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STOLEN DREAMS OR COLLATERAL DAMAGE: CLIMATE AND ECONOMIC GROWTH IN TIME OF COVID-19*

Hany Abdel-Latif, Hala Abou-Ali,[1] Yasmine Abdelfatah,[2] Nada Rostom,[3]
Amal Abdelfatah,[4] and Said Kaawach[5]

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Send correspondence to:
Hany Abdel-Latif
Swansea University
info@hanomics.com

[1] Cairo University, Egypt
[2] Universities of Canada, Egypt
[3] American University Cairo, Egypt
[4] Universities of Canada, Egypt
[5] University of Huddersfield, UK

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Abstract

This paper investigates the coupled dynamics of climate and growth in the Middle East and North Africa (MENA) region, considering exogenous shocks such as the COVID-19, with no presumptions on the direction of causality. We utilise temperature and precipitation departures from their historical trends to quantify climate change. We estimate country-specific and panel vector autoregressive models with exogenous variables to supplement existing attempts that integrate climate change in economic modelling. Our findings lend evidence to the interrelation between climate change and economic growth without ruling out bi-directional causality, a reality that many climate studies tend to overlook.

Keywords: Climate change, economic growth, COVID-19, MENA countries.

JEL Classifications: C33, O40, O44, Q54.

ملخص

تتناول هذه الدراسة الديناميكيات المقترنة بالمناخ والنمو في منطقة الشرق الأوسط وشمال إفريقيا (MENA)، مع الأخذ في الاعتبار الصدمات الخارجية مثل جائحة فيروس كورونا المستجد، مع عدم وجود افتراضات بشأن اتجاه العلاقة السببية. تستخدم الدراسة انحرافات درجات الحرارة ومعدلات هطول الأمطار عن اتجاهاتها التاريخية لتحديد التغير في المناخ. تقدر الدراسة نماذج مُتجه الانحدارِ الذاتيِّ للسلاسلِ المَقطَعيَّةِ (PVAR) ونماذج مُتجه الانحدارِ الذاتيِّ الخاصة بالدولة مع المتغيرات الخارجية لتكملة المحاولات الحالية التي تدمج تغير المناخ في النمذجة الاقتصادية. وتقدم نتائج الدراسة دليلاً على العلاقة المتبادلة بين تغير المناخ والنمو الاقتصادي دون استبعاد العلاقة السببية ثنائية الاتجاه، وهي حقيقة تميل العديد من دراسات المناخ إلى التغاضي عنها.

1. Introduction

Climate change is a pressing challenge to humanity, but its awareness is con- tinuously rising, especially amongst young generations. In a sharp rebuke to the United Nations' leaders, Greta Thunberg, a Swedish teenager activist, said: "You have stolen my dreams and my childhood with your empty words"[6]. She urged world leaders for more bold and collective actions to tackle the climate crisis. Rising temperatures and sea levels, extreme weather fluctuations, and food and water insecurity are a few symptoms of the ongoing problem. Sci- entists across the globe confirm Greta's fears: The threat of climate change to humankind is real. Forty years following the first world climate conference in Geneva 1979, more than 11000 scientists from 153 countries urged policymakers to address climate change before it is too late as no corner of the globe is immune from its devastating consequences (Ripple et al., 2019).

Many believe that economic activities that accumulate greenhouse gas (GHG) emissions are to blame for the climate crisis and are responsible for changing temperature, among other calamitous impacts (Eboli et al., 2010). Satellite images during COVID-19 lockdowns showed how global emissions dropped remarkably as a result of receded economic activity[7]. On the other hand, others argue that economic growth and distributive measures are essential in combat- ing extreme poverty. According to this view, the success in lifting millions of people out of poverty would not have been possible without sustained periods of economic growth (Anand et al., 2014), and thus climate change is merely *collateral damage* towards a more significant cause. Yet, there is growing evidence of the adverse economic impacts of climate change on growth, productivity, among other possible outcomes (Kahn et al., 2019). Thus, while growth is necessary, economic activity can induce environmental damage that has high economic costs and can slow-down economic growth over the long run. Unlike the majority of existing research, this paper provides an empirical investigation of the climate-growth joint dynamics, with no presumptions imposed on the direction of causality.

Our paper contributes to this debate by investigating the bidirectional causality between climate and economic growth in the MENA region while accounting for exogenous shocks like COVID-19. Several reasons explain why the MENA region is an intriguing case. First, because of the region's diverse and distinct economic structures, adaptation and sensitivity to climate risks vary enormously. Nonetheless, environmental damages that can trigger spillover effects require addressing the climate crisis on a regional scale. Second, the fragile ecosystems of the MENA region, combined with limited adaptive capabilities, necessitate more proactive and evidence-based climate policies. The physical damage ranges from coastline erosion in

[6] https://www.reuters.com/article/us-climate-change-un/you-have-stolen-my-dreams-an-angry-thunberg-tells-u-n-climate-summit-idUSKBN1W81HO

[7] https://www.weforum.org/agenda/2020/03/emissions-impact-coronavirus-lockdowns-satellites/

Egypt, Lebanon, and the UAE to harsh environments in countries with large desert areas, such as the Gulf countries, and water stress issues in all Arab countries, with the possible exception of Lebanon. Third, several studies have predicted alarming levels of risk and an unstable climate outlook across the MENA region (Hergersberg, 2016; World Bank, 2017; Merlone et al., 2019).[8] Fourth, climate change impacts have significant public and private economic costs which makes our study valuable for policymakers in the MENA region.

