ERF Working Papers Series

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ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

Working Paper No. 1520
December 2021

# DANCES WITH WOLVES: WEATHER AND HEALTH DISASTERS AND FISCAL SUSTAINABILITY IN MENA[1]

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We would like to thank Dr. Nada Eissa from Georgetown University for the time she put into reviewing our paper. Her constructive comments provided valuable insights to refine the paper's contents and analysis.

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[1] This work was sponsored by the Economic Research Forum (ERF) and benefited from both financial and intellectual support from the ERF. The contents and recommendations do not necessarily reflect ERF's views.
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First published in 2021 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

## Abstract

Fiscal sustainability is a major source of concern in light of successive weather and health disasters. We estimate the contemporaneous and long-run effects of weather vis-à-vis health disasters on the fiscal sustainability of 21 Middle East and North Africa (MENA) economies during 1990-2020 using two-way fixed-effects and two-step system generalized method of moments strategies. We also examine if domestic resource mobilization and external financing act as fiscal stabilizers that mitigate disaster effects. We find that weather disasters reduce the budget and overall fiscal balances by 2.1 percent and 2.2 percent instantaneously and by 5.4 percent and 6.2 percent after one year, respectively. Health disasters reduce the budget and overall fiscal balances respectively by 0.4 percent and 0.3 percent instantaneously, with no long-run effects observed. Our estimates indicate that government debt can help mitigate all types of disasters. Domestic resources from sovereign wealth funds and business taxation are more effective in mitigating the effects of weather disasters compared to external sources of finance. Countries with higher foreign reserves and net savings are better able to fiscally endure health disasters. This study emphasizes the significance of domestic resource mobilization vis-à-vis external sources of finance in times of disasters.



**Keywords:** Fiscal sustainability, budget balance, domestic resource mobilization, debt, weather disasters, health disasters, MENA.
**JEL Classifications:** Q54; Q58; F59; H87.



## ملخص

تعد الاستدامة المالية مصدر قلق رئيسي في ضوء الكوارث المناخية والصحية المتتالية. تسعى هذه الدراسة إلى تقدير التأثيرات المعاصرة وطويلة المدى للطقس بالإضافة إلى الكوارث الصحية على الاستدامة المالية لواحد وعشرين اقتصادًا في الشرق الأوسط وشمال إفريقيا خلال الفترة 1990-2020 باستخدام إستراتيجيات أسلوب المعمم للحظات في نظام ثنائي الاتجاه ثابت التأثير من خطوتين. كما تستقصي الدراسة ما إذا كان حشد الموارد المحلية والتمويل الخارجي يمكن أن يعملا بمثابة عوامل استقرار مالية تخفف من آثار الكوارث. وقد وجدت الدراسة أن كوارث الطقس تخفض الموازنة وأرصدة المالية العامة الإجمالية بنسبة 2.1٪ و2.2٪ على الفور وبنسبة 5.4٪ و6.2٪ بعد عام واحد على التوالي. في حين تخفض الكوارث الصحية من الموازنة وأرصدة المالية العامة الإجمالية بنسبة 0.4٪ و0.3٪ على التوالي، مع عدم ملاحظة آثار طويلة المدى. وتشير تقديرات الدراسة إلى أن الدين الحكومي يمكن أن يساعد في التخفيف من آثار جميع أنواع الكوارث. وتعد الموارد المحلية من صناديق الثروة السيادية وضرائب الأعمال أكثر فعالية في التخفيف من آثار الكوارث المناخية مقارنة بمصادر التمويل الخارجية. وتكون الدول التي تتمتع باحتياطيات أجنبية عالية ومدخرات صافية أكثر قدرة على تحمل الكوارث الصحية من الناحية المالية. وتؤكد هذه الدراسة على أهمية حشد الموارد المحلية بالإضافة إلى مصادر التمويل الخارجية في أوقات الكوارث.

## 1. Introduction and background

Natural disasters have dominated the top five long-term global risks of the World Economic Forum 2020 for the first time (Eckstein et al., 2018). These include extreme weather, climate action failure, natural disasters, biodiversity loss, and human-made environmental disasters. Over the past decade, the number of people affected by natural disasters worldwide tripled to two billion (IRIN, 2005). Weather-related and health disasters (pandemics and epidemics) accounted for nearly 95 percent of all global natural disasters since 1900, according to the Centre for Research on the Epidemiology of Disasters (CRED). In addition, climate change, including global warming and disrupted wildlife habits, fuels weather-related disasters, increases the risk of disease outbreaks, and widely affects human health. The Coronavirus disease (COVID-19) pandemic is one recent example.

COVID-19 had a significant impact on the economies of the Middle East and North Africa (MENA) region. Disruption in the global value chains and capital flows weighed on domestic production and demand. Declines in oil production, tourism receipts, and remittances further challenged the region's economic resilience. As a result, the MENA region's GDP contracted by 3.4 percent in 2020. Some MENA economies shrank by as high as 25 percent (Regional Economic Outlook, 2021). Fiscal sustainability is a major source of concern for policymakers in the MENA region in the wake of the COVID-19 pandemic and the associated accumulation of sizeable public debts.

This study examines fiscal sustainability in MENA economies in the face of rising natural disasters. We first develop a model-based fiscal reaction function approach to estimate the impact of health vis-à-vis weather-related disasters, henceforth referred to as weather disasters. Specifically, we estimate the *contemporaneous* and *long-run* effects of weather as opposed to health disasters on the fiscal stance of 21 MENA economies during 1990-2020 by employing two-way fixed-effects and two-step system generalized method of moments (GMM) empirical strategies. Second, we assess if domestic resource mobilization (DRM) and external sources of finance mitigate the disaster-induced negative fiscal effects. The aim is to robustly identify the most effective macro-fiscal mitigation channels to preserve and restore fiscal sustainability in the aftermath of disasters.

Two strands of literature are relevant to our inquiry. The first is pertinent to natural disasters. Empirical research on natural disasters is in its infancy, with few but growing studies examining the multiple facets of disaster phenomena and their economic impacts. Most (if not all) studies provide evidence of a negative impact of natural disasters on economic growth, but they only focus on economic growth. A recent review of empirical work on the economic impact of natural disasters shows that natural disasters have *direct* significant negative economic effects, such as high property losses in developed countries and casualties in developing countries (Botzen et al., 2019). The review also shows *indirect* significant negative economic effects, especially in lower-income, smaller, and less-diversified economies. These indirect effects are less severe in large, developed economies that are better able to cope with negative production shocks. Early studies that estimate the effects of external shocks, including

natural disasters, on short-run growth dynamics in developing countries show that natural disasters have a negative short-run impact on growth dynamics (Felbermayr and Gröschl, 2014; Noy, 2009; Raddatz, 2007). The size of this impact is mitigated by a country's institutional and structural macroeconomic characteristics, such as literacy, institutional quality, per capita income, openness to trade…etc. (Noy, 2009). Extending earlier investigations to the short- and long-run impact of various types of natural disasters on countries in different income groups indicates that smaller and poorer countries are more vulnerable and that most of the growth cost occurs in the disaster year (Raddatz, 2007). These results suggest that there is an *indirect* fiscal effect caused by the drop in output growth. Studies, however, overlook this effect and focus on the negative impact on economic growth.

