta_{1T}T_{i,t} + \beta_{2T}T_{i,t}^2$ was, respectively, 0.026 (statistically significant at 5%) and 0.037 (statistically significant at 1%).

Finally, we experimented with enhancing the set of country-specific explanatory variables, in particular by including indicators of development level (which were explained in Section 2.3 and listed in Table 2.2), the lagged value of Military Personnel (which we had not originally included on the grounds of ambiguity surrounding its explanatory role as explained in Section 2.3), as well as the variables listed in Table A2.8. In all cases we found the results to support our original conclusion regarding the impact of climatic factor.

Table 2.10. Comparing estimates of specifications (2.1) and (2.4)

Dependent: conflict onset

climatic factor used:	$\beta_{1T}T_{i,t} + \beta_{2T}T_{i,t}^2$ Temperature	$\%\Delta T_{i,t}$ Growth Rate of Temperature	$TD_{i,t}$ Temperature Deviation from Climate	$PD_{i,t}$ Precipitation Deviation from Climate	-- --
(A) Estimates based on equation (2.1) with full sample, reported in Table 2.5; sample size: 4463					
Estimated AME	0.0317***	0.00707**	0.00677*	-0.0042**	--
R^2	0.2819	0.2765	0.2780	0.2757	0.2746
L	-597.23	-601.76	-600.52	-602.39	-603.29
AIC	1326.47	1333.53	1335.055	1334.78	1334.59
BIC	1749.11	1749.77	1764.09	1751.02	1744.42
(B) Estimates based on equation (2.4) with *reduced* sample; sample size: 2678					
Estimated AME	0.21*	0.00821**	0.015**	-0.0116***	--
R^2	0.2542	0.2533	0.2558	0.2551	0.2520
L	-577.9	-578.65	-576.67	-577.28	-579.67
AIC	1251.8	1253.30	1253.35	1250.56	1253.35
BIC	1534.66	1536.15	1547.99	1533.41	1530.31
(C) Estimates based on equation (2.1) with *restricted* sample; sample size: 2224					
Estimated AME	0.0374	0.0173**	0.0154*	-0.00754*	--
R^2	0.1994	0.1983	0.1995	0.1966	0.1955
L	-542.0861	-542.8295	-542.0183	-543.9887	-544.7094
AIC	1216.172	1215.659	1218.037	1217.977	1217.419
BIC	1592.838	1586.618	1600.41	1588.936	1582.671
(D) Estimates based on equation (2.4) with restricted sample; sample size: 2224					
Estimated AME	0.317*	0.0162**	0.0182**	-0.00891**	--
R^2	0.2563	0.2546	0.2567	0.2535	0.2518
L	-503.5323	-504.7215	-503.2512	-505.4388	-506.583
AIC	1103.065	1103.443	1104.502	1104.878	1105.166
BIC	1377.004	1371.675	1384.148	1373.11	1367.691

- See the notes below Table 2.5. The dependent variable in all cases, the set of regressors in (A) and (C) and the sample in (A) are identical to that used in Table 2.5. The set of regressors in (B) and (D) replace the country-specific explanatory variables with country-specific fixed effects. The sample size in (A) and (B) is the maximum possible number of observations in each case and in (C) and (D) is the maximum possible common observations.

2.5. Summary and conclusion

In this chapter we have empirically examined the existence and robustness of the relationship between climatic factors and the probability of onset of armed conflicts once all other relevant factors are accounted for. This was motivated by the *received wisdom* which identifies several channels relating climatic factors to conflicts which could be grouped as:

(i) The indirect long-term channels that operate through altering other risk factors by affecting, for example, economic wellbeing – such as the level of production in the agricultural sector.

(ii) The more direct long-term channels which function via changing the environment and therefore affecting attitude towards aggression and violence.

(iii) The short-term climatic shocks – such as heat waves, droughts or floods – which significantly disrupt life via causing sudden severe shortages and even epidemic of diseases. These could then result in poverty and force migration hence leading to fertile grounds for conflict.

It is therefore important to understand whether climatic factors have a significant effect on conflict after taking into account the impact of all other contributing factors. In order to examine this question empirically, we have constructed a dataset consisting of a sample of 139 countries over the period 1961-2011 which, for each country-year observation, contains the relevant country-specific characteristics which are believed to feature in affecting the probability of an armed conflict as well as recording whether there has been an armed conflict. In particular, we have constructed different measures of climatic factors based on daily record of temperature and precipitation in each country. We used CRU TS3.22 (Harris et al. 2014) dataset, which provides monthly gridded fields based on daily values and is calculated on high-resolution (0.5x0.5 degree) grids based on an archive of monthly values provided by thousands of weather stations distributed globally. Therefore, after matching the weather stations by their host countries and measuring the annual values of our main variables, we prepared the climatic dataset corresponding to our sample in a country-year format.

After establishing that (i) a steady and persistent climate warming cannot be ruled out, and (ii) there is a significant positive correlation between the incidence of armed conflicts and climate warming, we have used our dataset to estimate the direct contribution of each of the climatic factors once all other likely country-specific elements are accounted for. Our findings suggest that climate warming is instrumental in raising the probability of onset of armed conflicts. Given the robustness of this finding, it conveys an important policy message. In addition to this message, which results from the main focus of our research, a number of points are worth highlighting:

- Dividing the sample by grouping the observations into *cold*, *mild*, and *hot* climates shows that the nature of climate matters and that change in climatic factors are likely to have different impact – in terms of magnitude and sign – in different climates. In particular, change in climatic factors in *hot* regions is found to be more effective.

- By allowing a time lag for the effect of climatic factors we have found that passage of time does not erode the climate effect.

- Examining whether there is an interdependency in the way temperature and precipitation (the two main climatic factors) affect the onset of conflicts, we have found that dryness (low precipitation) increases the effect of temperature growth.

- We have established that allowing country fixed effects to capture all country-specific characteristics does not alter the qualitative conclusions but leads to an over-estimation of the impact of climatic factors. We have indicated that this could be due to the fact that this method restricts the sample to conflict countries only hence could, in practice, be subject to sample selection bias.

- Comparing the standardised marginal effect of variables of interest we have found *peace duration*, *annual temperature*, and *population* to play the most influential (in terms of significant quantitative impact) respectively. While *peace duration* and *population* have been highlighted in the literature as being the more important factors, our finding regarding the robust impact of *annual temperature* is a significant contribution to the literature which reports unclear and vague results in this respect.

- Finally, while conducting this study, we found some evidence implying the existence of a complex relationship between *Per Capita GDP* and conflict: *Per Capita GDP* only possesses a significant coefficient when it is interacted with *Regime Instability* (see the results in Table A2.6 in the Appendix). In other words, the impact of a change in per capita income is contingent on political factors. This finding, together with the discussion in the literature on the role of economic and political development in the literature, motivates the research question for the next chapter. Using *Per Capita GDP* as an indicator of economic development and capturing the level of political development by various interpretations of the *Polity Score* in Chapter 3 we shall focus on the robust specification of the joint contribution of these after all other relevant factors are accounted for.

Appendix

Table A2.1. Full list of conflicts in the sample

Year	GWNO	Location	Side A	Side B
1989	**41**	Haiti	Haiti	Military faction (forces of Himmler Rebu and Guy Francois)
1991	**41**	Haiti	Haiti	Military faction (forces of Raol Cédras)
2004	**41**	Haiti	Haiti	FLRN, OP Lavalas (Chimères)
1965	**42**	Dominican Republic	Dominican Republic	Military faction (Constitutionalists)
1990	**52**	Trinidad and Tobago	Trinidad and Tobago	Jamaat al-Muslimeen
1994	**70**	Mexico	Mexico	EZLN
1996	**70**	Mexico	Mexico	EPR
1963	**90**	Guatemala	Guatemala	FAR I
1965	**90**	Guatemala	Guatemala	FAR I
1972	**92**	El Salvador	El Salvador	Military faction (forces of Benjamin Mejia)
1979	**92**	El Salvador	El Salvador	ERP, FPL
1977	**93**	Nicaragua	Nicaragua	FSLN
1982	**93**	Nicaragua	Nicaragua	Contras/FDN
1989	**95**	Panama	Panama	Military faction (forces of Moisés Giroldi)
1964	**100**	Colombia	Colombia	FARC
1962	**101**	Venezuela	Venezuela	Military faction (navy)
1982	**101**	Venezuela	Venezuela	Bandera Roja
1992	**101**	Venezuela	Venezuela	Military faction (forces of Hugo Chávez)
1965	**135**	Peru	Peru	ELN, MIR
1982	**135**	Peru	Peru	Sendero Luminoso
2007	**135**	Peru	Peru	Sendero Luminoso
1967	**145**	Bolivia	Bolivia	ELN
1989	**150**	Paraguay	Paraguay	Military faction (forces of Andres Rodriguez)
1973	**155**	Chile	Chile	Military faction (forces of Augusto Pinochet, Toribio Merino and Leigh Guzman)
1963	**160**	Argentina	Argentina	Military faction (Colorados)
1974	**160**	Argentina	Argentina	ERP
1972	**165**	Uruguay	Uruguay	MLN/Tupamaros
1971	**200**	United Kingdom	United Kingdom	PIRA
1998	**540**	Angola	Angola	UNITA
2002	**540**	Angola	Angola	FLEC-FAC, FLEC-R
2004	**540**	Angola	Angola	FLEC-FAC
2007	**540**	Angola	Angola	FLEC-FAC
2009	**540**	Angola	Angola	FLEC-FAC
1977	**541**	Mozambique	Mozambique	Renamo
1967	**552**	Zimbabwe (Rhodesia)	Zimbabwe (Rhodesia)	ZAPU
1973	**552**	Zimbabwe (Rhodesia)	Zimbabwe (Rhodesia)	ZANU, ZAPU
1966	**560**	South Africa	South Africa	SWAPO
1981	**560**	South Africa	South Africa	ANC
1985	**560**	South Africa	South Africa	ANC
1971	**580**	Madagascar (Malagasy)	Madagascar (Malagasy)	Monima
1971	**600**	Morocco	Morocco	Military faction (forces of Mohamed Madbouh)
1975	**600**	Morocco	Morocco	POLISARIO
1991	**615**	Algeria	Algeria	Takfir wa'l Hijra
1980	**616**	Tunisia	Tunisia	Résistance Armée Tunisienne
2011	**620**	Libya	Libya	NTC, Forces of Muammar Gaddafi
1963	**625**	Sudan	Sudan	Anya Nya
1971	**625**	Sudan	Sudan	Sudanese Communist Party
1976	**625**	Sudan	Sudan	Islamic Charter Front
1983	**625**	Sudan	Sudan	SPLM/A
2011	**625**	Sudan	Sudan	Republic of South Sudan
1966	**630**	Iran	Iran	KDPI
1979	**630**	Iran	Iran	KDPI
1979	**630**	Iran	Iran	MEK
1979	**630**	Iran	Iran	APCO
1986	**630**	Iran	Iran	MEK
1990	**630**	Iran	Iran	KDPI

GWNO (Gleditsch-Ward numbers) is the most common way of identifying countries by digits. *Side A* identifies the government side of the internal conflict. *Side B* identifies the opposition actor which usually includes a military opposition organisation.

Table A2.1. Full list of conflicts (continued)

Year	GWNO	Location	Side A	Side B
1998	**200**	United Kingdom	United Kingdom	RIRA
1961	**220**	France	France	OAS
1978	**230**	Spain	Spain	ETA
1985	**230**	Spain	Spain	ETA
1991	**230**	Spain	Spain	ETA
1992	**359**	Moldova	Moldova	PMR
1989	**360**	Rumania	Rumania	NSF
1990	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Republic of Armenia
1990	**365**	Russia (Soviet Union)	Russia (Soviet Union)	APF
1993	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Parliamentary forces
1994	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Chechen Republic of Ichkeria
1999	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Chechen Republic of Ichkeria
1999	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Wahhabi movement of the Buinaksk district
2007	**365**	Russia (Soviet Union)	Russia (Soviet Union)	Forces of the Caucasus Emirate
1991	**372**	Georgia	Georgia	National Guard and Mkhedrioni
1992	**372**	Georgia	Georgia	Republic of Abkhazia
1992	**372**	Georgia	Georgia	Republic of South Ossetia
2004	**372**	Georgia	Georgia	Republic of South Ossetia
1993	**373**	Azerbaijan	Azerbaijan	Military faction (forces of Suret Husseinov)
1995	**373**	Azerbaijan	Azerbaijan	OPON forces
1990	**432**	Mali	Mali	MPA
1994	**432**	Mali	Mali	FIAA
2007	**432**	Mali	Mali	ATNMC
1990	**433**	Senegal	Senegal	MFDC
1992	**433**	Senegal	Senegal	MFDC
1995	**433**	Senegal	Senegal	MFDC
1997	**433**	Senegal	Senegal	MFDC
2000	**433**	Senegal	Senegal	MFDC
2003	**433**	Senegal	Senegal	MFDC
2011	**433**	Senegal	Senegal	MFDC
1991	**630**	Iran	Iran	MEK
1993	**630**	Iran	Iran	KDPI
1996	**630**	Iran	Iran	KDPI
1997	**630**	Iran	Iran	MEK
1999	**630**	Iran	Iran	MEK
2005	**630**	Iran	Iran	PJAK
1984	**640**	Turkey	Turkey	PKK
1991	**640**	Turkey	Turkey	Devrimci Sol
2005	**640**	Turkey	Turkey	MKP
1961	**645**	Iraq	Iraq	KDP
1963	**645**	Iraq	Iraq	Military faction (forces of Abd as-Salam Arif), NCRC
1973	**645**	Iraq	Iraq	KDP
1982	**645**	Iraq	Iraq	SCIRI
1987	**645**	Iraq	Iraq	SCIRI
1991	**645**	Iraq	Iraq	SCIRI
1995	**645**	Iraq	Iraq	PUK
1993	**651**	Egypt	Egypt	al-Gama'a al-Islamiyya
1966	**652**	Syria	Syria	Military faction (forces loyal to Nureddin Atassi and Youssef Zeayen)
1979	**652**	Syria	Syria	Muslim Brotherhood
2011	**652**	Syria	Syria	FSA
1975	**660**	Lebanon	Lebanon	LNM
1982	**660**	Lebanon	Lebanon	LNM
1990	**666**	Israel	Israel	Hezbollah
2000	**666**	Israel	Israel	Fatah, PNA
2006	**666**	Israel	Israel	Hezbollah
1979	**670**	Saudi Arabia	Saudi Arabia	JSM
1992	**702**	Tajikistan	Tajikistan	UTO
1998	**702**	Tajikistan	Tajikistan	Forces of Khudoberdiyev, UTO
2010	**702**	Tajikistan	Tajikistan	IMU
1999	**704**	Uzbekistan	Uzbekistan	IMU

Table A2.1. Full list of conflicts (continued)

Year	GWNO	Location	Side A	Side B	Year	GWNO	Location	Side A	Side B
1975	**435**	Mauritania	Mauritania	POLISARIO	2004	**704**	Uzbekistan	Uzbekistan	JIG
1991	**436**	Niger	Niger	FLAA	1961	**750**	India	India	NNC
1994	**436**	Niger	Niger	CRA	1966	**750**	India	India	MNF
1995	**436**	Niger	Niger	FDR	1969	**750**	India	India	CPI-ML
1997	**436**	Niger	Niger	UFRA	1979	**750**	India	India	TNV
2007	**436**	Niger	Niger	MNJ	1982	**750**	India	India	PLA
2000	**438**	Guinea	Guinea	RFDG	1983	**750**	India	India	Sikh insurgents
1987	**439**	Burkina Faso	Burkina Faso	Popular Front	1989	**750**	India	India	Kashmir Insurgents
1980	**450**	Liberia	Liberia	Military faction (forces of Samuel Doe)	1989	**750**	India	India	ABSU
1989	**450**	Liberia	Liberia	NPFL	1990	**750**	India	India	PWG
2000	**450**	Liberia	Liberia	LURD	1990	**750**	India	India	ULFA
1966	**452**	Ghana	Ghana	NLC	1992	**750**	India	India	NSCN - IM
1981	**452**	Ghana	Ghana	Military faction (forces of Jerry John Rawlings)	1992	**750**	India	India	ATTF
1983	**452**	Ghana	Ghana	Military faction (forces of Ekow Dennis and Edward Adjei-Ampofo)	1992	**750**	India	India	PLA
1986	**461**	Togo	Togo	MTD	1993	**750**	India	India	NDFB
1984	**471**	Cameroon	Cameroon	Military faction (forces of Ibrahim Saleh)	1994	**750**	India	India	ULFA
1966	**475**	Nigeria	Nigeria	Military faction (forces of Patrick Nzeogwu)	1995	**750**	India	India	NLFT
1967	**475**	Nigeria	Nigeria	Republic of Biafra	1996	**750**	India	India	MCC, PWG
2004	**475**	Nigeria	Nigeria	Ahlul Sunnah Jamaa	1997	**750**	India	India	ATTF, NLFT
2004	**475**	Nigeria	Nigeria	NDPVF	1997	**750**	India	India	KNF
2009	**475**	Nigeria	Nigeria	Jama'atu Ahlis Sunna Lidda'awati wal-Jihad	2000	**750**	India	India	NSCN - IM
2011	**475**	Nigeria	Nigeria	Jama'atu Ahlis Sunna Lidda'awati wal-Jihad	2003	**750**	India	India	UNLF
2009	**482**	Central African Republic	Central African Republic	CPJP	2006	**750**	India	India	NLFT
1966	**483**	Chad	Chad	Frolinat	2008	**750**	India	India	DHD - BW
1976	**483**	Chad	Chad	FAN	2008	**750**	India	India	PULF
1989	**483**	Chad	Chad	Islamic Legion, Revolutionary Forces of 1 April, MOSANAT	2009	**750**	India	India	NDFB - RD
1997	**483**	Chad	Chad	FARF, MDD	1971	**770**	Pakistan	Pakistan	Mukti Bahini
2005	**483**	Chad	Chad	FUCD	1974	**770**	Pakistan	Pakistan	BLF
1993	**484**	Congo	Congo	Ninjas	1990	**770**	Pakistan	Pakistan	MQM
1964	**490**	DR Congo (Zaire)	DR Congo (Zaire)	CNL	1995	**770**	Pakistan	Pakistan	MQM

Table A2.1. Full list of conflicts (continued)

Year	GWNO	Location	Side A	Side B	Year	GWNO	Location	Side A	Side B
1967	**490**	DR Congo (Zaire)	DR Congo (Zaire)	Opposition militias	2004	**770**	Pakistan	Pakistan	BLA
2006	**490**	DR Congo (Zaire)	DR Congo (Zaire)	CNDP	2007	**770**	Pakistan	Pakistan	TNSM
2007	**490**	DR Congo (Zaire)	DR Congo (Zaire)	BDK	2011	**770**	Pakistan	Pakistan	BLA
1971	**500**	Uganda	Uganda	Military faction (forces of Idi Amin)	1975	**771**	Bangladesh	Bangladesh	JSS/SB
1974	**500**	Uganda	Uganda	Military faction (forces of Charles Arube)	1971	**780**	Sri Lanka	Sri Lanka	JVP
1994	**500**	Uganda	Uganda	LRA	1984	**780**	Sri Lanka	Sri Lanka	LTTE, TELO
1982	**501**	Kenya	Kenya	Military faction (forces of Hezekiah Ochuka)	1989	**780**	Sri Lanka	Sri Lanka	JVP
1965	**516**	Burundi	Burundi	Military faction (forces loyal to Gervais Nyangoma)	2003	**780**	Sri Lanka	Sri Lanka	LTTE
1991	**516**	Burundi	Burundi	Palipehutu	2005	**780**	Sri Lanka	Sri Lanka	LTTE
1994	**516**	Burundi	Burundi	CNDD	1996	**790**	Nepal	Nepal	CPN-M
2008	**516**	Burundi	Burundi	Palipehutu-FNL	1974	**800**	Thailand	Thailand	CPT
1996	**517**	Rwanda	Rwanda	ALiR	2003	**800**	Thailand	Thailand	Patani insurgents
1991	**522**	Djibouti	Djibouti	FRUD	1967	**811**	Cambodia (Kampuchea)	Cambodia (Kampuchea)	KR
1999	**522**	Djibouti	Djibouti	FRUD - AD	1990	**811**	Cambodia (Kampuchea)	Cambodia (Kampuchea)	FUNCINPEC, KPNLF, KR
1964	**530**	Ethiopia	Ethiopia	ELF	1989	**812**	Laos	Laos	LRM
1964	**530**	Ethiopia	Ethiopia	Ogaden Liberation Front	1963	**820**	Malaysia	Malaysia	CCO
1975	**530**	Ethiopia	Ethiopia	ALF	1974	**820**	Malaysia	Malaysia	CPM
1976	**530**	Ethiopia	Ethiopia	EPRP, TPLF	1981	**820**	Malaysia	Malaysia	CPM
1976	**530**	Ethiopia	Ethiopia	WSLF	1969	**840**	Philippines	Philippines	CPP
1977	**530**	Ethiopia	Ethiopia	OLF	1970	**840**	Philippines	Philippines	MIM
1977	**530**	Ethiopia	Ethiopia	SALF	1993	**840**	Philippines	Philippines	ASG, MNLF
1983	**530**	Ethiopia	Ethiopia	OLF	1997	**840**	Philippines	Philippines	CPP
1983	**530**	Ethiopia	Ethiopia	SLM	1999	**840**	Philippines	Philippines	CPP
1991	**530**	Ethiopia	Ethiopia	IGLF	1965	**850**	Indonesia	Indonesia	OPM
1993	**530**	Ethiopia	Ethiopia	AIAI	1967	**850**	Indonesia	Indonesia	OPM
1994	**530**	Ethiopia	Ethiopia	OLF	1975	**850**	Indonesia	Indonesia	Fretilin
1996	**530**	Ethiopia	Ethiopia	ONLF, AIAI	1976	**850**	Indonesia	Indonesia	OPM
1996	**530**	Ethiopia	Ethiopia	ARDUF	1981	**850**	Indonesia	Indonesia	OPM
1998	**530**	Ethiopia	Ethiopia	ONLF	1984	**850**	Indonesia	Indonesia	OPM
1998	**530**	Ethiopia	Ethiopia	OLF	1990	**850**	Indonesia	Indonesia	GAM

Table A2.1. Full list of conflicts (continued)

Year	GWNO	Location	Side A	Side B	Year	GWNO	Location	Side A	Side B
1997	**531**	Eritrea	Eritrea	EIJM - AS	1992	**850**	Indonesia	Indonesia	Fretilin
1999	**531**	Eritrea	Eritrea	EIJM - AS	1997	**850**	Indonesia	Indonesia	Fretilin
2003	**531**	Eritrea	Eritrea	EIJM - AS	1999	**850**	Indonesia	Indonesia	GAM
1991	**540**	Angola	Angola	FLEC-R	1989	**910**	Papua New Guinea	Papua New Guinea	BRA
1994	**540**	Angola	Angola	FLEC-FAC, FLEC-R	1992	**910**	Papua New Guinea	Papua New Guinea	BRA
1996	**540**	Angola	Angola	FLEC-FAC					

Table A2.2. Conflict data categories

Onset of conflicts (ongoing as missing)			Onset of conflicts			Incidence of conflicts		
	Number	%		Number	%		Number	%
No conflict	5,286	95.85	**No conflict**	6,123	95.97	**No conflict**	5,286	82.85
Minor	190	3.45	**Internal conflict**	229	3.59	**Internal conflict**	938	14.7
Major	39	0.70	**Internationalised**	28	0.44	**Internationalised**	156	2.45
Total	5,515	100	**Total**	6,380	100	**Total**	6,380	100

Table A2.3. Missing observations

Variable	Missing (%)	Missing (#)	Available/Total
Military Personnel	50.4	3217	3163/6380
GDP Growth	10.5	668	5712/6380
GDP Per Capita	10.4	661	5719/6380
Anocracy	1.3	83	6297/6380
Regulation of Political Participation	1.3	83	6297/6380
Regime Instability	0.8	50	6330/6380
Population	0.0	3	6377/6380
Neighbouring Conflict	0.0	0	6380/6380
Peace Duration	0.0	0	6380/6380
Ethnic Heterogeneity Index	0.0	0	6380/6380
Oil Exporter	0.0	0	6380/6380
Cold War	0.0	0	6380/6380
Rough Terrain	0.0	0	6380/6380
MENA	0.0	0	6380/6380
Temperature	0.0	0	6380/6380
Precipitation	0.0	0	6380/6380

Table A2.4. Sample autocorrelations coefficients for the annual average temperature and precipitation levels

lags	**0**	**1**	**2**	**3**	**4**
1	0.9978 (0.9592)				
2	0.9975 (0.9589)	0.9979 (0.9590)			
3	0.9974 (0.9571)	0.9974 (0.9589)	0.9979 (0.9591)		
4	0.9972 (0.9559)	0.9973 (0.9568)	0.9975 (0.9588)	0.9979 (0.9593)	
5	0.9972 (0.9573)	0.9972 (0.9554)	0.9974 (0.9568)	0.9975 (0.9585)	0.9979 (0.9595)

The figures in parentheses are the coefficients for precipitation. All coefficient estimates are statistically significantly different from zero at 1%.

Table A2.5. Summary statistics for the regions

Regions	**Number**	**%**	**Cum. %**
Western Europe and the US	816	12.8	12.8
Eastern Europe and Central Asia	619	9.7	22.5
Middle east and North Africa	897	14.06	36.55
South and East Asia and Oceania	1,034	16.21	52.77
Latin America	1,116	17.5	70.27
Sub-Saharan Africa	1,898	29.75	100
Total	6,380	100	

Table A2.6. Logit estimates of equation (2.1) with different climatic factors: log odds of selected explanatory variables

Dependent: conflict onset	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Regressors $x_{i,t}$:	--	$CT_{i,t}$	$CP_{i,t}$	$T_{i,t}$	$P_{i,t}$	$TD_{i,t}$	$PD_{i,t}$	$\Delta T_{i,t}$	$\Delta P_{i,t}$	$\%\Delta T_{i,t}$	$\%\Delta P_{i,t}$	$Humidex_{i,t}$
Regime Instability	-2.067	-2.206	-1.950	-2.170	-1.886	-2.012	-2.037	-2.109	-2.069	-2.133	-2.067	-2.108
[decaying]	(-1.47)	(-1.64)	(-1.37)	(-1.61)	(-1.32)	(-1.40)	(-1.44)	(-1.49)	(-1.47)	(-1.50)	(-1.47)	(-1.54)
GDP Per Capita	-0.230*	-0.214	-0.227*	-0.213	-0.227*	-0.228*	-0.232*	-0.233*	-0.230*	-0.235*	-0.230*	-0.225*
[real, log, lagged]	(-1.90)	(-1.63)	(-1.88)	(-1.60)	(-1.88)	(-1.86)	(-1.90)	(-1.92)	(-1.89)	(-1.94)	(-1.90)	(-1.75)
GDP Per Capita	0.459**	0.489**	0.443**	0.483**	0.435**	0.449**	0.456**	0.465**	0.460**	0.469**	0.459**	0.468**
& Regime Instability	(2.23)	(2.46)	(2.11)	(2.43)	(2.07)	(2.12)	(2.19)	(2.24)	(2.23)	(2.25)	(2.23)	(2.33)
[interacted]												
Peace Duration	2.235***	2.156***	2.228***	2.151***	2.226***	2.245***	2.238***	2.246***	2.237***	2.245***	2.235***	2.164***
[decaying]	(7.57)	(6.93)	(7.56)	(6.88)	(7.52)	(7.46)	(7.55)	(7.59)	(7.56)	(7.59)	(7.58)	(7.02)
Ethnic Heterogeneity Index	0.0121***	0.00927***	0.0122***	0.00913***	0.0123***	0.0121***	0.0120***	0.0121***	0.0121***	0.0121***	0.0121***	0.0105***
[Index]	(3.70)	(2.92)	(3.82)	(2.86)	(3.87)	(3.69)	(3.66)	(3.71)	(3.69)	(3.72)	(3.71)	(3.34)
Rough Terrain	0.128	0.299***	0.107	0.306***	0.0953	0.134*	0.127	0.128	0.127	0.128	0.128	0.230**
[% in Total]	(1.60)	(2.74)	(1.19)	(2.80)	(1.08)	(1.67)	(1.58)	(1.60)	(1.58)	(1.60)	(1.60)	(2.18)
Population	0.363***	0.411***	0.347***	0.412***	0.337***	0.360***	0.365***	0.363***	0.364***	0.362***	0.363***	0.406***
[log, lagged]	(4.89)	(5.78)	(4.60)	(5.75)	(4.48)	(4.79)	(4.88)	(4.90)	(4.89)	(4.92)	(4.89)	(5.79)
GDP Growth	0.0115*	0.0109	0.0113*	0.0107	0.0114	0.0114*	0.0115*	0.0111	0.0114*	0.0111	0.0115*	0.0107
[real, lagged]	(1.73)	(1.64)	(1.67)	(1.61)	(1.64)	(1.72)	(1.71)	(1.63)	(1.70)	(1.64)	(1.74)	(1.61)
Climate: $\beta_{1x}x_{i,t}$		0.477**	1.063	0.521**	1.677	0.448**	-0.00073**	0.158*	-0.00033	0.0962**	0.000473	0.0354*
		(2.09)	(0.79)	(2.21)	(1.39)	(2.27)	(-2.12)	(1.74)	(-0.94)	(2.31)	(0.15)	(1.73)
Climate: $\beta_{2x}x_{i,t}^2$		0.250*	-0.0836	0.239*	-0.132	-0.0339						
		(1.66)	(-0.78)	(1.73)	(-1.37)	(-0.32)						
Climate: $\beta_{3x}x_{i,t}^3$						-0.0991*						
						(-1.71)						
MENA		0.914*	0.685	0.917*	0.750*	0.637	0.594	0.599	0.583	0.601	0.575	0.794*
[Region dummy]		(1.90)	(1.60)	(1.89)	(1.82)	(1.56)	(1.49)	(1.51)	(1.48)	(1.52)	(1.46)	(1.74)
R^2	0.2746	0.2814	0.2747	0.2819	0.2760	0.2780	0.2757	0.2760	0.2751	0.2765	0.2747	0.2781
L	-603.29	-597.66	-603.29	-597.23	-602.14	-600.52	-602.39	-602.19	-602.94	-601.76	-603.28	-600.46

- The dependent variable 'onset of conflict', is set to unity if there is onset of conflict and to zero otherwise.
- The sample size in all regressions is 4463, consisting an unbalanced combination of 139 countries over the period 1961-2011.
- The numbers in parentheses are the corresponding t-ratios (standard errors are clustered at the country level). R^2 and L are the pseudo R^2 and log pseudo likelihood values respectively.
- '*', '**' and '***' respectively denote significance at 10%, 5% and 1% critical values based on standard errors clustered at the country level.
- We only report the fixed effect of *MENA* region where the base line region is Sub-Saharan Africa.
- The following variables are in Logarithmic format: Population, GDP per capita, Rough Terrain, and Precipitation. This variable is measured in the decaying form $2^{-RD/0.5}$ where RD is the *Regime Instability* defined in Table 2.1. See Hegre and Sambanis (2006) and Gurr and Jaggers (2000) for details of advantages in using this transformation.
- This variable is measured in the decaying form $2^{-PD/8}$ where PD is the *Peace Duration* defined in Table 2.1. See Hegre and Sambanis (2006) for details of advantages in using this transformation.