A few research papers focus on the bi-directional relationship between climate change and economic growth, see Brini (2021) for example. Moreover, research on the climate-growth joint dynamics in the MENA region is rare, especially in time of external shocks such as COVID-19. Yet, quantifying this nexus is a prerequisite for an informed policy debate regarding the urgency and choice of actions to mitigate its most severe impacts. Therefore, this study attempts to fill this gap by investigating the inter-relationship between climate change and economic growth in the MENA region controlling for exogenous shocks such as the COVID-19 pandemic.

To that end, we employ a set of individual and panel vector autoregressive models with exogenous variables, VARX and PVARX, respectively, on a quarterly dataset on growth and climate variables for thirteen MENA countries over the period 2001Q1-2021Q1. While our set of endogenous variables include a climate variable (temperature or precipitation), GDP growth, and the inflation rate, we use a proxy for how stringent individual governments responses were to the COVID-19 shock as our exogenous variable. We then stimulate shocks to climate variables and GDP growth and trace their impacts on each other to study the climate-growth joint dynamics. For identification purposes, we use sign restrictions, following Fry and Pagan (2011), and report the single model for which the impulse response functions (IRFs) are closest to median values of the impulse vector (i.e., median target).

Our findings show that while higher temperature levels (defined as deviation from historical norms) adversely impact GDP growth, increased economic ac- tivities (GDP growth) contribute significantly to higher temperature levels. Moreover, higher precipitation levels (defined as deviation from historical norms) could contribute to higher growth rates in MENA countries, while higher growth rates may lead to lower precipitation levels.

The remainder of this paper proceeds with a review of the literature, Section 2. Section 3 presents the dataset and methodology. Section 4 outlines the empirical results, and Section 5 concludes.

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[8] The World Bank (2017) indicates that 80-100 million people in the MENA are subject to water stress in 2025. Besides, heatwaves and increases in temperature have repeatedly been occurring in the region in recent years. Hergersberg (2016) predicted that the MENA temperatures would be4˚C higher by 2050. By 2100, daytime temperatures could reach 50˚C, with 200 days of extreme weather each year (Merlone et al., 2019).The highest temperature recorded in the region has been54˚C in Mitribah, Kuwait, and 53.9˚C in Basra, Iraq, in 2016 (Merlone et al., 2019).

2. Literature Review

Although traditional economic models have not explicitly accounted for cli- mate change, several economists have attempted to integrate climate change into mainstream models. For example, within the neoclassical growth model, climate change could be perceived as a depreciation driver since the increased frequency of extreme weather events can hinder capital accumulation and production (Farmer et al., 2015). Others employ integrated assessment models (IAMs), with a neoclassical flavor, to examine the GDP-climate dynamics by incorporating capital accumulation and saving effects (Koomey et al., 2019). However, many have criticized IAMs for underestimating the long-term cost of climate because as, by design, it excludes the growth impact (Piontek et al., 2019).

Such theoretical endeavors have focused on explaining the effect of climate change on growth and vice versa, but not the interplay between both variables. Fankhauser and Tol (2005), for instance, provided a framework using the Ramsey-Cass-Koopmans model to illustrate the impact of climate change on eco- nomic growth. The latter model assumes that economic growth happens over two periods with different generations, with two factors, capital accumulation and savings, identified as the primary channels explaining the climate-growth dynamics. Holding savings constant, a negative impact of climate change on output will lower investment levels, leading to lower capital stock, production, and consumption levels. According to endogenous growth models, lower in- vestments also slow down technical progress, labor productivity and human capital accumulation. Besides, forward-looking agents are likely to change their saving behavior as climate change materializes and affects returns on investments negatively, which will then affect the accumulation of capital and growth. The direction in which saving will be affected is not, however, apparent. Savings may well fall because, faced with lower rates of return, economic agents may prefer to consume now rather than save. Agents may also decide to increase savings to compensate for the shortfall in future income.

Empirical research, on the other hand, has documented possible adverse growth impacts of climate change, especially in developing countries, which are more prone to climatic shocks.[9] Other studies find that an increase in the atmospheric concentration of GHG emissions would lead to significant losses in output growth (Dell et al., 2014). Additionally, empirical evidence reveals that climate risk exposure has increased the average cost of debt, particularly in developing nations (Buhr et al., 2018). A striking shortcoming in many of these studies is the treatment of climate variables as strictly exogenous while growth can also increase GHG emissions, the key driver of observed climate change (Granados et al., 2012).