The second relevant strand of literature is pertinent to the determinants of fiscal deficits, for which theoretical and empirical evidence exists. Early theoretical work advocates the so-called 'equilibrium' approach to fiscal policy, also referred to as the 'tax-smoothing' hypothesis of government budgetary policy (e.g. Barro, 1979). According to this viewpoint, governments vary budget deficits to maintain the expected constancy in tax rates. In this sense, the budgetary authorities decide on the tax and public deficit policies that reduce the excess burden of taxation for a given path of government spending within an intertemporal optimization framework over a long time horizon. However, the size and persistence of budget deficits in many countries are not fully consistent with this equilibrium viewpoint. Later studies attempted to explain these patterns and stressed differences in political institutions as a key determinant of fiscal deficit. A formal analysis of the political and economic determinants of budget deficits in industrial economies partially supports the equilibrium viewpoint but, importantly, shows that multi-party coalition governments, especially those with a short expected tenure, are poor at reducing budget deficits (Roubini and Sachs, 1989). A recent survey of the literature on the determinants of fiscal deficits concludes that the main determinants of budget deficits are more diversified and include economic growth, debt, unemployment, trade openness, level of development, level of urbanization, extreme weather events, inflation, aid, military spending, political factors, and the quality of budgetary institutions (Mawejje and Odhiambo, 2020).

Reviewing the studies combining these two strands of literature, we only identified one study that empirically estimates the impact of large-scale extreme weather events on changes in public budgets in different country groupings, namely developing countries, Organisation for Economic Co-operation and Development (OECD) countries, and European Union (EU) countries (Lis and Nickel, 2010). Controlling for macroeconomic, budgetary, and political variables, empirical evidence suggests a variation in the response of fiscal deficits to weather disasters by country grouping, with developing countries facing a significantly larger effect than advanced economies. Evidence further suggests a significant positive effect of the lagged change in the debt ratio, real GDP growth, and inflation on budget balances. On the other hand, the lagged change in the nominal long-term interest rate and the election year dummy exhibit significant negative coefficients for OECD and EU countries. Descriptive analysis points in the same direction and shows that extreme weather events have a negative budgetary impact in the EU and the US, estimating the direct and indirect effects of extreme weather events on

public finances between 0.3 percent to 1.1 percent of GDP (Heipertz and Nickel, 2008). Although some work has evaluated the implications of natural disasters for fiscal policy and predicted their negative impact on budget balances (Benson and Clay, 2004; IMF, 2008; Wildasin, 2007), none have conducted an ex-post analysis.

There is a scarcity of studies combining weather and health disasters on the one hand and fiscal balances on the other hand, as well as the compounded effect of these disasters on the public finances of MENA economies. Our paper is the first to address this gap in the literature by comparatively estimating both the short- and long-run fiscal impacts of weather and health disasters in MENA. The value-added of our study is twofold. First, it is the first to empirically examine the determinants of weather and health disaster fiscal costs and, importantly, report on potential mitigation strategies. Second, our findings will quantify and compare the impact of weather and health disasters and thus enable governments to adjust their fiscal spaces efficiently and maintain fiscal and debt sustainability while smoothing out these disasters. Such an analysis is timely in light of the current successive waves of weather and health disasters.

## 2. Data and conceptualization

Recent work has focused on the adverse economic effects of health disasters, especially the ongoing COVID-19 pandemic. While we hypothesize that health disasters have significant negative effects on the fiscal sustainability of MENA economies, we argue that weather disasters are no less relevant. Hence, we compare the fiscal impacts of weather and health disasters in magnitude and persistence. Validating this hypothesis blows a whistle, giving an early warning to avert possible risks associated with future weather and health disasters. We also hypothesize that fiscal stabilizers can be used to mitigate the magnitude of effects that follow disasters.

Specifically, we seek to answer five research questions. (1) What is the estimated *instantaneous* and *long-term* impact of weather and health disasters on the fiscal sustainability of MENA countries? (2) How do the *magnitude* and *persistence* of the impacts of health disasters compare to weather-induced shocks? (3) Are MENA economies ready to shoulder the fiscal costs of weather and health disasters by depending on domestic resources or is external finance also needed? (4) Can MENA countries commit to supporting the maintenance of debt sustainability during a weather or health disaster? (5) Can MENA countries use their sovereign wealth funds (SWFs) as a mitigation measure in the face of weather and health disasters?

To answer these research questions and capture the endogenous response of fiscal policy to the macroeconomic environment, fiscal shocks, and weather and health disasters, we construct an unbalanced panel dataset. The dataset merges budget and overall fiscal balances (outcomes of interest) with the incidence and estimated damage of weather and health disasters and determinants of budget and overall fiscal balances. The data, described below, covers 21

MENA countries[3] over the period 1990-2020. We provide the summary statistics of the data used in the Appendix (Table A.1).

### 2.1. Budget balance

The choice of fiscal stance measures for the dependent variable is widely discussed in the fiscal reaction functions literature. We empirically assess fiscal sustainability and evaluate how weather and health disasters affect the fiscal stance of a country. The main outcome is the primary budget balance as a share of GDP (Lis and Nickel, 2010; Maltritz and Wüste, 2015; Roubini and Sachs, 1989). It is calculated as the sum of net revenues of non-interest expenditures (total net expenditures of interest payments). Several reasons justify the choice of primary balance as it better reflects the government fiscal stance and helps evaluate the impact of both the automatic fiscal stabilizers and the discretionary policy measures.

As a robustness check, in addition to the primary balance, we use the overall fiscal balance as a share of GDP (Berger et al., 2007; Lewis, 2012). The latter is a commonly used indicator that assesses the stance of fiscal policy, measuring the difference between revenues and grants, and expenditure and net lending.

The outcome data are from the International Monetary Fund (IMF), the International Financial Statistics dataset (IFS), and the IMF's World Economic Outlook (WEO).

### 2.2. Weather and health disasters

Our primary measures for natural disasters are (1) the incidence of weather and health disasters; (2) the economic damages[4] (in US dollars) of weather disasters; and (3) the estimated number of people affected by health disasters. Information on weather and health disasters and their human and physical impacts comes from the Emergency Events Database (EM-DAT), which is a service of the Centre for Research on the Epidemiology of Disasters (CRED).[5] The EM-DAT reports the number of people killed, injured, or rendered homeless as well as the estimated monetary damage. A disaster is defined as an incident meeting any of the following criteria: (1) ten or more people reported killed; (2) 100 people reported affected; (3) declaration of a state of emergency; or (4) call for international assistance.

The EM-DAT divides natural disasters into six subgroups: biological (epidemic, pandemic, insect infection, and animal accident); geophysical (earthquake, volcanic activity, and mass movement); climatological (drought, glacial lake outburst, and wildfire); hydrological (flood, landslide, and wave action), meteorological (storm, extreme temperature, and fog); and extra-terrestrial disasters (impact and space weather). Weather disasters include the following three

[3] Algeria, Bahrain, Egypt, Djibouti, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.

[4] The economic damages include the breakdown figures by sectors: social, infrastructure, production, environment, and other.