Table A2.7. Explanatory variables with summary statistics, by history of conflict within the sample period

Variable	Number of Observation	Mean	Std. Dev.	Min	Max	Number of Observation	Mean	Std. Dev.	Min	Max
	History of conflict					No history of conflict				
Regime Instability	4004	0.135	0.320	0	1	2326	0.061	0.221	0	1
Per Capita GDP	3691	7.171	1.333	3.913	10.724	2028	8.646	1.573	4.424	11.314
Peace Duration	4052	0.58256	0.36318	0.0055	1	2328	0.1678	0.2249	0.00358	1
Ethnic Heterogeneity Index	4052	50.945	32.174	1	144	2328	36.189	35.241	0	144
Rough Terrain	4052	2.180	1.380	0	4.421	2328	1.844	1.520	0	4.557
Population	4052	16.231	1.429	12.534	20.923	2325	15.602	1.570	12.305	21.019
GDP Growth	3676	4.00581	7.56162	-64.05	189.829	2036	3.9801	5.2789	-41.8	33.991
Military Personnel	1893	1.697	0.785	0	4.386	1134	1.820	0.7	0.248	4.146
Regulation of Political Participation Index	3972	3.21903	1.1723	0	5	2325	3.8886	1.1964	0	5
Anocracy	3972	0.290	0.454	0	1	2325	0.138	0.345	0	1
Cold War	4052	.207798	.405781	0	1	2328	.22551	.41801	0	1
Oil exporter	4052	0.212	0.409	0	1	2328	0.100	0.300	0	1
Neighbouring Conflict	4052	0.64955	0.47716	0	1	2328	0.5180	0.4997	0	1
Latitude	4052	0.219	0.149	0.011	0.667	2328	0.387	0.196	0.014	0.711
Malaria	4052	49.673	43.679	0	100	2245	17.589	34.570	0	100
Soil Quality	4052	12.66	9.344	0.154	48.1481	2154	13.02	8.768	0	55.073
Tropical Area	4052	48.353	43.365	0	100	2245	21.733	36.126	0	100
Crop Production Index	4020	72.32	30.929	7.61	235.67	2291	89.768	63.566	1.35	962.57
Tropics	4052	0.65079	0.47678	0	1	2328	0.279	0.448	0	1
Temperature	4052	70.886	11.695	20.12	85.64	2328	57.917	15.704	18.68	84.38
Precipitation	4052	1127.26	806.017	21.5	3635.8	2328	1034.4	721.27	13.4	3675.7
Climate Temperature	4052	70.572	11.698	22.364	83.84	2328	57.498	15.742	22.082	82.37
Climate Precipitation	4052	6.6569	1.0161	3.0680	8.1985	2328	6.6383	.89414	2.59525	8.2094
Temperature Deviation from Climate	4052	0.315	0.765	-2.322	4.122	2328	0.419	1.019	-3.48	4.356
Precipitation Deviation from Climate	4052	-2.248	161.848	-724.7	898.37	2328	3.359	165.50	-919.58	1340.1
Change in Temperature	4052	0.017	0.847	-4.32	3.6	2328	0.024	1.165	-5.4	5.22
Change in Precipitation	4052	0.265	214.39	-1186.3	1089.5	2328	-0.409	234.44	-1864.2	1745.2
Growth Rate of Temperature	4052	0.038	1.536	-13.79	17.425	2328	0.085	2.744	-20.866	26.017
Growth Rate of Precipitation	4052	2.622	24.816	-73.2	300.453	2328	3.686	33.243	-82.572	471.37
Humidex Index	4052	26.1561	9.82575	-10.58	40.5764	2328	16.015	12.453	-11.689	39.249

Table A2.8. Extra variables used for robustness checks

Variable	Concept[1]	Description	Source
Ethnic fractionalization index	Ethnic fragmentation	Using the structural distance between languages as a proxy for the cultural between groups in a country	Fearon (2003)
Ethnolinguistic diversity	Ethnic fragmentation	ranges from 0 to 100 and measures the probability that two randomly selected individuals belong to different ethnolinguistic groups	Collier and Hoeffler (2004)
Language diversity	Ethnic fragmentation	Number of languages in Ethnologue	Fearon and Laitin (2003)
Share of largest ethnic group	Ethnic fragmentation	Share of largest ethnic group	Fearon and Laitin (2003)
Language diversity	Ethnic fragmentation	Linguistic component of ehet	Vanhanen (1999)
Religion diversity	Ethnic fragmentation	Religious component of ehet	Vanhanen (1999)
Ethnic dominance	Ethnic dominance/polarisation	Ethnic dominance measure	Collier and Hoeffler (2004)
Oil production	Resources	Oil production in metric tons. 1932-69: USGS, 1970-2000: WB, 2001-2011: EIA	Ross (2013)
Oil exports	Resources	In thousands barrels per day. Data from EIA	Ross (2013)
Partially free Polity	Inconsistency of political institutions	Dummy for a country with limited respect for political rights and civil liberties	Freedom House (2013)
Regime instability dummy	Political instability	whether the country had a change of Polity score in any of the three prior years[2]	Author's coding using Polity IV
Presidential democracy	Political system	Presidential democracy system	Cheibub et al. (2010)
Autonomy	Political system	Country has de facto autonomous regions	Hegre and Sambanis (2006)
Neighbours' median polity	Neighbourhood political economy	Median polity of the continent	Author's coding
Count of neighbourhood conflicts	Neighbourhood war	Total number of neighbours at war in a given year	Hegre and Sambanis (2006)

[1] See the categorisations in Hegre and Sambanis (2006).
[2] Originally the change in Polity score should be equal or greater than three; see Fearon and Laitin (2003) for details.

Chapter 3

Internal Armed Conflicts: contribution of Economic and Political Development

3.1. Introduction

High levels of national wealth and development and consistent democracy are widely regarded as important factors that contribute to sustained civil peace (Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Hegre and Sambanis, 2006; Collier and Rohner, 2008). However, repeated occurrences of conflicts in democratic regimes – e.g. India (1961, 1966, 1983, 1989, 1995, 1997, 2005, 2008) and Philippines (1993, 1997, 1999)[19] – and their complete absence in some rich countries with non-democratic regimes – such as Kuwait or Saudi Arabia – are counter examples that cannot be simply regarded as exceptions.[20]

Understanding the underlying causes of the anomaly highlighted above is important, in particular because it raises a question regarding whether democracy alone promotes peace, and if not then how does its role interact with the extent of development. A glance through the relevant literature on this issue suggests that both the quality of political institutions and the extent of development matter for the containment of risk of conflicts but there is also evidence that their roles are in fact contingent on each other. Therefore, building on the work of Collier and Rohner (2008), in this chapter we re-examine the empirical determination of probability of onset of internal armed conflicts by focusing on the role of per capita income – which is considered as a proxy for the level of development – and the regime type – which is an indicator of level of democracy and quality of political institutions. Our intensive empirical analysis of a rich dataset suggests that more well-off autocracies seem to be less prone to conflict, where this does not hold for democracies. We also find that major political disruptions could escalate the chances of armed conflicts regardless of the regime type, and that their impact is larger the higher is per capita income. Our findings highlight the importance of political stability in keeping peace and emphasise the role of stable democracy.

The rest of the chapter is organised as follows. Section 3.2 reviews the literature. Section 3.3 describes the data and methodology employed in the empirical analysis. Section 3.4 presents and discusses the empirical evidence based on using a measure of regime type as a proxy for political development and in Section 3.5 we provide evidence based on replacing the regime type measures with those that correspond to regime

[19] The full list of democratic regimes with conflict since 1960 is in Table A3.1 in the Appendix.
[20] To stress this in Table A3.2 in the Appendix we provide the list of countries with high income which have experienced an armed conflict since 1960. Table A3.3, additionally, lists the wealthy autocracies.

instability. Section 3.6 briefly presents our robustness checks and Section 3.7 concludes the chapter.

3.2. Literature review

Internal armed conflicts are amongst the most tormenting development issues of our era (World Economic Forum, 2015 and 2016) and are therefore of utmost concern. A better understanding of how they could be prevented, curtailed and/or contained requires a good knowledge of their cause and impact. Only then can policy makers take on the challenging task of designing policies to avoid their onset and/or to limit their effects. As explained in some detail in Chapter 2, a number of studies have focused on the motivating, or provoking, factors such as 'greed' and 'grievance'. For instance, the rational choice hypothesis considers the civil war phenomenon as an outcome of (a special form of) non-cooperative behaviour within the game theory framework where the greed motive simply reflects opportunities for rebels (or rebel leaders) to enrich themselves, possibly by seizing resource rents. Grievance, in contrast, is seen as a behavioural pattern which is invoked by relative deprivation, social exclusion and inequality. In the case of resource rich countries, insufficiently compensated land expropriation, environmental degradation, insufficient job opportunities, and labour migration could be considered as giving rise to grievance motives. In short, there are three, by now classical, causes of internal armed conflict and insurgency: (i) looting motivation (Collier and Hoeffler, 2004); (ii) religious reforming, nationalist or economic grievances (Gurr, 1971); and (iii) favourable conditions (Fearon and Laitin, 2003). The first two explain the motivation behind insurgency and the third one justifies the feasibility of forming and maintaining insurgent groups. The ongoing research in this area has led to some policy implications which aim at reducing the risk of conflict and encouraging peace. Specifically recommended policies are: (i) stimulating growth and creating jobs – especially for youth (Collier and Hoefller, 2004); (ii) spreading democracy and tolerance for ethnic and religious minorities (Fearon and Laitin, 2003); and (iii) improving state's defence capability (Fearon and Laitin, 2003; Collier and Hoefller, 2004). In addition, the feasibility hypothesis, which is based on the self-fulfilling nature of the conflict phenomenon, proposes that where rebellion is possible, it will occur. Therefore, it is thought to be possible to reduce the onset of armed conflicts by making the circumstances more difficult. For instance, Fearon and Laitin (2003) regard state weakness as the prime source of rebel opportunities.

Models proposed on the basis of both the rational choice and the feasibility hypotheses have been assessed empirically by various studies where a number of explanatory variables, which we outlined and used in Chapter 2, are considered to provide proxies for capturing the relevant measures. In the context of the above hypotheses, for instance, Collier et al. (2009) use the 'per capita GDP', 'GDP growth rate' and 'male secondary education level' as reliable proxies for 'forgone earnings' on the grounds that 'low forgone earnings facilitate conflict' while Fearon and Laitin (2003) regard 'per capita GDP' primarily as a proxy for 'state sovereignty' and therefore represent government's military capabilities.

In addition to the rational choice and feasibility hypotheses, there is a third strand of literature which sees low levels of economic and political development as factors responsible for the onset of armed conflicts. It is argued that the lower is the extent of economic development the smaller will be the opportunity cost of a conflict and this link is stronger at the lower levels of democratic accountability. There is, however, only a limited number of studies that focus on the relationship between development, political institutions, and armed conflicts and they, by and large, do not provide quantitative assessments of the nature of the relationship. Collier and Rohner (2008) is an exception, who use data on incidents of guerrilla warfare[21], as well as COW classification of civil war[22] and find that although the net effect of democracy is ambiguous, it is systematically related to the effect of income. In particular, they claim that "*as* [per capita] *income rises, not only might democracies become safer, but the greater weight placed upon the goal of accountability might make autocracies absolutely more prone to violence*" (p. 532). The only other empirical evidence we have found in the existing literature is reported in Hegre and Nome (2010) who find the relationships between democracy and conflict and development and conflict to be interdependent. Using UCDP/PRIO conflict data and the Scalar Index of Polities (instead of conventional Polity Index) as a proxy for democracy level they find support for the results reported by Collier and Rohner (2008) stating that "*increasing the level of economic development reduces the risk of armed conflict only for democratic countries, and increasing the level of democracy only for developed countries*" (p. 27).

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[21] Defined as any armed activity, sabotage, or bombing aimed at the overthrow of the regime.
[22] See Correlates of War at http://cow.dss.ucdavis.edu/data-sets/COW-war and Sarkees and Wayman (2010). These include any armed conflict that involve: (1) military action internal to the metropole of the state system member; (2) the active participation of the national government; (3) effective resistance by both sides; and (4) a total of at least 1,000 battle-deaths during each year of the war.

This chapter is motivated by the further need for enhancing our understanding of the impact of economic and political developments levels on the onset of internal armed conflicts. We shall therefore attempt to undertake more in depth empirical analysis of the relevant data to explore this question. In Chapter 2 we found per capita GDP to have a correctly signed but statistically insignificant effect on the probability of onset of conflict. We noted that this finding is in agreement with the empirical evidence reported in the literature. However, an additional complication stems from the lack of clarity about the role assigned to per capita income in the literature since it has been used in as a measure of 'development', 'opportunity cost' and/or 'state's sovereignty'. Our aim in this chapter is to further investigate the role of per capita income, particularly in conjunction with the effect of level of democracy, in determining the probability of armed conflicts, after all other likely effects are accounted for.

3.3. Data and methodology

We shall use the same dataset that we constructed and used in Chapter 2. However, given the focus of the research question in this chapter, some further clarifications regarding the choice of the dependent and explanatory variables are required.

First, we shall continue to use the term 'conflict' to refer 'internal armed conflicts' as defined by UCDP, namely: "*a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths*".[23] However, since we shall also examine the incidence of armed conflicts it is worthwhile to pay specific attention to how these two variables are defined and constructed. Our sample consists of data for 139 countries over the period 1961-2011. The onset is characterised by a dichotomous variable denoted by $y_{i,t}$ for country i in year t in the sample. $y_{i,t} = 1$ if a new conflict, or one that is separated from the last onset of any conflict by at least one year, has started in country i in year t. Otherwise, $y_{i,t} = 0$. The incidence, too, is characterised by a dichotomous variable. However, in the case of incidence $y_{i,t} = 1$ if there is an active, newly started or on-going, conflict in country i in year t. Otherwise, $y_{i,t} = 0$.

[23] See Chapter 2 for further details. Armed conflicts are classified into 'internal', 'interstate', 'extra systemic', and 'internationalised internal' types.

Next, it is worthwhile to clarify at the outset the main issues in connection with the use of regression analysis which are based on conditioning the probability of $y = 1$ in a country on variables which represent the country's relevant features. In particular:

(i) There is a potential simultaneity problem since internal armed conflicts could, in principle, alter the socio-economic characteristics of the nation. As a result, we follow the common practice in these circumstances of using the lagged values of the time-varying explanatory variables.[24]

(ii) The onset cases form a subsample of the incidence cases, since incidence not only accounts for all onsets, but also for every observation where there is an active conflict as long as the annual number of fatalities reaches the threshold. Thus, when constructing the onset sample the on-going conflicts are treated as missing. Otherwise a country-year observation with an on-going conflict cannot be distinguished from one with no conflict, which in turn can lead to inaccurate results. The top panel of Table 3.1 displays the summary statistics distinguishing between the onset and incidence in the full sample.[25]

(iii) The occurrence of internal armed conflict is not evenly distributed across countries and varies with the extent of economic and political development. As a preliminary indication of this, in the lower part of Table 3.1 we provide the summary statistics for the subsamples based on four groups of countries: 'high-income & democratic', 'high-income & autocratic', 'low-income & democratic', 'low-income & autocratic' which show a non-negligible variation in the frequency of onset and incidence. It is worth to note in passing that according to the relative frequencies reported in the table: (a) democracies have a higher chance of entering into a new conflict compared to autocracies in high and low income countries; and (b) amongst the high-income countries, conflicts last longer in democracies

[24] The alternative approach is to use an appropriate instrumental variable estimator. But in these cases it is difficult to find robust instruments. It might, of course, be argued that the lagged variables should be used as instruments. However, using the lagged variables directly as the explanatory variables is more efficient in these circumstances and, as mentioned above, is also justified on the grounds that it takes time for the effect to materialise.

[25] Collier and Hoeffler (2004) advocate this distinction stating that "*Initiation and duration are radically different processes*" (p. 572). They explain the shortcoming of their previous work in this respect and recommend that "*Ongoing wars are coded as missing observations as to not conflate the analysis of civil war initiation and duration*" (p. 572).

compared to autocracies while the opposite is true for low-income countries. Figures 3.1 and 3.2 further illustrate these points by means of histograms.

Figure 3.1. Number of conflicts by regime type and income level

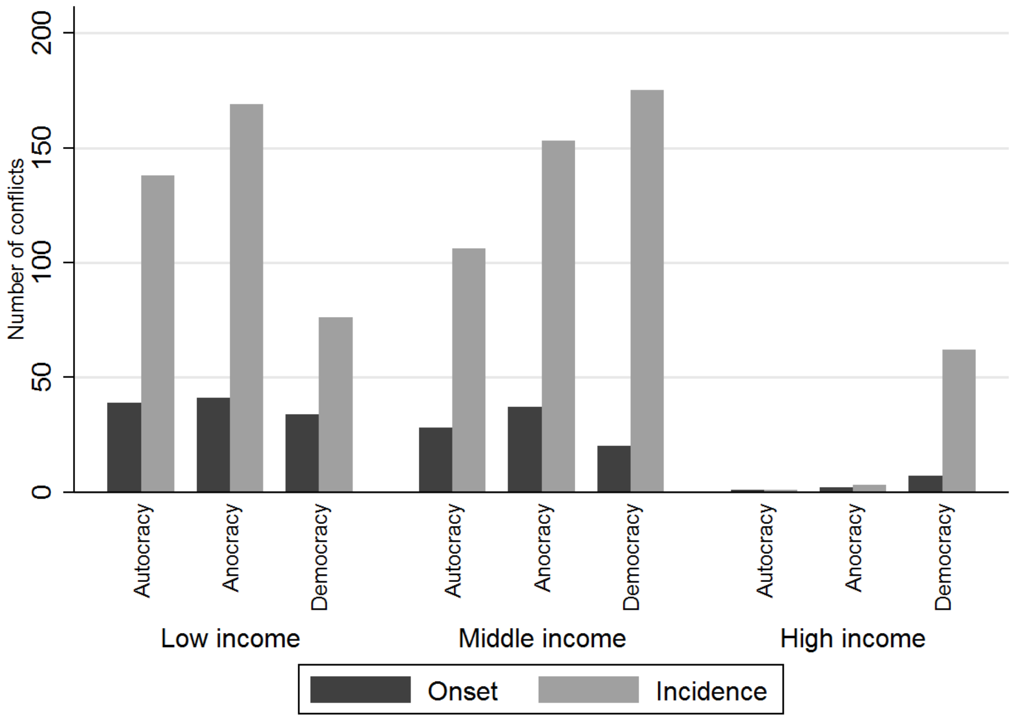
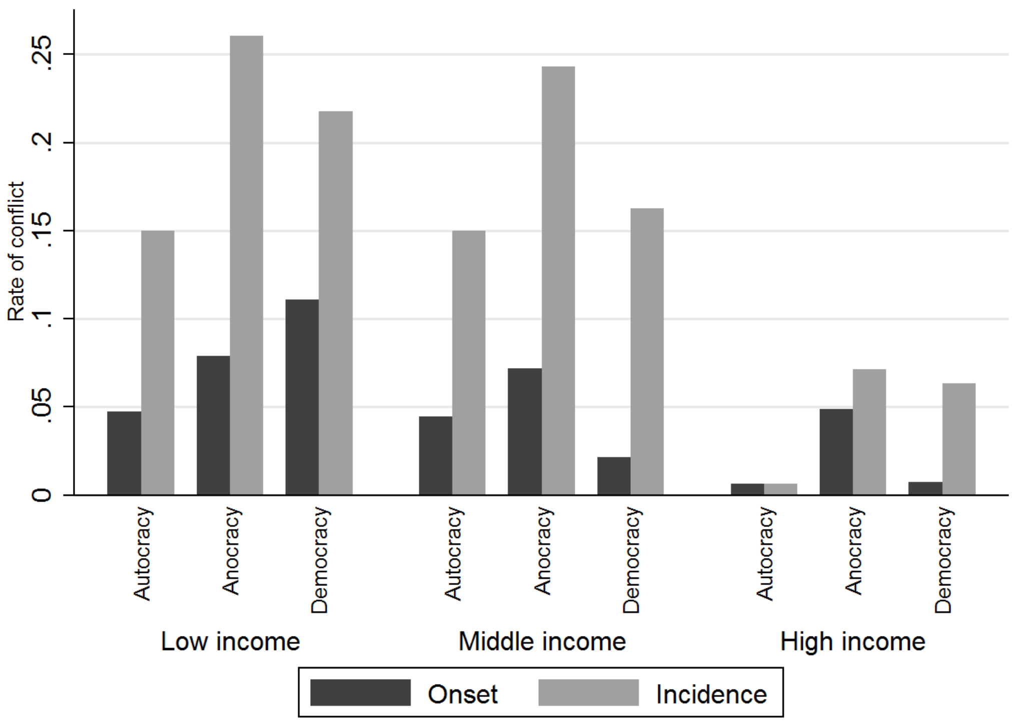


Figure 3.2. Rate of conflicts by regime type and income level



Rate of conflict is measured as sample frequency (observed conflicts / total observations)

Table 3.1. Summary statistics for the internal armed conflicts in the sample[1]

	All Countries in Full Sample								
		Sample Size, N			**100×Mean[5]**			**S.D.**	
Onset[2]		5515			4.15			0.1995	
Onset[3]		6352			3.61			0.1864	
Incidence[4]		6224			15.07			0.3578	
	Countries with High Per Capita Income[6]								
	Democratic Regimes[7]			**Anocratic Regimes[7]**			**Autocratic Regimes[7]**		
	N	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**
Onset[2]	941	0.85	0.0919	41	2.43	0.1561	155	0.65	0.080
Onset[3]	1006	0.80	0.0889	42	2.39	0.1543	155	0.65	0.080
Incidence[4]	997	6.42	0.2452	42	4.76	0.2155	155	0.65	0.0801
	Countries with Middle Per Capita Income[6]								
	Democratic Regimes[7]			**Anocratic Regimes[7]**			**Autocratic Regimes[7]**		
	N	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**
Onset[2]	944	2.22	0.147	528	8.52	0.2794	626	3.19	0.176
Onset[3]	1104	1.90	0.136	652	6.9	0.2536	721	2.77	0.164
Incidence[4]	1102	16.24	0.369	642	24.76	0.4319	707	14.28	0.350
	Countries with Low Per Capita Income[6]								
	Democratic Regimes[7]			**Anocratic Regimes[7]**			**Autocratic Regimes[7]**		
	N	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**	**N**	**100×Mean[5]**	**S.D.**
Onset[2]	315	10.16	0.3026	527	7.21	0.2589	817	5.39	0.2259
Onset[3]	361	8.86	0.2846	681	5.58	0.2297	932	4.72	0.2122
Incidence[4]	361	21.61	0.4121	656	25.46	0.4359	911	15.15	0.3587

[1] We have treated the 'internationalised internal armed conflicts' as missing in order to maintain the focus of analysis on 'Internal armed conflicts'.

[2] All ongoing conflicts are treated as missing.

[3] All ongoing conflicts are treated as no-conflict.

[4] All newly started and ongoing conflicts are treated as a conflict. The reason for differences in the sample size is that in the difference between the onset and incidence internationalised conflicts.

[5] 100×Mean is the relative frequency, given that the variables are set to either 0 or 1.

[6] The income thresholds are $875 and $10725, based on the World Bank evaluations in 2005.

[7] Democratic, anocratic, and autocratic regimes are identified using the Polity Score. See below for further details.

As for the choice of explanatory variable, while we shall use the same variables which we identified and used in the previous chapter – see Table 2.1 in Chapter 2 – here we shall group them differently so as to distinguish the general control variables from those on which we wish to focus. The former group consists of '*Peace Duration*', '*Ethnic Heterogeneity*, '*Rough Terrain*', '*Population*', '*GDP Growth*', a variable representing the climatic factor –the annual average temperature and its growth rate which were found in the previous chapter to have significant impact – as well as dummy variables for '*Cold*

War', '*Oil exporter*', '*Neighbouring Conflict*' and '*Region*'. These variables do not directly reflect the level of development and/or democracy and will always feature as the fixed set of control variables in all our regressions.

The focus group consists of two variables which capture the level of development (how potentially well-off a country is) and democracy (the quality and characteristics of a country's political institutions). For the former, we shall use the real Per Capita GDP in constant $US prices. In addition, we shall also examine if the explanatory role of income is altered when Per Capita GDP is replaced with the per capita income thresholds advocated in World Bank (2014a).

To capture the level of democracy, we shall use the Polity IV index which consists of six component measures that record key qualities of executive recruitment, constraints on executive authority and political competition and is a weighted average score that reflects the 'regime authority spectrum' on a 21-point scale assigning -10 to '*hereditary monarchy*' and +10 to '*consolidated democracy*' as well as the three special cases of '*interregnum*' regimes, regimes in '*transition*' and those having a '*foreign interruption*' which are respectively assigned the score -77, -88 and -66.[26] We shall exclude the latter category from our analysis, in all cases treating them as missing observations, and use $RT_{i,t}^{0}$ in our regressions to denote the Polity Score for country i in year t in the sample.

