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Does The Environment Matter? Climate Change, Transboundary Effects, Economic Growth and Conflicts

Eleftherios Giovanis and Öznur Özdamar

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Eleftherios Giovanis[1] and Öznur Özdamar[2]

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Send correspondence to:
Eleftherios Giovanis
Izmir Bakircay University
eleftherios.giovanis@bakircay.edu.tr

[1] Izmir Bakircay University, Faculty of Economics and Administrative Sciences Department of International Trade and Business, Menemen, İzmir, Turkey, giovanis95@gmail.com
[2] Izmir Bakircay University, Faculty of Economics and Administrative Sciences Department of Economics, Menemen, İzmir, Turkey, oznur.ozdamar@bakircay.edu.tr

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Abstract

The relationship between climate change and violent conflict has been the focus of rigorous scholarly and policy discourse in recent decades. The adverse economic conditions can be a significant conduit that connects the two phenomena. We aim to explore the impact of economic growth and food production indices on conflict. Specifically, the objective is to link the causal path of climatic conditions to economic and food production outcomes and armed conflict. We apply Probit and Instrumental Variable (IV) Probit regressions using a panel of 16 countries in the MENA region, including Iraq and Turkey. We employ weather conditions as instruments for the economic and food production indices. Moreover, we use country dyadic data to examine the impact of shared river basins on conflict. For the incidence of armed conflict, we use the UCDP/PRIO Armed Conflict Dataset in 1960-2022, and for the Gross Domestic Product (GDP), food production indices and climatic conditions, we use data from the World Development Indicators. The findings show that international aid, GDP, and food production indices negatively affect the incidence of conflict, while natural resource rents increase the likelihood of conflict. Regarding the river-shared basins, we find that when the rivers cross the borders, and if two or more countries share a river basin, then the incidence of conflict increases. Future research should further explore the interaction between climatic change and conflict and whether is conditioned by economic, social, political, and demographic factors to understand how they contribute to conflict.

Keywords: Climate Change; Conflict; Economic Growth; Transboundary externalities.
JEL Classifications: D74, O11, Q54, R11.

ملخص

كانت العلاقة بين تغير المناخ والصراع العنيف محور خطاب علمي وسياسي صارم في العقود الأخيرة. يمكن أن تكون الظروف الاقتصادية المعاكسة قناة مهمة تربط بين الظاهرتين. نهدف إلى استكشاف تأثير النمو الاقتصادي ومؤشرات إنتاج الغذاء على الصراع. والهدف على وجه التحديد هو ربط المسار السببي للظروف المناخية بنتائج الإنتاج الاقتصادي والغذائي والنزاعات المسلحة. نطبق انحدارات Probit and Instrumental Variable (IV) Probit باستخدام مسح من 16 دولة في منطقة الشرق الأوسط وشمال إفريقيا، بما في ذلك العراق وتركيا. نستخدم الظروف الجوية كأدوات لمؤشرات الإنتاج الاقتصادي والغذائي. علاوة على ذلك، نستخدم بيانات صبغية قطرية لدراسة تأثير أحواض الأنهار المشتركة على الصراع. بالنسبة لحدوث الصراع المسلح، نستخدم مجموعة بيانات الصراع المسلح UCDP/PRIO في 1960-2022، وبالنسبة للناتج المحلي الإجمالي (GDP)، ومؤشرات إنتاج الغذاء والظروف المناخية، نستخدم بيانات من مؤشرات التنمية العالمية. تظهر النتائج أن المعونة الدولية والناتج المحلي الإجمالي ومؤشرات إنتاج الغذاء تؤثر سلبًا على حدوث الصراع، في حين أن ريع الموارد الطبيعية يزيد من احتمالية نشوب الصراع. فيما يتعلق بأحواض الأنهار المشتركة، نجد أنه عندما تعبر الأنهار الحدود، وإذا كان هناك دولتان أو أكثر تشتركان في حوض نهر، فإن حدوث الصراع يزداد. يجب أن تستكشف الأبحاث المستقبلية التفاعل بين التغير المناخي والصراع وما إذا كانت مشروطة بعوامل اقتصادية واجتماعية وسياسية وديموغرافية لفهم كيفية مساهمتها في الصراع.

1. Introduction

Extreme weather events have become more frequent and intense since the middle of the 20th century worldwide and are likely to become even more pronounced throughout the 21st century due to climate change (IPCC, 2012). In particular, the number and length of warm weather spells and heat waves have increased globally. The evidence shows that such extreme temperature events will further augment at the global scale, giving rise to more severe droughts. Two widely-publicized theories consider the relationship between natural resources and violent conflict. The first reflects on the tacit motivations of a natural resources abundance to engage in conflicts and war, and the second explores how resource scarcity influences violence and conflicts. Although, it is unusual to describe abundant and scarce resources as determinants of conflict at first glance, both hypotheses may simultaneously be valid. Typically, the former theory is correlated with exhaustible resources and fits into the overarching framework of the so-called "resource curse hypothesis". The latter is most frequently related to natural resources, such as land and water, and it has gained attention since it is correlated with concerns about the impact of global climate change (Dunning, 2005; Humphreys, 2005; Butler and Gates, 2012; Koubi et al., 2012).

Advocates of the thesis “resource scarcity causes conflict” thesis claim that weather shocks would affect conflict trends and patterns through the reduction in the productivity of rainfed agriculture or cattle herding, which would reduce the opportunity cost of conflict participation, aggravating conflicts or exacerbating competition for decaying resources. Other scholars have pointed out that this may not be so straightforward, and they argue that weather shocks decrease both the opportunity cost of conflict and the value of the contested award (Butler and Gates, 2012; Burke et al., 2015a). Theoretical models predicting that conflicts arise when weather conditions are favorable, are simple to create, as abundant resources can become strong incentives for engagement in conflicts. Climate variability may heighten the likelihood of conflict, particularly in less-developed countries that rely heavily on agriculture, face economic decline, experience elevated food costs, exhibit political instability, and possess limited adaptive capabilities (Dell et al., 2014).

Following the discussion so far, this study has two aims. The first is to explore the impact of climate change- proxied by various measures mentioned in the data section- on economic outputs, such as income per capita and crop production. The second aim is to explore the impact of those economic outcomes on conflict. Furthermore, we will use country dyadic data to explore the scarcity dimension and its role in economic growth and conflicts. In particular, research shows that water scarcity increases the risk of conflict in river-sharing dyads relative to other pairs of countries that do not face scarcity-related phenomena (Gleditsch et al., 2002; Devlin and Hendrix, 2014; Brochmann and Gleditsch, 2012; Gleditsch, 2012).

Recognizing the transmission mechanisms and the impact of climate change on economic outcomes and the relationship between economic growth, food production and conflicts is essential for investigating successful climate change adaptation and mitigation strategies and preventing future conflicts. The adoption of a transboundary view of climate risk, which specifically recognizes the interconnections between people, ecosystems and economies in a globalized world, alters the complexity and nature of the challenge of adaptation and creates opportunities to reinvigorate international adaptation cooperation.

2. Literature Review

The literature provides various theories and mechanisms that establish a link between climate-induced unfavorable economic conditions and conflicts. These factors encompass lower opportunity costs associated with engaging in violence, diminished abilities of the state, and socio-political and economic disparities and grievances (Hsiang et al., 2013). The empirical literature does not provide strong evidence for a direct connection between climate, economy, and conflict. Instead, it shows that this relationship is dependent on the scale and context. The evidence strongly indicates that economic conditions play a significant role in connecting climate changes and violence in countries and regions that rely on agriculture, host politically marginalized groups, and have inadequate and ineffective institutions (Hsiang and Burke, 2014).