[9] Many African countries are in an area where 80% of the damages from climate change will occur (Tol, 2018). Moreover, according to Abidoye and Odusola (2015), the sectors driving growth in developing countries, such as agriculture, energy, forestry, tourism, coastal and water resources, are the most vulnerable to climate change.

Copiello and Grillenzoni (2020) confirm the inter-link between growth and climate change where economic activities amplify global warming, which in re- turn hinder economic development. However, a higher growth level may create room for climate change mitigation policies, including subsidizing innovation of carbon-free technology (Salman et al., 2019) and taxing carbon-emitting sources of energy (Fawzy et al., 2020). On the other hand, some types of growth can undermine the economy's adaptive capacity and climate change mitigation efforts. Unlike economic growth in climate highly-exposed sectors such as agriculture, a growth model less dependent on these sectors can enhance the economy's adaptability (Chapman et al., 2017). Thus, it is imperative to exam- ine the climate-growth interrelationship instead of focusing on causality in one direction or another.

3. Data and Methodology

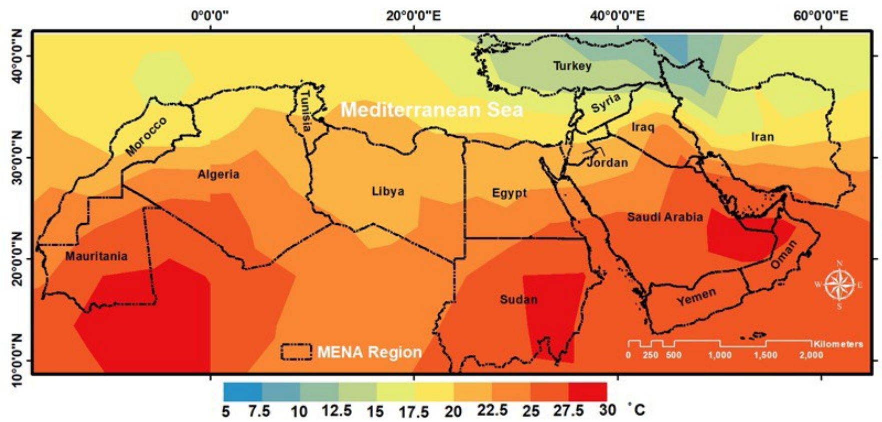
3.1. Data description

To frame the growth impacts of climate change, Kahn et al. (2019) propose a stochastic growth model in which labor productivity is affected by country- specific climate variables – defined as deviations of temperature and precipitation from their historical norms. We follow their approach in defining climate variables. Our dataset includes quarterly population-weighted climate data and GDP growth rate for a panel of thirteen MENA countries over the period 2001Q1 to 2021Q1, determined by data availability. These countries are Algeria, Bahrain, Egypt, Iran, Jordan, Kuwait, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey and United Arab Emirates. Geographically gridded monthly measures of temperature and precipitation come from the National Centers for Environment Prediction/National Center for Atmosphere Research (NCEP/NCAR) data and National Oceanic and Atmospheric Administration (NOAA) (Kalnay et al., 1996). We measure temperature in degrees Celsius, ° C and precipitation in mm/day. We average monthly climate data to obtain quarterly series for each country. We collect quarterly GDP and inflation series from the Global Economy database[10] and the international financial statistics (IFS) of the International Monetary Fund (IMF). To account for the strictness of COVID-19 lockdowns and their impacts on economic activities, we use the Oxford COVID-19 Government Response Tracker (OxCGRT) stringency index for which records policies that primarily restrict people's behavior.

Figure 1 depicts the variation in average maximum temperature in MENA countries over the period 1980-2017. Data on real GDP growth reveals increasing trends among MENA countries across different income groups. Data show several points of negative growth in MENA countries even before the COVID- 19 pandemic hit the whole world since 2020Q1. Onwards, the pandemic had an impoverishing effect on several MENA countries.

[10] https://www.theglobaleconomy.com/download-data.php

Figure 1: Variation in Average Maximum Temperature 1980-2017



Notes: Figure shows the variation in average maximum temperature in MENA countries between 1980 and 2017.

3.2. Empirical Methodology

For empirical estimation, we employ country-specific and panel vector autoregressive models with exogenous variables (VARX and PVARX, respectively) to accommodate shocks such as COVID-19. A simple $VARX_{k,m}(p, s)$ including a stationary k-dimensional vector series y_t which depends on its own past p values and the past s values of a stationary m-dimensional vector series x_t, takes the following form:

$$y_t = \sum_{\ell}^{p} \Phi_\ell y_{t-\ell} + \sum_{j=1}^{s} B_j x_{t-j} + \epsilon_t \tag{1}$$

where Φ and B_j are endogenous and exogenous coefficient matrices, respec- tively, and $_t$ a k-dimensional mean-zero white noise vector time series.[11] We follow the model specification in Eq. 1 to produce a set of country-specific impulse response functions to study the climate-growth dynamics at country level. For identification purposes, we impose sign restrictions on the impulse response functions (IRFs). Our sign constraints explore the space of orthogonal shock decompositions to determine whether the responses satisfy the imposed constraints. Moreover, we formally present our PVARX model as follows:

$$Y_t = A(l)_{i0} + A(l)_{i1} Y_{t-1} + F(J)_{ij} X_t + \zeta_{it} \tag{2}$$

where i and t indicate the cross-section and time dimensions of our dataset, respectively. Y_t is