As an alternative to using the Polity Score itself, which provides a continuous measure of regime types, Collier and Rohner (2008) propose categorising regimes into '*democratic*' and '*non-democratic*'. We shall use $RT_{i,t}^{1}$ in our regressions to denote their dummy variable, which is defined as follows

[26] In our explanations we make frequent use of the key terms 'state', 'government', and 'regime'. Therefore, to prevent any confusion we define these at the outset. Following Hague and Harrop (2013), a state, or a country, is regarded as a sovereign "… *political community formed by a territorial population subject to one government*". As Barfield (1997) explains, general categories of state institutions include administrative bureaucracies, legal systems, and military or religious organisations. A state is, therefore, an indestructible union of citizens having the chief characteristic of permanence and continuity. The 'government' is a part of the state and is said to "*consists of institutions responsible for collective decisions for society*" (Hague and Harrop, 2013). A regime, as explained in Siaroff (2005) and Van den Bosch (2013) is the type of political system that exists in a sovereign state which is considered to be a more permanent form of political organisation than its specific government, but less permanent than the state itself. Political regimes are normally classified by their distance from a 'fully fledged consolidated democracy' which is defined, e.g. by the Economist Intelligence Unit which compiles the Democracy Index, as a situation in which civil liberties and basic political freedoms are respected and reinforced by a political culture conducive to the thriving of democratic principles. According to Morlino (1998, 2004), the minimal definition of democracy suggests that such a regime has all the following characteristics: (i) universal, adult suffrage; (ii) recurring, free, competitive and fair elections; (iii) more than one political party; and (iv) more than one source of information.

- $RT_{i,t}^{1} = 1$ if country *i* in year *t* is has an *non-democratic* regime – i.e. if its Polity Scores is either within [-10, +5] interval or -77 or -88.

- $RT_{i,t}^{1} = 0$ if the country in question is treated as one with a *democratic* regime – i.e. if its Polity Scores is within [+6, +10] interval.

We shall first examine in some detail the explanatory role of $RT_{i,t}^{0}$ and then check whether replacing it with $RT_{i,t}^{1}$ provides a sharper empirical distinction. We then build on this approach following the classification proposed by the Centre for Systemic Peace[27] and examine whether a further dividing of the '*non-democratic*' regimes, associated with $RT_{i,t}^{1} = 1$, can provide any additional insight. To this end, we note that within our sample the proportion of countries that have a *democratic* and an *autocratic* regime is 43.6% and 32%, respectively. To check if *autocracies* are sufficiently distinct from the rest – i.e. from *anocratic* regimes, *interregnum* regimes or regimes in *transition*[28] – we report in Table 3.2 the statistical test results for equality of sample means for the main characteristics of the countries with these regimes. As can be seen from the table, the null hypothesis of equality of means is rejected in all cases. Thus merging *anocracies* and *autocracies* into one group on the assumption that there are ample similarities amongst them could hide differences arising from institutional quality and frequent periods of instability. We therefore define the following dummies to replace the $RT_{i,t}^{1} = 1$ cases:

- $RT_{i,t}^{2} = 1$ if country *i* in year *t* is has an *autocratic* regime, i.e. its Polity scores lies within [-10, -6] interval. $RT_{i,t}^{2} = 0$ otherwise;

- $RT_{i,t}^{3} = 1$ if country *i* in year *t* is has an *anocratic* regime, an *interregnum* regime or a regime in *transition*, i.e. its Polity scores lies within [-5, +5] interval or corresponds to either -77 or -88. $RT_{i,t}^{3} = 0$ otherwise.

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[27] .

[28] In order to facilitate the use of the Polity Score measure in time-series analyses, Marshall and Gurr (2013) applied some simple treatments, or 'fixes', to convert instances of 'standardised authority scores' (-66, -77, and -88) to conventional polity scores, i.e., within the range, -10 to +10, as the follows: -66 Cases of foreign 'interruption' are treated as 'system missing'; -77 Cases of 'interregnum', or anarchy, are converted to a 'neutral' Polity score of '0'; -88 Cases of 'transition' are prorated across the span of the transition. Yet, tracking them down is possible.

Finally, applying the same principle, we shall also consider the effect of separating *anocratic* regimes from *interregnum* regimes and regimes in *transition*, by replacing $RT_{i,t}^{3} = 1$ cases with the following dummies:

- $RT_{i,t}^{4} = 1$ if country *i* in year *t* is has an *anocratic* regime, $RT_{i,t}^{4} = 0$ otherwise;
- $RT_{i,t}^{5} = 1$ if country *i* in year *t* is has an *interregnum* regime or a regime in *transition*, $RT_{i,t}^{5} = 0$ otherwise.

Table 3.2. Autocracy vs. Anocracy: testing the equality of sample means of the main country-specific characteristics

Characteristic	P-value*
Population	0.0000
Peace years	0.0000
GDP growth	0.0292
Ethnic heterogeneity index	0.0000
Rough terrain	0.0002
Annual temperature	0.0001
Oil exporter	0.0000
Neighbour in war	0.0014
GDP per capita	0.0235
Polity index	0.0000
Regime durability	0.0000
Major instability	0.0000

* Probability of not rejecting the null hypothesis of equality based on two sample t-ratio test.

3.4. Evidence on the explanatory role of economic and political development

In this section we provide the results of regression analyses that concentrate on quantifying the impact of economic and political development on conflict. We shall proxy economic and political development respectively by the real per capita income and the Polity score, as outlined above, as our focus explanatory variables and augment all the regressions with the same set of control variables specified above.

3.4.1. Using the Polity score to represent political development

We start our regression analysis with specifications based on GDP^{pc} and RT^{0} where the latter provides a continuous measure of political development. In order to highlight the relevance of these variables in explaining conflicts, in Figures 3.3 and 3.4 we show how annual real per capita GDP and the Polity scores, averaged across the countries within the sample, compare with the conflict patterns when plotted over the sample period, 1961-2011.

Given the nature of aggregation, these figures are, of course, rather illustrative and can only provide an indication of how GDP^{pc} and RT^0 have, on average, evolved over time in comparison the dependent variable. Nevertheless, even at this level of aggregation the existence of some mild counter cyclical pattern is evident which encourages the use of more detailed regression analysis. We therefore start by examining the coefficient estimates of the following general specification

$$y_{i,t} = \alpha_0 + \gamma_0 GDP^{pc}_{i,t-1} + [\beta_0 + \delta_0 GDP^{pc}_{i,t-1}] RT^0_{i,t-1} + [\beta_1 + \delta_1 GDP^{pc}_{i,t-1}] (RT^0_{i,t-1})^2 + \mu_{0,r} + \theta_{0,t} + z'_{i,t-1}\varphi_0 + u^0_{i,t}, \quad (3.1)$$

where $t \in [1, T]$ and $i \in [1, N]$ are the year and country indices respectively, $y_{i,t} = 1$ if there is an onset of an internal armed conflict in country i in year t and $y_{i,t} = 0$ otherwise, $\mu_{0,r}$ is the region fixed effect where each country in the sample is associated with a specific geo-political region denoted by the subscript $r \in [1, R]$, $\theta_{0,t}$ is the year fixed effect, z_i is the vector of the conditioning explanatory variables outlined above, and $u_{i,t}$ is the appropriate disturbance term. The specific functional form of equation (3.1) is postulated on the basis of two main assumption: (i) the impact of regime type is nonlinear, and (ii) the interaction effect of regime type with per capita GDP is inverse-u-shaped. This is because we do not want to rule out, a priori, the possibility that the impact of regime type and the effectiveness of a rise in per capita are enhanced as we approach autocracy or democracy extremes. Nevertheless, to provide a complete picture, we shall also estimate all the relevant restricted versions of (3.1).

Table 3.3 reports the estimated values of the relevant parameters, associated with (3.1) and its restricted versions, which capture the impacts of RT^0 and GDP^{pc}. As can be seen from column (I), the general model in (3.1) is not supported by the data in that none of the crucial coefficients are statistically significant. Looking at the other columns, we also find that the interaction effects too, captured by δ_0 and δ_1, are statistically insignificant (although their signs are consistent with an inverse-u-shaped effect).

Figure 3.3. Per capita GDP and conflict pattern

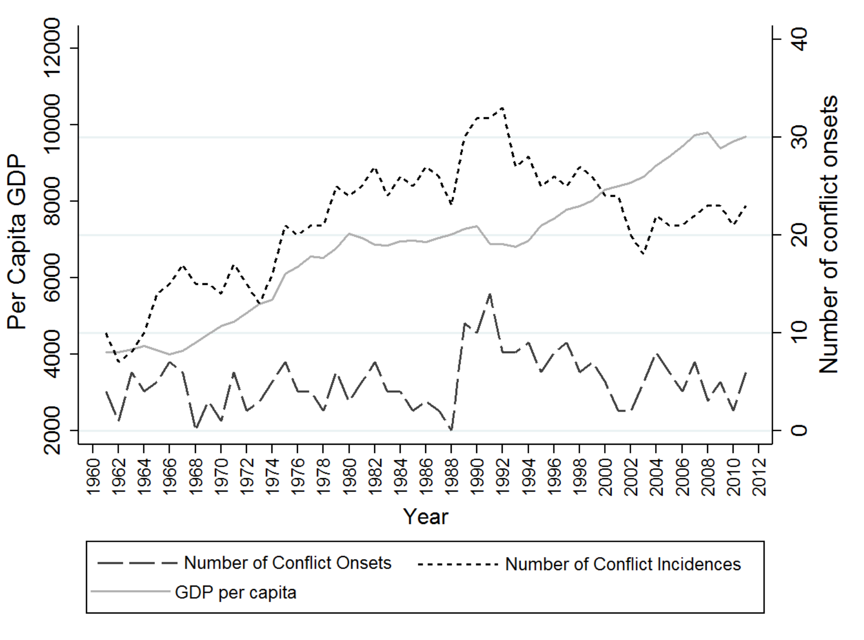


Figure 3.4. Polity score and conflict pattern

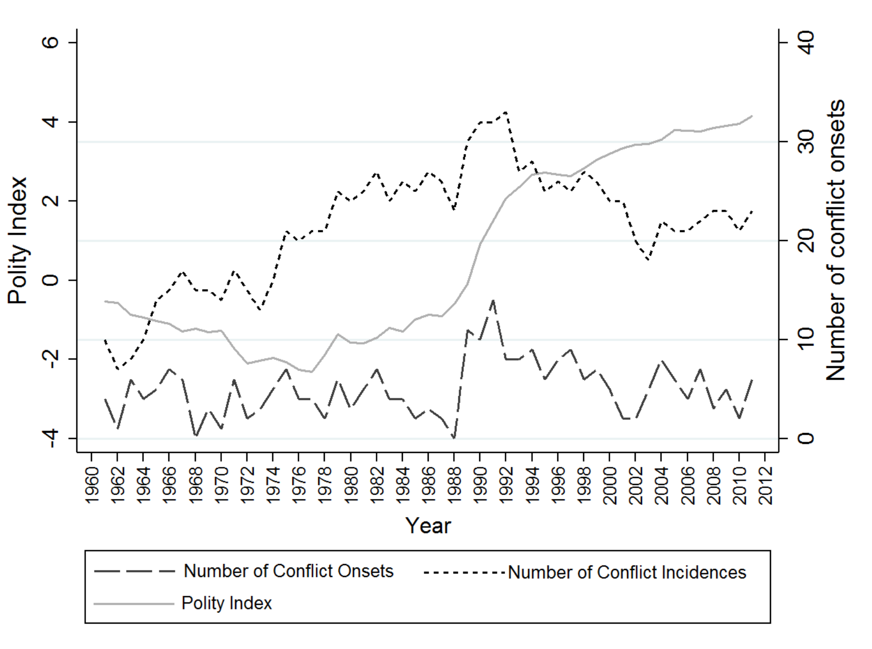


Table 3.3. Estimates of equation (3.1) and its restricted versions

Dependent: conflict onset

	(I)	(II)	(III)	(IV)	(V)
α_0	-12.05***	-11.59***	-11.60***	-11.70***	-11.69***
γ_0	-0.0661	-0.159	-0.158	-0.175*	-0.178*
β_0	0.0223	0.0250	0.0294*	0.0510	0.0278*
β_1	0.00806	-0.00745**	-0.00742**	--	--
δ_0	0.00136	0.000640	--	-0.00333	--
δ_1	-0.00213	--	--	--	--
R^2	0.2761	0.2756	0.2756	0.2726	0.2725
L	-602.08	-602.494	-602.49	-605.03	-605.08
AIC	1336	1335	1333	1338	1336
BIC	1759	1751	1743	1748	1739

The dependent variable is probability of onset of internal armed conflict. The sample size in all regressions is 4463, consisting an unbalanced combination of 139 countries over the period 1961-2011. All regressions include the same control variables as explained above. The coefficient estimates report log-odds. '***', '**' and '*' denote significance at 1%, 5% and 10% respectively based on t-ratios using standard errors clustered at the country level. R^2 and *L* are the *pseudo* goodness of fit and log-likelihood value, respectively. *AIC* and *BIC* are Akaike and Schwarz information criteria (based on the log-likelihood), respectively.

In addition, the estimated coefficient of GDP^{pc}, γ_0, which is negative in all cases as expected, is significant only in columns (IV) and (V). On the other hand, only columns (II) and (III) support a negative quadratic impact associated with RT^0. Working on the assumption that GDP^{pc} is a crucial explanatory variable, from the estimates reported in Table 3.3 we conclude that our dataset favours the restricted form in column (V) and therefore our chosen model is

$$y_{i,t} = \alpha_0 + \beta_0 RT^0_{i,t-1} + \gamma_0 GDP^{pc}_{i,t-1} + \mu_{0,r} + \theta_{0,t} + z'_{i,t-1}\varphi_0 + u^0_{i,t}, \quad (3.1)'$$

which excludes both quadratic and interaction effects and also suggests that, ceteris paribus, (i) $\gamma_0 < 0$: relatively richer countries are less likely to experience an internal armed conflict, thus economic development promotes peace; (ii) $\beta_0 > 0$: the more democratic is a country's regime the more likely it is to experience an internal armed conflict, hence democracy per se does not promote peace; and (iii) the interaction term between GDP^{pc}_i and RT^0_i is statistically insignificant: the effects of economic and political development are not contingent on each other. These results are interesting in that they provide a preliminary insight into the way economic and political development contribute to the onset of internal armed conflicts within our specific dataset. However, while the absence of non-linearity could be accepted, the lack of any interaction effect is not fully in line with the explanations in the literature and require further investigation.

We therefore continue our regression analysis by replacing RT_i^0 with the RT_i^j dummies which allow us to associate a specific type of political regime with a range of Polity score as outlined in Section 3.3 above.

3.4.2. The role of specific regimes based on Polity score

Following Collier and Rohner (2008), we first examine how the above results change when we group regimes into 'democratic' and 'non-democratic' by using the RT_i^1 dummy which we defined in Section 3.3. Hence, we estimates

$$y_{i,t} = \alpha_1 + \gamma_1 GDP_{i,t-1}^{pc} + [\lambda_1 + \eta_1 \, GDP_{i,t-1}^{pc}] RT_{i,t-1}^1 + \mu_{1,r} + \theta_{1,t} + z_{i,t-1}' \varphi_1 + u_{i,t}^1, \quad (3.2)$$

which treats democracies, for which $RT_i^1 = 0$, as the baseline – thus, λ_1 and η_1 provide a measure of deviation from democracy. Our estimates are reported in the first column of Table 3.4 which show that, unlike Collier and Rohner (2008) who found that a higher per capita GDP is associated with peace in democracy and with conflict in autocracies – namely, $\gamma_1 < 0, \lambda_1 < 0$, and $\eta_1 > 0$ – we find no evidence supporting a change in per capita GDP or regime type across countries to have a significant effect; in fact per capita GDP itself does not play any significant explanatory role either.

Given the evidence in Table 3.2 which shows that the characteristics of autocracies are statistically distinct from the rest (amongst the non-democratic regimes), next we examine whether treating democracies as the baseline regime as in (3.2) but dividing the non-democratic regimes corresponding to $RT_i^1 = 1$ into autocracies and the rest (consisting of anocratic, interregnum or in transition) by means of RT_i^2 and RT_i^3 dummies (which we defined in Section 3.3) provides an insight into the role of regime type in determining the onset of conflicts. Hence, we estimate

$$y_{i,t} = \alpha_2 + \gamma_2 GDP_{i,t-1}^{pc} + [\kappa_2 + \sigma_2 GDP_{i,t-1}^{pc}] RT_{i,t-1}^2 + [\kappa_3 + \sigma_3 GDP_{i,t-1}^{pc}] RT_{i,t-1}^3 + \mu_{2,r} + \theta_{2,t} + z_{i,t-1}' \varphi_2 + u_{i,t}^2, \quad (3.3)$$

The parameter estimates of equation (3.3) are reported in the 2nd column in Table 3.4 and again indicate no evidence supporting a change in per capita GDP or regime type across countries to have a significant effect – i.e., $\kappa_2 = \kappa_3 = \sigma_2 = \sigma_3 = 0$ cannot be rejected. We also continue to find that per capita GDP does not play any significant explanatory role either.

Table 3.4. Logit estimates of coefficients of regression equations (3.2)-(3.4)

Dependent: conflict onset

Regressors	**(3.2)**	**(3.3)**	**(3.4)**
per capita GDP: $GDP^{pc}_{i,t-1}$	-0.234	-0.254	-0.235
non-democracy: $RT^{1}_{i,t-1}$	-1.108	--	--
$RT^{1}_{i,t-1} \times GDP^{pc}_{i,t-1}$	0.153	--	--
autocracy $RT^{2}_{i,t-1}$	--	-0.541	-0.404
$RT^{2}_{i,t-1} \times GDP^{pc}_{i,t-1}$	--	0.0218	0.0002
anocracy, *interregnum, transition:* $RT^{3}_{i,t-1}$	--	-1.280	--
$RT^{3}_{i,t-1} \times GDP^{pc}_{i,t-1}$	--	0.206	--
anocracy: $RT^{4}_{i,t-1}$	--	--	-0.152
$RT^{4}_{i,t-1} \times GDP^{pc}_{i,t-1}$	--	--	0.0446
interregnum, transition: $RT^{5}_{i,t-1}$	--	--	-4.296*
$RT^{5}_{i,t-1} \times GDP^{pc}_{i,t-1}$	--	--	0.627*
R^2	0.2711	0.2747	0.2769
L	-606.25	-603.25	-601.40
AIC	1340	1338	1338
BIC	1750	1761	1774

See notes to Table 3.3 for other details.

Finally, we move on to examine whether separating anocratic regimes from interregnum regimes and regimes in transition makes any difference. This requires estimating

$$y_{i,t} = \alpha_3 + \gamma_3 GDP^{pc}_{i,t-1} + \left[\psi_2 + \pi_2 GDP^{pc}_{i,t-1}\right] RT^{2}_{i,t-1} + \left[\psi_4 + \pi_4 GDP^{pc}_{i,t-1}\right] RT^{4}_{i,t-1} + \left[\psi_5 + \pi_5 GDP^{pc}_{i,t-1}\right] RT^{5}_{i,t-1} + \mu_{3,r} + \theta_{3,t} + z'_{i,t-1}\varphi_3 + u^{3}_{i,t}, \quad (3.4)$$

Recall that $RT^{5}_{i} = 1$ represents observations in which the corresponding regimes are politically unstable, hence separating this category from others might help capturing homogeneity 'within' categories as well as heterogeneity 'between' categories. This follows from Fearon and Laitin (2003) and Hegre and Sambanis (2006) who argue that political instability has a robust association with conflict. The estimated coefficients are reported in the 3rd column in Table 3.4 where the only significant coefficient whose estimated value happens to be statistically significant (at 10% critical level) is ψ_5 but we find its value to be negative, with the counter-intuitive implication that regime instability reduces the probability of onset!

3.4.3. Using per capita income levels as alternative

The fact that the estimated effect of $GDP_{i,}^{pc}$ reported in Table 3.4, corresponding to specifications (3.2)-(3.4), turns out to be statistically insignificant is somewhat unsatisfactory. However, since per capita GDP is used as a proxy for the extent of economic development, a more thorough examination of its impact is important. We therefore group the countries into income levels, using the *low-income* countries as the baseline and replacing $GDP_{i,}^{pc}$ in our regressions with the following income-level dummies

- $MI_{i,t} = 1$ if country *i* in year *t* is a *middle-income* country; $MI_{i,t} = 0$ otherwise
- $HI_{i,t} = 1$ if country *i* in year *t* is a *high-income* country; $HI_{i,t} = 0$ otherwise

where the per capita income thresholds, recommended by World Bank (2014a), are as follows: *low-income* with per capita GDP ≤ \$875; *middle-income* with per capita GDP within \$875- \$10725 range; and *high-income* with per capita GDP > \$10725.

Table 3.5 reports the estimated coefficients of the regressions with income level dummies where baseline is low income democracy. As the 1st column – which is associated with the model in (3.2) – shows, moving to higher income levels and/or to non-democratic regimes makes no difference in the probability of onset. The estimates in the second column – associated with the model in (3.3) – do not provide any statistically significant explanation. Finally, the estimates in the third column – corresponding to the model in (3.4) – show that the interaction term $RT_i^5 \times HI_i$ has highly significant and positive effect: high income countries with unstable regimes – i.e. those with interregnum regimes and/or regimes in transition.

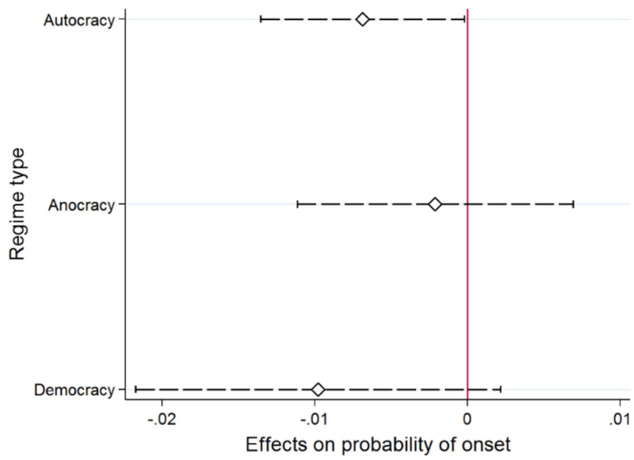
Our results so far do not fully agree with those reported in Collier and Rohner (2008) who find that democracies (autocracies) become safer (less safe) as income rises. On the contrary, our findings suggest autocracies becoming safer at a higher per capita income level(see Figure 3.5), and we find no evidence in support of the claim that democracies are safer than non-democratic countries except for high income countries with unstable regimes.

Table 3.5. Logit estimates of coefficients of regression equations (3.2)-(3.4) with per capita income level dummies instead of GDP^{pc}

Dependent: conflict onset	**(3.2)**	**(3.3)**	**(3.4)**
Regressors			
middle-income: $MI_{i,t-1}$	-0.593	-0.635	-0.583
high-income: $HI_{i,t-1}$	-0.288	-0.261	-0.019
non-democracy: $RT^1_{i,t-1}$	-0.195	--	--
$RT^1_{i,t-1} \times MI_{i,t-1}$	0.498	--	--
$RT^1_{i,t-1} \times HI_{i,t-1}$	-0.767	--	--
autocracy: $RT^2_{i,t-1}$	--	-0.365	-0.362
$RT^2_{i,t-1} \times MI_{i,t-1}$	--	0.247	0.208
$RT^2_{i,t-1} \times HI_{i,t-1}$	--	-1.561	-1.783
anocracy, interregnum, transition: $RT^3_{i,t-1}$	--	-0.051	--
$RT^3_{i,t-1} \times MI_{i,t-1}$	--	0.556	--
$RT^3_{i,t-1} \times HI_{i,t-1}$	--	0.628	--
anocracy: $RT^4_{i,t-1}$	--	--	0.0896
$RT^4_{i,t-1} \times MI_{i,t-1}$	--	--	0.310
$RT^4_{i,t-1} \times HI_{i,t-1}$	--	--	0
interregnum, transition: $RT^5_{i,t-1}$	--	--	-0.766
$RT^5_{i,t-1} \times MI_{i,t-1}$	--	--	1.399
$RT^5_{i,t-1} \times HI_{i,t-1}$	--	--	4.973***
R^2	0.2720	0.2759	0.2800
L	-605.51	-602.25	-597.69
AIC	1343	1342	1335
BIC	1765	1784	1783

See notes to Table 3.3 for other details.

Figure 3.5. AMEs of GDP^{pc} for different regime types with 90% CIs based on estimates of equation (3.3)



3.4.4. Incidence versus onset

As a final check on the role of income level and regime type in determining the probability of internal armed conflicts, we re-estimate the regressions in (3.2)-(3.4) replacing the 'onset' sample with the 'incidence' sample. Thus, while all the explanatory variables are kept as before, the dependent variable in this exercise is now defined such that $y_{i,t} = 1$ if there is an incidence of an internal armed conflict in country i in year t and $y_{i,t} = 0$ otherwise. Therefore, this dummy picks up both the onset of a conflict and, to some extent, its duration (which were set to missing in the onset sample). As pointed out by Collier and Hoeffler (2004), the onset and incidence are radically different processes and the robustness of the regressions based on the latter sample is likely to suffer from endogeneity problem due to intrinsic reverse causality since some of determinants of a conflict are highly likely to be influenced by its persistence. We therefore consider these estimates for completeness only bearing in mind that they are likely to be biased.[29] Tables A3.4 and A3.5 in the Appendix report the values of the relevant coefficients obtained by estimating regression equations (3.2)-(3.4) using the incidence sample. Income effects are now statistically significant in all cases and suggest that, ceteris paribus, the higher is income the greater is the probability of conflict incidence. We regard the positive effect of income as an anomaly within a context in which income acts as a proxy for economic development, and can therefore interpret it

[29] An additional problem arises from using the same control explanatory variables which we had identified as appropriate based on the onset sample. However, this is a less important issue and the variables we have chosen are in fact used interchangeably in the literature when estimating the probability of onset and incidence.

as being due, most likely, to the above-mentioned simultaneity bias problem. However, we acknowledge in passing that similar evidence has been interpreted in the literature as picking up a specific channel: recruiting and organising insurgency is costly and is easier to undertake in wealthier countries.

In sum, the evidence reported in this section lends some, rather mild, support to the claim that per capita income and the regime type contribute to predicting the probability of onset of internal armed conflict, and their explanatory roles are contingent on each other. However, given the weak, and somewhat disappointing, nature of this evidence on the one hand and the importance of the underlying question on the other, further empirical investigation into the nature of the relationship, within the context of determining role of economic development and political development/stability, is carried out in the next section.

3.5. Reconsidering the explanatory role of economic and political factors

In light of the evidence presented and discussed above, in this section we continue our empirical investigation by focusing on the explanatory role of per capita income when it is paired with measures of *political stability* instead of *political regime* which could be considered as an alternative proxy for political development. In fact, one might argue that based on the above evidence political stability could indeed provide a more suitable proxy: amongst the regime types considered above, *anocracies*, *interregnum*, and *transition* regimes are known to be relatively more unstable compared to those regimes which are represented by the extrema of the polity spectrum and are known to oscillate between *autocracy* and *democracy*; they are not sufficiently democratic to successfully remove motivations for rebellion, and at the same time, cannot become sufficiently repressive to hinder the organisation of rebel groups (Muller and Weede, 1990). They are therefore more likely to be exposed to conflicts. This then begs the question of clearly distinguishing between the empirical relevance of political regime type and political stability in determining the onset of conflicts.[30] Therefore, building on the existing literature (Fearon and Laitin, 2003; Collier and Hoefler, 2004; Hegre and Sambanis, 2006) and the results obtained thus far, we now turn to estimating regression equations which focus on the explanatory role of GDP_i^{pc} and the measure of *political* or *regime*

[30] For example: (i) democratic regimes are not necessarily more efficient in maintaining domestic peace; and (ii) the breakdown of any political regime is often accompanied by violence (Hegre and Nome, 2010).

instability defined as a decay function of the number of years since the last indication of major regime instability. A country i is said to have had major regime instability in year t if it has experienced at least a three point change in its Polity score in that year. As in Chapter 2, we use $RI_{i,t}^0 = 2^{-RD_{i,t}/0.5}$ where RD is number of years since the last indication of major regime instability. However, since $RI_{i,t}^0$ is a continuous measure of regime instability it does not allow us to separately assess the relevance of extent of instability. Therefore, we also consider replacing it with the following measures of regime stability:

(i) *Regime Instability*, denoted by $RI_{i,t}^1$ and defined as a dummy variable: ${RI^1}_{i,t} = 1$ if country i has experienced any change in its Polity score in one of the years $t-1$, $t-2$ or $t-3$; ${RI^1}_{i,t} = 0$ otherwise.

(ii) *Minor Regime Instability*, denoted by $RI_{i,t}^2$ and defined as a dummy variable: ${RI^2}_{i,t} = 1$ if country i has experienced a less than three units change in its Polity score in one of the years $t-1$, $t-2$ or $t-3$; ${RI^2}_{i,t} = 0$ otherwise.