According to the neo-Malthusian framework, resource scarcity arises from climatic conditions, resulting in competition and conflicts (Homer-Dixon, 1994). Most studies posit that the impact of climate on conflict is mediated by economic circumstances. The initial stage of this causal sequence highlights that unfavorable climate circumstances, such as droughts, higher temperatures, reduced precipitation levels, and severe weather phenomena, have a detrimental effect on output (Barrios et al., 2010; Dell et al., 2014; Hsiang and Burke, 2014; Burke et al., 2015a). Shrinking incomes and diminished economic opportunities are subsequently theorized to cause conflict by adversely affecting local labor markets, since the value of engaging in conflicts is likely to rise relative to the value of participating in normal economic activities. Specifically, the opportunity cost of participating in conflicts and rebellions diminishes if the anticipated gains from peaceful occupations, such as farming, are inferior to the anticipated gains from affiliating with criminal or insurgent factions. In such circumstances, when people anticipate more financial gains from engaging in criminal or insurgent actions rather than pursuing legal and peaceful endeavors, the likelihood of predatory behavior increases (Hirshleifer, 1995; Chassang and Padro-i-Miquel, 2009).

Previous studies point to a strong association between global warming, climate change and conflicts (Auliciems and DiBartolo, 1995; Anderson et al., 2000; Bohlken and Sergenti, 2010**;** Sutton, et al., 2010; Tol and Wagner, 2010; Bergholt and Lujala, 2012; Mares, 2013; Maystadt and Ecker, 2014; Maystadt et al., 2014; Bellemare, 2015; Burke et al., 2015b). For instance, Burke et al. (2009) found that a 1-degree Celsius rise in temperature in African countries south of the Sahara increases the rate of internal armed conflict by 4.5 percent in the same year and 0.9 percent in the following year. O'Loughlin et al. (2012) suggests that over the past two decades abnormally high temperatures and low rainfall have increased the likelihood of violent conflicts in East Africa, including Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Tanzania, and Uganda. Earlier research suggests that conflicts may diminish or destroy productive assets such as livestock herds through theft and transportation infrastructure through sabotage, leading to higher producer prices (Verpoorten, 2009; Blattman and Annan, 2010; Bundervoet, 2010). Zhang et al. (2007) investigate how conflicts in the pre-industrial period (1400-1900) were influenced by long-term cycles of temperature changes, and they find that temperature variation is associated with the frequency of wars in Europe and China. More specifically, on comparatively cool days, war frequency increases and population declines, where the impeding impact of cooling on agricultural production is the proposed mechanism connecting these variables. If the carrying capacity of the land is a link between temperatures and conflict, then local temperature increases should be correlated with the outbreak of war in tropical countries. "Hot years" in the tropics, after all, are correlated with lower agricultural production, as are cold years in temperate zones.

However, these studies reveal little about the channels and causal mechanisms through which climate change and extreme weather events affect people's incentives to engage in conflicts. Hence, recognizing the transmission mechanisms and conflict-driving factors is essential to the quest for successful climate change mitigation and conflict prevention strategies. Following the seminal work by Collier Hoeffler (1998, 2004) and Collier and Sambanis (2002), economic behavior and factors have been frequently used to explain people's incentives to engage in conflicts. For instance, Blattman and Miguel (2010) found that low per capita income and slow economic growth are main drives of civil conflict. Other studies have explored the role of ethnic or religious fractionalization, degree of democracy, and natural resources dependency as drivers of conflicts (Easterly and Levine, 1997; Hegre et al., 2001; Elbadawi and Sambanis, 2002; Fearon and Laitin, 2003; Humphreys, 2005; Brunnschweiler and Bulte, 2009).

Another variable explored is the natural resources rents as a percentage of the GDP. According to the resource curse hypothesis, an abundance of natural resources may raise the likelihood of conflict. Resource-rich countries often fail to capitalize on their abundance of resources, resulting in increased conflict, sluggish economic growth, and economic instability (Humphreys, 2005; Humphreys et al., 2007). The rents imposed on non-renewable resources might incentivize political corruption, detrimental extraction methods, and lead to related development issues (Kahl, 2008).

The aim of the study is to investigate the relationship between climate change, economic development, food security, and to establish a causal link between economic growth, food security and conflicts. Furthermore, we aim to extend the analysis by incorporating dyadic analysis and to examine the cases where countries share water, land or energy resources are more likely to engage in conflicts.

3. Methodology

Based on the discussion in the previous sections we will employ an instrumental Probit regression for panel data and estimate the following system of regressions.

$$econ_{it} = c + a_i + \varphi_t + \beta_1 cc_{it-1} + u_{it} \quad (1)$$

$$conflict_{it} = d + a_i + \varphi_t + b_1 econ_{it} + b'\mathbf{X}_{it} + u_{it} \quad (2)$$

The conflict-climate change relationship is decomposed into two stages, with the economic outcomes e.g. economic growth, productivity, and income, acting as the factors of transmission. Thus, we implement an Instrumental Variables (IV) approach with robust standard errors. In the first equation, *econ* represents the economic outcomes, such as GDP per capita, international aid, the Crop Production Index, the Livestock Production Index, the Food Production Index, the cereal yield index and the percentage of total natural resources rents. The first equation shows the regression of instrumental weather variables on the endogenous economic variables at *t-1* implying one year lag. Hence, the first-stage equation yields the effects of climate change, on income per capita and production indices and thereby provides statistical evidence on the strength of the weather variable as an instrument of the economic outcomes. In the second equation *conflict* is a dummy variable taking the value of 1 for conflict and 0 otherwise, and variable *cc* denotes climate change. Country and time-fixed effects are represented by α_i and φ_t, while in vector **X** we include population growth and the logarithm of the military expenditures.

The justification for taking population is that previous scholars have argued that population increases can lead to conflict, particularly if combined with resource scarcity (Homer-Dixon, 1994; Hauge and Ellingsen 1998; Tir and Diehl, 1998; Diehl and Gleditsch 2001; Urdal, 2005; Hegre and Sambanis, 2006). For the military expenses we could argue that it can be an endogenous variable because it is a part of the GDP and also because a common policy employed to mitigate conflict, terrorism and political instability within a nation is to increase military spending (Aziz and Khalid, 2019). Nevertheless, in this study, we aim to investigate whether military expenses increase the likelihood of conflict. More specifically, we argue that as conflict risk necessitates an increase in defense expenditures due to the inherent security concerns it will have a detrimental impact on the country's budget balance (Dinçer et al., 2021). Consequently, the increase in military and defense expenditures leads to a decrease in economic growth and thus, may increase the likelihood of conflict. Moreover, excluding the military expenses from the regressions slightly changes the estimated coefficients of the variables of interest.

The justification for employing an IV approach is that not only GDP, economic growth, and food, crop and livestock indices may cause conflict, but also the latter may affect food production indices and, thus, economic growth. In particular, conflict may reduce the availability of production inputs and income, reduce food security, increase food deprivation and the number of households have to rely on less preferred food, and lead to a lack of essential nutrition (Meleigy, 2010; Serneels and Verpoorten, 2015; Lin et al., 2022). However, our aim is to investigate the impact on economic and food production outcomes on conflict conditioning in weather conditions.

Then, we extend our analysis using dyadic data to account for shared water basins and their role in the incidence of conflict. In this case, we include additional control variables, such as the product of the logarithm of populations in pair countries *i* and *j*, the logarithm of the weighted distance between them, a dummy variable whether the countries taking the value of 1 if both countries are member of the World Trade Organization (WTO) at year *t*, and 0 otherwise. Another variable is a dummy taking the value of 1 if countries had a common colonizer at a given year *t*. In the case of the country dyadic data, we cluster the standard errors to dyadic pairs, as suggested by Cameron and Golotvina (2005).