[11] We omit the intercept for simplicity. Please note that a $VAR_k(p)$ model is merely a specialcase of the $VARX_{k,m}(p, s)$ model presented in Eq. 1 where $m = 0$.

a $G \times 1$ vector of endogenously determined variables, including GDP growth and temperature anomalies, enabling us to examine their joint dynamics. We also include the inflation rate as a proxy of macroeconomic policy soundness. X is a vector that can accommodate a set of exogenous variables. We use the Oxford COVID-19 government response tracker (OxCGRT) index to account for the strictness of lock-down in our sample, with the possibility of adding more exogenous variables in future revisions of this paper. ζ_{it} is a vector of independent and identically distributed errors with zero means, see Canova and Ciccarelli (2013) for more details. We use information criteria to select the optimal lag order in the PVARX specification and moment condition. Finally, we exploit our PVARX model to stimulate a standard deviation shock in one variable and trace its impacts on other endogenous variables in the system. The latter helps us studying the regional dynamics of climate change and economic growth.

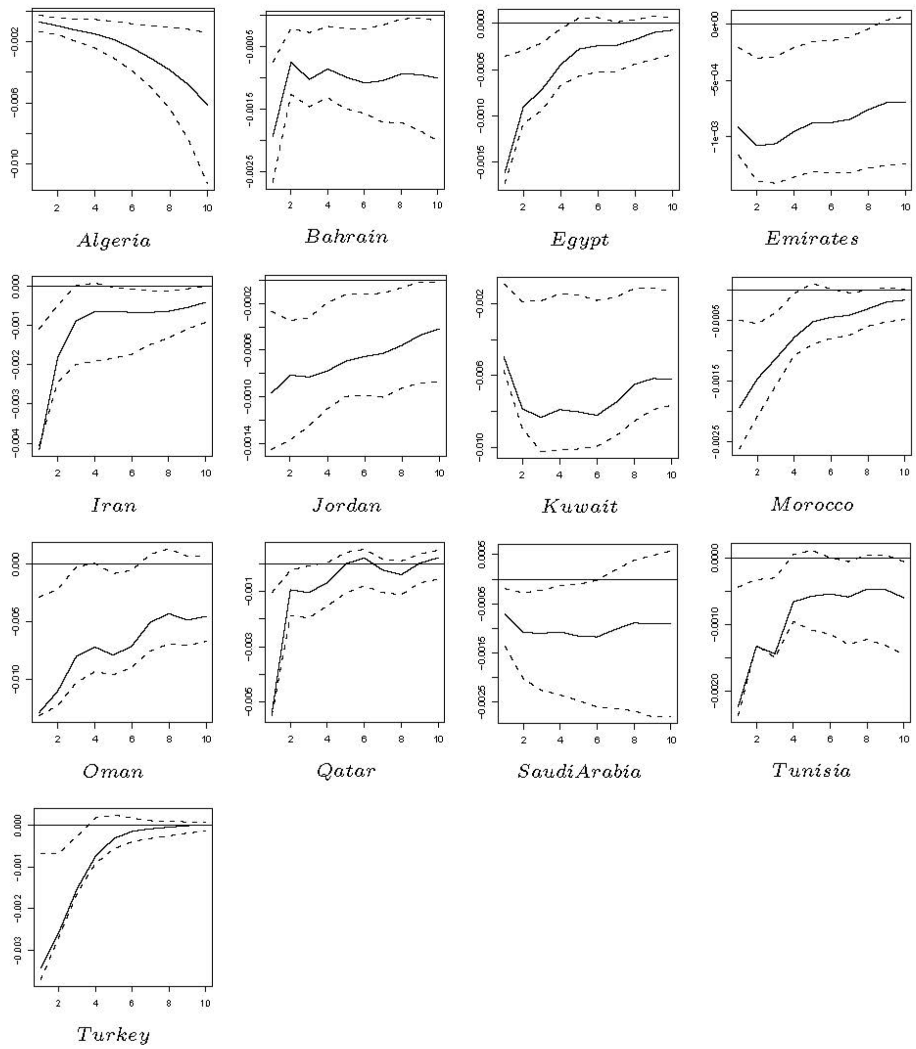
4. Empirical Results

We report our individual VARX and PVARX estimations, including three en- dogenous variables [economic growth rate, a climate variable (temperature or precipitation), and the inflation rate] along with one exogenous variable (OxCGRT), which takes the value of zero before 2020Q1. We de-trend climate variables to capture temperature and precipitation deviations from their historical norms rather than capturing quarter-over-quarter changes. This section focuses mainly on the impulse response functions (generated from our VARX and PVARX models) to study the effects of climate shocks on economic growth rates and vice versa.