(iii) *Major Regime Instability*, denoted by ${RI^3}_{i,t}$ and defined as a dummy variable: ${RI^3}_{i,t} = 1$ if country i has experienced a three units or larger change of Polity score, in one of the years $t-1$, $t-2$ or $t-3$; ${RI^3}_{i,t} = 0$ otherwise.

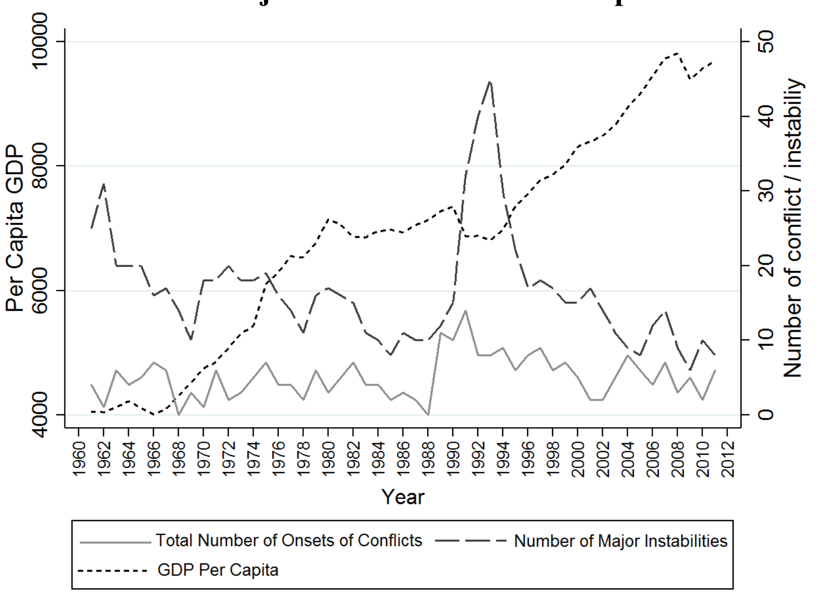
Tables 3.6 and 3.7 report the summary statistics for $RI^k, k = 0,1,2,3,$ which show that major instabilities are relatively more prevalent and, while they occur in all regime types, they are more frequent in *anocracies*; although there are more occurrences of minor instability in *autocracies* and *democracies, anocracies* still have the highest instability ratio. Additionally, the 67.03% rate of occurrence in *interregnum* and *transition* regimes place them on the top of the most likely regimes to experience major unstable events, right above *anocracies* with a 23.39% rate. Figure 3.6 depicts the annual average per capita GDP and the total number of annually observed conflict onsets and major regime instabilities over the sample period. On the whole, the patterns of the latter two series show a remarkable similarity, which is enhanced during the ears associated with the collapse of the USSR. Per capita GDP does not appear to have any co-movement with the onsets, but its fluctuations does, to some extent, reveal a related pattern.

Table 3.6. Frequency of Regime Instability

	Sample Size	Frequency	S.D.
$\boldsymbol{RI^0_{i,t}}$ (*Regime Instability: continuous*)	6330	10.77	0.29
$\boldsymbol{RI^1_{i,t}}$ (*Regime Instability*)	6297	21.22	0.41
$\boldsymbol{RI^2_{i,t}}$ (*Minor Regime Instability*)	6297	7.79	0.27
$\boldsymbol{RI^3_{i,t}}$ (*Major Regime Instability*)	6297	13.42	0.34

The frequency is simply the sample mean of $RI^k_{i,t}$ (scaled by 100) and S.D. is the standard error.

Figure 3.6. Pattern of conflicts, per capita GDP and major instabilities in the sample



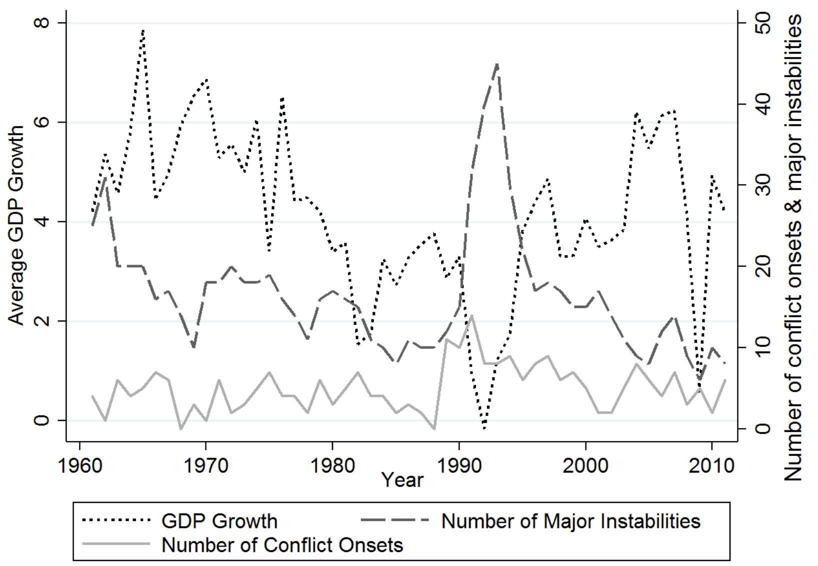


Table 3.7. Instability in different regime types

	Political Instability		
	Unstable	Stable	Instability rate
Autocracy	388	1878	17.1
Anocracy	419	872	32.4
Democracy	401	2156	15.7
Interregnum & Transition	128	54	70.1
Total	1336	4960	

In each case, 'Stable' periods are those during which the specific type of instability is not observed, hence $RI_{i,t}^{1} = 0$; otherwise the period is labelled as 'Unstable'. 'Instability rate' is defined as $(Unstable/Stable + Unstable) \times 100$.

Based on the above explanations, we now examine the explanatory role of political instability, captured RI^k, $k = 0,1,2,3,$ and test whether their effect is contingent on the extent of economic development captured by GDP^{pc} as before. To this end, we use a modified version of the regression equations (3.2) above, namely

$$y_{i,t} = \alpha_k + \gamma_k GDP_{i,t-1}^{pc} + \left[\lambda_k + \eta_k GDP_{i,t-1}^{pc}\right] RI_{i,t}^{k} + \mu_{k,r} + \theta_{k,t} + z_{i,t-1}' \varphi_k + v_{i,t}^{k},\ k = 0,1,2,3, \tag{3.5}$$

where we have replaced the regime type dummy with regime instability measures, RI^k.[31] Table 3.8 reports the estimated values of the relevant parameters for the four cases.

Table 3.8. Logit estimates based on equation (3.5)

Dependent: conflict onset **Regressors**	***k* = 0**	***k* = 1**	***k* = 2**	***k* = 3**
per capita GDP: $GDP_{i,t-1}^{pc}$	-0.296**	-0.246**	-0.196**	-0.274**
instability: $RI^k{}_{i,t}$	-2.384*	-0.714	1.504	-1.894*
$RI^k{}_{i,t} \times GDP_{i,t-1}^{pc}$	0.530***	0.153	-0.222	0.349**
R^2	0.2773	0.2605	0.2584	0.2632
L	-601.09	-615.05	-616.78	-612.81
AIC	1330	1358	1361	1353
BIC	1740	1767	1771	1763

The sample size in all regressions is 4463. See notes to Table 3.3 for other details.

[31] We have maintained the Polity score RT^0 to complement the latter (as a measure of regime authority).

As can be seen from the column labelled $k = 0$ which reports the estimates associated with RI^0, the estimate of γ_0 is statistically significant at 5% critical value and is negative as expected: the higher is per capita GDP, the higher is the level of economic development and hence the lower is the probability of onset. As for the effect of regime instability, although estimates of both λ_0 and η_0 are statistically significant at 10% and 1% significance level respectively, their signs are not very informative.

To provide a clearer picture, we plot the impact of $\lambda_0 + \eta_0 GDP_{i,t-1}^{pc}$ on the probability of onset for different levels of GDP^{pc}. Figures 3.7 illustrates the effect for the three income levels suggested by the World Bank (see above) and shows that the probability of onset is initially higher in lower income levels but this is reversed as the extent of regime instability exceeds a certain threshold. Figure 3.8 plots the average marginal effects, measured by evaluating the average sample values of $\lambda_0 + \eta_0 GDP_{i,t-1}^{pc}$ evaluated at the different income levels, and shows how the contribution of regime instability rises with GDP^{pc}. Thus whilst, ceteris paribus, a higher per capita GDP reduces the probability of onset, its overall effect is contingent on the extent of regime instability: a richer country with a more unstable regime is likely to be more conflict prone. This claim however requires some quantification the *extent of regime instability*. As explained above, we have done this by estimating equation (3.5) replacing RI^0 with RI^k, $k = 1,2,3$ which allow a distinction between major and minor instability. The estimates are reported in the respective columns of Table 3.8 and show that significant parameter estimates are only obtained in column labelled $k = 3$ corresponding to major regime instability. Figures 3.9 and 3.10, which illustrate the contribution of major instability when its interacted with per capita GDP, shows a similar pattern.

In sum, regime stability measures seems to provide a better channel through which we can capture the role of political development in conjunction with economic development proxied by per capita GDP.

Figure 3.7. Predictive Margins of RI^0
based on estimates of equation (3.5)

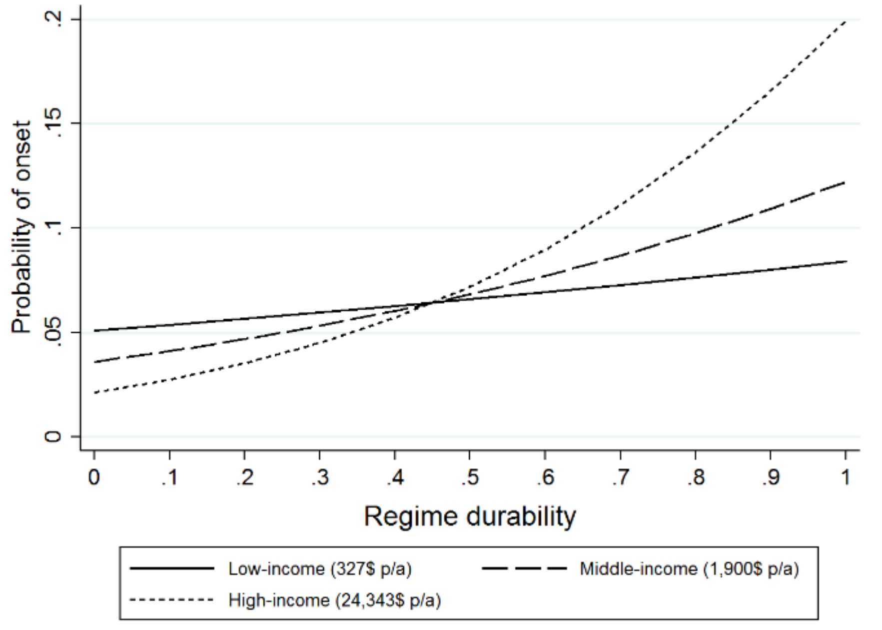


Figure 3.8. AMEs of RI^0 with 90% CI
based on estimates of equation (3.5)

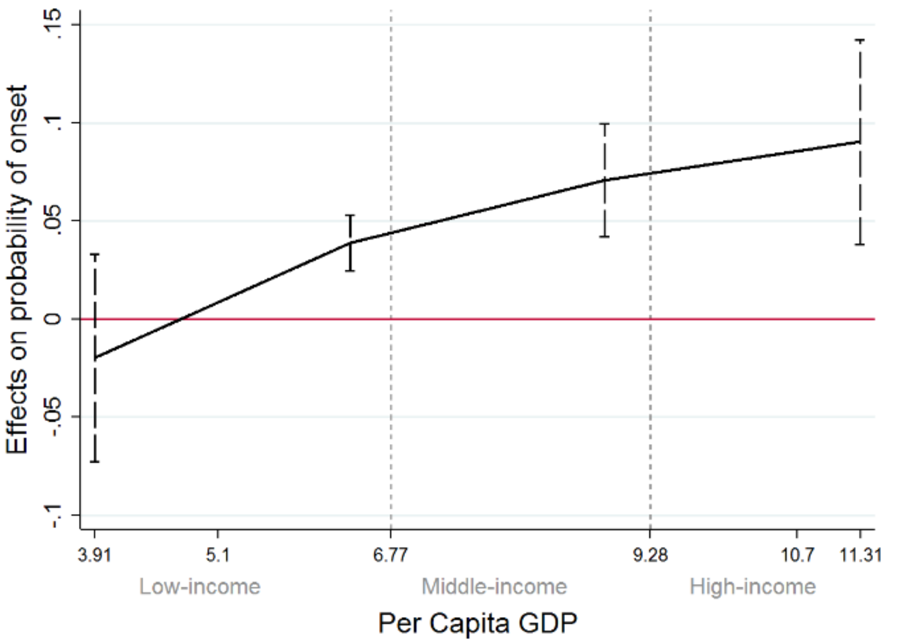


Figure 3.9. Predictive Margins of RI^3 based on estimates of equation (3.5)

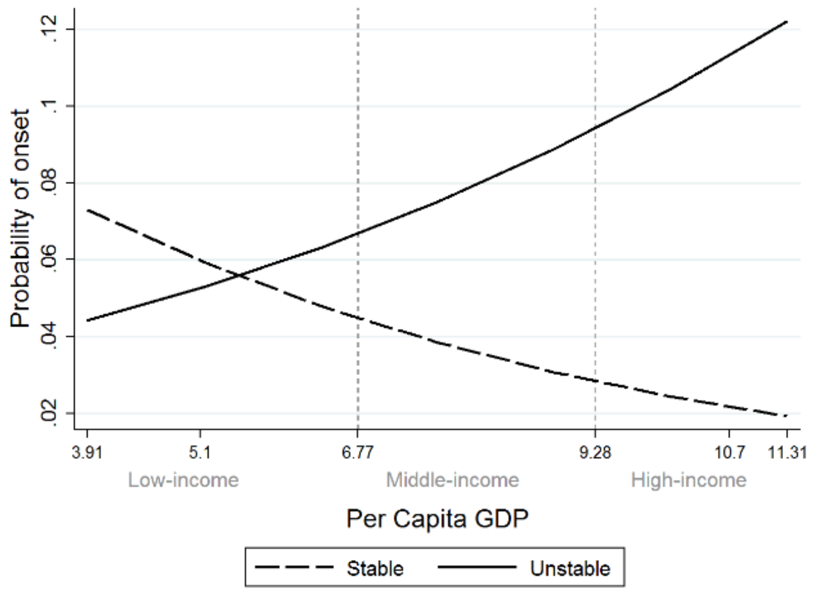
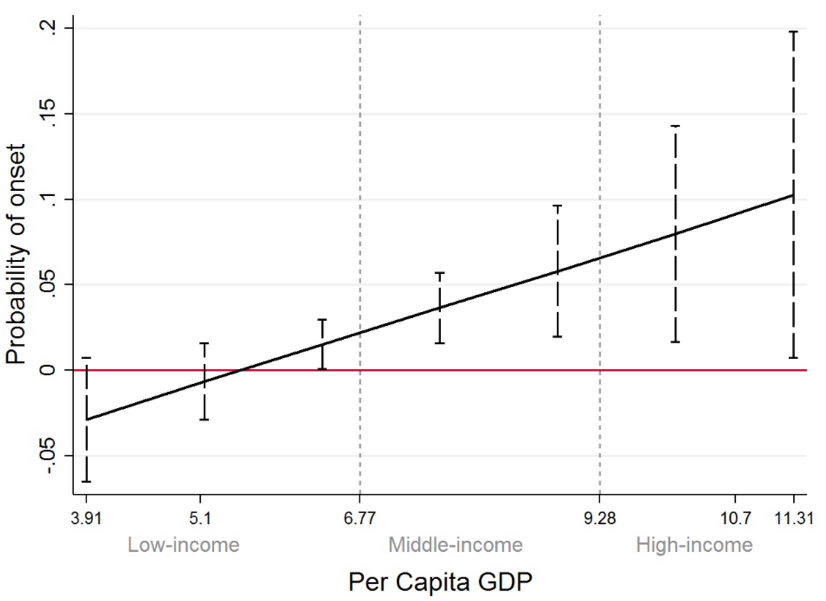


Figure 3.10. AMEs of RI^3 with 90% CI based on estimates of equation (3.5)



3.6. Robustness checks

Before concluding this chapter we check the robustness of our results. There are mainly three points which might be of some concern: (a) estimation method; (b) data consistency; and (c) the influence of observations corresponding to high leverage cases.

With respect to the estimation method, we have used the logit procedure since it does not require assuming a specific distribution function to represent the conditional probability and is predominantly used in similar studies. Nevertheless, we re-estimated the main regressions using probit (results are not reported) and found the results to be very close to those obtained with logit the latter yielding a higher value of the Pseudo R^2 and log-likelihood, as well as being better supported by Akaike and Schwarz Information Criteria.

In order to check the consistency of our dataset, we estimated the exact specification used in Collier and Rohner (2008), namely

$$y_{i,t} = \alpha_1^* + \gamma_1^* GDP_{i,t-1}^{pc} + \left[\lambda_1^* + \eta_1^* GDP_{i,t-1}^{pc}\right] RT_{i,t-1}^1 + \mu_{1,r}^* + \theta_{1,t}^* + z_{i,t-1}^{*'} \varphi_1^* + u_{i,t}^{*1}, \qquad (3.2^*)$$

where the control regressors in vector z_i^* are: population; ethnic fractionalisation index; rough terrain; oil exporter dummy; religious fractionalisation; non-contiguous states dummy; new states dummy; and major instability dummy. Table 3.9 presents the results comparing which show that the careful choice of control variables matter: although the estimated coefficients retain their signs, they become insignificant when control variables are chosen more carefully.

Table 3.9. Comparing estimates of equations (3.2) and (3.2*)

Dependent: conflict onset

Equation:		**(3.2)**	**(3.2*)**
non-democracy:	RT^1	-1.101	-2.01*
per capita GDP:	GDP^{pc}	-0.237	-0.581***
	$GDP^{pc} \times RT^1$	0.152	0.321**
	R^2	0.2715	0.1759
	L	-605.65	-685.15
	AIC	1339	1394
	BIC	1749	1471

The sample size is the maximum possible common observations (4456).

Finally, detecting the observations with high leverages and/or large residuals and re-estimating the models – using (i) the approach recommended in Pregibon (1981) to eliminate observations with high leverage from the sample, and (ii) the method advocated by Hosmer and Lemeshow (1989) and Hosmer et al. (2013) to omit observations with large residuals (based on Pearson and Deviance Residuals) – did not lead to any significant change which could influence our conclusions.

3.7. Summary and conclusions

In this chapter we have investigated the role of economic and political development in curtailing the onset of armed conflicts. We have argued that an a priori belief, which emerges from the literature and can be formulated as a testable hypothesis, is that economic development per se reduces the probability of conflicts but its impact is contingent on the extent of political development and the latter might in fact reverse the overall impact of former. That is, depending on the state of its political institution, a relatively wealthier country could experience a higher rate of conflict relative to a poorer one.

Using a cross-section time-series dataset covering 139 countries and spanning the period 1961-2011, we have estimated a number of differently specified empirical relationships which, after accounting for the most relevant conditioning explanatory variables, explain the contribution of economic and political development respectively proxied by per capita GDP and regime type or regime instability to probability of conflict onset. Our results suggest that using a measure of *regime type*, as suggested in the literature, does not support the above hypothesis as none of the crucial coefficients turn out to be statistically significant. Instead, estimates based on the specification which makes the impact of per capita GDP contingent on the extent *regime instability* support the above-mentioned hypothesis. In particular, we find that per capita GDP per se does significantly reduce the probability of conflict but its overall effect contributes positively to the onset of conflicts in more unstable regimes.

Our findings do not fully agree with the claims in Collier and Rohner (2008) on the peace promoting (demoting) role of per capita GDP in *democracies* (autocracies). Our evidence suggests that richer *autocracies* are less likely to experience an onset of conflict (see Figure 3.5). We also found some indications that such regimes are less likely to experience an incidence of conflict, in terms of frequency and duration, compared to their *democratic* counterparts. This is consistent with the evidence, pointed out in the existing literature, that rich *autocracies* tend to (i) invest heavily on armed forces in order to strengthen their 'repressive power' (Figures A3.1 and A3.2), and (ii) discourage rebellion by offering financial incentives, literally following a 'carrot and stick approach'. Ironically, as Figures A3.3-A3.4 show, rich autocracies do not perform badly, compared to democracies, with respect to Human Development Index (HDI) and GINI Index, and substantially outperform *anocracies* with respect to income equality.

One of the key findings of this study is that major political instability, whether caused by a positive or negative institutional change, could adversely affect peace. This finding favours gradual and steady reforms to sudden changes (e.g. short term drastic reforms of the type that are at times imposed by international institutions). This is because while major changes in political institutions could result in raising the probability of conflict, there is no strong evidence that minor changes have any significant impact. Our results also suggest an interesting complementary evidence: the destabilising role of sudden political change is likely to be higher the higher is the country's income-level.

Given the crucial importance of sustained peace for prosperity, the line of research followed in this chapter suggests a worthwhile future research project which focuses on understanding the links between climate change, political and economic stability and threats of spreading regional conflicts (Fankhauser and Tol, 2005; and CNA, 2007 and 2014).

Appendix

Table A3.1. Democracies which experienced armed conflicts

Polity score	Country	Year	Total conflicts	Polity score	Country	Year	Total conflicts
10	Israel	2006	3	8	Niger	1995	5
10	Israel	2000	3	8	Niger	1994	5
10	United Kingdom	1998	2	8	India	1994	20
10	Spain	1991	3	8	Philippines	1993	5
10	Spain	1985	3	8	India	1993	20
10	United Kingdom	1971	2	8	Venezuela	1992	3
10	Malaysia	1963	3	8	India	1992	20
9	India	2009	20	8	Pakistan	1990	7
9	India	2008	20	8	India	1990	20
9	Peru	2007	3	8	India	1989	20
9	India	2006	20	8	Panama	1989	1
9	India	2005	20	8	India	1983	20
9	Thailand	2003	2	8	India	1982	20
9	India	2003	20	8	India	1979	20
9	India	2000	20	8	Pakistan	1974	7
9	India	1997	20	8	Sri Lanka	1971	5
9	India	1996	20	7	Senegal	2011	7
9	India	1995	20	7	Mali	2007	3
9	Turkey	1991	3	7	Turkey	2005	3
9	Israel	1990	3	7	Georgia	2004	3
9	Trinidad and Tobago	1990	1	7	Mali	1994	3
9	Venezuela	1982	3	7	Turkey	1984	3
9	Spain	1978	3	7	Peru	1982	3
9	India	1969	20	7	Colombia	1964	1
9	India	1966	20	6	Pakistan	2011	7
9	India	1961	20	6	Burundi	2008	4
8	Senegal	2003	7	6	Niger	2007	5
8	Senegal	2000	7	6	Indonesia	1999	10
8	Philippines	1999	5	6	Argentina	1974	2
8	Philippines	1997	5	6	Venezuela	1962	3

Table A3.2. Countries with per capita GDP exceeding 10725 US$ which experienced armed conflicts

Income category	Country	Year	Total conflicts
High income	Israel	1990	3
High income	Israel	2006	3
High income	Israel	2000	3
High income	Spain	1985	3
High income	United Kingdom	1971	2
High income	United Kingdom	1998	2
High income	Saudi Arabia	1979	1
High income	France	1961	1
High income	Spain	1978	3
High income	Spain	1991	3
Upper middle income	Argentina	1974	2
Upper middle income	Libya	2011	1
Upper middle income	Turkey	1984	3
Upper middle income	Argentina	1963	2
Upper middle income	Russia	1994	5
Upper middle income	Turkey	2005	3
Upper middle income	Venezuela	1962	3
Upper middle income	Turkey	1991	3
Upper middle income	Trinidad and Tobago	1990	1
Upper middle income	Venezuela	1982	3
Upper middle income	Russia	2007	5
Upper middle income	Russia	1993	5
Upper middle income	Mexico	1996	2
Upper middle income	Mexico	1994	2
Upper middle income	Romania	1989	1
Upper middle income	Russia	1990	5
Upper middle income	South Africa	1985	3
Upper middle income	South Africa	1966	3
Upper middle income	South Africa	1981	3
Upper middle income	Venezuela	1992	3

Table A3.3. Autocratic countries in the sample with per capita GDP exceeding 10725 US$

Polity Score	Country	Time period
[-10, -8]	Oman	1986-2011
-8	United Arab Emirates	1976-2011
[-10, -7]	Bahrain	1981-2011
-7	Kuwait	1996-2011
-10	Saudi Arabia	1972-2011
-9	Gabon	1977
-7	Spain	1970-1974

Figure A3.1. Military expenditure share (with respect to GDP) by regime type by income level

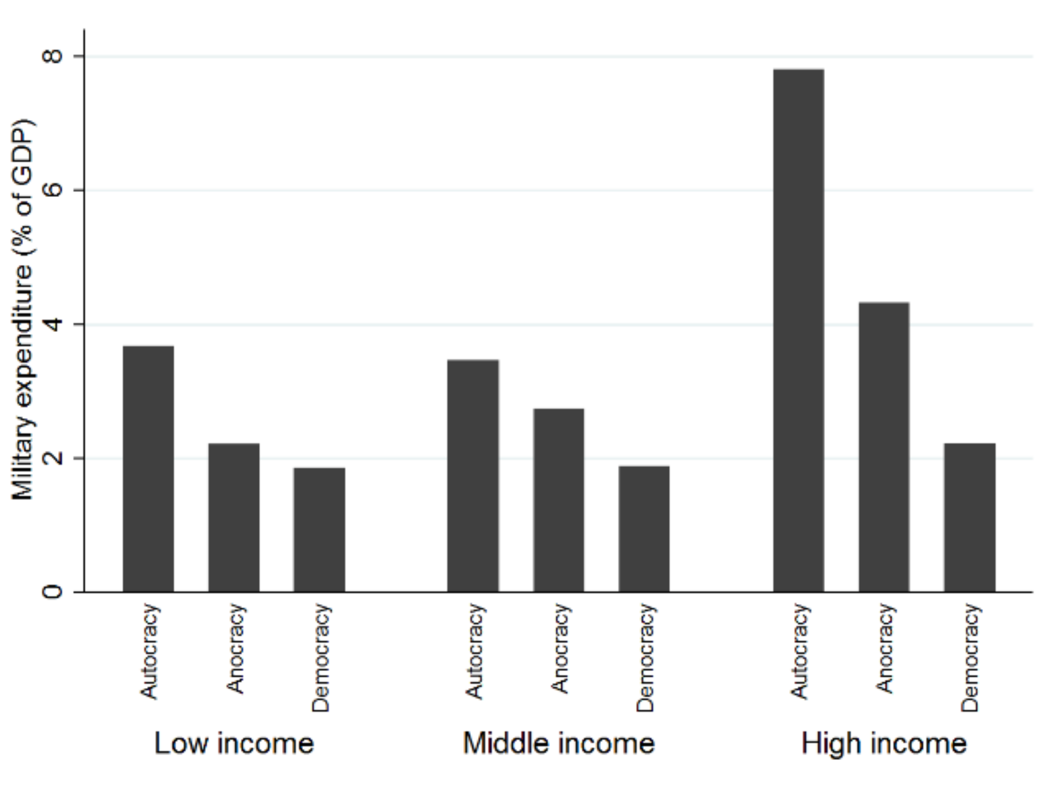


Figure A3.2. Number of military personnel per 1000 people by regime type by income level