While this topic has been investigated by Koubi et al. (2012), our empirical analysis differs in several ways. First, apart from the temperature and precipitation, we employ additional proxies of climate change, such as the SPEI. Second, apart from economic growth and income, we also include the livestock, crop and food production indices, as proxies of food security and as additional outputs in the first-stage regression. Third, we will extend our analysis using dyadic data or country pairs and to investigate the potential transboundary effects, such as whether countries sharing common resources e.g. water and river basins, are more likely to engage in conflict due to climate change, either because of shortage or abundance, as we have discussed very briefly the two main theories in the introduction. Thus, using the dyadic data, we will investigate the transboundary effects of climate change taking place in some countries on the economic growth in other countries.

4. Data

4.1 Data Description

The data on civil conflict and their impact used in the empirical work are documented in the UCDP/PRIO Armed Conflict Dataset from the Peace Research Institute Oslo, and it includes almost 2,000 conflicts around the globe covering the period 1946-2021. The dataset is described in Gleditsch et al. (2002) and Pettersson and Öberg (2020). Civil war is described as an event involving separate parties that results in at least 25 deaths annually in combat. We focus on MENA region countries that have experienced conflicts, and data are available. These include Algeria, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Saudi Arabia, Syrian Arab Republic, Tunisia, Turkey, and Yemen.

For the control and main variables of interest, such as income per capita, crop production index and others, we will employ data from the World Development Indicators dataset that covers almost 220 economies and contains around 1,400 indicators. Similarly, for the climate change data, such as the temperature and rainfall levels, we will derive the information from the World Development Indicators. Depending on the data availability, the analysis will cover the period 1960-2021. Furthermore, we will employ the Standardized Precipitation and Evapotranspiration Index (SPEI), developed by Vicente-Serrano et al. (2010), and which also includes the temperature, or the Palmer Drought Severity Index (PDSI) developed by Palmer (1965) that accounts for temperature, soil moisture and evapotranspiration.

The fourth variable is the annual freshwater withdrawals as percentage of internal resources, which encompass the entirety of water taken from sources, excluding any losses due to evaporation from storage basins. The withdrawals also include water extraction from desalination plants in nations where they serve as a substantial water source. Total withdrawals for agriculture and industry encompass the combined amount of water taken for irrigation, livestock production, and direct industrial usage, which includes water used for cooling thermoelectric plants. Withdrawals for domestic purposes encompass water utilization for drinking, public services, commercial establishments, and residential use.

For the river-shared basins, we use dyadic data, as in the study by Brochmann and Gleditsch (2012). However, we should mention that due to data availability, we use the period 1960-2009 for the time-variant variables, such as the total length in km of boundary marked by the river, the total shared basin in squared km and the percentage of the total shared basin in the upstream state. On the other hand, for the time-invariant variables, such as the number of rivers crossing the country boundary and whether a pair of countries share a river basin, we consider the period 1960-2022.

4.2 Summary Statistics

In Table 1, we report the summary statistics. In Panel A, we present the summary statistics of the outcome of interest, which is conflict, taking a value of 1 for the incidence of conflict and 0 otherwise. Since we report the average, the value of 0.3388 indicates that countries in the period we examine have experienced conflicts at roughly 34 per cent. Panel B refers to the economic variables explored, which are the endogenous and outcome variables in equation (1). The Net official development assistance (NODA) and official aid received are expressed in US$ and 2015 constant prices. We should highlight that negative values imply that countries have sent more assistance than they have received. The second variable is the Real GDP expressed in US$ and 2015 constant prices. The rest of the variables refer to production indices. In particular, the first variable is the crop production index, which shows agricultural production. The food production index covers food crops that are considered edible and contain nutrients, while the livestock production index includes meat and milk from all sources, dairy products such as cheese and eggs, honey, raw, silk, and wool. Cereal yield is measured as kilograms per hectare of harvested land and includes wheat, rice, barley, maize, oats, rye, millet, sorghum, buckwheat, and mixed grains.

The last variable we explore is the total natural resources rents, which are the sum of oil, natural gas, coal, mineral, and forest rents. [3]

In Panel C, we report the additional variables in equation (2) that may influence the incidence of the conflict, which are the population growth and the military expenses as a percentage of GDP. In Panel D, we present the weather variables, which include the average temperature in Celsius, the average precipitation measured in depth of millimeters (mm) per year, the SPEI and the annual freshwater withdrawal, which is measured as a percentage of internal resources.

We should highlight that in all cases, we take the logarithms of the economic variables, except for the natural resources' rents, as they are expressed as a percentage of GDP. Similarly, we do not take the logarithms of the population growth, and the military expenses expressed as a percentage of GDP. Regarding the weather variables, we take the logarithms of the average temperature, precipitation and the annual freshwater withdrawals. We should mention that negative values of SPEI imply a drier climate, and positive values imply a more wet climate. In particular, values higher than 2 are considered extremely wet, while values below -2 are extremely dry (Li et al., 2015).

Table 1. Summary Statistics

	Average	**Standard Deviation**	**Minimum**	**Maximum**
	Panel A: Main Dependent Variable			
Conflict	0.3388	0.4735	0	1
	Panel B: Economic Related Variables			
NODA	4.07e+08	1.08e+09	-1.44e+08	2.20e+10
Real GDP	1.35e+11	1.73e+11	1.60e+09	1.19e+12
Crop Production Index	64.348	36.438	0.73	179.571
Food Production Index	1.124	5.068	3.921	0.7091
Livestock Production Index	1.310	173.88	59.834	36.467
Cereal Yield	2,271.49	2,427.64	151.3	21,865.5
Total natural resources rents (% GDP)				
	Panel C: Control Variables			
Population Growth	2.76	2.402	-27.722	19.052
Military Expenses (% GDP)	6.650	6.439	0.0175	48.517
	Panel D: Weather Variables			
Average Temperature	21.125	4.414	9.31	29.84
Average Precipitation	233.037	181.037	18.1	661
SPEI	-0.2878	1.0892	-2.907	3.166
Annual Freshwater Withdrawal (% internal resources)	15.010	23.723	0.008	92.95

4.3 Unit Root Tests

[3] https://databank.worldbank.org/source/world-development-indicators

One issue that can be raised is that the number of countries (N=17) is smaller than the time dimension, which is 62 years (T). In particular, when the N<T, then we may have non-stationary time series data. This issue is eliminated with the country dyadic data where the N is significantly larger than T, as we will show later. Nevertheless, we will present the first-generation unit root tests, and then we will test for cross-country dependence and perform the second-generation unit root tests. Finally, we will estimate the cointegration test. In Table 2, we report the first-generation unit-root, including the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), In, Pesaran and Shin (IPS); and Levin, Lin and Chu (LLC) (Maddala and Wu, 1999; Levin et al., 2002; In et al., 2003). According to the estimates of Table 2 and the ADF and PP tests, we conclude that most variables are stationary, except for NODA and the Livestock Production Index, while based on the IPS and LLC tests, all variables are stationary. In particular, the null hypothesis of non-stationarity is rejected according to the p-values within the square brackets.