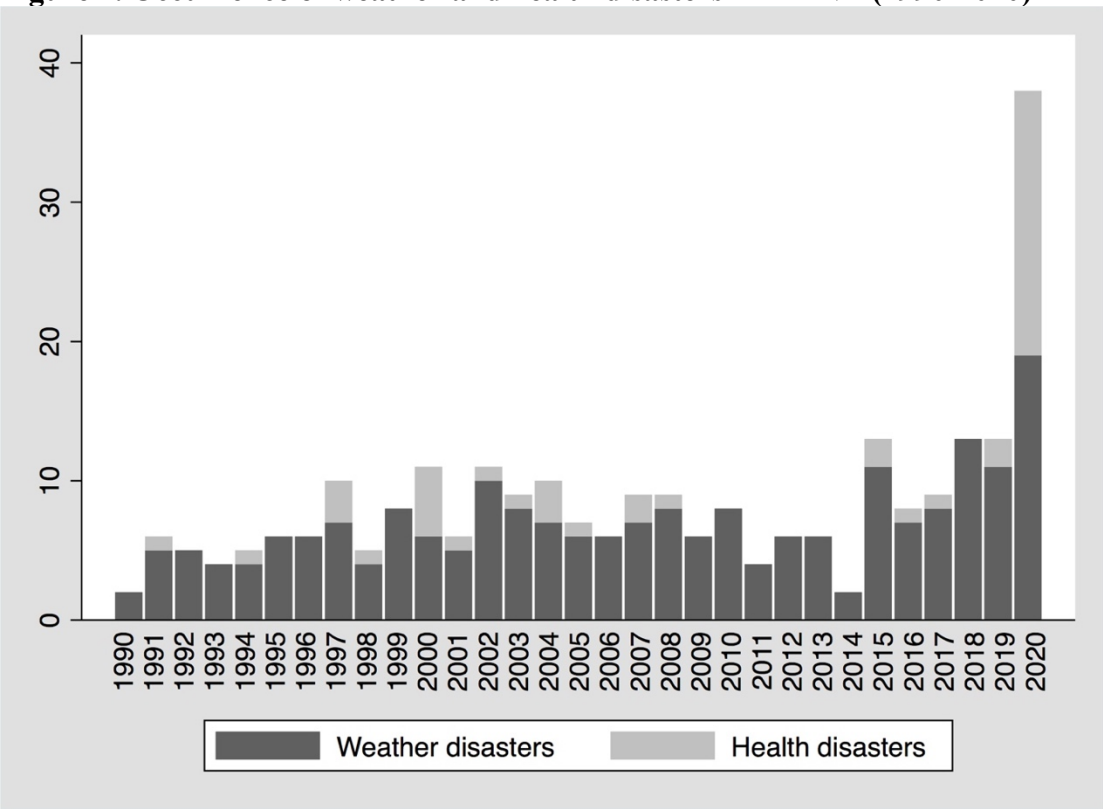
[5] Established in 1973 as a non-profit institution, CRED is based at the Catholic University of Louvain in Belgium (see www.cred.be).

subgroups: hydrological; meteorological; and/or climatological. The EM-DAT categorizes health disasters, including pandemics and epidemics, under the biological subgroup of natural disasters.

As we presume that the impact of weather and health disasters on fiscal balance depends on the magnitude of disasters, we standardize our disaster measures of (2) the weather disasters damage in US dollars and (3) the estimated number of people affected by epidemics and pandemics. Since the current year's population and GDP have been affected by the disaster itself, we divide the measures for the number of people affected by the population size in the year *prior* to the disaster and divide the direct damage measure of the disaster by the *previous* year's GDP (Cavallo et al., 2013; Hallegatte and Przylnski, 2010; Noy, 2009; Raddatz, 2007). To verify that the way we construct the disaster measure using the two standardized variables does not cause any endogeneity in our model, we re-estimate our model specifications using the disaster measure (1) as a binary dummy indicator of disaster occurrence.

Figure 1 illustrates how weather and health disasters evolved over time in MENA, denoting an upward trend since 2016. In 2020 alone, the number of weather and health disasters combined amounted to 38 incidents, with weather and health contributing equally. In terms of the total affected prior to the COVID-19 pandemic, the deaths due to weather disasters were six times the deaths due to health disasters during 1990-2019. This proportion will change significantly after accounting for the total affected by COVID-19 in the EM-DAT.

**Figure 1. Occurrence of weather and health disasters in MENA (1990-2020)**




Source: Authors' calculations based on EM-DAT data.

### 2.3. Determinants of budget balance

The selection of the other determinants of budget balance is based on robust evidence from the literature on fiscal reaction functions in the spirit of the Roubini and Sachs (1989) framework for analyzing the determinants of budget deficit. We include a set of variables to reflect four categories of budget balance determinants.

The first set is *budgetary* and is captured by two variables: the lagged change in the gross debt (as a share of GDP) and total reserves (in months of imports). The lagged change in the gross debt is a measure of debt stabilization and sustainability of fiscal policy motives of governments. On the one hand, a higher debt ratio puts pressure on the government to improve budget balances in order to achieve long-term sustainability of the fiscal position. On the other hand, a higher debt ratio implies higher interest payments and as a result worsens the budgetary balance. Diverting from Roubini and Sachs (1989), we use gross debt figures because data on net government debt is not available for many countries in our sample. Moreover, gross debt data is more reliable and comparable than that of net debt (de Haan and Sturm, 1997). In addition, sustaining the stability of the budget balance requires adequate reserves to meet the external liabilities and imbalances of the exchange rate (El Mahmah and Kandil, 2019). We use total reserves coverage in months of imports comprising holdings of monetary gold, special drawing rights, reserves of IMF members held by the IMF, and holdings of foreign exchange under the control of monetary authorities.

The second pertains to *economic status* (Roubini and Sachs, 1989), and is captured by three variables: real GDP growth, a measure of output and the transitory impact of the state of the economy on fiscal performance; the lagged change in the deposit interest rate; and the inflation rate. Inflation can affect the budget balance through various channels. On the one hand, inflation can reduce real tax revenues, resulting in higher budget deficits. Moreover, inflation leads to higher long-term interest rates, implying higher debt service costs and, consequently, a worse fiscal balance. On the other hand, inflation can positively affect the fiscal balance through the bracket creep on income tax revenue and by eroding the value of nominal government debt.

The third is *political* and captured by two variables; the first of which is the legislative election, a measure of political business cycles. During election years, politicians tend to be more willing to increase spending and reduce taxes (Hallerberg et al., 2007). We include a dummy variable taking the value of one in a given year when a new legislative election took place. The second variable is military spending as a share of GDP, which is a measure of the effect of political instability and the military's involvement in the government on budget deficit volatility (Roubini and Sachs, 1989).

Other variables in the fourth category include oil prices as well as population growth, which is a demographic variable to control for the country-size effect (El Mahmah and Kandil, 2019). One of the key determinants of fiscal sustainability of MENA economies is oil prices, given its

influence on the fiscal policy and economic growth of the oil-exporting MENA countries. Annual oil prices are used to reflect the changes in oil prices, which capture the oil price shocks.

We obtain the determinant variables from the World Bank's World Development Indicators (WDI), the IMF's IFS, and the IMF's WEO.

### 2.4. Disaster mitigating factors

We explore a list of variables that reflect how a country's economic and financial conditions can act as fiscal stabilizers that insulate the economy from the fiscal impact of weather and health disasters. We group the variables into two main categories to examine if it is feasible for MENA economies to shoulder the fiscal costs of disasters only by mobilizing domestic resources or if external finance is needed as well.

The first group of variables captures *domestic resources* and consists of six main variables: (1) profit tax (percentage of commercial profits), which governments can mobilize and leverage during disasters; (2) total government debt (percentage of GDP), which is a proxy for the sustainability of government finance as governments can draw from or accumulate debt to accelerate disaster relief efforts and offset the decline in fiscal revenues during disasters; (3) natural resource rents, including oil rents (percentage of GDP), which can reinforce fiscal space during disasters; (4) total reserves in months of imports, a measure of the amount of hard-currency reserves held by central banks, which can act as a buffer stock against capital outflows during disasters; (5) adjusted net savings (percentage of GNI), which is an indicator of economic sustainability that mirrors the change in the comprehensive wealth of a country as governments can withdraw from national savings to compensate for the consumption of natural resources during disasters; and (6) SWFs, especially stabilization ones, which we anticipate will play a robust stabilizing role against fiscal stress during disasters.