4.1. Country-Specific VARX Models

Based on a set of country-specific VARX models, Figure 2 shows the impulse response function (IRFs) of GDP growth in response to one standard deviation (1SD) positive shock to temperature (defined as deviation from historical norms). While we have a diverse group of countries in our sample, Figure 2 suggests that rising temperatures would adversely affect output growth in all MENA countries. Across all country-specific IRFs, depicted in Figure 2, GDP growth responses to 1SD temperature shock are negative and statistically different from zero. These adverse effects of temperature on growth are persistent and long- lasting in most countries in the MENA region. These findings cast doubts on studies suggesting significant adverse growth impacts of increasing temperatures only in countries reliant on agriculture or those with fewer resources devoted to mitigating efforts. The effects of extreme temperatures may well go beyond the agricultural sector as it could negatively affect labor productivity, investment and health.

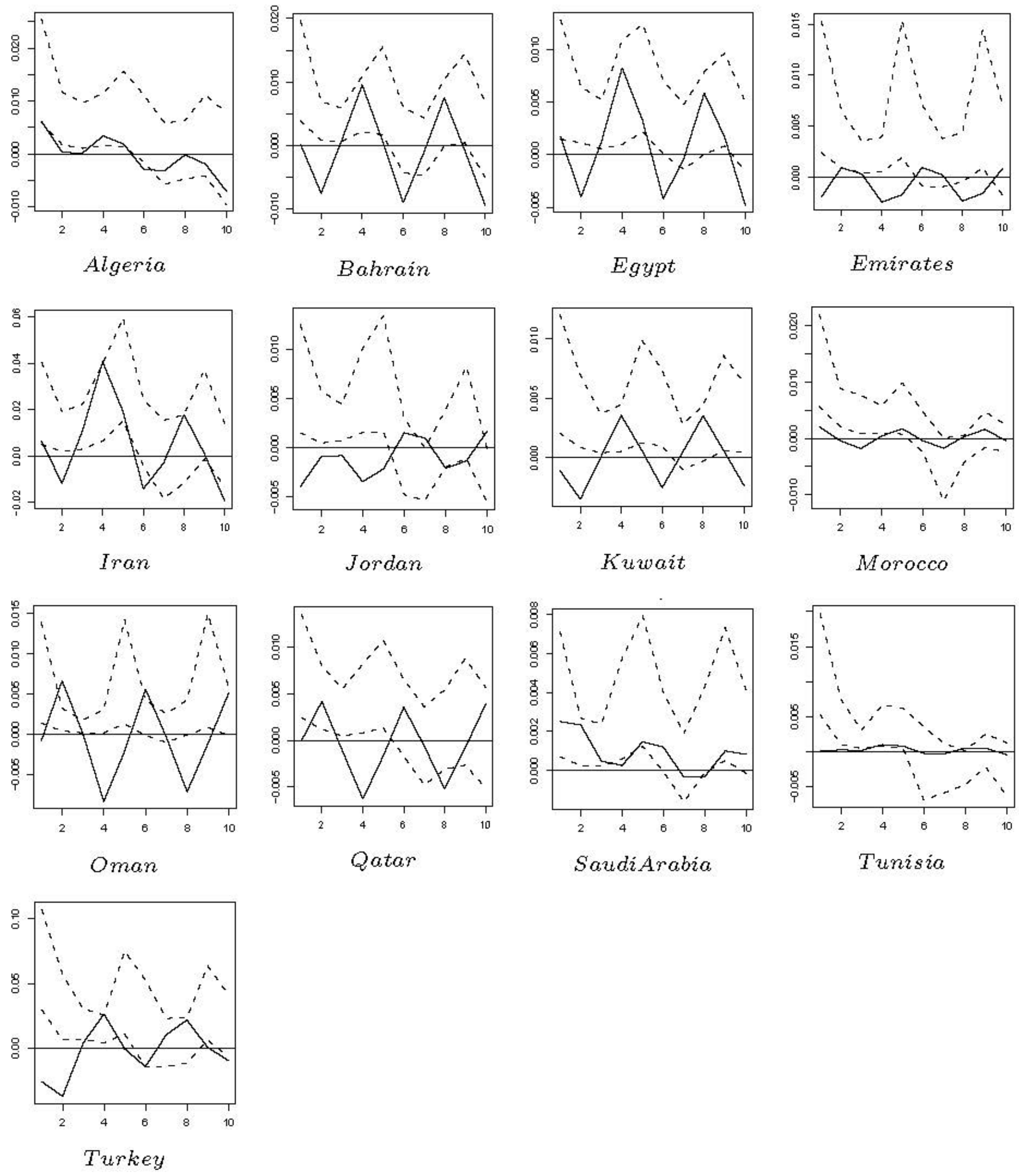
Figure 2: GDP Response to A One SD Temperature Shock



Notes: Figure shows the (sign restricted) GDP impulse response functions to a one standard deviation shock to temperature based on a set of country-specific VARX models. The solid lines depict median impulse responses with 95% bootstrapped confidence bounds over quarterly time horizon.