Table 2. First-Generation Panel Unit Root Tests

	Panel A: First-Generation Unit Root Tests			
Variables	ADF[1]	PP[1]	IPS[2]	LLC[2]
Conflict	140.987 [0.000]	281.079 [0.000]	-4.644 [0.000]	-10.479 [0.000]
NODA	14.0271 [0.9005]	37.590 [0.3081]	-2.337 [0.0018]	-2.929 [0.0017]
Log of Real GDP	47.366 [0.0013]	76.524 [0.000]	-2.402 [0.0012]	-3.910 [0.001]
Log of Crop Production Index	39.5494 [0.0122]	45.246 [0.0941]	-2.211 [0.0132]	-3.922 [0.001]
Log of Food Production Index	44.017 [0.0035]	57.997 [0.0063]	-2.118 [0.0140]	-6.304 [0.000]
Log of Livestock Production Index	22.047 [0.4571]	29.156 [0.7040]	-1.446 [0.6265]	-3.908 [0.002]
Log of Cereal Yield	33.582 [0.0541]	131.627 [0.000]	-2.4826 [0.0017]	-2.843 [0.0022]
Total natural resources rents (% GDP)	85.070 [0.000]	94.783 [0.000]	-2.738 [0.000]	-6.192 [0.000]
Population Growth	144.277 [0.000]	100.538 [0.000]	-2.421 [0.0022]	-2.142 [0.0161]
Military Expenses (% GDP)	39.584 [0.0889]	46.655 [0.0727]	-1.852 [0.0891]	-2.228 [0.0129]
Log of Average Temperature	35.924 [0.0309]	147.770 [0.000]	-3.423 [0.000]	-4.039 [0.000]
Log of Average Precipitation	97.742 [0.000]	636.051 [0.000]	-8.297 [0.000]	-7.231 [0.000]
SPEI	104.875 [0.000]	453.624 [0.000]	-5.508 [0.000]	-5.012 [0.000]
Annual Freshwater Withdrawal (% internal resources)	76.998 [0.0053]	56.665 [0.0046]	-2.007 [0.0764]	-4.281 [0.000]

Notes: p-values within the square brackets.
1.Chi-Square statistic for the ADF and Phillips Perron tests.
2.T-Statistic for the IPS and LLC tests

In Panel A of Table 3, we report the Pesaran (2021) CD test. Based on the associated p-value, we reject the null hypothesis of the non-existence of the cross-sectional dependence among countries, thus, second-generation unit root tests might be more appropriate. In panel B of Table 3, we report the second-generation panel unit root tests. The first test we apply is the Pesaran's (2007) test, and the second is the Hadri test (Hadri, 2000). We should mention that we report the CIPS with a trend, but the conclusions remain the same when we estimate the CIPS test without a trend.

Furthermore, the z-statistic value becomes higher when we exclude the trend. The third test is the Breitung test (Breitung, 2000; Breitung and Das, 2005). Based on the results and the p-values, we reject the null hypothesis of unit root tests, and we conclude the variables are stationary, except for the military expenses variable, which according to all three tests, is non-stationary.

Table 3. Cross-Dependency Test and Second-Generation Panel Unit Root Tests

	Panel A: Cross-Country Dependency Test		
	Test Statistic	P-value	
Pesaran (2004) Cross Sectional Dependency Test	-3.52	0.000	
	Panel B: Second-Generation Unit Root Tests		
Variables	CIPS	Hadri	Breitung
Conflict	-5.362 [0.000]	10.702 [0.000]	-6.742 [0.000]
NODA	35.912 [0.031]	12.378 [0.000]	-5.243 [0.000]
Log of Real GDP	59.774 [0.000]	37.930 [0.000]	8.772 [0.000]
Log of Crop Production Index	-2.077 [0.019]	89.004 [0.000]	-3.802 [0.000]
Log of Food Production Index	-2.250 [0. 012]	23.730 [0.000]	-3.424 [0.0042]
Log of Livestock Production Index	-2.036 [0.021]	24.447 [0.000]	-2.461 [0.0395]
Log of Cereal Yield	-3.248 [0.000]	21.237 [0.000]	-1.855 [0.0318]
Total natural resources rents (% GDP)	-2.511 [0.006]	33.174 [0.000]	-2.483 [0.027]
Population Growth	-6.389 [0.000]	2.792 [0.0026]	-4.573 [0.000]
Military Expenses (% GDP)	0.102 [0.541]	0.9269 [01770]	2.618 [0.9956]
Log of Average Temperature	-9.397 [0.000]	19.974 [0.000]	-2.561 [0.0492]
Log of Average Precipitation	-17.149 [0.000]	3.966 [0.000]	-2.950 [0.0015]
SPEI	-11.017 [0.000]	18.499 [0.000]	-4.189 [0.000]
Annual Freshwater Withdrawal (% internal resources)	-4.817 [0.000]	8.543 [0.000]	-4.705 [0.000]

Notes: p-values within the square brackets.

5. Empirical Results

5.1 Impact of Income Per Capita and Food Production Indices on Conflict

In Table 4 we report the Instrumental Variables (IV) Probit regression estimates. From the first stage regression, we find that the average precipitation and SPEI have a negative relationship with the international aid, implying that higher values of those weather variables are associated with fewer droughts improving agriculture and farming. Furthermore, higher levels of precipitation and SPEI require less intense use of water stored or water resources available in the country, such as rivers and lakes. Thus, improved farming leads to higher income and less need for financial and humanitarian aid, followed by natural disasters and conflicts. On the other hand, we find no association between temperature, freshwater withdrawals and international aid. Nevertheless, in the second stage regression, we find that international support reduces the incidence of conflict. This finding explains the role of international aid as it aims to moderate the adverse effects of extreme weather events and natural disasters (Fink and Redaelli, 2011; Mogge et al., 2023) including extreme heatwaves and droughts in the MENA region that affect agriculture, tourism, food security, crop and livestock production, and water resources (Thornton et al., 2009; Binita et al., 2015; Paloviita et al., 2016; Hill and Porter, 2017; Namdar et al., 2021).

We observe that population growth and military expenses are positively related to the incidence of conflict, which we also find in the rest of the regressions in Table 4. This finding is consistent with the discussion in the methodology section and the results of previous studies (Homer-Dixon, 1994; Hauge and Ellingsen, 1998; Tir and Diehl, 1998; Diehl and Gleditsch, 2001; Urdal, 2005; Hegre and Sambanis, 2006; Fang et al., 2020). According to the weak instrument *F-statistic* test, which is higher than 10 in all cases and based on its associated *p-values*, we reject the null hypothesis that our instruments are weak. Furthermore, using the Hausman endogeneity test, we accept the null hypothesis of no-endogeneity, except for the case of the international aid at the 10% significance level. This finding implies that we need to be cautious about the estimates.

Then, we explore the impact of Real GDP expressed in US$ on conflict. In this case, we find a positive relationship between precipitation, SPEI, freshwater withdrawals and GDP. Similarly, we find that crop, cereal yield, food, and livestock indices reduce the incidence of conflict. The largest impact is recorded in the food production index, followed by the livestock index and GDP. Regarding temperature, we find a negative association with the livestock index, while a quadratic relationship is found with the GDP and the crop, cereal yield and food production indices. In particular, the temperature affects positively the GDP, but after the turning point of 18°C degrees, the GDP reduces. The turning points for the crop and food production indices are 19°C and 20.5°C, respectively. This indicates that high average temperatures may have an adverse effect on food production, food security and thus, on GDP and economic growth.

The last indicator we explore is the natural resources rents, where we find a positive impact on the incidence of conflict. Regarding weather conditions, we uncover a negative relationship between precipitation and natural resource rents, and a positive relationship with temperature. On the other hand, we find an insignificant relationship between natural resource rents, SPEI, and freshwater withdrawals. We should highlight that there is no clear explanation for this relationship. On the one hand, the extractive processes of natural resources can have an adverse effect on the environment, increasing temperature and global warming (Balsalobre-Lorente et al., 2018; Aladejare, 2022). On the other hand, high-temperature levels, a reduction in precipitation and rainfall, desertification and droughts may degrade forests and water resources (Abdi et al., 2013).