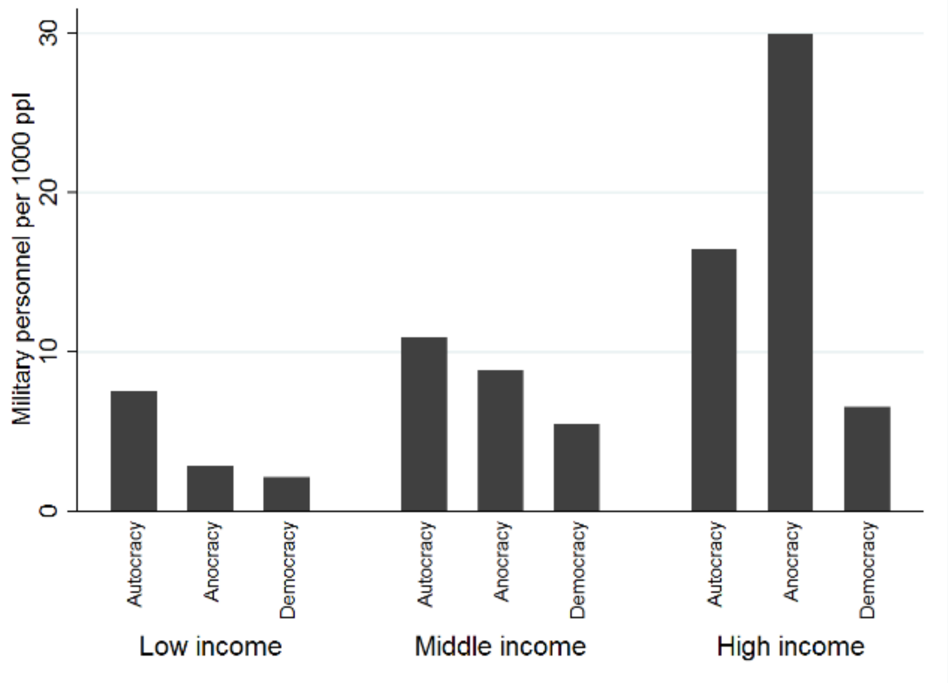
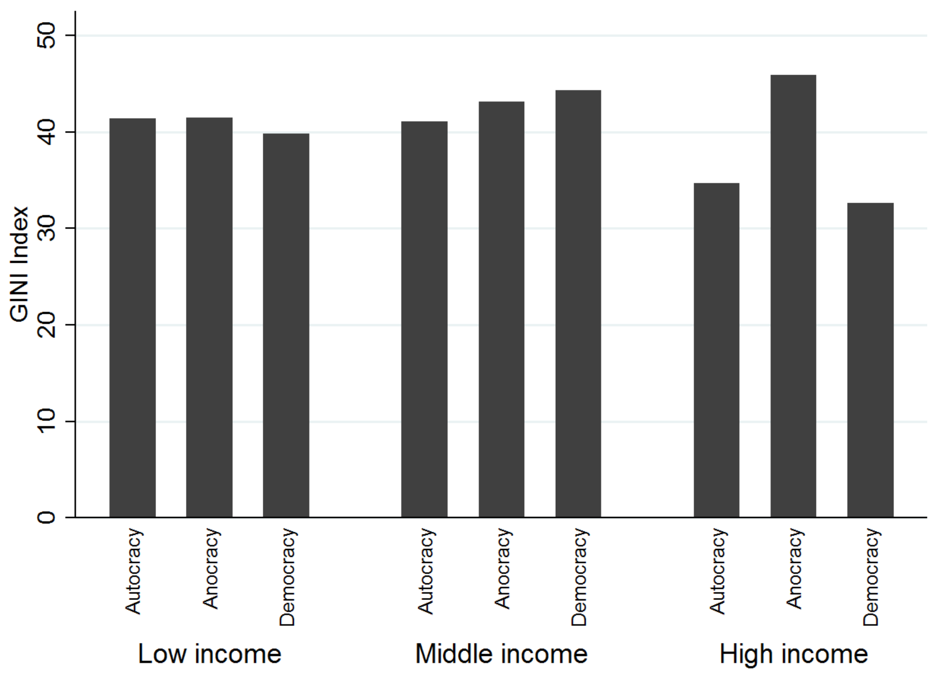
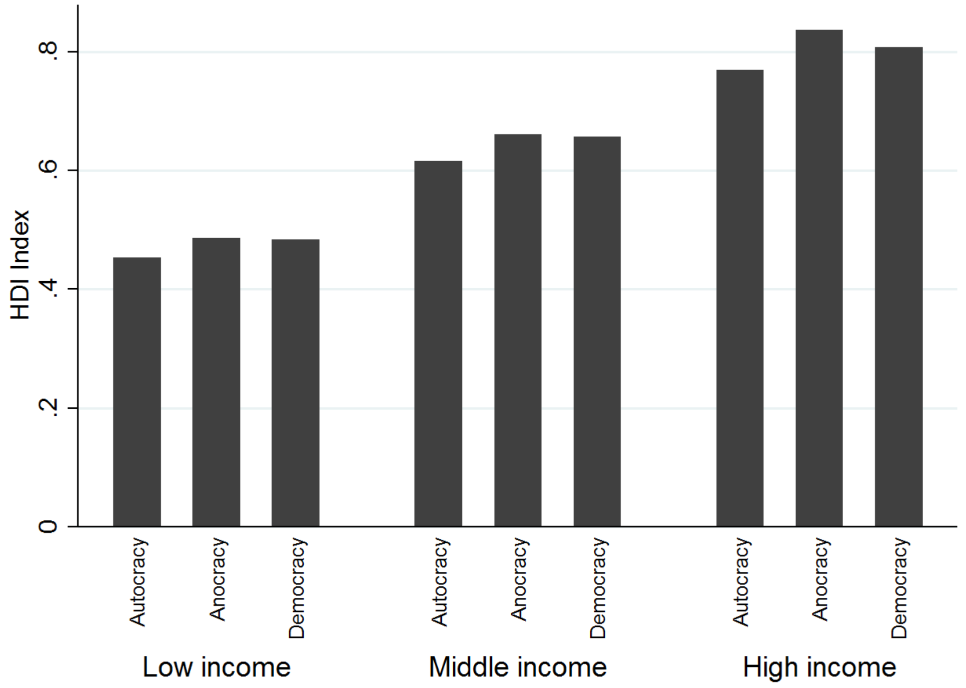


Figure A3.3. Gini index by regime and income level



- The Gini index is a measurement of the income distribution of a country's residents. This number, which ranges between 0 and 1 and is based on residents' net income, helps define the gap between the rich and the poor, with 0 representing perfect equality and 1 representing perfect inequality.
- WIID provides the most comprehensive set of income inequality statistics, which is an updated and improved set of all available GINI data from various sources (UNU-WIDER, 2017). However, data availability is still incomplete for autocracies, especially the wealthy ones. For instance, GINI data in entirely unavailable for Saudi Arabia, Kuwait, UAE, etc.

Figure A3.4. HDI index by regime type and income level



- The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalised indices for each of the three dimensions. The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean (UNDP, 2013).

Table A3.4. Logit estimates of coefficients of regression equations (3.2)-(3.4) with probability of incidence of internal armed conflict as dependent variable

Dependent: conflict incidence	**(3.2)**	**(3.3)**	**(3.4)**
Regressors			
per capita GDP: $GDP_{i,t-1}^{pc}$	0.351**	.283*	0.294*
polity score: $RT_{i,t-1}^{0}$	--	--	--
$RT_{i,t-1}^{0} \times GDP_{i,t-1}^{pc}$	--	--	--
non-democracy: $RT_{i,t-1}^{1}$	2.511*	--	--
$RT_{i,t-1}^{1} \times GDP_{i,t-1}^{pc}$	-0.369*	--	--
autocracy: $RT_{i,t-1}^{2}$	--	3.761**	3.806**
$RT_{i,t-1}^{2} \times GDP_{i,t-1}^{pc}$	--	-0.642**	-0.654***
anocracy, interregnum, transition: $RT_{i,t-1}^{3}$	--	1.961	--
$RT_{i,t-1}^{3} \times GDP_{i,t-1}^{pc}$	--	-0.247	--
anocracy: $RT_{i,t-1}^{4}$	--	--	2.839**
$RT_{i,t-1}^{4} \times GDP_{i,t-1}^{pc}$	--	--	-0.372*
interregnum, transition: $RT_{i,t-1}^{5}$	--	--	-1.209
$RT_{i,t-1}^{5} \times GDP_{i,t-1}^{pc}$	--	--	0.155
R^2	0.5576	0.5642	0.5662
L	-1054.19	-1038.44	-1033.69
AIC	2242	2214	2209
BIC	2684	2669	2677

The sample size in all regressions is 5401. See notes to Table 3.3 for other details.

Table A3.5. Logit estimates of coefficients of regression equations (3.2)-(3.4) with probability of incidence of internal armed conflict as dependent variable and per capita income level dummies instead of GDP^{pc}

Dependent: conflict incidence	**(3.2)**	**(3.3)**	**(3.4)**
Regressors			
middle-income: $MI_{i,t-1}$	0.967**	0.913**	0.975**
high-income: $HI_{i,t-1}$	1.816***	1.866***	1.961***
polity score: $RT_{i,t-1}^{0}$	--	--	--
$RT_{i,t-1}^{0} \times MI_{i,t-1}$	--	--	--
$RT_{i,t-1}^{0} \times HI_{i,t-1}$	--	--	--
non-democracy: $RT_{i,t-1}^{1}$	0.458*	--	--
$RT_{i,t-1}^{1} \times MI_{i,t-1}$	-0.917*	--	--
$RT_{i,t-1}^{1} \times HI_{i,t-1}$	-2.511**	--	--
autocracy: $RT_{i,t-1}^{2}$	--	0.139	0.121
$RT_{i,t-1}^{2} \times MI_{i,t-1}$	--	-1.325***	-1.357***
$RT_{i,t-1}^{2} \times HI_{i,t-1}$	--	-4.104***	-4.149***
anocracy, interregnum, transition: $RT_{i,t-1}^{3}$	--	0.733**	--
$RT_{i,t-1}^{3} \times MI_{i,t-1}$	--	-0.89*	--
$RT_{i,t-1}^{3} \times HI_{i,t-1}$	--	-0.650	--
anocracy: $RT_{i,t-1}^{4}$	--	--	0.887***
$RT_{i,t-1}^{4} \times MI_{i,t-1}$	--	--	-1.128**
$RT_{i,t-1}^{4} \times HI_{i,t-1}$	--	--	-1.645***
interregnum, transition: $RT_{i,t-1}^{5}$	--	--	-0.312
$RT_{i,t-1}^{5} \times MI_{i,t-1}$	--	--	-0.006
$RT_{i,t-1}^{5} \times HI_{i,t-1}$	--	--	3.823***
R^2	0.5591	0.5657	0.5692
L	-1050.41	-1034.68	-1026.56
AIC	2238	2213	2201
BIC	2693	2688	2689

The sample size in all regressions is 5401. See notes to Table 3.3 for other details.

Chapter 4

Climate Change and Internal Migration: A Case Study of Iran

4.1. Introduction

In the latest Global Risk Reports by World Economic Forum (2015, 2016) armed conflicts and migration are considered as the most likely, and most substantial, risk factors of 2015 and 2016. That these factors are in turn influenced by climatic conditions is also a well-documented consensus. It is therefore crucial to quantify the magnitude and significance of this influence. In Chapter 1 we examined the contribution climatic conditions to armed conflicts using a global dataset. In this chapter we investigate the way they affect migration.

Migration is a rather complex dynamic process and its complexity undermines the accuracy of corresponding data. To overcome this problem, we focus our analysis on a specific type of migration. In particular, since there is some evidence that – due to the cost of relocation and benefits of community networks in familiar and nearby locations – most of the displacements caused by climate change primarily take place within national borders (Beyani, 2014), we carry out our investigation on internal migration within a country that has experienced, and is subject to, significant variations in its climate. Iran provides a good case.

Mass migrations have been a longstanding feature of humanity. The cause of this movement is attributed to civil conflict, war, religious intolerance, and economic opportunities (UNEP, 2012). Issues relating to climate induced migration are not new and have already been discussed on a smaller scale since the early 90s, for instance Intergovernmental Panel on Climate Change's (IPCC) first assessment report (IPCC, 1990) identified human migration as the greatest single impact of climate change. The International Organization for Migration (IOM, 1992) raised concerns regarding the dramatic increase in mass displacements and suggested a substantial rise in their numbers when larger areas of the earth become uninhabitable due to climate change.

The number of natural disasters has more than doubled over the last two decades. According to reports by the Internal Displacement Monitoring Centre (IDMC) and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), in 2008 more than 20 million people were displaced by sudden-onset of climate-related natural disasters and extreme weather events, compared to 4.6 million internally displaced over the same period by conflict and violence which could have been provoked by climate change (OCHA-IDMC, 2009). Projections suggest 25 million to 1 billion displacements by 2050, with 200 million being the most widely cited estimate (IOM, 2009). The IOM defines environmental migrants as "*persons or groups of persons who, for compelling* *reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad*" (UNEP, 2012).

It is now well-established that climate change can bring about both sudden destructive natural phenomena – such as floods and storms – and gradually eroding natural phenomena – such as drought and desertification. These are known to cause large scale crop failures, famine, displacements and over-urbanisation (resulting from excessive rural-to-urban movement); in a 2010 IOM and Gallup World Poll (Esipova et al., 2011), almost 12% of respondents believed severe environmental problems would require them to move within the next five years.

Despite the fact that the impact of climate change will eventually be spread globally, certain regions and/or countries are likely to be more severely affected initially, i.e. less developed and relatively poorer countries with weak infrastructure and inability to respond quickly (IPCC, 1997), or countries with low geographical altitude. Given its high level of water scarcity and the fact that a significant source of its inhabitants' income/livelihood is directly and inflexibly reliant on water dependent agriculture, the MENA (Middle East and North Africa) region is considered to be highly vulnerable to climate change in the coming decades (Joseph and Wodon, 2013). It is widely acknowledged that climate change and induced droughts had a significant role in the Syrian civil war (Brown and Crawford, 2009; Kelley et al., 2015).[32] In 2007, eastern Syria – along with Turkey, northern Iraq and western Iran – entered a three-year drought, the region's worst since data recording started (Kelley et al., 2015). This, along with weak governance, led Syria to experiencing water scarcity, crop failure and livestock death, which drove an estimated 1.5 million rural population to cities in search of better living conditions. The resulting excess demand for food-stuff raised food prices and enhanced the existing economic and social tensions that subsequently led to the civil war.

It has been predicted that the average global temperature will rise between 1.1°C and 6.4°C by the end of this century (IPCC, 2007)[33] which would lead to changes in precipitation patterns – i.e. an increase in rainfall in wet climates, and a decrease in dry

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[32] Kelley et al. (2015) also predict an increasingly drier and hotter future for climate in the Eastern Mediterranean.

[33] Data are based on comparing 2090-2099 expected temperature to 1980-1999 the actual temperature.

climates (World Bank, 2014b). For instance, in the terms of the consequences for Iran on which we shall be focussing, the World Resources Institute suggests that a 3^{o}C increase in temperature would reduce Iran's crop yields by 30%. Gohari et al. (2013) measured the impact of climate change on four major crops (wheat, barley, rice, and corn) in Iran and predicted a decrease of 2.9% to 16.6% (in average and measured separately for different scenarios) in their production over the period 2015 to 2044. It is perceivable that a persistent decrease in crop yields in specific regions depletes farmers' incomes, raises regional food insecurity and is likely to eventually cause internal emigration. In fact, due to its geographic and environmental conditions, Iran is particularly predisposed to the consequences of climate change: in terms of land, more than 80% of the country is arid or semi-arid, with around 20% desert coverage and roughly 9% forest area (UNDP, 2010). Moreover, the shares of arable and agricultural lands – in respect to total land area – have respectively declined from 10.1% and 39.2% in 1996, to 9.3% and 28.5% in 2011. More specifically, in comparison with global averages, the country is severely lacking in rainfall: the annual averages for precipitation and temperature in Iran are 326^{mm} and 17^{o}C respectively[34], with these values being 1121^{mm} and 19^{o}C globally[35] (World Bank, 2014a).

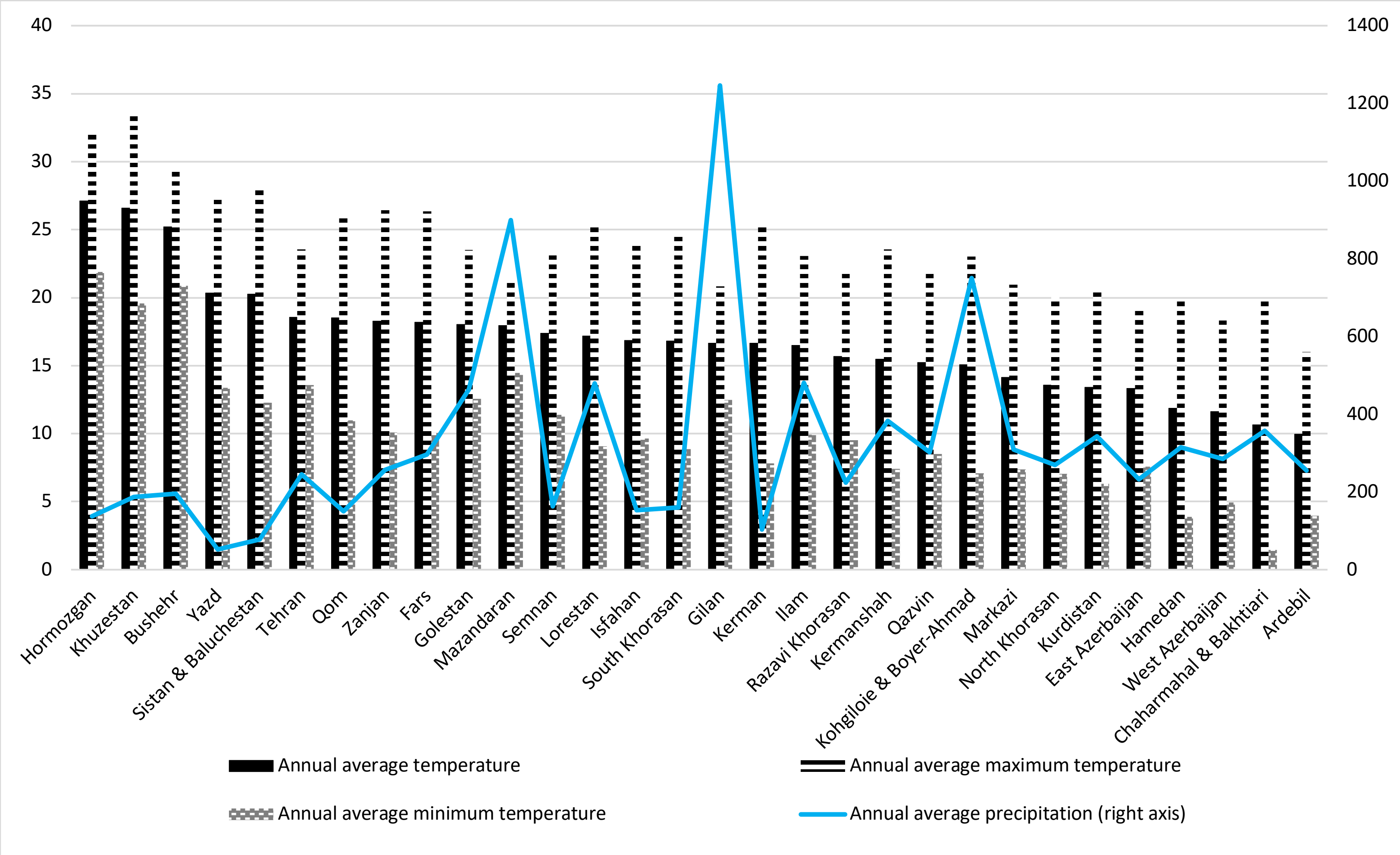
Projections suggest a considerable rise of 1.4^{o}C, 1.8^{o}C, and 2.3^{o}C in temperature and fall of 8%, 28%, and 15% in precipitation by 2020, 2035, and 2050 respectively – compared to observed values of 1961-1990 (UNDP, 2015). Figure 4.1 illustrates the annual average, minimum, and maximum temperatures as well as the annual precipitation by province. There is a slight but significant correlation (-0.16 statistically significant at 1% level) between annual temperature and precipitation across Iranian provinces. This means that the effect of climate change may potentially be amplified in regions with low rainfall and hot weather as a result of a change in either.

Iran is an interesting case study in the MENA region because the country is already experiencing a number of serious environmental problems. There have been multiple episodes of sand storms in the western parts of the country and some of the major rivers and lakes have either dried up or are receding (see Appendix 1 for examples).

Such phenomena are likely to have economic consequences and already there have been reports of, albeit infrequent, incidences of minor but fatal disputes over water in the affected regions. Based on the projections by the United Nations Development

[34] This is based on data from Iran's National Climate Change Office, for the period 1996-2011.
[35] Measured for 173 countries for 1996-2011 (World Bank, 2014a).

Figure 4.1. Annual temperature and precipitation by provinces (sorted by annual temperature)



Temperature units are in Celsius, Precipitation units are in Millimetre

Programme (UNDP) and Iran's National Climate Change Office (NCCO), areas with a higher share of rural population will receive the biggest drop in precipitation (Figures 4.2 and 4.3). These environmental issues have already alarmed the government whose officials have gone as far as predicting outbreaks of 'water-wars' in the near future followed by large scale migration (Ilna, 2015).

Figure 4.2. Rural population distribution (SCI, 2015)

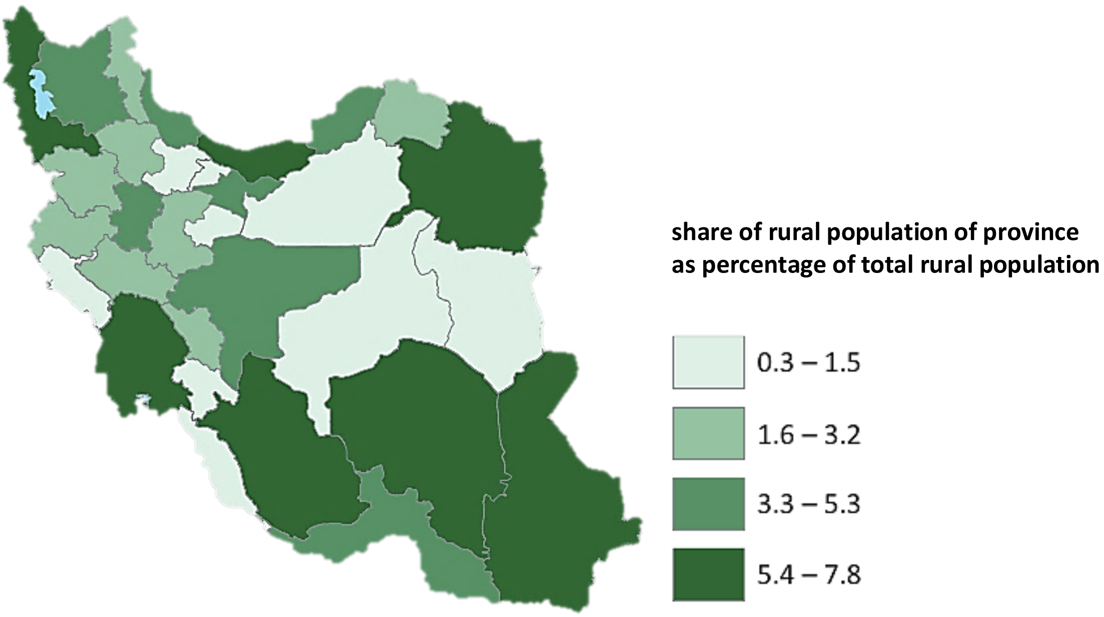
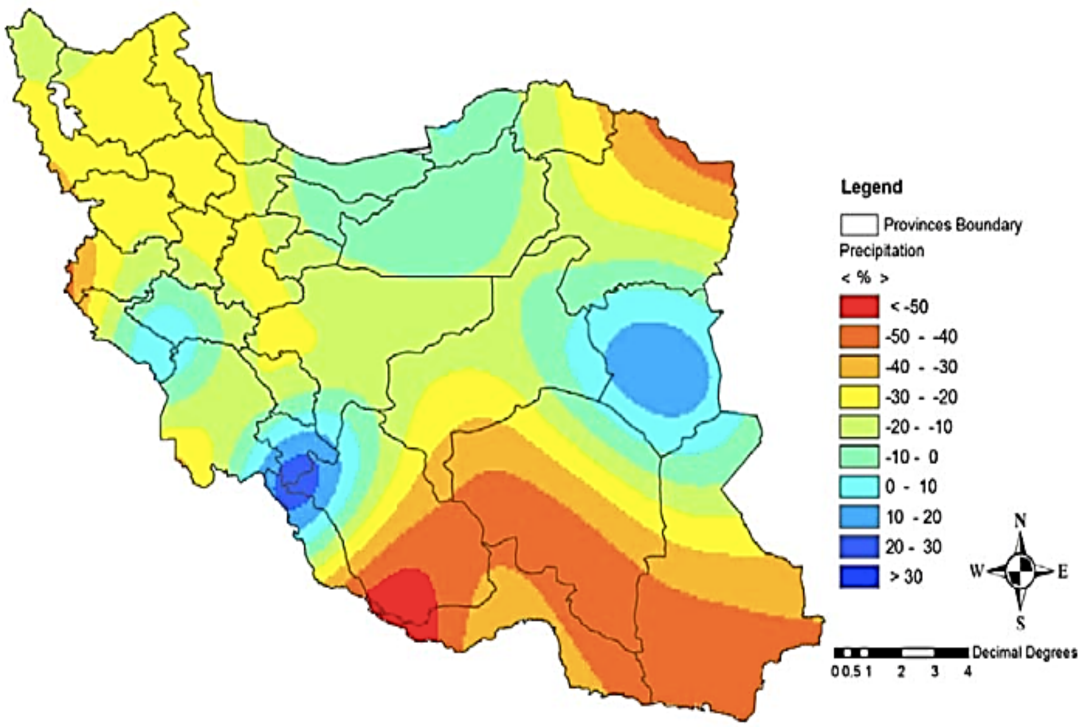


Figure 4.3. Changes of precipitation in 2035 compared to 1961-1999 (UNDP, 2015)



While the environmental concerns might be the major reasons underlying the current and future migration patterns, migration per se is not a new phenomenon in Iran. A major episode in the recent history of internal migration in Iran occurred when the country went through fundamental changes following the discovery of major oil fields in the first decade of 20th century. The resulting economic growth transformed the main cities into major centres of economic activity and led to the first major waves of rural-to-urban migration. The Land Reform Act of the 1960s and the oil boom of the early 1970s further boosted this pattern (Taleb and Anbari, 2005). Finally, the 1979 revolution and the Iran-Iraq war in 1980-1988 substantially contributed to the rural-to-urban trends of migration (Mahmoudian and Ghassemi-Ardahaee, 2014). Consequently, of the total population of about 75 million people in 2011 (SCI, 2011), 71% is settled in urban areas and this number is expected to reach 80% by 2050 (Mahmoudian and Ghassemi-Ardahaee, 2014). Demographic data suggest that: (i) over the last three decades on average one million people per annum have moved within the borders of the country; and (ii) in the 1996-2011 period there has been a 5% decrease in the rural population and a substantial rise of 44% in the urban population (which clearly cannot be explained solely by net birth rates).

The severe environmental impacts of climate change and the dynamic pattern of migration makes Iran an interesting case study for understanding the nature of link between these phenomena. The rest of this chapter is organised as follows. Section 4.2 reviews the literature. Section 4.3 describes the data. Section 4.4 outlines our empirical methodology. Section 4.5 presents and discusses the evidence and Section 4.6 checks its robustness. Section 4.7 concludes the chapter.

4.2. A brief review of the literature

As early as 1990, the IPCC warned that the greatest single impact of climate change could be on human migration – with millions of people displaced by shoreline erosions, coastal floodings and severe droughts. In 1992, the IOM, together with the Refugee Policy Group, published a report on 'Migration and Environment' that stated: "*Large numbers of people are moving as a result of environmental degradation that has increased dramatically in recent years. The number of such migrants could rise substantially as larger areas of the earth become uninhabitable as a result of climate change.*" (IOM, 1992).

In general, the analysis are built on the idea that mass displacements are caused by climate-caused resource scarcity.[36] There are a number of studies which quantify the effect of climatic factors on food production. For instance: You et al. (2009) find that a 1^{o}C increase in temperature can reduce wheat production by about 3% to 10% if it occurs during the period in which the crop is growing; Ozdogan (2011) explain that an increase of 1^{o} to 4^{o}C can negatively affect winter wheat production by 5% to 35%.

Suhrke and Hazarika (1993) claim that studies on environment and migration can be classified into two types: one is ascribed to 'minimalists' and concludes that environment is only a contextual factor in migration decisions; the other is associated with 'maximalists' and claims that environment directly forces people to relocate. More specifically, they suggests that "… [*minimalists*] *focus on the impact of a particular process*…" (p. 5) and are of the view that "…*we lack sufficient knowledge about the process to draw firm conclusions*…" (p. 4) whilst maximalists focus on extracting environmental variables from a cluster of causes and find that "…*environmental degradation has already displaced millions of people, and more displacement is on the way*…" (p. 4). Our contribution in this chapter builds on the maximalists' approach in that it seeks to quantify the impact of environmental factors on migration within Iran.