Similarly, drawing from our county-specific VARX models, Figure 3 plots the IRFs of temperature in response to one standard deviation (1SD) increase in economic growth rate. The IRFs, depicted in Figure 3, show that increasing output growth would contribute to increased temperature levels across MENA countries. Our findings align with climate research suggesting that economic activities increase carbon dioxide emissions, leading to rising global temperatures. Several empirical studies have documented such a strong coupling of economic growth and GHG emissions, which is contributing significantly to human-induced climate change.

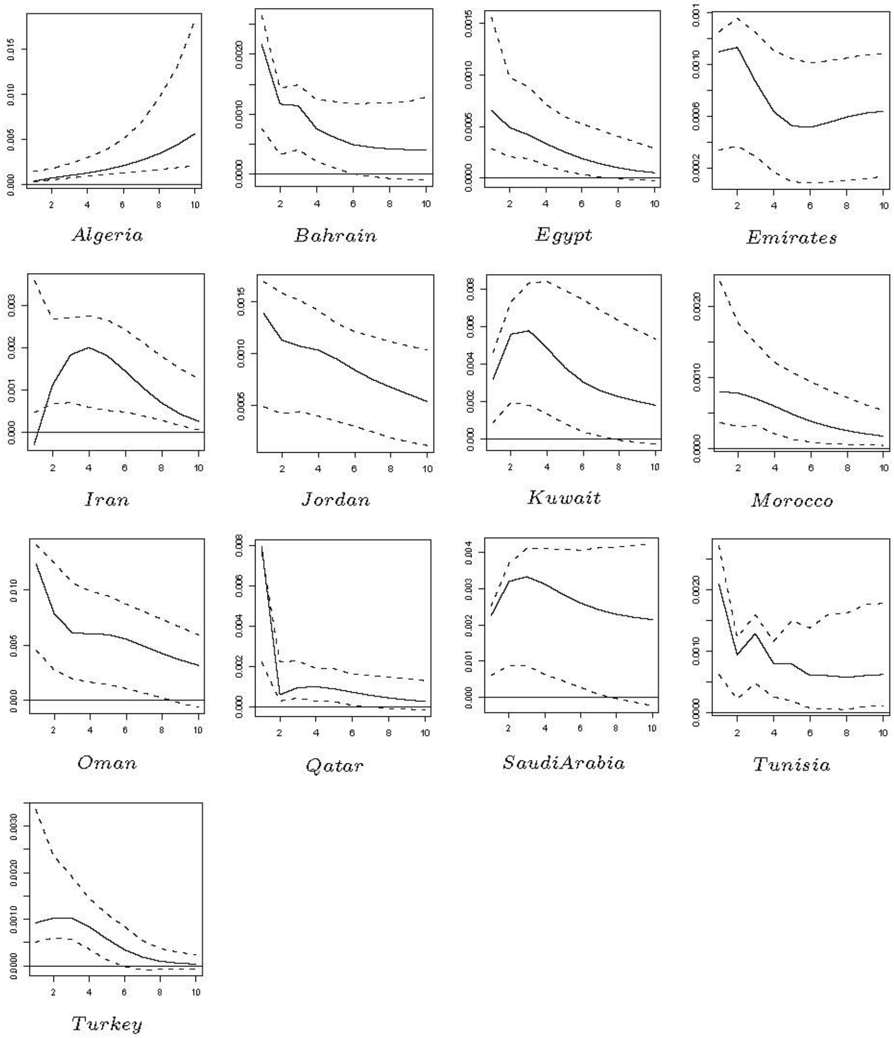
Figure 3: Temperature Response to A One SD GDP Shock



Notes: Figure shows the (sign restricted) temperature impulse response functions to a one standard deviation shock to GDP growth based on a set of country-specific VARX models. The solid lines depict median impulse responses with 95% bootstrapped confidence bounds over quarterly time horizon.

Using precipitation levels (defined as deviations from historical norms) instead of temperature to gauge climate change in our country-specific VARX models, we replicate the above IRFs for climate and economic growth shocks. Figures 4 and 5 plot the IRFs for GDP and precipitation, respectively. A key conclusion derived from Figure 4 can be that increased precipitation levels would contribute to increasing output growth levels in the MENA region. The latter findings are not surprising since rainfall is closely associated with economic growth, especially in dry areas. The volume of precipitation in the MENA region is relatively low, and our results suggest positive growth impacts of rainfall across MENA countries.

Figure 4: GDP Response to A One SD Precipitation Shock



Notes: Figure shows the (sign restricted) GDP impulse response functions to a one standard deviation shock to precipitation based on a set of country-specific VARX models. The solid lines depict median impulse responses with 95% bootstrapped confidence bounds over quarterly time horizon.