We should highlight that we tested for the quadratic terms of precipitation and SPEI but these are statistically insignificant. One explanation for this is that MENA regions are characterized by low rainfall levels which are required for agricultural production. Temperatures can have a positive value on economic outcomes, and crop and livestock yields when there is enough precipitation to prevent possible droughts (Palagi et al., 2022; Zittis et al., 2022). Moreover, these findings can be elucidated by previous studies (Saadi et al., 2015; Lelieveld et al., 2016), which examine the decrease in winter rainfall and its effects on agricultural output in the MENA region, highlighting the difficulties presented by the dry climate. Specifically, the MENA region is primarily characterized by arid or semi-arid conditions, featuring elevated temperatures and substantial rates of evaporation. Precipitation causes high temperatures, which in turn result in quick evaporation, diminishing the efficacy of rainfall for agricultural purposes. Moreover, the precipitation in the Middle East and North Africa (MENA) region is not only limited in quantity but also exhibits significant fluctuations, both on a yearly and seasonal basis. This fluctuation can exert pressure on crops if the time of rainfall does not coincide with the crop growth stages when water is most crucial.

Another factor that contributes to the correlation between precipitation and the outcomes examined is the soil characteristics. In numerous areas of the MENA region, the soil tends to have excessive salinity or is otherwise less fertile, which hampers the ability of rainfall to effectively support crop growth. The quick percolation or low water-holding capacity of sandy soils also impacts the availability of water to crops. Furthermore, due to the scarcity and erratic nature of rainfall, agriculture in numerous nations in the Middle East and North Africa (MENA) region is primarily dependent on irrigation. Insufficient management of irrigation in certain areas can result in the overutilization of water, leading to the salinization and deterioration of soil quality. Consequently, this has a detrimental effect on agricultural productivity (Marrou et al., 2021).

The third reason is based on the threshold effects. Specifically, in certain agricultural settings, precipitation can exhibit threshold effects, whereby a specific quantity of rainfall is required to enhance crop yields, livestock, and consequently, GDP. However, any further increase in rainfall may result in decreasing returns or even adverse consequences, such as flooding. However, in the MENA region, the often meagre amounts of rainfall may lead to infrequent or minimal surpassing of these thresholds, resulting in a more direct and predictable link. Furthermore, the crops cultivated in the MENA region are typically ones that have been modified to thrive in dry conditions, such as barley and wheat. These crops exhibit a linear response to increased water availability up to a certain threshold. Beyond this point, extra water does not have a substantial positive effect on yield and may potentially have a detrimental impact on production due to issues such as waterlogging or soil erosion (Marrou et al., 2016).

Our findings are consistent with previous studies, which argue scarcity of essential resources like food can exacerbate social tensions, trigger competition among groups, and lead to social unrest (Collier and Hoeffler, 1998, 2002a; Martin-Shields and Stojetz, 2019). For instance, Iyigun et al. (2017) found that permanent increase in agricultural productivity may reduce conflict. The authors argue that productivity can diminish the requirement for land, so mitigating the competition for its control. Likewise, a rise in agricultural output has the potential to increase real wages and the cost of choosing to engage in military activities. Similarly, Collier and Hoeffler (1998, 2002a) found that initial income and population size affect negatively and positively respectively the incidence of conflict. On the other hand, the relationship between ethno-linguistic fractionalization and the amount of natural resources is non-monotonic, which initially both increase the duration and risk of civil war but then they reduce it. However, according to the results by Arif et al. (2021), the natural resource rents may have a negative impact on the likelihood of conflict in the presence of better quality of government institutions for the global sample, and the developed and developing countries. Nevertheless, in our study, we do not include the quality of government institutions as control and second, we explore only the MENA region countries.

Table 4. Instrumental Variables Probit Equations

First Stage Regression	DV: Logarithm of International Aid	DV: Logarithm of Real GDP per Capita	DV: Logarithm of Crop Index	DV: Logarithm of Livestock Index	DV: Logarithm of Food Index	DV: Logarithm of Cereal Yield	DV: Percentage of natural resources rents
Logarithm of Average Temperature	1.577 (2.413)	6.985** (3.523)	10.350*** (3.088)	-0.5799* (0.3243)	2.322*** (0.7093)	0.3732 (0.3549)	31.157** (12.655)
Logarithm of Average Temperature Squared		-1.210* (0.622)	-1.7590*** (0.5724)		-0.3840*** (0.1329)		
Logarithm of Average Precipitation	-0.2766* (0.1522)	2.542*** (0.1902)	0.7080*** (0.1510)	0.2429*** (0.0843)	0.1084*** (0.0337)	0.7383*** (0.0073)	-14.259*** (4.444)
Annual Freshwater Withdrawal (% internal resources)	0.0092 (0.0089)	0.0024 (0.0021)	0.0071*** (0.0014)	0.0031* (0.0017)	0.0014*** (0.0004)	-0.0181** (0.0073)	0.0168 (0.0392)
Annual Freshwater Withdrawal Squared (% internal resources)						0.00011** (0.00005)	

Table 4. Instrumental Variables Probit Equations (contd.)

First Stage Regression	DV: Logarithm of International Aid	DV: Logarithm of Real GDP per Capita	DV: Logarithm of Crop Index	DV: Logarithm of Livestock Index	DV: Logarithm of Food Index	DV: Logarithm of Cereal Yield	DV: Percentage of natural resources rents
SPEI	-0.1556*** (0.0494)	0.0340** (0.0147)	0.0534* (0.0302)	0.0089 (0.145)	0.0075 (0.0345)	0.0452*** (0.0151)	-0.2722 (0.3372)
Second Stage Regression	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict
Logarithm of International Aid	-0.4770*** (0.1303)						
Logarithm of Real GDP per Capita		-1.623*** (0.5469)					
Logarithm of Crop Index			-0.5335* (0.2876)				
Logarithm of Livestock Index				-1.823*** (0.3349)			
Logarithm of Food Index					-3.940*** (1.392)		
Logarithm of Cereal Yield						-1.194*** (0.2790)	
Percentage of natural resources rents							0.0606*** (0.021)
Population Growth	0.0762** (0.0318)	0.0675** (0.0321)	0.0736** (0.0310)	0.0601** (0.0306)	0.0658** (0.0334)	0.0762** (0.0318)	0.0972** (0.0431)
Logarithm of Military Expenses	0.2487*** (0.0526)	0.2074*** (0.0368)	0.2007*** (0.0385)	0.1998*** (0.0405)	0.1902*** (0.0412)	0.2487*** (0.0526)	0.3633*** (0.0978)
No. Observations	847	940	926	926	926	926	734
Wald Chi-square	26,892.48 [0.000]	221,185.32 [0.000]	387,742.64 [0.000]	739,620.09 [0.000]	993,829.14 [0.000]	45,688.96 [0.000]	13,989.54 [0.000]
Weak Instrument F-Statistic Test	13.39 [0.0095]	336.51 [0.000]	388.30 [0.000]	10.06 [0.0395]	65.90 [0.000]	40.41 [0.000]	15.04 [0.0046]
Wald test of exogeneity	3.145 [0.0762]	1.524 [0.2170]	0.270 [0.6063]	1.454 [0.2282]	0.372 [0.5421]	1.077 [0.3003]	2.516 [0.1126]

Robust standard errors within parentheses. P-values within brackets.
***, ** and * denote significance at the 1%, 5% and 10% level.