The second group of variables we include reflects *external financing* and consists of four main variables: (1) total external debt (percentage of GDP), which is a measure of an economy's outstanding actual liabilities vis-à-vis non-residents as governments can exploit and/or pile up foreign debt to support disaster relief and counterbalance the fiscal revenue decay during disasters; (2) grants and other revenue (percentage of revenue), a measure of the amount of grants received from other foreign governments, international organizations, and other government units, among others, which governments can unconditionally benefit from during disasters; (3) personal remittances received (percentage of GDP), which can grant governments additional fiscal space during disasters; and (4) the net barter terms of trade index, which is the percentage ratio of the export unit value indexes to the import unit value indexes (measured relative to the base year 2000) and therefore indicates the change in the value of a country's export basket expressed in units of import baskets, as financial gains attained by an economy from its exports becoming more expensive and/or its imports becoming cheaper can smooth the fiscal stress brought on by disasters.

We obtain this list of variables from the WDI database and the IMF's IFS datasets. We construct the two dummy variables for SWFs in general and stabilization funds in particular based on information from the Sovereign Wealth Fund Institute (SWFI) and the International Forum of Sovereign Wealth Funds (IFSWFs).

## 3. Methodology

### 3.1 Estimating weather and health disaster impacts

#### 3.1.1. Static longitudinal specification

Building on the literature spanning fiscal reaction functions (Roubini and Sachs, 1989) and natural disasters (Noy, 2009), we propose a two-way fixed-effects model to estimate the causal impact of weather and health disasters on budget and overall fiscal balances, reflecting fiscal sustainability. For each country $i$ at year $t$, the following *parsimonious* specification is estimated four times, once for each of our weather and health impact indicators of interest:

$$\Delta b_{i,t} = \gamma_{0i} + \gamma_1 X'_{i,t} + \gamma_2 D_{i,t} + \eta_i + \tau_t + \epsilon_{it} \quad (1)$$

The dependent variable, $\Delta b_{i,t}$, is either the change in the net primary balance or in the overall fiscal balance for country $i$ at year $t$. $X'_{i,t}$ denotes the four vectors of determinants pertinent to budgetary, economic, political, and demographic and other factors. $D_{i,t}$ is the disaster variable. To investigate whether the construction of the damage variable ($D_{i,t}$) could have created an endogeneity problem, we convert the *continuous* disaster measure of the weather disasters damage in US dollars and the estimated number of people affected by epidemics and pandemics into a *binary* indicator for the occurrence of a disaster (1 = disaster, 0 = no disaster) and examine whether this alters our results.[6] $\eta_i$ and $\tau_t$ are sets of country- and year-fixed effects, respectively. $\gamma_{0i}$ is a country-specific intercept and $\epsilon_{it}$ is a random and normally distributed disturbance term.

By including country-fixed effects, we eliminate any confounding from unobserved country characteristics that are constant over time within each country. The year fixed effects allow us to define the counterfactual of an affected country as the same country without the disaster effect. If disasters increase fiscal deficit, we should observe an increase relative to the country's average levels in the indicator during the disaster or in the period following it.

We are also confident that our fixed-effects model additionally overprotects against omitted-variable bias. In particular, the effect of disasters on the countries that have consistently experienced weather and/or health shocks over our estimated time period is under-estimated, as weather and/or health shocks are largely part of the "fixed effect" of these countries. Since these countries are also likely to be the most severely affected, the fixed-effects model may

[6] Because the binary approach masks the distinctions between the magnitudes of different disasters, we only record (binary variable=1) those disasters whose magnitude is bigger than the mean for that type of disaster data.

yield estimates that are too conservative. This is accentuated by our use of a relatively short period framework. Moreover, some countries may be poor at the start of our data series because of the disasters they have experienced up to that point. Ignoring this effect implies that our conservative estimates are more likely *not* to detect an effect of disasters. However, our model indeed produces a substantial detrimental effect of disasters, especially as our time series is extended.

### 3.1.2. Long-term dynamic specification

The model specification represented by equation (1) assumes that the impact of weather and health disasters on budget balances is immediate. Most of the empirical research makes this assumption about the impact of natural disasters in general (Botzen et al., 2019). However, in this study, we hypothesize that the long-run effects of disasters on the fiscal sustainability of MENA economies are not to be underestimated. We propose a *parsimonious* long-term dynamic specification to allow for the possibility of the disaster's long-run effects. As per this specification, the *lagged* disasters ($D_{i,t-1}$) and the *lagged* determinants ($X'_{i,t-1}$), together with current disasters ($D_{i,t}$) and other determinants ($X'_{i,t}$), affect fiscal sustainability, be it measured by net lending/ borrowing or overall fiscal balance. We include the lags of the budget balances ($\Delta b_{i,t-1}$) as explanatory variables on the right-hand side of the specification to capture the persistence in fiscal (un)sustainability. The long-term dynamic specification is as follows.

$$\Delta b_{i,t} = \gamma_{0i} + \alpha \Delta b_{i,t-1} + \gamma_1 X'_{i,t} + \beta_1 X'_{i,t-1} + \gamma_2 D_{i,t} + \beta_2 D_{i,t-1} + \epsilon_{it} \quad (2)$$

According to this specification, $\gamma_2$ estimates the immediate short-run impact of a weather or health disaster on budget balances. The long-run impact begins after a one-year lag and is given by

$$\frac{\gamma_2 + \beta_2}{1 - \alpha},$$

where $\alpha$ captures the persistence of the adjustment process, specifically the total adjustment of the budget balance following a weather or health disaster.

In equation (2), the lagged dependent variable is endogenous and typically correlates with the lagged error term. Requiring the residuals to sum to zero within countries implies that the errors are correlated. Hence, the estimation of equation (2) by fixed effects models will yield biased and inconsistent estimates, especially with relatively limited time periods (Blundell et al., 2000; Cameron and Trivedi, 2005; Wooldridge, 2002). To address these concerns, we use the two-step Arellano-Bond GMM estimator to estimate equation (2). This estimator was first posited by Arellano and Bover (1995) and then developed by Blundell and Bond (1998). Our proposed two-step "system" GMM estimator has superior finite sample properties to handle the issues of endogeneity of contemporaneous changes in the independent variables and the endogeneity

of the lagged level of budget balances in the dynamic specification. The two-step estimator combines the regression equation in differences and the regression equation in levels into one system, within which the lagged values of the explanatory variables are used as instruments. It is properly designed for dynamic panels that may contain fixed effects in addition to idiosyncratic errors that are possibly heteroskedastic and correlated within but not across countries. This property, among others of the "system" GMM dynamic panel estimator, is thoroughly discussed by Roodman (2009).

Using the residuals from equation (2), we have the following moment conditions:

$$E[(\epsilon_{i,t} - \epsilon_{i,t-1})X_{i,t-k}] = 0, \;\; E[\epsilon_{i,t}(X_{i,t-k} - X_{i,t-k-1})] = 0 \qquad (3)$$

To establish our moment conditions, we assume that the disaster dummy is strictly exogenous and therefore serves as a standard instrumental variable (IV). Using this IV helps minimize the incidence of bias due to potential mismeasurement in the exogenous disaster variables. We assume that the remainder of the current and lagged explanatory variables in equation (2) are potentially endogenous. We construct the moment conditions for each of these variables for each lag length from two and higher.