Figure 5, which plots the IRFs of precipitation levels, shows that increased economics activities may further reduce precipitation levels in the MENA region.[12]

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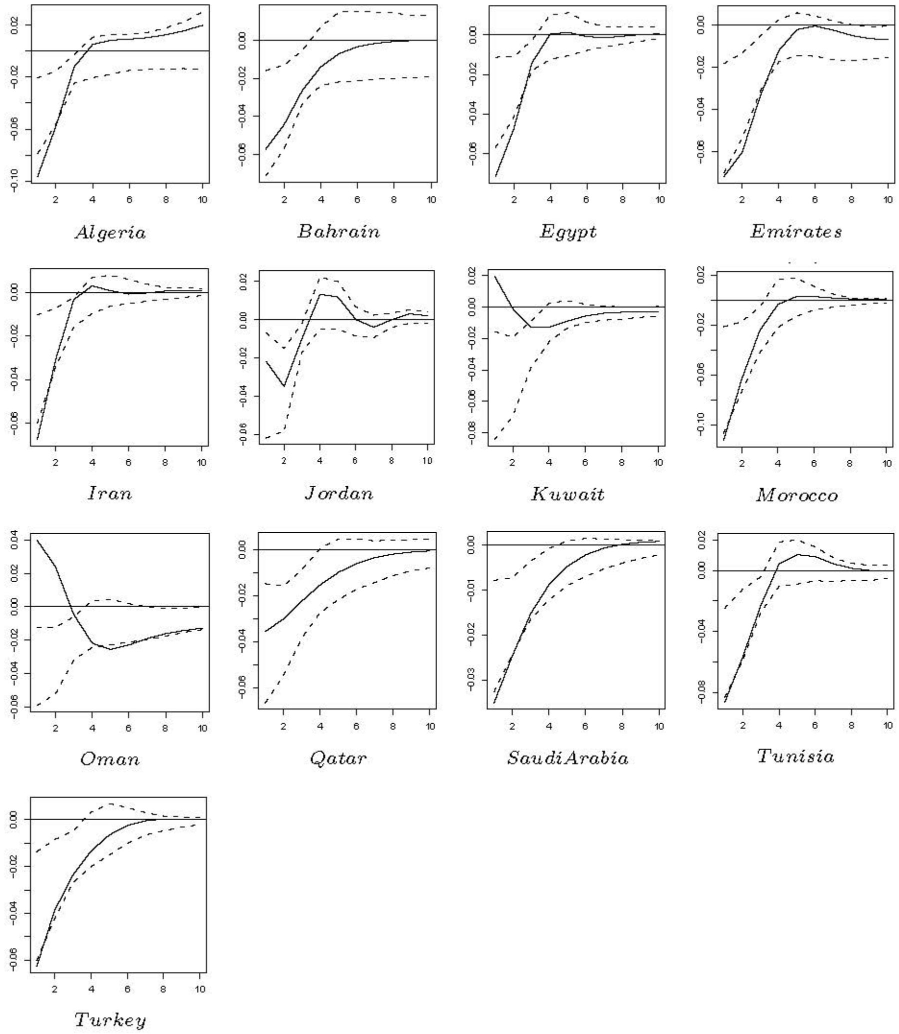
[12] We thank our anonymous reviewer for pointing out that since that growth in the MENA region is heavily dependent on exporting fossil fuels, and the latter depends on growth in importing countries, we should be cautious when interpreting the estimated coefficients. AS such, this is one

Figure 5: Precipitation Response to A One SD GDP Shock



Notes: Figure shows the (sign restricted) precipitation impulse response functions to a one standard deviation shock to GDP growth based on a set of country-specific VARX models. The solid lines depict median impulse responses with 95% bootstrapped confidence bounds over quarterly time horizon.

4.2. Panel VARX Estimation

As highlighted earlier, in addition to our country-specific VARX models, we also estimate a PVARX model for each climate variable (temperature and precipitation) to examine the climate-growth dynamics at the MENA regional level. Besides our proxy variable that captures climate conditions, and similar to our VARX specification, we include output growth rate and the inflation rate as endogenous variables and the OxCGRT index as an exogenous variable. We use our PVARX estimations to produce the impulse response functions (IRFs) for climate and

limitation of our estimation strategy. Our model does not capture cross-country growth-climate spillovers, leaving room for future research to develop our work further.

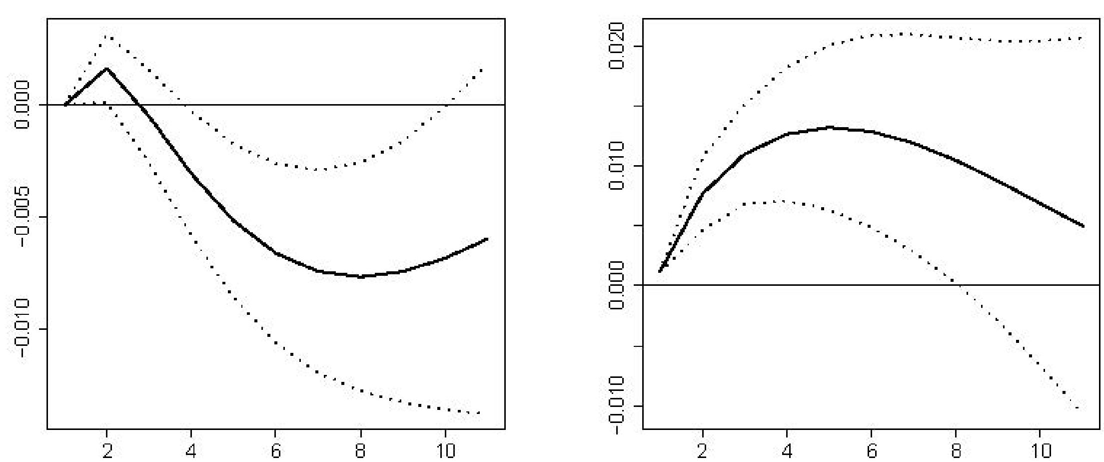
growth variables to examine their interrelationship. The latter IRFs, shown in Figures 6 and 7, conform to previous conclusions from the country-specific VARX based IRFs.