Regarding the weather conditions, previous studies found that temperature increases, reduced storage of precipitation as snow, and reduction of rainfall result in a decrease in the availability of water, a reduction in GDP, crop yield and agricultural productivity (Barrios et al., 2010; Turral et al., 2011; Dell et al., 2014; Rojas-Downing et al., 2017). Since precipitation, rainfall, and temperature directly influence agricultural production, it is argued that the agricultural sector is most affected (Deschenes and Greenstone, 2007; Barnwal and Kotani, 2013). The agricultural sector is highly susceptible and prone to the impacts of climate change, making it the most sensitive and vulnerable among other sectors (Deressa et al., 2005). The agricultural sector is a vital industry that contributes to job creation, ensures food security, supplies raw materials to the industrial sector, and contributes to the country's foreign exchange earnings through international trade.

Thus, as agricultural production is a crucial component of those economies, its reduction leads to a decrease in GDP. Even though some economies of the MENA region rely on oil and gas, such as Saudi Arabia, Qatar, Kuwait, Iraq and the United Arab Emirates, the agricultural sector is still important in Turkey at 6.5% of GDP, reaching as high as 36.6% of the GDP in Syria, and ranging between 10-17% in Algeria, Morocco, Egypt, and Iran[4].

The next set of regressions considers ethnic fractionalization. The relationship between ethnic fractionalization, natural resources, and armed conflict has been the subject of extensive research in political science and economics. Ethnic fractionalization refers to the extent of ethnic diversity within a nation. Previous studies indicate that elevated levels of ethnic diversity can lead to heightened tensions and potential conflicts. In multi-ethnic societies, intergroup conflicts can be intensified by competition for resources and political power, especially when several ethnic groups want to safeguard or promote their interests (Fearon and Laitin, 2003; Ross, 2004; Esteban et al., 2012; Wegenast and Basedau, 2014). The hypothesis of the "resource curse" posits that nations endowed with abundant natural resources may be prone to experiencing heightened and protracted conflicts. The existence of important resources can serve as a motivating factor for groups to engage in battles for dominance, resulting in a spectrum of conflicts that span from civil wars to minor clashes.

The relationship between ethnic fractionalization and natural resources can exacerbate conflict. For example, when resources are focused in certain areas controlled by specific ethnic communities, it might result in tensions between different groups. Moreover, the unequal allocation of resource profits among various ethnic groups might contribute to grievances and escalate violence.

To measure ethnic diversity as an additional control, we employ the Historical Index of Ethnic Fractionalization (HIEF), which is an ethnic fractionalization indicator across 165 countries over the period 1945-2013. The objective of this index is to provide a deeper understanding of how shifts in ethnic diversity over time impact social, political, and economic outcomes. Unlike prior indices, the HIEF index has a time dimension, illustrating the changes in ethnic fractionalization, which enables longitudinal investigations. The HIEF dataset is specifically created to facilitate research on the influence of ethnic diversity on different societal outcomes, such as governance, democracy, and economic development. This is achieved by examining the historical shifts in ethnic composition.

The dataset is derived from the Harvard Dataverse and described by Dražanová (2019). In Table 5, we repeat the second-stage regressions of Table 4 using the HIEF as a robustness check. We should highlight that we estimate separately the regressions, because the HIEF is available up to

[4] https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

the year 2013, while our main estimates reach until the year 2021. Nevertheless, the estimated coefficient of the variables of interest- the international aid, real GDP, the natural resources rents, and the food, crop, cereal, and livestock indices- remain similar to those in Table 4.

However, we find an insignificant coefficient of the HIEF in all regressions, except for the natural resources rent, where we see a positive and significant coefficient, implying that a higher degree of ethnic diversity increases the incidence of conflict. One explanation for finding a significant coefficient is that the presence of natural resources may exacerbate tensions in ethnically diverse societies by intensifying competition over resources and revenues. This implies that we need to control both variables to capture the confounding effect. On the other hand, the insignificant coefficients of the HIEF in the rest of the regressions indicate that the relationship between ethnic diversity and conflict might be indirect, potentially mediated through other variables. For instance, ethnic diversity might influence economic conditions, and agricultural production indices, such as we study here, which then contribute to conflict.

Table 5. Instrumental Variables Probit Equations including the Ethnolinguistic Index

Second Stage Regression	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**
Logarithm of International Aid	-0.5086*** (0.1336)						
Logarithm of Real GDP per Capita		-1.705** (0.769)					
Logarithm of Crop Index			-0.5953** (0.2527)				
Logarithm of Livestock Index				-1.4453*** (0.1739)			
Logarithm of Food Index					-3.782*** (0.6682)		
Logarithm of Cereal Yield						-1.246*** (0.1886)	
Percentage of natural resources rents							0.0571** (0.028)
Population Growth	0.0988** (0.0404)	0.0689** (0.0331)	0.0794** (0.0358)	0.0703** (0.0329)	0.0695** (0.0335)	0.0705** (0.0333)	0.1035*** (0.0296)
Logarithm of Military Expenses	0.2869*** (0.0705)	0.2871*** (0.0454)	0.2349*** (0.0407)	0.2290*** (0.0401)	0.2243*** (0.0392)	0.2190*** (0.0291)	0.3277*** (0.0629)
Ethnic Fractionalization Index	0.8748 (2.071)	0.9581 (1.794)	0.7386 (1.626)	0.7861 (1.763)	0.7565 (1.641)	0.9665 (1.891)	0.8777** (0.4170)
No. Observations	611	728	702	704	702	706	544
Wald Chi-square	18,698.47 [0.000]	275,185.51 [0.000]	203,184.82 [0.000]	643,315.34 [0.000]	738,729.55 [0.000]	43,654.58 [0.000]	11,427.74 [0.000]
Weak Instrument F-Statistic Test	13.02 [0.0112]	397.26 [0.000]	232.10 [0.000]	11.15 [0.0288]	64.80 [0.000]	23.17 [0.000]	13.79 [0.0092]
Wald test of exogeneity	0.0740 [0.0701]	0.2094 [0.6112]	0.3186 [0.4204]	1.2843 [0.2548]	0.327 [0.5835]	1.417 [0.2742]	2.516 [0.1126]

Robust standard errors within parentheses. P-values within brackets.
***, ** and * denote significance at the 1%, 5% and 10% level.

5.2 The role of Shared Water Basins using Country Dyadic Data

In this section, we discuss the role of transboundary shared water basins in the MENA region, Iran and Turkey. There are three major river basins. The first is the Jordan River basin, and the headwaters originate from three main springs: the Hasbani River, originating in Lebanon; the Banias River, originating in Syria, and the Dan River, originating in Israel (Mukhar, 2006; Shentsis et al., 2021). The second is the Euphrates-Tigris basin, which has its origins in the mountains of eastern Turkey, flowing through Syria and Iraq, and empties in the Persian Gulf (FAO, 2009), which is a water basin for Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (Al-Rashed and Sherif, 2000). The third water basin is the Nile basin, and its drainage basin covers eleven countries: Burundi, Egypt, Eritrea, Ethiopia, Kenya, the Democratic Republic of the Congo, Rwanda, the Republic of Sudan, South Sudan, Tanzania, and Uganda (Oloo, 2007; Paisley and Henshaw, 2013). For the water basins, we consider river sources. More specifically, the *River Cross* refers to the total number of rivers crossing the country boundary, and the *River Boundary* is the total length in km of boundary marked by the river. *Shared Basin* is a dummy variable taking the value of 1 if the dyad has any shared rivers, and *Total Basin* is the total shared basin in squared km. The last two variables are the *Perc Upstream*, which shows the percentage of total shared basin in the upstream state, and the *Basin Upstream*, which measures the total area in sq km of river basins in the state with more total upstream river.