The United Nations Conference on Environment and Development (UNCED, 1992) identified four fragile eco-systems: 'desertification', 'deforestation', 'low-lying coastal land' and 'vanishing islands'. Suhrke and Hazarika (1993) too come to the similar conclusion that the most common forms of environmental degradation – which they argue to cause population displacement – are: desertification, land degradation, rising sea levels induced by global warming, and deforestation. In terms of impact, it appears that desertification is a greater threat: e.g., an IOM study (Gemenne et al., 2012) finds that in the past 30 years twice as many people have been affected by droughts as by storms – 1.6 billion compared to approximately 718 million. Studies on Africa, as a potentially vulnerable region, suggest that millions of people have already been displaced because of desertification (Hjort af Ornas and Salih, 1989; Bennett, 1991). As explained in the

[36] This argument is similar to that implied by the neo-Malthusian theory. Malthus (1798) proposed that population naturally increases in geometric ratio but the means of subsistence (i.e. agricultural production or food) increases only in an arithmetic ratio. This makes it impossible for agricultural production to sustain growing populations indefinitely. He continues by arguing that if we do not take control of the population growth voluntarily (called as a negative check), diseases, famines and wars (positive check) reduce population size and establish the necessary balance with resources. The neo-Malthusian theory accepts the opposing tendencies of (i) unlimited demographic expansions and (ii) limited food production, but adds to that factors such as technological expansion, exhaustion of mineral resources and other non-renewable resources, generation of various forms of pollution and etc.

previous section, since Iran too is a country with vast arid zones and a high tendency to desertification, it falls into the vulnerable regions based on the above categorisation.[37]

There are already a number of case studies which consider the link between climate and migration. Andersen et al. (2010) investigate the situation in Bolivia and find that on average about 2000 people annually leave their place of origin to escape bad climate. Joseph and Wodon (2013) focus on the Yemen and conclude that climate feature as one of the important push factors but not a significant pull factor in migration decisions. Joseph et al. (2014) too examine migration in Yemen and find that higher temperature and its variability have significant, but small, effect on net-migration in the country. Hassani-Mahmooei and Parris (2012) predict that climate is likely to lead to around 3 to 10 million internal migrations over the next 40 years in Bangladesh. Backhaus et al. (2015) study international migrations from the developing countries regions to OECD countries and suggest that a 1°C increase in temperature is associated with 1.9% increase in annual bilateral migration flows.

Finally, it is important to note at the outset that climate change and migration are most likely to affect each other in the form a vicious circle. On the one hand, climate change leads to migration via its adverse effect on resources and production (Andersen et al., 2010; Hassani-Mahmooei and Parris, 2012; Joseph and Wodon, 2013; Backhaus et al. 2015). On the other hand, migration causes climate change through the excess demand for resources generated by the rising population (Kalnay and Cai, 2003; Zhou et al., 2004). However, the latter process is likely to be more of a long-term consequence. In this chapter, therefore, we shall only focus on the former channel.

4.3. The data

We use construct our dataset using the information on individual characteristics provided by the Iranian National Census data. Up until 2006, nationwide censuses used to take place every ten years and since 2006 their frequency has been reduced to every five years. We use the standard definition of a 'migrant' as an individual who has changed his or her place of residence during the census period. Thus, for instance, a migrant in the 2006 census dataset is one who has changed his or her place of residence at some point in time between 1996 and 2006. We concentrate our analysis on internal migration and only

[37] However, only 0.85% of its area is of low-lying land and 1.27% of its population live in places where elevation is below 5 meters (World Bank, 2014a).

consider inter-provincial[38] movements within the country. We therefore disregard movements between locations within the same province as well as all international migrations. Our sample is constructed using the pooled cross-section data from the two censuses covering March 21 1996 to March 20 2006 and March 21 2006 to March 20 2011.[39] This dataset covers the migration matrix for 30 provinces and includes 1740 (=30×29×2) observations, with 870 (=30×29) different province-pairs in a balanced structure. We exclude the earlier censuses because they lack data on most variables and a province reform was implemented during 1988-1996 period which affected the geographical boundaries.[40]

We use the gravity-based regression analysis, outlined in Section 4, to estimate the impact of climatic and other factor on migration. Thus, dependent variable is a measure of migration which varies over origin and destination as well as over time. Given the difference in the time intervals that the two censuses cover, we measure migration by the average annual number of inter-provincial migrants in each census recorded under *immigration*, instead of *emigration*; this choice was made simply because data on the emigration were found to be less accurate due to a higher number of un-stated responses.[41] Figures 4.4 and 4.5 plot the average annual number, and the corresponding rate, of province-level emigration over the two census periods. It is clear that the number of internal emigrants slightly decreased in the more recent census period, and this drop is enhanced in terms of the proportion of people annually leaving their place of origin. The three main explanations put forward for this, are:

(a) The former census covers the years of adjustment that followed the Iran-Iraq war. Thus, a part of the relatively large movement in population could therefore be accounted for by relocation of those displaced during the war year.

(b) The period also coincided with post-war reconstruction years as well as the industrial development policy years of 1993-2001. As a result, waves of migration

[38] Inter-district migration would have been a better choice but the information at the district level is not available in the dataset. Appendix A2 discusses a number of issues encountered when compiling the data.

[39] The Iranian calendar starts on 21 March.

[40] Apart from *Alborz* that was created in 2010 and is treated as part of *Tehran* in our estimations; i.e. Movements to/from *Alborz* are added to *Tehran's* for 2010 and 2011, also movements between *Alborz* and *Tehran* are considered as intra-province movements and therefore omitted. Other provinces created as the result of the mentioned reforms are *Golestan* (separated in 1996 from *Mazandaran*), *Qazvin* (separated from *Tehran* in 1996), and *North*, *Razavi*, and *South Khorasans* (all three were created in 2004 from the original *Khorasan*). See Appendix A2 for further details.

[41] In a closed system with accurate data, immigration of A from B should be equal to emigration of B to A.

towards the cities targeted by these policies, in response to the new opportunities, accounts for another part of the relatively large movement in population.

Figure 4.4. Number of emigrants by province and census period

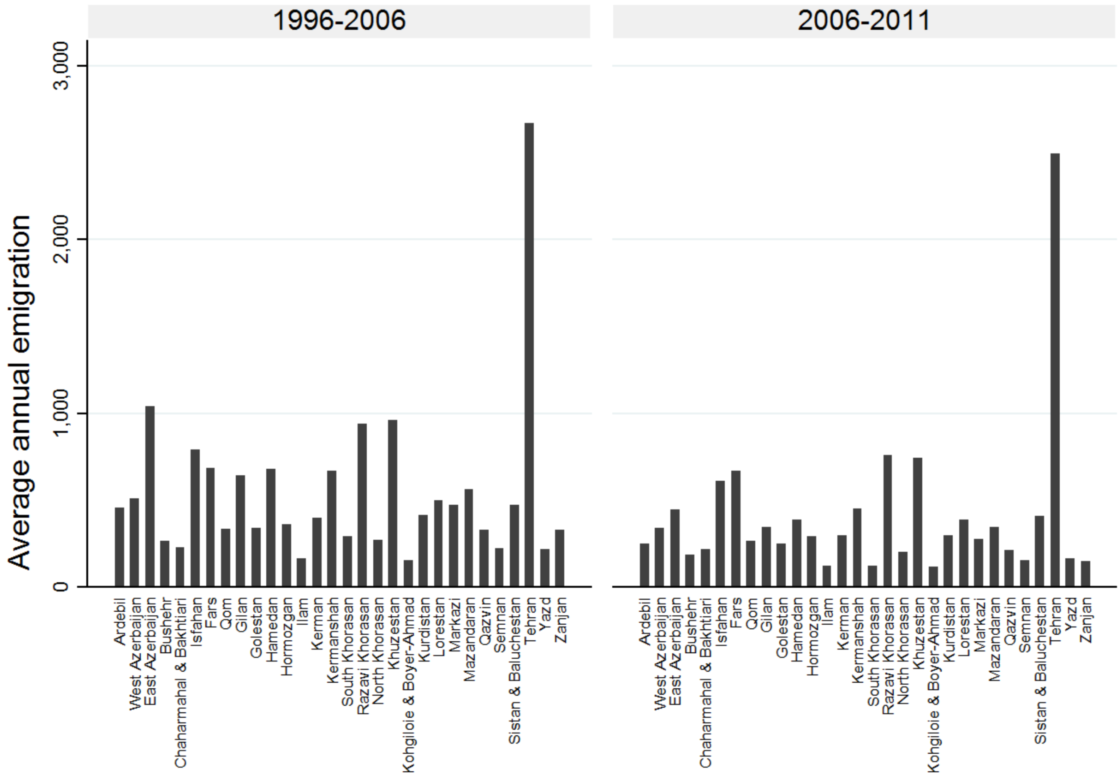
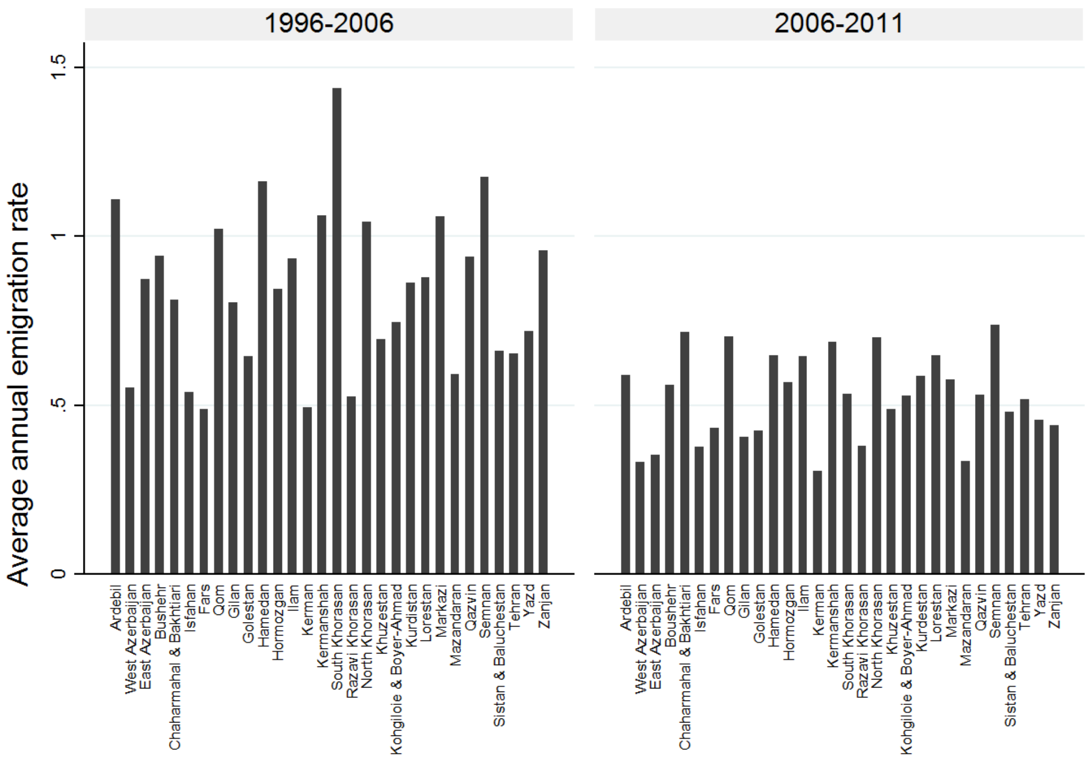


Figure 4.5. Rate of emigration by province and census period



Note: $Emigration\ rate = 100 \times (Average\ annual\ emigration / Mid\ census\ population)$

(c) At the same time, the on-going infrastructure improvement policies were increasingly targeted towards the less developed regions helped reducing the stream of migrants from those parts. This explains the drop in inter-province migrations in the more recent years, which was further enhanced by the impact of the global financial and trade sanctions imposed on Iran which significantly diminished the level of economic activity and depressed migration in pursuit of better opportunities.

The explanatory variables used as determinants of migration are divided into three main groups and comprise:

(I) *Gravity factors*: distance[42]; area; population; GDP[43]; and growth. The first three are measures of size while the latter two respectively reflect the actual and potential economic size.

(II) *Climatic factors*: average annual temperature and precipitation, and their absolute and relative deviations from the *climate*[44].

(III) *Non-climatic factors,* which are divided into four sub-groups:

(III.i) *Economic factors*: income-based Gini coefficient, inflation, and unemployment rate;

(III.ii) *Demographic factors*: share of educated population and share of population living in rural areas;

(III.iii) *Health factors*: rural health centres and healthcare professional[45] density (per 10,000 inhabitants);

(III.iv) *Geographic factors*: ratio of rangeland and desert areas in total area.

With the exception of the distance which is constant over time, all variables vary over both province and time and are therefore measured either as the midpoint value or as the average value over the census periods.[46] More precisely, the midpoint value is used for variables such as population which exhibit a consistent trend over time whereas the

[42] Distance is measured as the driving distance between capitals of provinces and is obtained from Google maps.
[43] Real GDP is measured by deflating the – publicly available – nominal values using 'spliced' price indices. Splicing is the process of combining two or more index numbers covering different base years into a single series. We used this method as the base year of price indices were dissimilar.
[44] Definition of 'climate' is given in footnote 11. See Table 4.1 for details.
[45] The figure consists of general practitioners, dentists, vets, pharmacists, and other health care specialists.
[46] Note that whilst in principle the province areas vary over time since boundary changes are implemented periodically.

average value is utilised for variables which fluctuate over time, e.g. temperature deviation. Tables 4.1 presents the list and definition of province-level the above variables which are used in our regression analysis in Section 5.[47] Given that our investigation focuses on the impact of climatic variables, we note at the outset that a positive (negative) deviation in temperature (precipitation) over the period in question from their climate levels is noticeable. This trend is illustrated by means of histograms in Table 4.2 which show that in that there is a warming up and drying up trend in Iran over the 1996-2011 period.

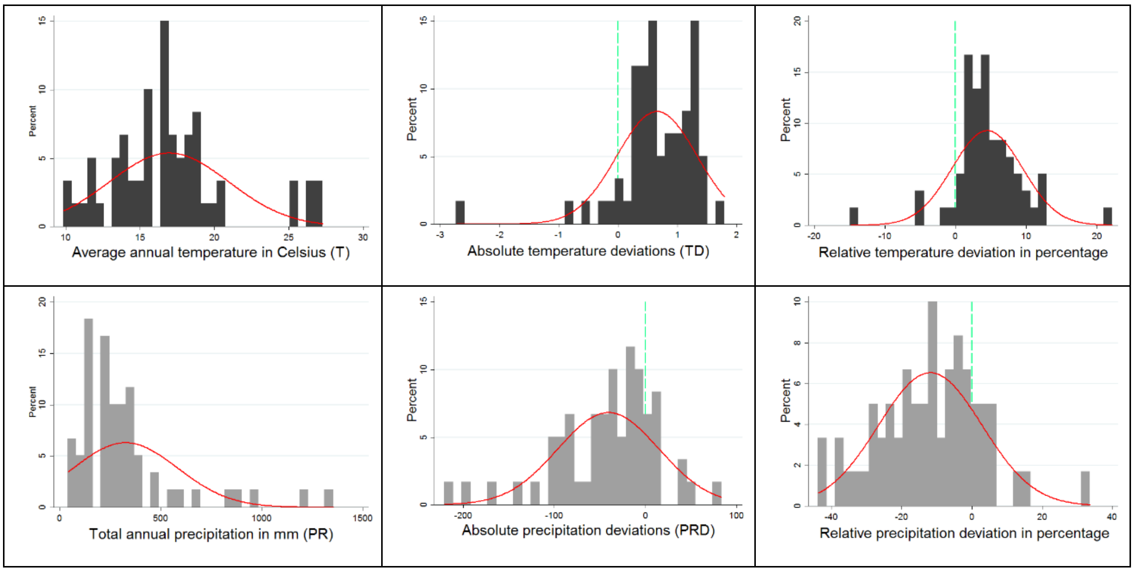
Table 4.1. List and definition of the variables used in the regression analysis

Notation	Definition
M_{ij}	number of people leaving the origin *i* for destination *j* (the dependent variable)
D_{ij}	driving distance, in km, between the origin *i* for destination *j*
A_k	total area in square km
P_k	total population
Y_k	real GDP in constant 2003 prices in domestic currency (millions of Iranian rials)
G_k	growth rate of income
T_k	average annual temperature (in Celsius)
TD_k	absolute temperature deviations
PR_k	total annual precipitation in mm
PRD_k	absolute precipitation deviations
$GINI_k$	income-based Gini index
INF_k	inflation rate
UR_k	share of the unemployed in working age population (as % of total working population)
ER_k	share of educated population (as % of the over 5 year old population)
RPS_k	share of rural population (as % of total population)
RHD_k	number of rural health centres per 10000 rural population
HPD_k	number of health professionals per 10000 population
RR_k	share of the area covered with rangeland (as % of total area)
RD_k	share of desert area (as % of total area)

- Unless otherwise stated, all variables are measured as annual averages over the census period; midpoint averages were used in cases where annual observations over the census period was unavailable.
- The raw data on climatic variables were obtained from the Iranian National Climate Change Office.
- T_k is the mean over the census period of the average the daily temperature of province's capital city, i.e. (maximum daily temperature + minimum daily temperature)/2. $TD_k = T_k - CT_k$ where CT_k is the moving average of T_k of over the last 30 years.
- PR_k is the mean over the census period of the total precipitation for each province's capital city for each year. $PRD_k = PR_k - CPR_k$ where CPR_k is the moving average of PR_k of over the last 30 years.

[47] For summary statistics see Tables A4.2 and A4.3 in the Appendix.

Table 4.2. Climatic factors' deviations by provinces



- The above histograms demonstrate that there has been an overall increase in temperature and fall in precipitation across provinces during the sample period.
- $\overline{TD}$ = +0.66ºC and $\overline{PD}$ = -41^{mm} are the average absolute changes in temperature and precipitation.
- %$\overline{\Delta T}$ = +4.5% and %$\overline{\Delta P}$ = -12% are the average relative changes in temperature and precipitation.

4.4. Empirical methodology

We use the gravity principle to determine the specification of our regression equations. Economists have used the gravity model (inspired by Newton's Universal Gravitation Law) to explain the flow of goods, capital as well as to study migration.[48] More specifically, we postulate the gravity equation

$$M_{ij} = D_{ij}^{\delta} W_i W_j, \qquad (4.1)$$

where M_{ij} and D_{ij} respectively denote the number of migrants and the distance between locations between i and j, and W_k is the relevant gravity variable for the respective location $(k = i, j)$, and δ is the constant parameter – if D and W are accurate measures one would expect $\delta = -2$ as in the original gravity equation. As mentioned above, we approximate D by the driving distance between the capital cities of provinces. As for W, we assume it is a composite measure defined as a weighted basket of variables that reflect the importance and attractiveness of a location. As explained in the above section, the

[48] Tinbergen (1962) is one of the first studies of trade flows between regions across the world proposing and using the gravity model. See Anderson (1979) for the original theoretical explanations and Lowry (1966), Greenwood (2005), Beine et al. (2015), and Backhaus et al. (2015) for applications of the gravity model in migration studies.

main such variables, which are most commonly used in this context, are growth, GDP, population and area respectively denoted by $G,\ Y, P$ and A. Hence, we let

$$W_k = \exp(\gamma_k + \beta_{g,k} G_k)\, Y_k^{\beta_{y,k}} P_k^{\beta_{p,k}} A_k^{\beta_{a,k}},\ k = i, j, \tag{4.2}$$

where $\beta_{g,k},\ \beta_{y,k},\ \beta_{p,k}$ and $\beta_{a,k}$ are the respective weights and γ_k embodies all other omitted observable and unobservable factors. The basic specification consisting of (4.1) and (4.2) is therefore further augmented by replacing γ_k with the relevant explanatory variables whose omission could bias the parameter estimates of the basic model above. Amongst these variables, which were outlined above and listed in Table 4.1, our focus will be on those which represent the role of climate. We denote the relevant climatic variables by vector x, whose elements will include one or more of T, TD, PR, PRD. The rest of the variables, which are used as control explanatory variables to reduce the omitted variable effect, are denoted by $z' = (GINI, INF, UR, ER, RPS, RHD, HPD, RR, RD)$ – see Table 4.1 for definitions. Finally, we also include the destination province and census fixed effects, denoted by ω_j and τ_t respectively, where the subscript $t = 1{,}2$ refers to the two censuses.

Substituting from (4.2) into (4.1) to eliminate $W_k,\ k = i, j$, using the log-linear version of the resulting equation, and augmenting it with x_k, z_k, ω_j and τ_t, the corresponding general linear regression equation therefore is,

$$\begin{aligned} \ln M_{ij,t} = \theta &+ \delta lnD_{ij} + \beta_{g,i} G_{i,t} + \beta_{g,j} G_{j,t} + \beta_{y,i} \ln Y_{i,t} + \beta_{y,j} \ln Y_{j,t} \\ &+ \beta_{p,i} \ln P_{i,t} + \beta_{p,j} \ln P_{j,t} + \beta_{a,i} \ln A_{i,t} + \beta_{a,j} \ln A_{j,t} + x'_{i,t} \beta_{x,i} + x'_{j,t} \beta_{x,j} \\ &+ z'_{i,t} \beta_{z,i} + z'_{j,t} \beta_{z,j} + \omega_j + \tau_t + \varepsilon_{ij,t} \end{aligned} \tag{4.3}$$

where θ is a constant intercept and $\varepsilon_{ij,t}$ is the random disturbance term of the regression. While $E[\varepsilon_{ij,t}] = 0$ for all i, j and t and $E[\varepsilon_{ij,1}\ \varepsilon_{ji,2}] = 0$ for all i, j are the standard assumptions, we cannot rule out $E[\varepsilon_{ij,t}\ \varepsilon_{ji,t}] \neq 0$ since the reasons that a large number of people move from one province to another could be highly correlated with the reasons why a small number of people move in the opposite direction. Therefore, while OLS estimator yields unbiased estimates of the parameters of the above model, we need to use standard errors which are clustered at province-pair level in order to take account of correlated errors within pairs.

4.5. Evidence

The gravity theory predicts δ to be negative with its magnitude exceeding unity (closer to 2), and distance D_{ij} is on the whole expected to play a significantly dominant role in explaining migration. This is because distance is known to represent the cost of migration, not only in terms of relocation cost but also with respect to costs arising from difficulties in adapting to farther away districts, maintaining close contact with the place of origin, etc.

If the theory holds in its strict form, the main gravity factors G_k, Y_k, P_k and A_k are expected to have positive and significant effects for $k = i, j$. This is because W_k reflects the so called attraction or importance associated with location k: there is likely to be a greater movement between two locations as the importance of one or both increases. However, it is perceivable that the estimated values of the coefficients of G_k, Y_k, P_k and $A_k, k = i, j$, are also affected by push and pull motives. This is because the gravity equation of migration can also be justified theoretically on the basis of the random utility model (Molho, 1986) which compares the expected utilities that an individual assigns to living in the two specific locations – origin i and destination j – where the comparison involves the expected benefits and/or losses which increase and/or reduce the relative attractiveness of the destination, e.g. a higher expected relative income, a relatively higher population, or a relatively larger area. On the whole, therefore, while one would expect the impact of G_k to be positive for $= i, j$ – since growth promotes mobility – the following scenarios with respect to Y_k, P_k and A_k could be it is envisaged:

(i) $\beta_{y,j} > 0$ and $\beta_{y,i} < 0$: relative prosperity matters, therefore a higher income in the destination would add to its attraction but in the origin it is likely to weaken emigration motives.

(ii) $\beta_{p,j} < 0$ and $\beta_{p,i} > 0$: large populations crowd out opportunities, therefore a less (more) populated destination (origin) could make it more (less) attractive and hence strengthen emigration motives. However, the effect of such motives could be modified by the equally plausible possibility that the bigger are the populations of the two provinces the larger is likely to be the cross migration, hence expecting both P_i and P_j to exert positive effects.

(iii) Regarding $\beta_{a,j}$ and $\beta_{a,i}$, there is no clear evidence available in the existing literature. It is, however, tempting to speculate that the larger are the two provinces the greater is the cross migration, hence to expect both coefficients to be positive. However, while $\beta_{a,i} > 0$ is easier to perceive, the impact of A_j is a priori ambiguous.

Once the effect of the main gravity factors and the additional control variables in vector z, as specified above, are accounted for, we expect to find climatic deterioration in a province to increase emigration. Therefore, we anticipate $\beta_{x,i} > 0, \beta_{x,j} < 0$ when x is a measure of temperature, and the opposite is expected when it is a precipitation measure.

The effects of gravity and climatic factors, based on OLS estimates of different versions of equation (4.3), are reported in Table 4.3. Column A gives the estimates which exclude any climate factors and can be compared with (i) columns B to E where we examine the effect of adding separately each temperature or precipitation measures, one at a time, i.e. setting $x = T$, $x = TD$, $x = PR$, or $x = PRD$, and (ii) columns F and G where in contrast we add both measures, $x' = (T, PR)$ or $x' = (TD, PRD\ )$, on the grounds that their linear combination could better captures the climate effect.

In all cases, the coefficient of distance has the anticipated negative sign, is highly significant and, in fact, its estimated values are not much different from the expected theoretical size of $\delta = -2$. Moreover, based on partial correlation analysis (not reported), D_{ij} appears to be the single most important discouraging factor as it explains on average about 23% of variations in $M_{ij,t}$, which is considerable. In fact, as can be seen from Figure 4.6, 90% of internal emigrations in Iran occur within a radius of 625km from the original location. This is less than the average distance between provinces of 867km, implying that the relocation cost factor is effective and migrants tend to move to the closest neighbouring provinces with suitable conditions.

Table 4.3. Effects of gravity and climatic factors on Iran's inter-province migration

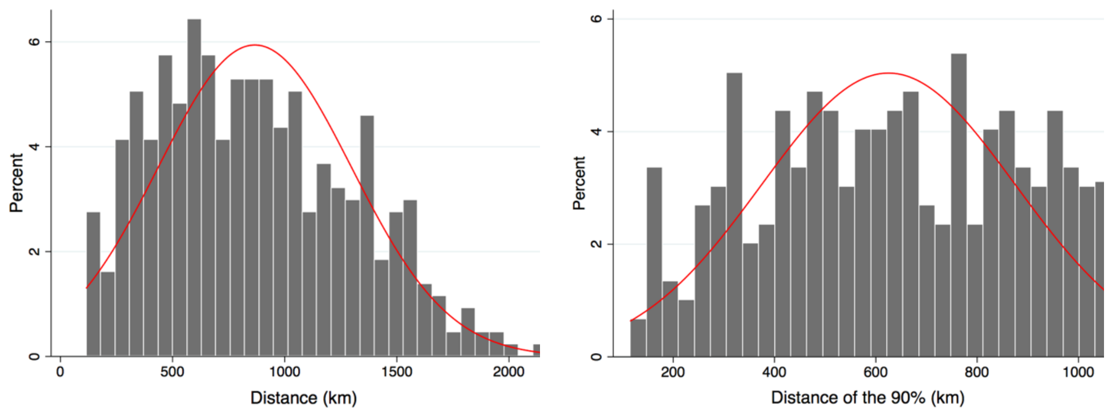
		A	B	C	D	E	F	G
Dependent: M_{ij} (migration from i to j)								
distance:	D_{ij}	-1.677***	-1.693***	-1.682***	-1.677***	-1.686***	-1.693***	-1.692***
growth rate:	G_i	0.0339***	0.0222***	0.0338***	0.0344***	0.0401***	0.0226***	0.0405***
	G_j	0.00287	0.00246	0.00405	0.0128**	0.0202***	0.0132**	0.0213***
real GDP:	Y_i	0.0641	-0.0918	0.0635	0.0850	0.0415	-0.0708	0.0385
	Y_j	0.460**	0.468*	0.597**	0.512**	0.622***	0.595**	0.757***
population:	P_i	1.092***	1.253***	1.034***	1.124***	1.122***	1.265***	1.062***
	P_j	-1.572**	-1.631	-2.386**	-1.567**	-1.522**	-1.955*	-2.326**
area:	A_i	0.233***	0.162***	0.212***	0.185***	0.229***	0.115*	0.199***
	A_j	-3.586	-3.716	-4.007	-2.977	1.703	-3.587	1.267
temperature:	T_i	--	0.852***	--	--	--	0.853***	--
	T_j	--	0.144	--	--	--	0.757	--
temperature deviation:	TD_i	--	--	0.0896***	--	--	--	0.124***
	TD_j	--	--	0.0899	--	--	--	0.0901
precipitation:	PR_i	--	--	--	-0.141**	--	-0.141**	--
	PR_j	--	--	--	-0.347***	--	-0.376***	--
precipitation deviation:	PRD_i	--	--	--	--	-0.00233***	--	-0.00255***
	PRD_j	--	--	--	--	-0.00155***	--	-0.00155***
	R^2	0.8307	0.8388	0.8316	0.8315	0.8350	0.8396	0.8366
	$\bar{R}^2$	0 .8250	0 .8332	0 .8258	0 .8256	0 .8293	0 .8338	0 .8307
	L	-1719	-1677	-1714	-1715	-1697	-1672	-1688
	AIC	3552	3471	3547	3548	3511	3466	3498
	BIC	3863	3793	3869	3870	3833	3799	3832
	F_z	10.95 (0.000)	9.06 (0.000)	10.79 (0.000)	10.26 (0.000)	11.12 (0.000)	8.99 (0.000)	10.84 (0.000)
	Reset	11.20 (0.000)	12.13 (0.000)	11.87 (0.000)	10.65 (0.000)	11.18 (0.000)	11.53 (0.000)	12.13 (0.000)

- OLS estimates based on the regression equation (4.3) with the dependent variable $\ln M_{ij}$ as defined in Table 4.1; all regressions include the additional control variables in vector z and the destination province and census fixed effects, and differ only with respect to climatic explanatory variables.
- The sample size in all regressions is 1740, consisting a balanced combination of 30 provinces over the two census periods covering 1996-2011.
- '*', '**' and '***' respectively denote significance at 10%, 5% and 1% critical values based on standard errors clustered at the province level. We used Huber/White estimators (or robust standard errors or sandwich estimators of variance) to treat heteroscedasticity throughout the analysis in this chapter.
- L is the log-likelihood value; *AIC* and *BIC* are the Akaike and Schwarz information criteria; F_z is the F ratio based on the exclusion of the control variables in vector z, with p-values in parentheses; *Reset* is Ramsey's reset specification test with p-values in parentheses.