Figure 6, panel a, shows that 1SD shock to temperature levels, defined as deviation from historical norms, would have negative and statistically significant impacts on GDP growth rates in the MENA region. These results are in line with previous IRFs estimations based on country-specific VARX models presented in Figure 2. Similarly, the IRFs plotted in Figure 6, panel b, confirm those findings summarized by Figure 3: increased economic activities (GDP growth) contribute significantly to higher temperature levels in the MENA region.

Finally, using deviations of precipitation levels from their historical norms as a proxy for climate conditions, our PVARX based IRF estimations presented in Figure 7, panel a and b, confirm previous conclusions. More specifically, Figure 7 panel a, shows the GDP IRF to 1SD precipitation shock which is positive and statistically significant in line with the country-levels IRFs shown in Figure 4. The conclusion drawn from these IRF graphs points to that higher precipitation levels (defined as deviation from historical norms) could contribute to higher growth rates in MENA countries. Moreover, Figure 7 panel b, which also support our findings in Figure 5, shows that higher growth rates may lead to lower precipitation levels in the MENA region.

Figure 6: Panel VARX IRFs: Climate Variable – Precipitation

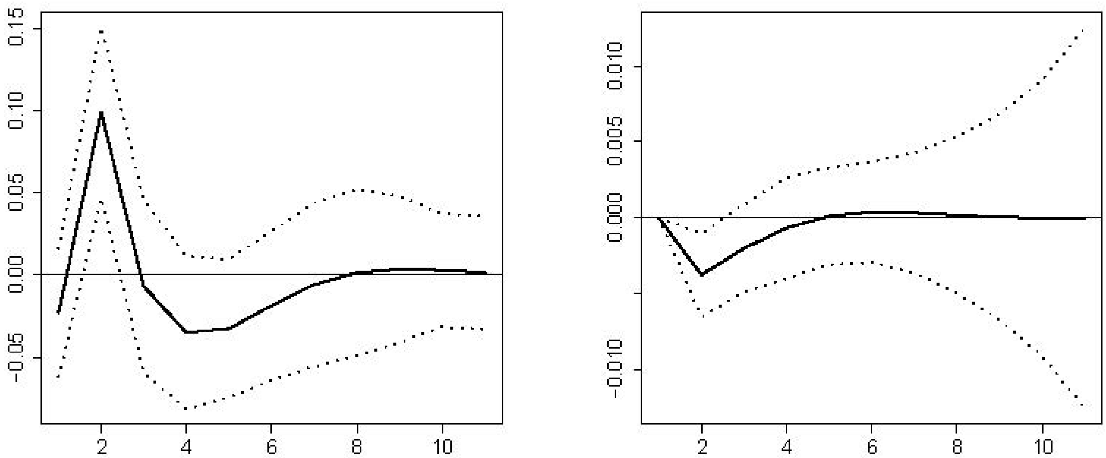
(a) Shock: Temperature, Response: GDP Growth **(b) Shock: GDP Growth, Response: Temperature**



Notes: Figure shows impulse response functions (IRFs) from a panel autoregressive model estimation of economic growth, temperature and inflation rate.

Figure 7: Panel VARX IRFs: Climate Variable - Temperature

(a) Shock: Precipitation, Response: GDP Growth **(b) Shock: GDP Growth, Response: Precipitation**



Notes: Figure shows impulse response functions (IRFs) from a panel autoregressive model estimation of economic growth, precipitation and inflation rate.

5. Conclusion

Climate change has been drawing the path to development in the MENA region. Existing studies project climate change will materialize in the region with heat stress, increasing water scarcity, and poor air quality in urban areas. This paper uses a set of country-specific VAR and panel VAR models, treating climate and growth as interdependent and endogenous variables while incorporating exogenous variables. Our findings provide empirical evidence of the interrelation between climate change and economic growth in the MENA region. We find that while higher temperature levels (defined as deviation from historical norms) adversely impact GDP growth, increased economic activities (GDP growth) contribute significantly to higher temperature levels. Moreover, higher precipitation levels (defined as deviation from historical norms) could contribute to higher growth rates in MENA countries, while higher growth rates may lead to lower precipitation levels.

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