In Table 6, we report the Probit regressions. We should highlight that since the control variable of the logarithm of distance between the capital of a country pair is time-invariant we employ random effect Probit and IV-Probit regressions. Furthermore, since the river-shared basins are only available up to 2007, we have applied data interpolation for the time-variant variables of *River Boundary*, *Total Basin*, *Perc Upstream* and the *Basin Upstream*. The justification is that weather conditions may affect those variables. For instance, high temperatures and low levels of precipitation and SPEI may reduce the length of river boundaries, the total shared basin and the percentage of total shared basin in the upstream state, expressed in squared km. Therefore, we apply the interpolation for 2008-2022 using the weather conditions employed in the earlier estimates.

We should mention that for the continuous river variables, such as the time-variant variables of *River Boundary*, *Total Basin* *Perc Upstream* and the *Basin Upstream*, we do not consider their logarithms because there are countries that do not share a river. Thus, the variables take the value of 0 km, and we will have many missing observations. Based on the results of Table 6, we find a positive relationship between all the river-shared basins and conflict. In particular, river boundaries (*River Boundary*) increase by 10% the incidence of conflict, the increase of one percentage of the total shared basin in the upstream state (*Perc Upstream*) increases the probability of armed by 0.33%, and the total area in squared km of river basins in the state with more total upstream rivers (*Basin Upstream*) increase the incidence of conflict by 9.7%. On the other hand, even though we find a positive relationship between conflict and rivers crossing the borders of countries (*River*

Cross), the estimated coefficient is statistically insignificant. One potential explanation is that the number of rivers may not be so important as is their length and volume of water.

Regarding GDP and the inter-capital distance, we find a negative relationship with the incidence of conflict. Another factor we consider is the ratio of population between the two countries. In particular, if the ratio is larger than 1, then the first country in the pair has a larger population than the second country. In this case, we observe that the population ratio is positively related to the likelihood of armed conflict. We derive the same concluding remark if we replace the population ratio with the log of the pair-country population.

Our findings are consistent with previous studies (Buhaug and Gleditsch, 2006; Brochmann and Gleditsch, 2012). The negative relationship between conflict and distance can be explained by the fact that the potential for the prompt deployment of military responses during emergencies is diminished due to the large distances between home bases and operational regions. Users must redirect combat forces to safeguard lengthy supply and communication lines that are susceptible to enemy interdiction, which in turn increases the need for long-haul transportation (Collins, 1998). Similarly, a growing population and higher consumption may increase competition for scarce resources (Homer-Dixon, 1994; Tir and Diehl, 1998; Bernauer and Siegfried, 2012; Brochmann and Gleditsch, 2012; Tir and Stinnett, 2012).

Table 6. Panel Probit Equations using Country Dyadic Data

	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict
River Cross	0.0782 (0.0513)					
River boundary		0.1004*** (0.322)				
Shared Basin			0.0085*** (0.003)			
Total Basin				0.0191*** (0.0057)		
Perc Upstream					0.0034** (0.0014)	
Basin Upstream						0.0972* (0.0505)
Log of Real GDP	-1.391*** (0.324)	-1.394*** (0.322)	-1.394*** (0.321)	-1.394*** (0.321)	-1.395*** (0.321)	-1.394*** (0.321)
Log of Distance	-0.2715*** (0.0731)	-0.2772*** (0.0734)	-0.2772*** (0.0733)	-0.2768*** (0.0731)	-0.2771*** (0.0733)	-0.2772*** (0.0731)
Deterrence Factor: Population Ratio	0.2703*** (0.1022)	0.2701*** (0.1022)	0.2703*** (0.1021)	0.2703*** (0.1021)	0.2702*** (0.1022)	0.2703*** (0.1021)
No. Observations	47,277	47,277	47,277	47,277	47,277	47,277
Wald Chi-square	14,952.32 [0.000]	14,952.32 [0.000]	14,952.32 [0.000]	14,952.32 [0.000]	14,952.32 [0.000]	14,952.32 [0.000]

Robust standard errors within parentheses. P-values within brackets.
***, ** and * denote significance at the 1%, 5% and 10% level.

In Table 7, we report the IV-Probit estimates only for the time-variant variables of River Boundary, Total Basin Perc Upstream and the Basin Upstream. The concluding remarks are the same as those derived from Table 6. Regarding the first-stage regressions and the weather conditions, we find that average precipitation and SPEI increase the squared kilometers of rivers, while freshwater withdrawals and temperature present a negative relationship. Precipitation and rainfall may provide additional water resources in the MENA region countries, which are especially rare or not frequent and suffer from extreme heatwaves and droughts, . Rainfall, consequently, may increase the water basins, including rivers and lakes (Trenberth et al., 2014; Mosley, 2015).

Table 7. Panel Instrumental Variables Probit Equations using Country Dyadic Data

First Stage Regression	**DV: River boundary**	**DV: Total Basin**	**DV: Perc Upstream**	**DV: Basin Upstream**
Logarithm of Average Temperature	-2.249** (0.932)	-3.881** (1.802)	-0.0049** (0.0023)	-0.729** (0.353)
Logarithm of Average Precipitation	0.4979*** (0.0948)	6.196*** (1.281)	0.0024** (0.0011)	0.891*** (0.242)
Annual Freshwater Withdrawal (% internal resources)	-0.0441*** (0.0055)	-0.2753*** (0.0525)	-0.0006** (0.0003)	0.0357*** (0.009)
SPEI	0.1821*** (0.0341)	1.2314*** (0.2532)	0.00025** (0.0001)	0.186*** (0.351)
Second Stage Regression				
	DV: Conflict	**DV: Conflict**	**DV: Conflict**	**DV: Conflict**
River boundary	0.0618*** (0.0142)			
Total Basin		0.0159*** (0.0025)		
Perc Upstream			0.0029*** (0.0011)	
Basin Upstream				0.0891** (0.0392)
Log of Real GDP	-1.192*** (0.113)	-1.191*** (0.115)	-1.202*** (0.119)	-1.212*** (0.114)
Log of Distance	-0.226*** (0.0652)	-0.262*** (0.0449)	-0.242*** (0.0303)	-0.215*** (0.0442)
Deterrence Factor: Population Ratio	0.0660* (0.0319)	0.0623** (0.0305)	0.0652** (0.0314)	0.0648** (0.0313)
No. Observations	45,867	45,867	45,867	45,867
Wald Chi-square	30,140.42 [0.000]	33,589.52 [0.000]	41,195.75 [0.000]	41,185.23 [0.000]
Weak Instrument F-Statistic Test	512.29 [0.000]	231.18 [0.000]	26.77 [0.000]	194.69 [0.000]
Wald test of exogeneity	1.382 [0.203]	1.996 [0.153]	1.855 [0.176]	1.479 [0.221]

Robust standard errors within parentheses. P-values within brackets.
*** and ** denote significance at the 1% and 5% level.

Next, for robustness checks, we include additional control variables. More specifically, in Table 8, we report the IV-Probit estimates using dyadic data and briefly describe the additional variables. We conclude that the estimates of the variables of interest, which are the shared-river data, are robust and are similar to those presented in Table 7. We do not report the estimates of the initial and the additional control variables because it is out of the study's aim. However, we highlight that the results show that if one of the countries is a member of the World Trade Organization (WTO), change in the common legal origin since transition and the peace of years are negatively associated with the incidence of armed conflict. On the other hand, contiguity, countries that are both non-democratic and were before involved in armed conflict increase the likelihood of conflict.