Economic growth, G_k, has positive effects in all cases as expected, consistent with the idea that growth in general encourages mobility, and its coefficient is on the whole statistically significant, especially after we account for climatic factors. But the effects of income, population and area seem to be affected by the pull/push factors. In particular:

- GDP at destination, Y_j, has positive and statistically significant effect in all cases but its coefficient is statistically insignificant for the origin, Y_i. This suggests that income plays a pull factor.
- Population, P_k, has a positive and statistically significant effect throughout (except in column B) with a positive (negative) sign for $k = i$ ($k = j$) indicating that its influence is driven by the push/pull process: a higher population crowds out opportunities.
- The area of the origin, A_i, has a positive and statistically significant coefficient in all cases and the coefficient of A_j is negative (except in column G) but statistically insignificant. Thus, in this case too, the 'push process' seems to be the determining factor where larger provinces are considered less desirable.

Figure 4.6. Distribution of D_{ij} (left) and 90% of D_{ij} (right)



90% of D_{ij} omits the highest decimal of distance migrants moved.

With respect to the influence of climatic factors, which are the main focus of this chapter, we find that on the whole hotter and drier climate lead to migration. In particular: (i) a rise in temperature in the origin increases emigration since both T_i and TD_i have positive and statistically significant coefficient (see columns B, C, F and G); and (ii) dryness, measured by a fall PR_i and/or PRD_i, in general stimulates migration, since the coefficients of the latter are always negative and statistically significant (see columns D, E, F and G). Therefore, while temperature can be clearly classified as push factor, we cannot unambiguously identify a pull factor amongst the measures of climatic we have used.

The results presented in Table 4.3 are consistent with those reported in other studies on the role of both climatic and non-climatic factors in determining migration cross-location flows – see, e.g., Andersen et al. (2010), and the study on Yemen by Joseph and Wodon (2013). However, the robustness of our estimates might have been undermined by a possibly high potential correlation between province area A_j and the province fixed effect ω_j; as pointed out in footnote 43 above, this is because although A_j varies across provinces, its value remains fixed over time except in the few occasions when some boundary changes were implemented. We therefore re-estimated the specifications presented in Table 4.3 by dropping the province fixed effect in order to check whether this problem had affected the results. The corresponding estimates are reported in Table A4.4 in the Appendix and show that excluding the province fixed effect changes the results in an interesting way. In particular:

- There is a minor change in the explanatory roles of distance and growth: the coefficient D_{ij} becomes slightly smaller in all cases, and G_k has a significant and positive effect in all cases (recall that G_j effect was previously insignificant in specifications in columns A, B and C).

- The effect of Y_i remain as before: its coefficient estimates retain the same sign and are still statistically insignificant. But there is an anomalous change in the effect of Y_j whose coefficients estimates lose in statistical significance and also become negative in columns B and F. This inexplicable alteration of the impact of income in destination province undermines the robustness of these estimates.

- The effects P_k and A_k become positive and statistically significant in all cases. Therefore, they are now consistent with the general gravity model and no longer comply with the push/pull process as implied by the previous results.

- The effects climate variables too are now consistent with the general gravity model: they are statistically significant throughout (except for PR_j in columns D and F), and imply that migration rises as the climate in general becomes hotter and more arid.

Given that dropping the province fixed effect leads to less plausible effect of income and somewhat unrealistic lack of evidence on the existence of any kind of push/pull process on the one hand, and it does not improve the overall statistical performance of the regressions on the other hand, we shall disregard the results in Table A4.4 and opt in favour of keeping the destination province dummies.[49] In particular, based on a comparison of the corresponding estimates which are reported in the columns of Table 4.3, we choose the specifications in either column F or G as our preferred model as they are statistically almost equivalent (the non-nested encompassing and augmented J tests did not help distinguish between these specifications). The specifications in Table 4.3, however, do not allow for any interaction between the two types of variables that represent climate and size. Since there is a valid argument that the impact of climate factors might be contingent on size factors, before finalising our model selection therefore we investigate this issue. More precisely, we re-estimate the modified versions of the specifications in columns C, E and G of Table 4.3 by augmenting them with the interaction effects between the climate variables – TD_k and PRD_k – and the two main variables representing size – Y_k and P_k – that vary over time. The corresponding estimates with and without interaction terms are reported in Table A4.5 in the Appendix: while there are some significant interaction effects, on the whole their inclusion weakens the contribution of climatic factors and does not necessarily improve the overall performance of the model. We therefore opt for excluding the interaction effects.

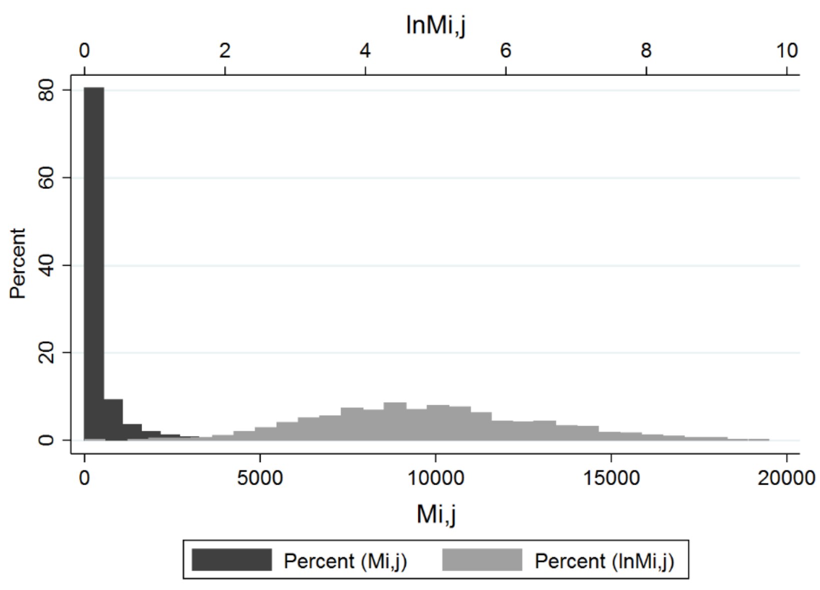
We conclude our discussion of evidence of climatic effects on migration by using our selected models to predict how a rise in average temperature and/or in dryness would stimulate migration. Evidently hotter provinces and those that experienced a larger growth tend to emit more migrants. Both T_k and TD_k have positive effect on emigration with average marginal effects of 19.7% and 8.4% for one s.d. increase respectively. Oppositely and as expected, drier provinces or those that became drier tend to push people out since both PR_k and PRD_k influence emigration negatively with average marginal effects of 9.9% and 14.4% for one s.d. decrease respectively.

[49] Nevertheless, it is encouraging that dropping the dummies does not in any way diminish the importance of the role climate factors play in influencing migration decisions.

4.6. Robustness

The evidence provided above was based on the application of OLS estimation method to a log-linear specification which is typically used when estimating regression equations based on the gravity principle. However, the raw data used to construct the dependent variable, i.e. cross location migration flows, can also be interpreted as the statistical data type known as 'count data' whose elements are integers that are obtained by counting a certain type of individuals within a given population. As can be seen from Figure 4.7, which plots data frequency of both M_{ij} and $\ln M_{ij}$, the underlying distribution seems to be consistent with both Poisson and log-normal distributions (measured at the bottom axis and top axis in Figure 4.7, respectively). Hausman et al. (1984) have shown that count data can be efficiently modelled using an appropriate Conditional Negative Binomial specification. Therefore, given that M_{ij} conforms to count data with Poisson-shaped distribution with over-dispersion, it might be argued that an alternative to estimation with OLS using $\ln M_{ij}$ as the dependent variable is to use their recommended conditional fixed-effects over-dispersion model with M_{ij} as the dependent variable.[50] The estimates corresponding to columns C, E and G are reported in Table A4.6 in the Appendix and show that the original results do not change substantially.

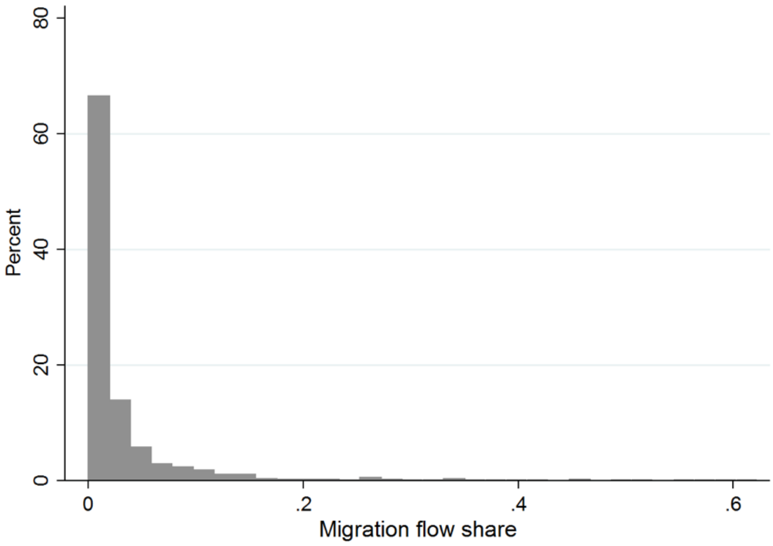
Figure 4.7. Distribution of migration flows



[50] See Allison and Waterman (2002) for details.

An alternative way of measuring the dependent variable, instead of using M_{ij}, is to use the share of emigrants, $m_{ij} = M_{ij}/\sum_i M_{ij}$. Figure 4.8 below depicts the distribution of m_{ij} which shows that it is rather similar to that of M_{ij} illustrated above. In fact, we found that using m_{ij} instead of M_{ij} does not alter the results in any significant way.

Figure 4.8. Distribution of migration flow shares, $m_{ij} = M_{ij}/\sum_i M_{ij}$



Similar to the previous chapter, we also located outliers and observations with high leverages, in order to test the results in their absence; some illustrations of post-estimation analysis are presented in Figures A4.7-A4.10 in the Appendix. Re-estimating equation (4.3) after excluding such outliers did not alter the general conclusions.

4.7. Conclusions

In this chapter we have empirically examined the existence and robustness of the relationship between climatic factors and internal migration in Iran. This was motivated by the received knowledge that climate change is associated with migration and human displacement. We chose Iran because the country has become increasingly vulnerable to climate change and has had a recent history of significant internal migration that was caused by the Iran-Iraq war. Therefore, the country provides a good opportunity for a case study which examines if climatic factors induce migration above and beyond that caused by other factors.

Our results, which are based on the period 1996-2011, suggest that push factors are the dominant cause of internal migration in Iran. As expected, cost of relocation, proxied by distance, and economic factors are the most important reasons driving internal migration. Although climatic factors are not the most important determinants of internal migration in Iran, their role, especially as *push factors*, is eminent even after rigorous robustness checks. Our findings suggest that people do tend to leave warmer and/or drier regions. However, we did not find sufficient evidence to ascertain that the choice of destination depends on climatic factors as the latter do not appear to act as *pull factors*. In terms of impact, distance, economic and wellbeing factors rank highest respectively: neighbouring regions are more frequently targeted, followed by locations that offer better opportunities.

As an indication of the magnitude of the climatic impact on internal migration in Iran, our results suggest the following:

- a one s.d. rise in annual temperature, which is equivalent to becoming 4°C hotter, would lead to 19.7% more emigration. Alternatively, a one s.d. rise in temperature with respect to the climate average, which is equivalent to becoming 0.7°C warmer, would increase emigration by 8.4%.
- a one reduction of 260mm in annual rainfall, which is equivalent to one s.d. fall in annual precipitation, would raise emigration by 9.9%. Alternatively, a one s.d. fall in precipitation with respect to the climate average, which is equivalent to 55mm less rainfall, would stimulate 14.1% increase in emigration.

Examining the impact of the other explanatory variables, the on-going migration indicate an urbanisation pattern developing in that migrants tend to favour bigger economies, perhaps because they have better job opportunities, access to better education facilities, better health care system, etc. This result is consistent with random utility model and is based on the expectations of bettering one's overall wellbeing.

It is worth stressing that while there is strong evidence that climatic factors influence the decision to leave, they do not play a clear role in shaping the strategy to choose the destination; they simply stimulate migration. Migration is not necessarily bad, either for the country or the people; as Bunea (2012) states, "*internal migration is a key mechanism for adjustment to regional economic shocks, especially when other tools prove useless*" (p. 127). However, the problem lies in excessive unregulated migration; to put it simply, the regional balance of a country would be irreparably damaged if all potential migrants were to leave for more prosperous locations which offered better economic opportunities and living conditions. The general policy implication of our study is therefore clear: there needs to be a strong collaboration between authorities responsible for the environment, climate, urbanisation, demographic, regional and migration policies since the harmful consequences resulting from a vicious circle of deterioration of rural regions and over-crowding of the urban regions could be irreversible.

With respect to specific policy recommendations concerning the situation in Iran, one strategy would be to seek funding and expert advice from the relevant international institutions. Article 4.4 of the Kyoto Protocol, the United Nations Framework Convention on Climate Change, states that financial assistance will be made available "*... shall also assist the developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting the costs of adaptation to these adverse effects*". Our evidence can be further built upon to illustrate that Iran is in a strong position to qualify for such funds; the country will then have a reasonable chance to succeed in securing a financial assistance programme provided it is clearly targeted to capacity building and adaptation measures which aim to improve localised resilience so as to reduce the impact of specific climatic effects. While there are different ways of stimulating localised resilience, it could be argued that the following policies might prove more effective:

(a) promoting individual-level innovation via development of sustainable and appropriately targeted micro-finance schemes which prioritise artisan traditional agricultural activities that utilise suitable irrigation methods;

(b) introducing micro-insurance for compensating the impact of climate-based anomalies, e.g. a rainfall insurance where pay-out is triggered when rainfall deviation reaches a certain size, as proposed by Gine et al. (2008) and Hertel and Rosch (2010);

(c) introducing forest cultivation and drought resistant crop policies – see Farzin (2014) and Lilleør and Van den Broeck (2011) respectively.

Given the encouraging and informative nature of the evidence, further research could focus on identifying, and enhancing our understanding of the role of, the push and pull factors which motivate migration. To this end, a combining data from different countries would help in assessing more precisely the role of climatic factors which are bound to play increasingly dominant role.

Appendix

A4.1. Examples of climatic change effects in Iran

One of the most disturbing and worrying episodes is the drying up of the 'Zayandehrood' River which flows through Isfahan (the second biggest city of Iran) and is the most important water resource for urban, industrial, and agriculture water consumptions of more than 3.7 million residents as well as for the survival of the 'Gav-Khuni' marsh and its valuable ecosystem.[51] The river, whose name literally translates into 'life-giving river' and flowed for 400 kilometres from the Zagros mountains, has practically changed into dirt and stones. Low rainfall and wrong irrigation plans are considered as the main reasons for this phenomena (Financial Times, 2014).

The second major environmental threat in Iran is the receding of the Urmia Lake – situated in the north west of the country – whose depth has reduced from 16m in 2000 to 10m.[52] This is thought to have been caused, mainly, by the drier climate and the change in water consumption patterns for irrigated agricultural operations (Delju et al., 2013). Due to droughts, overuse of surface water resources and dam constructions, the water level has decreased in such a way that one quarter of the lake has changed to saline area over the last 10 years; see Figure A4.1 below.[53] Acknowledging the role of climate change, Madani (2014) suggests that the major factors causing the country's water crisis are in fact agricultural production inefficiency and mismanagement. Some believe climate change intensified the problem, for instance, Delju et al. (2013) state "*the combined effect of these dams along with high exploitation of ground water intensified by recent drought cycles has brought the lake to a critical situation*" (p. 286). They also indicate that mean precipitation has decreased by 9.2% and the average maximum temperature has increased by 0.8°C over the last four decades. Hassanzadeh et al. (2012) identifies changes in inflows due to climate change and overuse of surface water resources as the dominant factors of the disaster, being responsible for 65% of the shrinkage, and dam over-construction (mismanagement) as the second major contributor with 25% share[54]. Overall, there is a general belief amongst scholars that climate change has been at least partly responsible.

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[51] Gohari et al. (2013) report that 73% of Zayandeh's water is used for agriculture. See Water Research Institute (2005) for details.
[52] See Figure A4.2 in Appendix for a series of satellite pictures taken at different times by NASA demonstrating the shrinkage.
[53] See Hassanzadeh et al., (2012). According to Delju et al. (2013), there are now 35 dams built on 21 rivers flowing to the lake.
[54] Lower precipitation around the lake was identified for the remaining 10%.

Figure A4.1. Change in the Lake Urmia's surface area

September 2000 **August 2010** **July 2014**

Source: (USGS, 2014)

Such crisis raise concerns regarding the likelihood of escalated tension and even conflict in Iran, a country surrounded by unstable neighbours – most notably Afghanistan and Iraq – with water shortages of their own. The resident representative of the UNDP in Tehran stated "*environmental challenges, especially water, ought to be the real future human security priority for Iran*" (Financial Times, 2014).

A4.2. Data issues

In this section we explain a number of problems which were encountered when raw data from the Statistical Centre of Iran (SCI) were used to compile migration data for this study.

A4.2.1. Data accuracy

When constructing the dataset on inter-province migration flows in Iran, we noticed the following issues which are worthy of pointing out:

Migration data

An inspection of the official migration data, compiled by SCI using responses to their survey questionnaires, shows that there is a gradual increase in the number of 'blank responses' when immigrant respondents are asked about their place of origin. This trend became apparent when we compared data from a number of past censuses; see Table A4.1 below. There is no clear explanation as to why responses to this specific question are suffering from such an anomaly. Since migration data is useful if it records both the destination and the original location of the immigrants, steps need to be taken to investigate and remedy this phenomenon. In our study we had no choice but to drop these observations.

Table A4.1. Blank Responses to "*Where from have you move*?"

Date of Survey	Census Period	Number of Blank Responses	Percentage of Blank Responses
1996	1986-1996	45,000	0.51%
2006	1996-2006	104,000	0.85%
2011	2006-2011	343,000	6.25%

The last column is the percentage of migrants who did not reveal their origin.

Rural migration

Official data also shows that the population of rural areas is falling (negative growth rate). Official data also shows that the number of people emigrating from the rural areas is decreasing (less people are leaving the rural areas). Figures A4.2, A4.3 and A4.4 show these statistics. Given that, by definition,

***Change in Population* = (*Births – Deaths*) + (*Immigration – Emigration*)**

holds for any community at any given year, we verified the consistency of official data by checking how the right-hand-side of the above compared with the left-hand-side. Unfortunately, we found a significant discrepancy where the latter figures turned out to be positive when the right-hand-side was negative. Since data on population, births and deaths are relatively accurate, the inconsistency is bound to arise from the recording of rural migration data.

One explanation for this anomaly might lie in the designation of communities as rural or urban. According to the Iranian demographic regulations, the urbanised area of the country comprises of towns, or cities, which consist of more than 5000 inhabitants; villages, which form the rural areas of the county, are communities with a smaller number of inhabitants. Official data also shows that the number of cities has been rising and the number villages are shrinking (Figures A4.5 and A4.6).[55]

[55] There are various reasons why the local authorities of a village might prefer their community to take a city status. See Irna (2015) and Zangene Shahraki (2013).

Figure A4.2. Annual number of emigrants in Iran (Total)

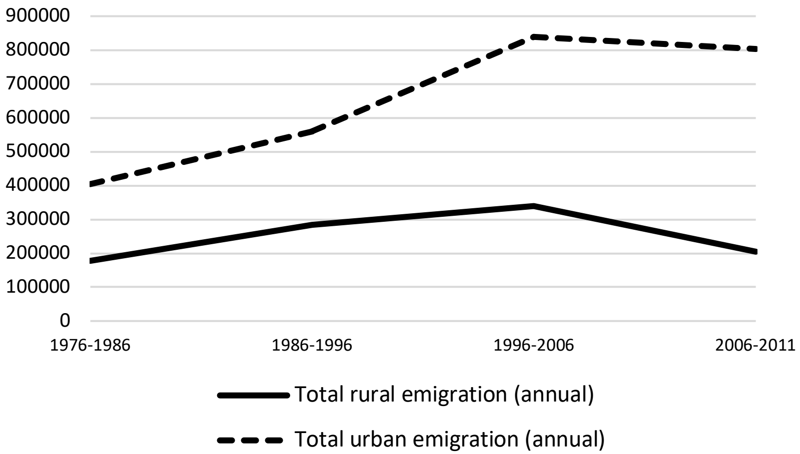


Figure A4.3. Annual emigration in Iran (share in total)

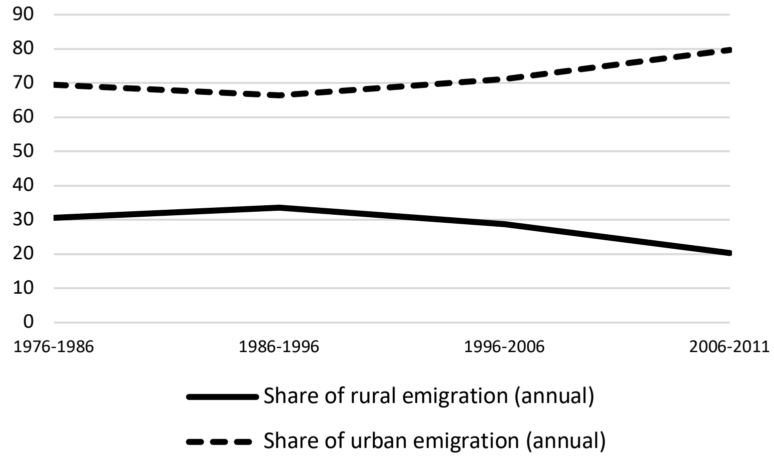


Figure A4.4. Population growth in Iran

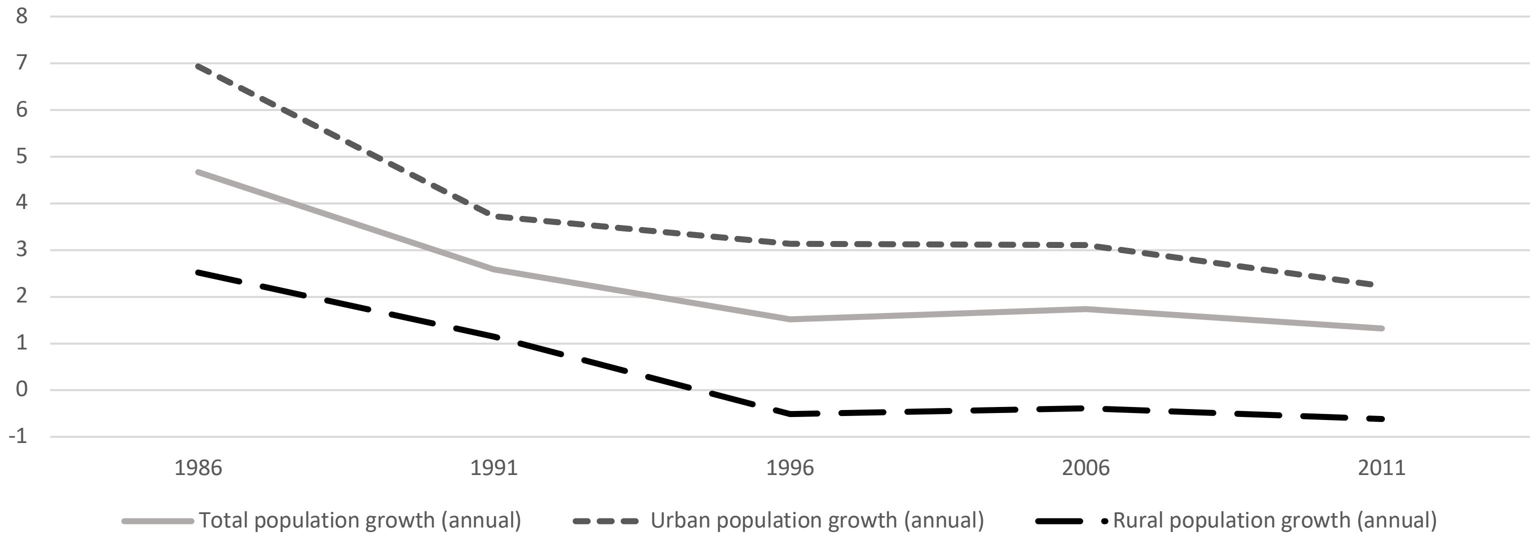


Figure A4.5. Number of urban cities in Iran

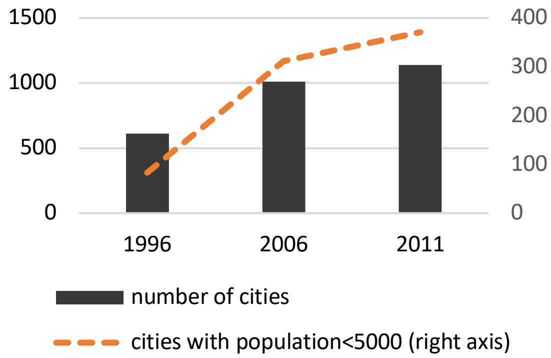
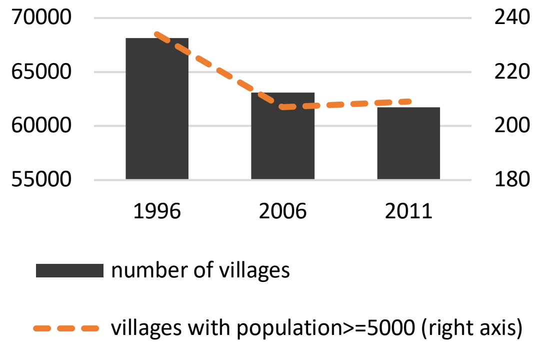


Figure A4.6. Number of rural villages in Iran



This drastic change in the numbers of cities and villages could partly explain data inconsistencies noted above since: (i) blank responses in questionnaires are explained by the fact that villages which were respondents' place of origin have in fact ceased to exist; and (ii) emigration from such villages cannot be correctly recorded hence is not reflected in the data. For these reasons, in this study we focused on migration in general and could not analyse the rural-to-urban migration due the data reliability issues.