Although the standard covariance matrix is already robust in theory in two-step estimation, being asymptotically efficient, it typically yields standard errors that may be downward biased (Arellano and Bond, 1991; Blundell and Bond, 1998). To account for this, we benefit from the finite-sample correction to the two-step covariance matrix derived by Windmeijer (2005) and made available by Roodman (2009). This correction makes two-step robust estimations more efficient, especially for the system GMM.

We consider the Arellano-Bond autoregressive (AR) test for autocorrelation of the residuals to verify that the differenced residuals do not exhibit significant AR(2) behavior. The former test has low power if the number of moment conditions is large. To ensure that the number of instruments is appropriate relative to the number of observations, we reduce the instrument count by creating one instrument for each variable and lag distance rather than one for each time period, variable, and lag distance, following Roodman (2009). In relatively small samples, as it is the case in this study, collapsing instruments can avoid the bias that arises as the number of instruments climbs toward the number of observations.

### 3.2 Estimating disaster mitigation effects

We extend the model specification in equation (1) to estimate if the domestic resources and external sources of finance of MENA countries, struck by weather and health disasters, mitigate disaster-induced changes in budget balances. We explore the effectiveness of a battery of fiscal stabilizers in determining countries' ability to mitigate disaster impacts on fiscal sustainability. We additionally include an explanatory variable, $Z_{i,t}$, denoting various fiscal

stabilizers, as explanatory variables in equation (1). $Z_{i,t}$ is also interacted with the disaster dummy, $D_{i,t}$, because we hypothesize that the effect of disaster on budget balances depends on the fiscal stabilizers in place. The significance of the coefficient on the interaction term of the countries hit by disasters is our concern. We estimate the following specification:

$$\Delta b_{i,t} = \gamma_{0i} + \gamma_1 X'_{i,t} + \gamma_2 D_{i,t} + \gamma_3 (D_{i,t} . Z_{i,t}) + \gamma_4 Z_{i,t} + \eta_i + \tau_t + \epsilon_{it} \quad (4)$$

The coefficient of interest ($\gamma_3$) measures the marginal effect of each fiscal stabilizer on the disaster-induced change in budget balances.

We also account for the direct effect of the mitigating factors, which allows us to validate that the significance of the interaction coefficient is not driven by a correlation between fiscal stabilizers and budget balances. $\gamma_4$ measures the effect of a fiscal stabilizer on fiscal sustainability in the case of no disaster occurrence.

## 4. Results and discussion

### 4.1 Estimated short-run impact of weather and health disasters

We first investigate the impacts of weather and health disasters on budget and fiscal balance indicators using our static model specification. Tables 1 and 2 report the results from the fixed-effects model estimation of equation (1) for the three reported measures of weather and health disasters: (1) occurrence of weather and health disasters; (2) weather disasters damage in US dollars; and (3) estimated people affected by health disasters. The impacts of weather and health disasters are estimated on the change in the net primary balance and in the overall fiscal balance.

Our estimates indicate a stronger detrimental effect of weather disasters compared to health disasters. Columns 1 and 2 of Table 1 indicate a significant negative impact of weather disasters occurrence on the budget and overall fiscal balances of MENA economies by ~2.1 percent and ~2.2 percent, respectively. Using the number of people affected measure of health disasters, columns 3 and 4 of Table 2 confirm the significant negative impact of health disasters on the budget and fiscal balances of MENA economies by ~0.4 percent and ~0.3 percent, respectively.

Compared to the coefficients of the other economic, budgetary, political, and other determinants in Tables 1 and 2, the negative impact of weather and health disasters on budget balances is the highest and most significant (except for military spending). Political instability and military involvement in governance can constrain economic activity and widen budget deficits in MENA countries. Columns 1 and 2 of Table 1 and columns 1, 2, 3, and 4 of Table 2 confirm a significant negative impact of military spending on widening fiscal deficit in MENA countries by around three percent.

**Table 1. Estimated *short-run* impact of *weather* disasters on budget balances (1990-2020)**

| | $D_{it}$= Disaster dummy | | $D_{it}$= Damage (US$) | |
|---|---|---|---|---|
| | Net lending/ borrowing | Overall fiscal balance | Net lending/ borrowing | Overall fiscal balance |
| | (1) | (2) | (3) | (4) |
| **Weather disasters** | | | | |
| Disaster dummy | -2.053* | -2.247* | | |
| | (1.198) | (1.261) | | |
| Damage (US$) | | | 0.128 | 0.255 |
| | | | (0.267) | (0.330) |
| **Other determinants** | | | | |
| Economic | | | | |
| GDP growth | 0.378*** | 0.351** | 0.346 | 0.280 |
| | (0.137) | (0.141) | (0.361) | (0.329) |
| Deposit interest rate | 0.816** | 0.605* | 0.925 | 0.598 |
| | (0.332) | (0.356) | (0.521) | (0.607) |
| Inflation | 0.009 | 0.055 | -0.191 | -0.132 |
| | (0.126) | (0.130) | (0.206) | (0.203) |
| Budgetary | | | | |
| Debt ratio | 0.063 | 0.050 | 0.156* | 0.148* |
| | (0.040) | (0.041) | (0.070) | (0.069) |
| Reserves (import cover) | 0.150 | 0.234 | 0.475*** | 0.520*** |
| | (0.172) | (0.182) | (0.131) | (0.146) |
| Political | | | | |
| Legislative election | -0.052 | -0.305 | -0.739 | -0.897 |
| | (1.196) | (1.235) | (0.851) | (1.204) |
| Military spending | -3.538*** | -3.307*** | -3.098** | -2.749** |
| | (0.532) | (0.551) | (0.941) | (0.909) |
| Others | | | | |
| Oil prices | -0.022 | -0.030 | 0.015 | 0.007 |
| | (0.024) | (0.026) | (0.027) | (0.033) |
| Population growth | 0.515 | 0.575 | 0.679 | 0.663 |
| | (0.455) | (0.507) | (1.240) | (1.474) |
| Constant | 6.825 | 6.061 | -5.313 | -5.156 |
| | (5.509) | (5.648) | (7.381) | (5.636) |
| $R^2$ | 0.401 | 0.356 | 0.390 | 0.325 |
| Number of countries | 9 | 9 | 9 | 9 |
| Number of observations | 150 | 147 | 103 | 102 |

Each column represents a separate regression. Standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively.

**Table 2. Estimated *short-run* impact of *health* disasters on budget balances (1990-2020)**

| | $D_{it}$= Disaster dummy | | $D_{it}$= Affected people | |
|---|---|---|---|---|
| | Net lending/ borrowing (1) | Overall fiscal balance (2) | Net lending/ borrowing (3) | Overall fiscal balance (4) |
| Health disasters | | | | |
| Disaster dummy | 2.117 | 1.743 | | |
| | (2.567) | (2.654) | | |
| Affected people | | | -0.379* | -0.301** |
| | | | (0.202) | (0.126) |
| Other determinants | | | | |
| Economic | | | | |
| GDP growth | 0.400*** | 0.374*** | 0.399 | 0.373 |
| | (0.137) | (0.143) | (0.242) | (0.224) |
| Deposit interest rate | 0.875*** | 0.696* | 0.869 | 0.691 |
| | (0.333) | (0.356) | (0.507) | (0.622) |
| Inflation | 0.033 | 0.083 | 0.037 | 0.087 |
| | (0.126) | (0.131) | (0.188) | (0.190) |
| Budgetary | | | | |
| Debt ratio | 0.049 | 0.036 | 0.048 | 0.035 |
| | (0.040) | (0.042) | (0.063) | (0.067) |
| Reserves (import cover) | 0.127 | 0.212 | 0.129 | 0.216 |
| | (0.177) | (0.187) | (0.189) | (0.168) |
| Political | | | | |
| Legislative election | -0.009 | -0.287 | -0.010 | -0.297 |
| | (1.210) | (1.252) | (0.406) | (0.612) |
| Military spending | -3.515*** | -3.271*** | -3.547*** | -3.297*** |
| | (0.539) | (0.560) | (0.622) | (0.595) |
| Others | | | | |
| Oil prices | -0.014 | -0.024 | -0.015 | -0.025 |
| | (0.024) | (0.027) | (0.017) | (0.025) |
| Population growth | 0.473 | 0.567 | 0.485 | 0.579 |
| | (0.458) | (0.512) | (0.965) | (1.135) |
| Constant | 5.862 | 4.814 | 6.127 | 5.038 |
| | (5.523) | (5.666) | (8.022) | (7.638) |
| $R^2$ | 0.391 | 0.343 | 0.392 | 0.344 |
| Number of countries | 9 | 9 | 9 | 9 |
| Number of observations | 150 | 147 | 149 | 146 |

Each column represents a separate regression. Standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively.