Table 8. Panel Instrumental Variables Probit Equations using Shared-River Basins Country

Dyadic Data and Additional Controls

	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict
River boundary	0.0613*** (0.0153)			
Total Basin		0.0151** (0.0026)		
Perc Upstream			0.0027*** (0.0009)	
Basin Upstream				0.0875*** (0.0215)
No. Observations	45,867	45,867	45,867	45,867
Wald Chi-square	232,525.62 [0.000]	250,834.26 [0.000]	248,154.93 [0.000]	248,154.93 [0.000]
Weak Instrument F-Statistic Test	795.71 [0.000]	834.26 [0.000]	31.482 [0.000]	653.23 [0.000]
Wald test of exogeneity	1.733 [0.188]	1.652 [0.197]	1.667 [0.196]	1.494 [0.221]

Robust standard errors within parentheses. P-values within brackets.
*** and ** denote significance at the 1% and 5% level.
Additional controls include peace years and a set of dummy variables indicating at a given year: whether the pair countries had a common colonizer, if the origin and destination countries are members of the WTO, if they share a common border, if one of the two countries is democracy, if both countries are not democratic, if the country-dyad has at least one major power, if the pair was before in conflict, and a dummy indicating whether the common legal origin change since transition.

Similarly, in Table 9, we report the estimates of Table 4 using country dyadic data. We should mention that we could have estimated regressions of Table 4 using dyadic data. Nonetheless, since we use population growth and military expenses at the country level and not dyadic, we performed the regressions using non-dyadic data. Nevertheless, in Table 9, we perform the regressions using the same control variables as in Table 8. We obtain the same concluding remarks, where international aid, GDP, and food production indices decrease the likelihood of conflict, while natural resource rents increase the probability of conflict. The estimated coefficients in Table 9 vary from those in Table 4 since we use dyadic data. However, these differences are higher in international aid, GDP and Foor Production Index, and we find similar estimated coefficients in the regressions of Crop, Livestock and Cereal Yield Indices.

Table 9. Panel Instrumental Variables Probit Equations using Country Dyadic Data

Second Stage Regression	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict	DV: Conflict
Logarithm of International Aid	-0.3249** (0.1478)						
Logarithm of Real GDP per Capita		-1.2922*** (0.2882)					
Logarithm of Crop Index			-0.5816** (0.2611)				
Logarithm of Livestock Index				-1.550*** (0.0637)			
Logarithm of Food Index					-2.599*** (0.4138)		
Logarithm of Cereal Yield						-0.9554*** (0.3548)	
Percentage of natural resources rents							0.0472** (0.0251)
No. Observations	41,854	45,867	45,442	45,442	45,442	43,689	35,211
Wald Chi-square	5,236,892.48 [0.000]	5,394,275.51 [0.000]	5,323,119.73 [0.000]	5,338,553.48 [0.000]	5,359,315.52 [0.000]	5,768,593.28 [0.000]	5,184,134.84 [0.000]
Weak Instrument F-Statistic Test	837.27 [0.000]	876.71 [0.000]	216.60 [0.000]	871.59 [0.000]	390.48 [0.000]	647.10 [0.000]	1,147.60 [0.000]
Wald test of exogeneity	2.792 [0.0949]	0.394 [0.5315]	1.572 [0.2099]	1.607 [0.2049]	1.909 [0.1671]	1.811 [0.1783]	0.152 [0.7029]

Robust standard errors within parentheses. P-values within brackets.
*** and ** denote significance at the 1% and 5% level.

Previous studies found that higher average temperatures and low levels of precipitation and rainfall are positively associated with an increased risk of conflict in regions with limited access to water resources (Kelley et al., 2015; Smith et al., 2018), supporting the idea that climate-related factors can exacerbate conflicts in certain regions. However, this study aimed to establish a link between conflict and economic and food production factors conditioned on weather conditions. In other words, instead of looking at the direct path between climate change, weather conditions and conflict, we explored how climate change may deteriorate the economic factors and food production indices and, consequently, how the latter can affect the incidence of conflict. Furthermore, as discussed earlier, scarcity of essential resources like food can exacerbate social tensions and lead to social unrest and armed conflicts (Collier and Hoeffler, 1998, 2002a; Martin-Shields and Stojetz, 2019). Studies have also investigated the role of economic factors in conflict-prone areas and found, among others, that agricultural productivity, economic growth and international aid were associated with reduced conflict risk (Collier and Hoeffler, 2002b; Hegre and Sambanis, 2006; Nielsen et al., 2011; Koubi et al., 2012; Muchlinski et al., 2016; Iyigun et al., 2017).

5.3 Limitations

We should highlight that the study has drawbacks. First, as we discussed, we have reported the findings for economic growth and international aid, natural resource rents and food production indices using non-dyadic data, and we repeated the estimates using dyadic data. In the former case, the results should be interpreted with caution as the time is longer than the number of observations, which is the countries, even though we have reported the unit root tests. Nevertheless, when we employ non-dyadic data, we include only the MENA region countries, Turkey and Iran. On the other hand, when we use the country dyadic data, we consider pairs between MENA region countries, Turkey, Iran and other countries globally. Second, we should treat the estimates with caution even though we attempted to reduce common sources of endogeneity, such as omitted variables, unobserved heterogeneity, and reverse causality. First, because we use Probit regression with random effects as we cannot perform fixed effects within Probit models. Second, we run random effects, especially in the case of dyadic data, because we have time-invariant independent variables, such as common colonizer. Moreover, whereas economic growth and food production indices may affect conflict, the latter can also have a detrimental effect on the same variables (Amodio and Maio, 2018; Novta and Pugacheva, 2021; Le et al., 2022). Nevertheless, this study aimed to explore the impact of economic and food production factors on the incidence of conflict conditioned on weather conditions.

6. Conclusions

In this study, we examined the impact of economic growth, international aid, food production indices and natural resource rents on the incidence of conflicts. The results show that average temperature is positively related to international aid, but negatively related to economic growth and food production indices. On the other hand, we found that precipitation and SPEI are positively associated with economic growth and food Production. Using weather conditions as instrumental variables, we found that increases in international aid, economic growth, and food production reduce the incidence of conflict but natural resource rents increase the likelihood of armed conflicts.

The findings of this study may provide various insights and policy implications. In particular, while we explore the impact of economic growth and food production indices on conflict, we argue that frequent, intensive and long-lasting conflicts may also deteriorate economic growth, food production and security. Moreover, intensive resource extraction may lead to environmental degradation by increasing temperature, reducing water resources and consequently negatively affect food production and GDP. Therefore, efforts should take place to reduce the frequency of internal and external conflicts to promote inclusive, peaceful societies for sustainable development in the region. This is because conflicts, not only have a negative impact on the ecological footprint, but also on sustainable production and consumption, leading to a decline in regional income levels. Conflicts may result in energy catastrophes and a decline in production and consumption due to air and water pollution.

Second, policymakers should focus on adaptation and mitigation strategies for climate change that secure efficient and adequate food production and improve agricultural sector and GDP. Also, urban development-induced renewable energy must be increased to attain sustainable environmental quality. This will stimulate the development of new technologies in the MENA region that promote energy efficiency and carbon-free economies. Adopting an alternative clean energy system (i.e., renewable energy) is crucial for safeguarding, restoring, and promoting the sustainable use of terrestrial ecosystems, combating desertification, managing forests, and reversing land degradation and biodiversity loss.

Third, the findings will assist in focusing the attention of government and policymakers on the formulation of effective environmental policies that achieve the objective of decarbonized economies and sustainable economic growth. To this end, we propose that future research focus on the underlying mechanisms by which internal and external conflicts impact ecological imprints.

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