A4.2.2. Province boundary changes during census periods

There were a number of boundary changes during the census periods, mainly due to splitting some provinces which had become too large over time. In order to keep the consistency of our data, we carried out the following adjustments:

(i) The *Alborz* province was created by splitting the *Tehran* province in 2010. This took place right in the middle of the last census period. We therefore treated *Alborz* as part of *Tehran* for the remaining two years, until 2011.

(ii) Regarding the rest of the boundary adjustments, which took place earlier, we have maintained the new set up and used following simple imputation techniques to fill in the data gaps: if province A was the original province that was divided into B and C at time *t*, then $x_{B,t-n} = [x_{B,t}/x_{A,t}]x_{A,t-n}$ where x is the variable for which data for years $t-n$ do not exist. This approached is justifies on the assumption that general socio-economic trends of provinces stay steady over a short period of time so that the ratio in square brackets does not fluctuate too much. Experimenting with data generated by replacing $[x_{B,t}/x_{A,t}]$ with

$\left[\sum_{j=0}^{S} x_{B,t+j}/S\left(x_{B,t+j} + x_{B,t+j}\right)\right]$ where S is the number of years for which data for the newly formed provinces exist did not change the results.

A4.3. Summary statistics of variables used in the analysis

Table A4.2. Main set of variables

Variable	Mean	S. D.	Min	Max
migration: $\boldsymbol{M_{ij}}$	472	1132	1	17263
distance: $\boldsymbol{D_{ij}}$	866.7861	431.3721	115.81	2171.33
area: $\boldsymbol{A_k}$	54291.67	49754.66	11526	181758
population: $\boldsymbol{P_k}$	2301172	2376081	516836.5	140e+07
real GDP: $\boldsymbol{Y_k}$	5.47e+07	8.72e+07	7185320	5.23e+08
growth rate: $\boldsymbol{G_k}$	4.470154	7.191452	-10.32443	32.93311
temperature: $\boldsymbol{T_k}$	16.94784	4.034144	9.862378	27.25607
temperature deviation: $\boldsymbol{TD_k}$	0.655705	0.677761	-2.73001	1.791346
precipitation: $\boldsymbol{PR_k}$	326.0772	259.2722	42.724	1352.98
precipitation deviation: $\boldsymbol{PRD_k}$	-41.2378	55.22882	-220.474	83.40334
gini index: $\boldsymbol{GINI_k}$	0.363855	0.032644	0.299494	0.440655
inflation rate: $\boldsymbol{INF_k}$	22.55018	8.584403	11.86731	45.47197
unemployment: $\boldsymbol{UR_k}$	13.47273	5.668302	6.782848	30.39204
education: $\boldsymbol{ER_k}$	81.97022	4.537251	63.66185	90.83269
rural population: $\boldsymbol{RPS_k}$	37.99476	12.25106	5.433073	56.24207
rural health centre: $\boldsymbol{RHD_k}$	1.22204	.4124574	.5754982	2.306632
rural health staff: $\boldsymbol{HPD_k}$	4.099713	1.118305	1.523783	7.327104
rangeland: $\boldsymbol{RR_k}$	53.26955	13.23568	3.920587	90.50834
desert: $\boldsymbol{RD_k}$	10.59286	14.40046	0	52.43863

The sample size in all cases is 1740.

Table A4.3. Variables descriptions by census

Variable	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
	2006 census				*2011 census*			
migration: M_{ij}	4.97	1.61	0	9.75	4.77	1.54	0.69	9.03
distance: D_{ij}	6.62	0.58	4.75	7.68	6.62	0.58	4.75	7.68
area: A_k	10.53	0.83	9.35	12.11	10.53	0.83	9.35	12.11
population: P_k	14.28	0.75	13.16	16.29	14.38	0.75	13.22	16.46
real GDP: Y_k	17.14	0.90	15.79	19.75	17.40	0.89	16.04	20.07
growth rate: G_k	10.02	5.52	5.45	32.93	-1.087	3.33	-10.32	7.43
temperature: T_k	2.81	0.23	2.29	3.31	2.79	0.23	2.29	3.30
temperature deviation: TD_k	6.89	4.10	2.10	22.19	2.12	4.64	-14.87	12.64
precipitation: PR_k	5.61	0.71	3.96	7.21	5.47	0.68	3.75	7.11
precipitation deviation: PRD_k	-7.11	14.48	-37.11	33.65	-16.81	13.12	-43.67	6.35
gini index: $GINI_k$	0.344	0.026	0.299	0.392	.383	0.026	0.33	0.44
inflation rate: INF_k	14.85	1.08	11.86	17.07	30.24	5.26	22.38	45.47
unemployment: UR_k	2.43	0.39	1.91	3.22	2.62	0.35	2.18	3.41
education: ER_k	4.39	0.06	4.15	4.50	4.42	0.05	4.25	4.51
rural population: RPS_k	3.62	0.45	1.99	4.02	3.47	0.51	1.69	3.93
rural health centre: RHD_k	0.018	0.29	-0.55	0.82	0.277	0.29	-0.447	0.83
rural health staff: HPD_k	1.348	0.273	0.518	1.931	1.49	0.236	1.08	2.02
rangeland: RR_k	3.92	0.53	1.37	4.51	3.92	0.22	3.43	4.19
desert: RD_k	1.73	1.22	0.00	3.98	1.73	1.21	0.00	3.98

The sample size in all cases is 870 in each census.

A4.4. Robustness

Table A4.4. Effects of gravity variables and climatic factors inter-province migration in Iran (estimation without province fixed effect)

		A	B	C	D	E	F	G
Dependent: M_{ij}								
distance:	D_{ij}	-1.550***	-1.589***	-1.557***	-1.549***	-1.564***	-1.589***	-1.576***
growth rate:	G_i	0.0327***	0.0214***	0.0326***	0.0332***	0.0388***	0.0219***	0.0392***
	G_j	0.0369***	0.0183***	0.0365***	0.0369***	0.0430***	0.0183***	0.0429***
real GDP:	Y_i	0.0594	-0.0926	0.0590	0.0804	0.0377	-0.0715	0.0350
	Y_j	0.111*	-0.134**	0.113*	0.111*	0.0933	-0.133**	0.0941*
population:	P_i	0.419***	0.771***	0.347**	0.429***	0.432***	0.781***	0.331**
	P_j	1.218***	1.286***	1.268***	1.218***	1.254***	1.286***	1.328***
area:	A_i	0.215***	0.149**	0.196***	0.167**	0.212***	0.101	0.184***
	A_j	0.173***	0.0582	0.154**	0.174**	0.170***	0.0540	0.141**
temperature:	T_i	--	0.836***	--	--	--	0.837***	--
	T_j	--	1.356***	--	--	--	1.357***	--
temperature deviation:	TD_i	--	--	0.0839**	--	--	--	0.118***
	TD_j	--	--	0.0850**	--	--	--	0.120***
precipitation:	PR_i	--	--	--	-0.141**	--	-0.142*	--
	PR_j	--	--	--	0.00232	--	-0.0125	--
precipitation deviation:	PRD_i	--	--	--	--	-0.00228***	--	-0.00249***
	PRD_j	--	--	--	--	-0.00224***	--	-0.00246***
	R^2	0.7823	0.8098	0.7836	0.7829	0.78965	0.8103	0.7922
	$\bar{R}^2$	0.7788	0.8064	0.7799	0.7791	0.7859	0.8068	0.7883
	L	-1937	-1820	-1932	-1935	-1908	-1817	-1897
	AIC	3933	3702	3926	3932	3878	3701	3860
	BIC	4091	3871	4095	4102	4047	3881	4040
	F_z	35.38	35.62	34.94	34.67	36.09	37.37	35.01
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	$Reset$	6.23	9.32	7.42	6.07	7.20	9.32	8.80
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

OLS estimates, repeating the regressions reported in Table 4.3 but excluding the province fixed effects. See the notes to Table 4.3 for other details.

Table A4.5. Comparing regressions with & without interaction effects

Dependent: M_{ij}	Temperature		Precipitation		Temperature & Precipitation	
	A1	A2	B1	B2	C1	C2
distance: D_{ij}	-1.682***	-1.687***	-1.686***	-1.689***	-1.692***	-1.695***
growth rate: G_i	0.0338***	0.0346***	0.0401***	0.0419***	0.0405***	0.0416***
G_j	0.00405	0.0128**	0.0202***	0.0283***	0.0213***	0.0230***
real GDP: Y_i	0.0635	0.122*	0.0415	0.0100	0.0385	0.0330
Y_j	0.597**	0.519	0.622***	0.949***	0.757***	0.846**
population: P_i	1.034***	0.758***	1.122***	1.166***	1.062***	0.959***
P_j	-2.386**	-2.262*	-1.522**	-2.002***	-2.326**	-2.370*
area: A_i	0.212***	0.204***	0.229***	0.241***	0.199***	0.204***
A_j	-4.007	-1.188	1.703	1.932	1.267	3.043
temperature deviation: TD_i	0.0896***	-0.682	--	--	0.124***	-0.265
$Y_i \times TD_i$	--	-0.116*	--	--	--	-0.0200
$P_i \times TD_i$	--	0.195***	--	--	--	0.0522
TD_j	0.0899	-1.415**	--	-	0.0901	-1.521***
$Y_j \times TD_j$	--	-0.170	--	--	--	-0.142
$P_j \times TD_j$	--	0.316**	--	--	--	0.289
precipitation deviation: PRD_i	--	--	-0.00233***	-0.0000523	-0.00255***	-0.00739
$Y_i \times PRD_i$	--	--	--	-0.000763	--	-0.000233
$P_i \times PRD_i$	--	--	--	0.000781	--	0.000639
PRD_j	--	--	-0.00155***	0.0155	-0.00155***	0.0185*
$Y_j \times PRD_j$	--	--	--	-0.00151**	--	-0.000612
$P_j \times PRD_j$	--	--	--	0.000642	--	-0.000630
R^2	0.8316	0.8331	0.8350	0.8354	0.8366	0.8377
$\bar{R}^2$	0.8258	0.8269	0.8293	0.8293	0.8307	0.8311
L	-1714	-1706	-1696	-1694	-1688	-1682
AIC	3546	3538	3511	3514	3498	3502
BIC	3869	3883	3833	3858	3831	3879
F_{int}	--	8.59 (0.000)	--	2.02 (0.091)	--	4.15 (0.000)
$Reset$	11.87 (0.000)	11.89 (0.000)	11.18 (0.000)	11.35 (0.000)	12.13 (0.000)	12.29 (0.000)

The dependent variable is $\ln M_{ij}$. See the notes to Table 4.3 for other details. Estimates in columns A1, B1 and C1 are the same as those in columns C and E and F in Table 4.3. F_{int} is the F ratio based on the exclusion of the interaction variables. Figures in parentheses are the p-values.

Table A4.6. Alternative estimates of the selected models (Negative Binomial)

Dependent: M_{ij}

		C	E	G
distance:	D_{ij}	-1.408***	-1.412***	-1.414***
growth rate:	G_i	0.0247***	0.0288***	0.0289***
	G_j	0.0173***	0.0265***	0.0264***
real GDP:	Y_i	0.103***	0.105***	0.102***
	Y_j	0.320***	0.354***	0.338***
population:	P_i	0.880***	0.841***	0.862***
	P_j	-0.386***	-0.394***	-0.401***
area:	A_i	0.168***	0.157***	0.152***
	A_j	0.372***	0.375***	0.396***
temperature deviation:	TD_i	0.0480*	--	0.0561**
	TD_j	-0.0386	--	-0.0313
precipitation deviation:	PRD_i	--	-0.00161***	-0.00166***
	PRD_j	--	-0.00121***	-0.00120***
	L	-10392	-10379	-10376
	AIC	20847	20820	20819
	BIC	21016	20989	20999

The dependent variable is M_{ij} and the estimation method is based on Conditional Negative Binomial specification. See the notes to Table 4.3 for other details. Estimates in columns labelled C and E and F correspond to the specifications in the same columns of Table 4.3. See the notes to Table 4.3 for other details.

Figure A4.7. Scatter plot of lnM_{ij} and the linear prediction based on model specification of G in Table 4.3

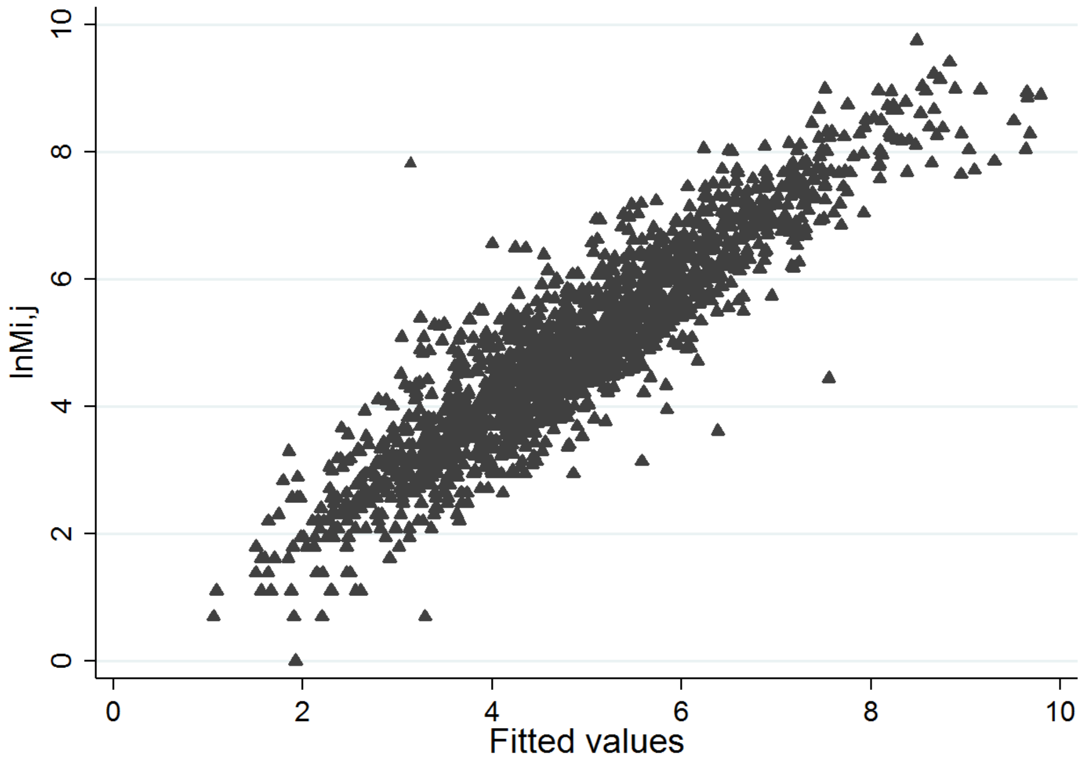


Figure A4.8. Scatter plot of linear prediction and predicted residuals of lnM_{ij} based on model specification of G in Table 4.3

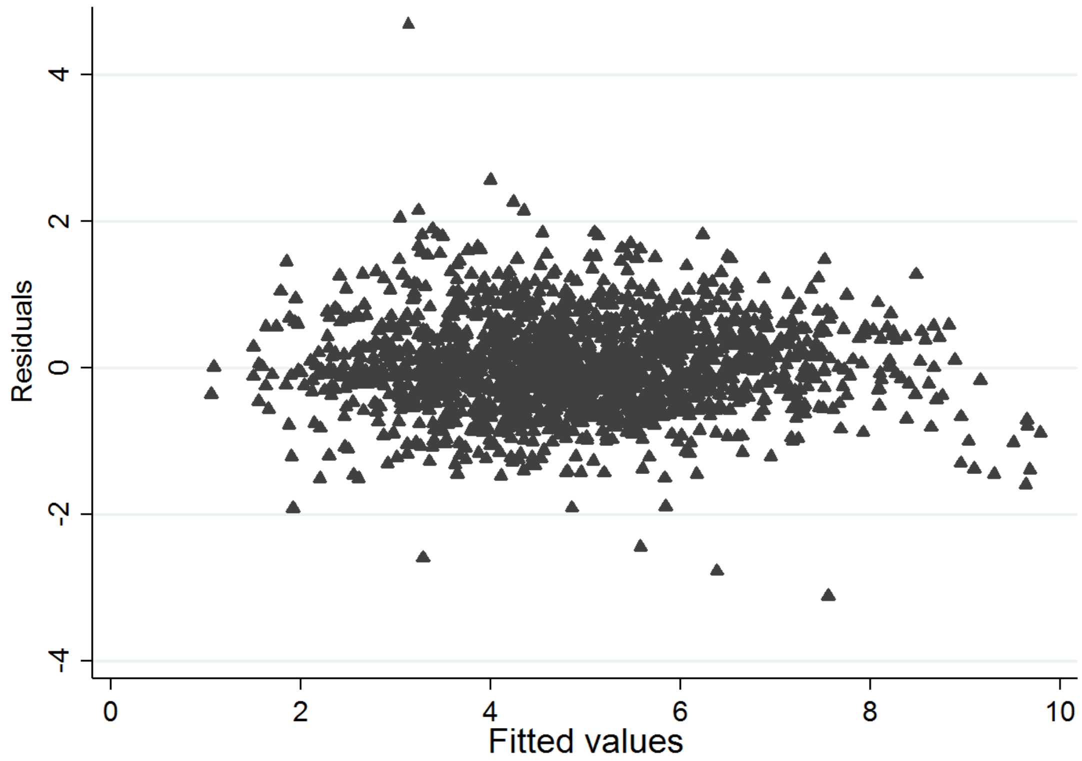
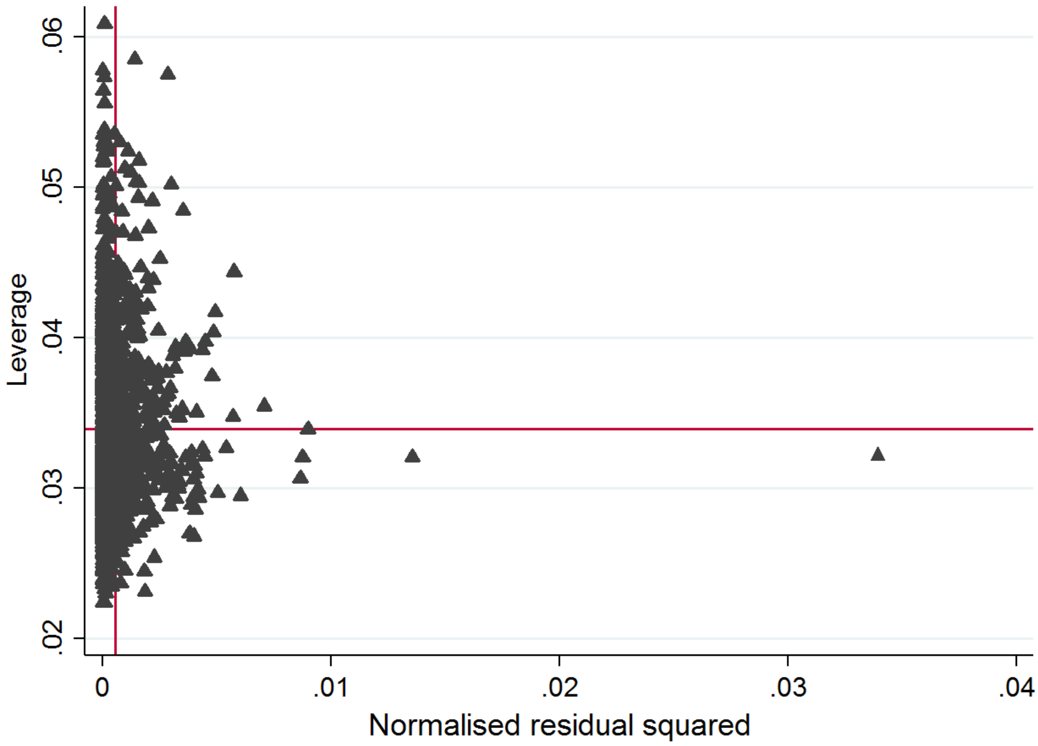
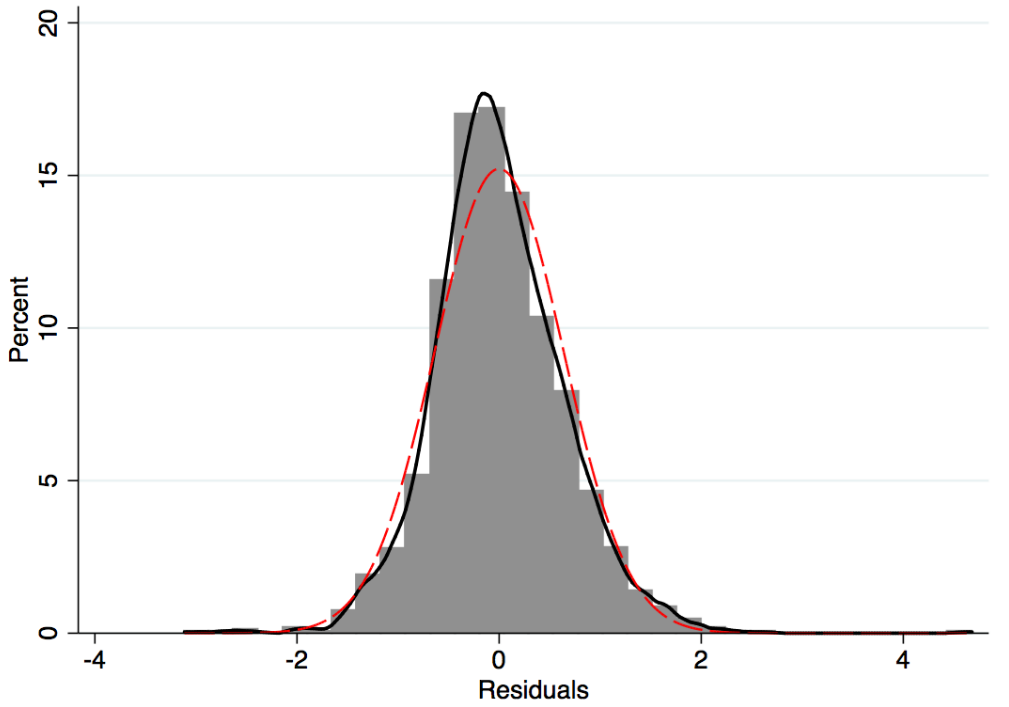


Figure A4.9. Leverage against the (normalised) residuals squared based on model specification of G in Table 4.3



Points above the horizontal line have higher-than-average leverage; points to the right of the vertical line have larger-than-average residuals.

Figure A4.10. Distribution of predicted residuals of $\ln M_{ij}$ based on model specification of G in Table 4.3



Kernel Density line is sold black and normal distribution is the long-dashed line

Chapter 5

Summary, conclusions and future research

5.1. Summary and conclusions

The contribution of this thesis could be summarised as an empirical study of the relationships that help explaining the determination of two social phenomena: internal armed conflicts and migration. Together with severe climate change, these are ranked highest amongst the most pressing risks facing humanity in terms of both their likelihood of occurrence and their impact (World Economic Forum, 2017). It is also believed that climate change influences the likelihood and nature of the conflicts and migration. We therefore centred our empirical analysis on understanding the nature and extent of this influence.

In Chapter 2 we constructed and used a pooled cross section time series dataset, comprising 139 countries over the period 1961-2011, to carry out a systematic econometric study of the role of climatic factors, proxied by the average levels of temperature and precipitation, on the onset of internal conflicts. Our main findings suggest that, once all other relevant country-specific characteristics (which are believed to affect the probability of an armed conflict) are accounted for, (i) climate warming is instrumental in raising the probability of onset of armed conflicts, and (ii) the effect is more enhanced the hotter are the regions. Given that these results survived various robustness tests, these findings convey an important policy message regarding the global political efforts to (i) reduce the extent, and prepare for the consequences, of climate warming, and (ii) to understand the causes, and hence curtail, the onset of armed conflicts.[56]

Whilst conducting our empirical search in order to identify the relevant country-specific characteristics that affect the onset of armed conflict, our results revealed a peculiar ambiguity regarding the impact of per capita income. Given the critical importance of curtailing internal armed conflicts for sustaining the world peace on the one hand, and the fact that the extent of economic and political development are known to shape a nation's tendency to engage in and/or to tolerate armed conflicts on the other, we devoted Chapter 3 to further investigating the role of per capita income in conjunction with the 'quality' of political institutions. Building on the existing contributions (Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Hegre and Sambanis, 2006; Collier and Rohner, 2008), the results of our empirical analysis confirm that the influence of these

[56] The Paris Climate Accord (an agreement within the United Nations Framework Convention on Climate Change dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020) and the setting up of the State and Peacebuilding Fund by the World Bank in 2008 are recent examples.

political institutions and the extent of development are contingent on each other. More specifically, our main findings indicate that (i) while per capita GDP per se does significantly reduce the probability of onset of internal armed conflicts, its overall effect contributes positively to the onset of conflicts in more unstable regimes; and (ii) major political instability (defined as a relatively substantial positive or negative change in the index measuring institutional quality), could adversely affect peace. The policy message of these results seem to advise against implementing short term drastic reforms of the type that are at times imposed by international institutions to promote long term economic prosperity.

In Chapter 4 we turned our focus on the role of climate change on migration. In the absence of a coherent dataset that accurately records the characteristics of migrants, we opted for a case study of causes of inter-province migration within a specific country using the census data. We chose Iran as the subject of our case study because of two reasons. First, the country has become increasingly vulnerable to climate change which is officially documented. Second, in addition to having a rich history of internal rural migration which is embedded in the ethnic culture of the country[57], Iran has had a recent history of significant internal migration that was caused by the Iran-Iraq war. We used two waves of national census data covering the period 1996-2011 to construct an inter-province dataset consisting of migration flows and the relevant province-level socio-economic variables, as well as data on temperature and precipitation levels, and used this dataset to estimate the impact of the latter on migration flows in the context of a generalised gravity model. Our main findings suggested that although climatic factors are not the most important determinants of internal migration in Iran, their role, especially as *push factors*, is eminent. In short, even after vigorous robustness checks we cannot reject the hypothesis that people emigrate from warmer and/or drier regions. While it is tempting to generalise the implication of this finding and claim climate warming as a major stimulating factor in decision to migrate, we postpone this task to future research. Regarding specific policy recommendations concerning the situation in Iran, however, the conclusion could not be clearer. Given that such migrations easily end up in a vicious circle of poverty associated with overcrowding of urban centres and desertification of the rural regions, the country should take advantage of 'financial assistance' and 'expert

[57] We refer to indigenous nomadic tribes of Iran. For a 'documentary style' study of impacts of climate change on the Qashqai and the Shahsevan, the two main nomadic confederations in Iran, see https://intercontinentalcry.org/climate-change-and-indigenous-nomadic-tribes-of-iran/.

advice' opportunities, such as those provided by the conclusions drawn from Article 4.4 of the Kyoto Protocol, to design and implement appropriate projects which aim to improve localised resilience so as to reduce the impact of specific climatic effects.

5.2. Possible future research

The future lines of research, on the basis of the work of this thesis, would focus on the empirical modelling of the relationships that help in quantifying the contribution of different factors which influence the onset and impacts of armed conflicts and migration.

A glance through the recent reports by the Institute for Economics and Peace[58], especially in their Global Peace Index documents, shows that severe human casualties, in particular the number of deaths, caused by internal armed conflicts have increased dramatically in the last decade. This alarming rise is explained to be due both to the higher intensity as well as a wider spread of conflicts. In such circumstances, a deeper knowledge of how different factors interact to fuel, intensify and spread armed conflicts is required to inform the badly needed effective policy making. An extension of our analyses in Chapters 2 and 3 in which one would attempt to explain alternative quantifiable measures of armed conflicts and further focus on the way the influential factors interact in shaping the onset and impact of provides a worthwhile future line of research.

As mentioned above in passing, a fruitful future line of research on migration would be to extend the work of Chapter 4 to understand if patterns identified in different countries support the same conclusions, and therefore identifying the most common, or general, determinants of migration once the most influential factors such as distance are allowed for. The difficulty in conducting an econometric study that extends beyond one country lies in the availability of raw data which could be used to construct a consistent pooled dataset. A line of research which invests in alternative ways of constructing suitable datasets is therefore essential. Given that a reasonable number of countries now compile survey data based on individual characteristics, e.g. income and expenditure surveys, a way forward might lie in identifying matching waves of survey data across a number of countries where respondents are required to provide details of any changes in their residence location. Matching such a dataset with the relevant administrative, economic and climatic data from the countries involved would facilitate a cross country

[58] http://economicsandpeace.org/reports/.

econometric study of migration and could enable drawing more general conclusions regarding the nature of migration decisions.

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