The results in Tables 1 and 2 also show that real GDP growth and deposit interest rates have a positive and significant effect on budget and fiscal balance volatility in MENA countries. The real GDP growth captures the degree of economic development during the period of study. The positive relationship of income with the budget and fiscal balance volatility suggests that countries with higher economic growth have more stable budget balances and more room to correct fiscal deficits. Although the reported income elasticities (~0.4) are rather low compared to those for developed countries (0.5) (van den Noord, 2000; Viren, 2000), they are arguably lower in developing countries (Tujula and Wolswijk, 2007). The findings also show a statistically significant impact of the lagged change in the deposit interest rate on budget balances. A one percent point increase in the deposit interest rate leads to an improvement in the budget balance of around 0.8 percent. Higher deposit interest rates typically lead to higher saving rates and larger balances.

The lagged change in the debt ratio results in a correction to the budget balance ratio (column 4 of Table 1), consistent with Tujula and Wolswijk (2007) and Afonso (2008). The statistically significant but small positive coefficient (~0.2) indicates that MENA countries with growing debt ratios commence fiscal consolidation efforts to improve their budget balances in the short run. The results also show that total reserves (in months of imports) and oil prices give rise to a correction in the budget balance ratio (columns 3 and 4).

### 4.2 Estimated long-run impact of weather and health disasters

Table 3 lists the results of estimating the long-run dynamic specification of equation (2) for MENA countries; these are the two-step system GMM estimates. We include lags of both dependent and independent variables, specifically: budget balance, overall fiscal balance, disaster dummy, GDP per capita growth, and debt ratio. Year dummies are included (but not reported) in all specifications to control for year fixed effects. In Table 4, we report the estimated long-run effects of changes in the explanatory variables of interest on both budget and overall fiscal balances, indicating how each parameter is calculated.

We find a significant effect of lagged budget and overall fiscal balances on each current respective balance, indicating that budget deficit volatility persistence is highly significant. This suggests that the fiscal performance in the previous year determines current year performance, and that in the absence of automatic stabilizers, the primary balance is likely to be pro-cyclical. This is not a surprising result: inertia in the budgetary process and fiscal policy is well documented (Javid et al., 2011).

**Table 3. Estimated *dynamic* impact of weather and health disasters on budget balances (1990-2020)**

| | Parameter | GMM estimate | | | |
|---|---|---|---|---|---|
| | | Weather disasters | | Health disasters | |
| | | $y_{it}$= Net lending/ borrowing | $y_{it}$= Overall fiscal balance | $y_{it}$= Net lending/ borrowing | $y_{it}$= Overall fiscal balance |
| | | (1) | (2) | (3) | (4) |
| **Lag net lending/ borrowing** | $\alpha$ | 0.438** | | 0.365 | |
| | | (0.202) | | (0.314) | |
| **Lag overall fiscal balance** | | | 0.457*** | | 0.624*** |
| | | | (0.156) | | (0.144) |
| **Disasters** | | | | | |
| Disaster dummy | $\gamma_2$ | -0.364 | -2.316 | -0.376 | -1.943 |
| | | (1.754) | (1.715) | (4.158) | (3.891) |
| Lag disaster dummy | $\beta_2$ | -2.696* | -1.026 | -1.749 | -8.019 |
| | | (1.549) | (1.906) | (5.981) | (5.666) |
| **Other determinants** | | | | | |
| Economic status | | | | | |
| GDP per capita growth | $\gamma_{11}$ | -0.030 | 0.210 | 0.101 | 0.274 |
| | | (0.246) | (0.290) | (0.309) | (0.245) |
| Lag GDP per capita growth | $\beta_{11}$ | -0.028 | -0.068 | 0.233 | -0.423 |
| | | (0.053) | (0.295) | (0.392) | (0.461) |
| Budgetary | | | | | |
| Debt ratio | $\gamma_{12}$ | -0.188** | -0.116 | -0.250** | -0.145 |
| | | (0.080) | (0.122) | (0.101) | (0.091) |
| Lag debt ratio | $\beta_{12}$ | 0.156*** | 0.095 | 0.234*** | 0.141 |
| | | (0.054) | (0.110) | (0.090) | (0.088) |
| Political | | | | | |
| Legislative election | $\gamma_{13}$ | 1.230 | 0.718 | 0.758 | -1.028 |
| | | (2.930) | (2.969) | (1.804) | (2.182) |
| Constant | $\gamma_{0i}$ | | | -0.355 | |
| | | | | (4.907) | |
| Arellano-Bond test for AR(1) in 1st differences | z-statistic | -2.08 | -2.09 | -1.58 | -2.39 |
| | Pr > z = | 0.038 | 0.036 | 0.115 | 0.017 |
| Arellano-Bond test for AR(2) in 1st differences | z-statistic | 1.23 | 1.03 | 0.91 | 1.39 |
| | Pr > z = | 0.219 | 0.302 | 0.363 | 0.163 |
| Number of countries | | 17 | 16 | 17 | 16 |
| Number of observations | | 351 | 267 | 351 | 267 |

Columns (1), (2), (3), and (4) represent separate estimations of equation (2). Estimates are two-step system GMM ones. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively.

**Table 4. Calculated *long-run* impact of weather and health disasters on budget balances from a dynamic model specification**

| Explanatory variable | Parameter calculation | Long-run effect estimate | | | |
|---|---|---|---|---|---|
| | | Weather disasters | | Health disasters | |
| | | $y_{it}$= Net lending/ borrowing | $y_{it}$= Overall fiscal balance | $y_{it}$= Net lending/ borrowing | $y_{it}$= Overall fiscal balance |
| | | (1) | (2) | (3) | (4) |
| Long-run disaster dummy | $(\gamma_2 + \beta_2)/(1-\alpha)$ | -5.439** | -6.155* | -3.350 | -26.478 |
| | | (2.582) | (3.570) | (13.958) | (23.707) |
| Long-run GDP per capita growth | $(\gamma_{11} + \beta_{11})/(1-\alpha)$ | -0.103 | 0.261 | 0.525 | -0.398 |
| | | (0.520) | (0.637) | (0.787) | (0.844) |
| Long-run debt ratio | $(\gamma_{12} + \beta_{12})/(1-\alpha)$ | -0.057** | -0.039 | -0.025 | -0.010 |
| | | (0.024) | (0.057) | (0.029) | (0.082) |

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively.

Significant long-run effects of weather disasters are observed for the two models in columns 1 and 2 of Table 4. While the incidence of weather disasters respectively decreases the budget balance and overall fiscal balance by ~2.1 percent and ~2.2 percent immediately (Table 1), the size of the long-run marginal effects is much larger, standing at ~5.4 percent, and ~6.2 percent, respectively, after one year (Table 4). On the contrary, no long-run effects are observed for health disasters despite their immediate significant average impact on budget and overall fiscal balances by 0.4 percent and 0.3 percent, respectively. The lagged value of the disaster dummy is significant for the budget balance (see column 1, Table 3), confirming an appropriate long-term dynamic specification (Table 4).

In contrast to Maltritz and Wüste (2015) and Tevdovski et al. (2021), column 1 of Table 4 shows that the coefficient on the lagged debt ratio turns out to be negative in the long run, indicating that higher debt is associated with lower budget balance and higher fiscal deficit. This result suggests that MENA countries do not commit to supporting the maintenance of debt sustainability during the time of a weather disaster and that higher debt ratios imply higher interest payments and, as a result, lead to a worsening budgetary balance. Hence, more fiscal efforts are needed to reinforce the primary balance and ensure debt sustainability in the region. The speed of convergence to the long-run steady state, given by $(1-\alpha)$, is ~56.2 percent and ~54.3 percent for the budget balance and overall fiscal balance, respectively, over a one-year period during the time of weather disasters. While in the time of health disasters, the speed of convergence to the long-run steady state is ~37.6 percent for the overall fiscal balance, over a one-year period. These speeds reflect how health disasters play a stronger role than weather disasters in hindering the efforts of MENA countries to meet adequate levels of fiscal deficit.

As the employed GMM method relies on IVs, we test the validity of the used instruments. We report the Arellano-Bond AR tests for autocorrelation of the residuals in Table 3. Failing to reject the null hypothesis suggests that the differenced residuals do not exhibit significant AR behavior.

### 4.3 Estimated effects of disaster mitigating factors

We explore all the disaster mitigating factors discussed in the data section. Only statistically significant ones are highlighted in this section.

The results presented in Tables 5 and 6 provide evidence on the factors that affect the size of the previously identified impact on the budget and fiscal balances of MENA economies. Specifically, we estimate equation (4) to test if business taxes, government debt, oil rents, reserves, net savings, SWFs, and stabilization funds (as domestic resources) and external debt, grants, remittances, and terms of trade (as external financing) in countries struck by weather and health disasters have any bearing on the magnitude of budget balance volatility and fiscal deficit surge. The reported coefficient on the interaction of the disaster measure and the mitigation variable in equation (4) defines the effect of a mitigating factor on the magnitude of the fiscal impact indicated in Tables 1 and 2.

Ordering the mitigating effects of weather disaster fiscal mitigators in Table 5 by effectiveness, SWFs come first as the main mitigator of weather disaster effects, surpassing all the other effective sources of domestic and external financing in MENA countries (business taxes, remittances, oil rents, and government debt). A one percent increase in SWFs' holdings can absorb the negative weather disaster effect on budget balance by almost one percent. Put simply, the budget balances of MENA countries are unitary elastic to SWFs' holdings in the time of a weather disaster. Countries with greater SWFs' holdings in the region can use it as a buffer stock against cash outflows during weather disasters. Business taxes come second in mitigating the effects of weather disasters on budget balances. Remittances, oil rents, and government debt are also significant mitigators. External debt and grants come as insignificant. Our findings confirm that DRM, rather than external financing, plays a pivotal role in mitigating the negative weather disaster effects on budget balances in MENA countries. In this case, we can argue that DRM is crucial not only to generate economic stability, growth, and redistribution, but also to strengthen the state-citizen relationship and make governments better able to manage disasters. It is a strong policy tool to create transformative eco-social and fiscal contracts.

In Table 6, total reserves in months of imports come first as the main mitigator of health disaster effects in the region, followed by net savings, grants, government debt, and terms of trade. In the time of health disasters, MENA governments can withdraw from their total reserves and national savings to compensate for the consumption of natural resources during disasters. Again, these findings confirm that DRM is the savior of MENA countries when hit by health disasters.

## 5. Conclusion

This study presents novel evidence on the short- and long-run impacts of weather and health disasters on budget and fiscal balances of 21 MENA countries over the period 1990-2020. The

aim is to guide future fiscal policy formulation and implementation, especially during natural disasters.

Our fixed-effects results show that weather and health disasters have a significant impact on the budget and overall fiscal balances of MENA economies. The GMM results show that the occurrence of weather disasters decreases budget and overall fiscal balances, respectively, by ~2.1 percent and ~2.2 percent instantaneously in MENA countries. The magnitude of the disaster's long-run effects is much larger, standing at ~5.4 percent and ~6.2 percent, respectively, after one year. Health disasters are only reducing budget and overall fiscal balances in the short run by ~0.4 percent and ~0.3 percent, respectively. We do not observe significant fiscal effects of health disasters in the long run.

Exploring various mitigating factors of disaster effects, our findings provide pertinent evidence on how MENA countries can strengthen their fiscal resilience to weather disasters by mobilizing domestic resources constituting the most effective disaster mitigation strategies. SWFs come first as the most effective mitigator of weather disaster effects, surpassing the effectiveness of the other significant sources of domestic and external finance in MENA countries (business taxes, remittances, oil rents, and government debt). With respect to health disasters, total reserves come first as the most effective mitigator, followed by net savings, grants, government debt, and terms of trade.

The results of this study confirm that DRM by MENA countries can play a critical role in mitigating the negative weather and health disaster effects on budget and fiscal balances, surpassing the role of external sources of finance. To conclude, DRM is the savior of MENA countries if hit by natural disasters.

**Table 5. Mitigating factors of *weather* disaster effects on fiscal sustainability (1990-2020)**

| | DRM | | | | | | | External financing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Business taxes | Government debt | Oil rents | Reserves | Net savings | SWFs | Stabilization SWFs | External debt | Grants | Remittances | Terms of trade |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| $D_{i,t}$ | -5.597** | -1.846* | 1.130 | 1.103 | -0.108 | -0.292 | 0.084 | -1.505 | -1.002 | -1.574 | 1.376 |
| | (1.979) | (1.034) | (0.780) | (1.325) | (1.281) | (0.177) | (0.183) | (1.086) | (1.481) | (1.058) | (2.106) |
| $D_{i,t} \cdot Z_{i,t}$ | 0.294** | 0.021* | -0.110** | -0.154 | -0.073 | 0.768*** | -0.199 | 0.007 | 0.049 | 0.180* | -0.018 |
| | (0.122) | (0.011) | (0.045) | (0.115) | (0.098) | (0.237) | (0.354) | (0.015) | (0.047) | (0.101) | (0.016) |
| $Z_{i,t}$ | -0.362* | 0.022 | 0.604*** | 0.224 | 0.329*** | 0.071 | 1.034 | -0.011 | 0.088 | -0.254 | 0.052*** |
| | (0.190) | (0.019) | (0.143) | (0.181) | (0.101) | (0.931) | (3.253) | (0.022) | (0.173) | (0.185) | (0.013) |
| GDP per capita growth | 0.076 | 0.110 | 0.044 | 0.073 | 0.064 | 0.045 | 0.037 | 0.106* | -0.118 | 0.056 | 0.092 |
| | (0.087) | (0.067) | (0.054) | (0.075) | (0.105) | (0.102) | (0.094) | (0.060) | (0.212) | (0.066) | (0.057) |
| Debt ratio | 0.018 | | 0.030 | 0.042 | 0.018 | 0.044 | 0.056* | | 0.082* | 0.040* | 0.033 |
| | (0.022) | | (0.026) | (0.029) | (0.018) | (0.030) | (0.030) | | (0.040) | (0.023) | (0.020) |
| Legislative election | 0.916 | 1.067*** | 0.843*** | 0.907** | 0.119 | -0.177 | -0.182 | 0.658 | 0.229 | 1.167*** | 0.903** |
| | (0.529) | (0.295) | (0.248) | (0.377) | (0.512) | (0.522) | (0.641) | (0.419) | (0.589) | (0.357) | (0.370) |
| Military spending | -4.204*** | -3.154*** | -2.684*** | -3.415*** | -2.782*** | | | -3.370*** | -2.938*** | -3.378*** | -3.103*** |
| | (0.913) | (0.296) | (0.292) | (0.358) | (0.341) | | | (0.459) | (0.716) | (0.630) | (0.377) |
| Constant | 28.156*** | 21.094*** | 7.294 | 20.848*** | 19.508*** | -2.734 | -4.193 | 25.147*** | 8.904* | 21.463*** | 16.462*** |
| | (3.809) | (2.917) | (5.058) | (4.782) | (4.406) | (4.689) | (4.048) | (3.184) | (4.691) | (4.887) | (4.357) |
| $R^2$ | 0.593 | 0.523 | 0.654 | 0.569 | 0.619 | 0.321 | 0.305 | 0.528 | 0.538 | 0.528 | 0.541 |
| Number of countries | 16 | 16 | 16 | 13 | 12 | 17 | 17 | 15 | 11 | 15 | 16 |
| Number of observations | 206 | 330 | 329 | 269 | 262 | 257 | 257 | 255 | 154 | 291 | 303 |

Each column represents a separate regression. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively. Year fixed effects are included in all estimations. Disaster damage rather than disaster dummy is used in the estimations of columns (6) and (7).

**Table 6. Mitigating factors of *health* disaster effects on fiscal sustainability (1990-2020)**

| | DRM | | | | | | | External financing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Business taxes | Government debt | Oil rents | Reserves | Net savings | SWFs | Stabilization SWFs | External debt | Grants | Remittances | Terms of trade |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| $D_{i,t}$ | 0.495 | -0.826* | -0.525 | -0.892* | -1.250** | -0.036 | 0.135 | -0.040 | -0.767* | 0.415 | -1.207*** |
| | (0.573) | (0.458) | (0.475) | (0.464) | (0.502) | (0.324) | (0.267) | (0.292) | (0.390) | (0.249) | (0.368) |
| $D_{i,t} \cdot Z_{i,t}$ | -0.016 | 0.011* | 0.018 | 0.101* | 0.087*** | 0.293 | -0.287 | -0.002 | 0.015** | -0.048 | 0.011*** |
| | (0.020) | (0.005) | (0.016) | (0.055) | (0.025) | (0.442) | (0.313) | (0.005) | (0.006) | (0.054) | (0.002) |
| $Z_{i,t}$ | -0.178 | 0.039** | 0.556*** | 0.152 | 0.314*** | 0.813 | -0.087 | -0.010 | 0.149 | -0.198 | 0.047*** |
| | (0.152) | (0.039) | (0.155) | (0.120) | (0.088) | (0.796) | (2.711) | (0.023) | (0.151) | (0.187) | (0.010) |
| GDP per capita growth | 0.073 | 0.093 | 0.041 | 0.069 | 0.036 | 0.023 | 0.014 | 0.099 | -0.105 | 0.050 | 0.080 |
| | (0.087) | (0.065) | (0.056) | (0.080) | (0.094) | (0.096) | (0.089) | (0.062) | (0.193) | (0.073) | (0.061) |
| Debt ratio | 0.013 | | 0.030 | 0.046 | 0.022 | 0.036* | 0.037* | | 0.074* | 0.042* | 0.037* |
| | (0.021) | | (0.025) | (0.028) | (0.016) | (0.019) | (0.019) | | (0.036) | (0.022) | (0.019) |
| Legislative election | 0.526 | 0.956** | 0.712** | 0.812** | 0.263 | 0.781** | 0.792** | 0.614 | 0.136 | 1.033*** | 0.727* |
| | (0.519) | (0.335) | (0.315) | (0.304) | (0.433) | (0.329) | (0.307) | (0.438) | (0.530) | (0.336) | (0.361) |
| Military spending | -4.214*** | -3.218*** | -2.614*** | -3.418*** | -2.818*** | | | -3.341*** | -2.929*** | -3.278*** | -3.124*** |
| | (0.956) | (0.357) | (0.330) | (0.387) | (0.378) | | | (0.465) | (0.800) | (0.628) | (0.371) |
| Constant | 25.729*** | 20.442*** | 7.626 | 20.802*** | 19.156*** | -2.188 | -1.853 | 24.507*** | 8.670 | 20.591*** | 16.297*** |
| | (3.607) | (3.147) | (5.171) | (4.546) | (4.494) | (3.133) | (2.549) | (2.939) | (4.948) | (4.875) | (3.760) |
| $R^2$ | 0.574 | 0.523 | 0.640 | 0.566 | 0.624 | 0.304 | 0.303 | 0.525 | 0.526 | 0.522 | 0.542 |
| Number of countries | 16 | 16 | 16 | 13 | 12 | 17 | 17 | 15 | 11 | 15 | 16 |
| Number of observations | 206 | 329 | 328 | 268 | 261 | 354 | 354 | 254 | 153 | 290 | 302 |

Each column represents a separate regression. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively. Year fixed effects are included in all estimations.

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# Appendix A

## Table A.1. Summary statistics

| Variable | Observations | Mean | Standard deviation |
|---|---|---|---|
| **Budget balance** | | | |
| Net lending/borrowing | 532 | -1.233 | 15.065 |
| Overall fiscal balance | 375 | -2.273 | 15.766 |
| **Disasters** | | | |
| Weather disaster dummy | 593 | 0.369 | 0.483 |
| (Log) Weather disaster damage (US$) | 449 | -1.091 | 2.739 |
| Health disaster dummy | 593 | 0.084 | 0.278 |
| (Log) Total affected by health disasters | 565 | -0.208 | 1.149 |
| **Determinants of budget balance** | | | |
| GDP growth | 564 | 4.587 | 9.351 |
| Deposit interest rate | 346 | 5.948 | 4.304 |
| Consumer price inflation | 363 | 5.534 | 8.501 |
| Gross debt (% of GDP) | 466 | 57.399 | 41.038 |
| Total reserves in months of imports | 456 | 8.444 | 10.104 |
| Legislative election dummy | 655 | 0.174 | 0.379 |
| Military expenditure (% of GDP) | 511 | 5.213 | 6.201 |
| Crude oil price (US$ per barrel) | 651 | 46.719 | 30.904 |
| Population growth | 625 | 2.711 | 2.309 |
| **Other disaster mitigating factors** | | | |
| Profit tax (% of commercial profits) | 298 | 13.100 | 9.227 |
| Oil rents (% of GDP) | 597 | 16.007 | 17.238 |
| Adjusted net savings (% of GNI) | 367 | 9.884 | 16.672 |
| Net barter terms of trade index (2000 = 100) | 470 | 126.865 | 41.578 |
| SWF dummy | 655 | 0.298 | 0.458 |
| Stabilization SWF dummy | 655 | 0.200 | 0.400 |
| Total external debt (% of GDP) | 346 | 54.724 | 65.895 |
| Grants (% of revenue) | 232 | 41.781 | 27.916 |
| Personal remittances received (% of GDP) | 452 | 5.160 | 6.492 |