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The Greater Beast: Weather-related and Health Disasters in MENA

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Abstract

Economic growth is a major source of concern in light of the successive weather-related and health disasters. We estimate the contemporaneous and long-run effects of weather-related vis-à-vis health disasters on the economic growth of 21 Middle East and North Africa (MENA) economies during 1980-2021 using two-way fixed-effects and two-step system general method of moments strategies. We also examine if macroeconomic fundamentals and domestic resource mobilization and external financing act as efficient mitigators of disaster effects. We find that the occurrence and damage of weather-related disasters decreases growth, respectively, by ~1.1 and ~2.0 percentage points instantaneously and by ~11.7, and ~3.4 percentage points, after one year. Health disasters occurrence and affected people measures are reducing growth in the short run by ~2.0 and ~0.3 percentage points, respectivelyand by ~22.3, and ~5.4 percentage points, after one year. Our estimates indicate that domestic resources from sovereign wealth funds can help mitigate all types of disasters. This study emphasizes the significance of domestic resource mobilization vis-à-vis external sources of finance in times of disasters.

JEL Classification: O40; O44; Q54; Q58

Keywords: Weather-related disasters; Health disasters; Economic growth; Mitigation; MENA.

1. Introduction

Natural disasters dominate 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 2 billion (IRIN, 2005). Weather-related and health (pandemics and epidemics) disasters accounted for nearly 95% of all natural disasters worldwide 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, MENA's GDP contracted by 3.4% in 2020. Some MENA economies shrank by as high as 25% (Regional Economic Outlook, 2021). Fiscal sustainability is a major source of concern for policymakers in MENA in the wake of the COVID-19 pandemic and the associated accumulation of sizeable public debts.

This study examines economic growth in MENA economies in the face of rising natural disasters. We first develop a model-based growth function approach to estimate the impact of health vis-à-vis weather-related disasters. Specifically, we estimate the contemporaneous and long-run effects of weather-related as opposed to health disasters on the economic growth of 21 MENA economies during 1980-2021 employing two-way fixed-effects and two-step system general method of moments (GMM) empirical strategies. Second, we assess if macroeconomic fundamentals and domestic resource mobilization (DRM) and external sources of finance mitigate the disaster-induced negative growth effects. The aim is to robustly identify the most effective mitigation channels to preserve and restore growth sustainability in the aftermath of disasters.

Weather-related disasters cause direct impact to the economy through mortality, morbidity, and loss of physical infrastructure (residentials, roads, telecommunication, electricity networks, etc.). These direct impacts are followed by consequent indirect impacts on the economy (in terms of income, employment, sectoral composition of production, inflation, etc.). Growth theory does not conclusively answer the question if weather-related disasters affect economic growth. The neoclassical growth models predict that the destruction of physical and/or human capital does not affect the rate of technological progress and, hence might only enhance short run growth as it drives countries away from their steady state levels. This phenomenon is known as the catch-up growth from below towards the steady state. In contrast, endogenous growth models may ascribe negative growth due to a disaster as a result of destruction in human capital and technology. In particular, endogenous growth models with technology exhibiting constant returns to capital predict no change in the growth rate following an exogenous capital shock. On the other hand, endogenous growth models exploiting increasing returns to scale in production predict that a capital stock destruction results in a lower growth path and, consequently, a permanent deviation from the previous growth trajectory.

The empirical economic research on weather-related disasters is only in its infancy with very few papers examining facets of disaster phenomena and its impacts. Hallegatte et al. (2007) construct a dynamic general equilibrium model that specifically includes the occurrence of extreme weather-related events and calculate the economic amplification ratio (the multiplier from direct capital destruction to indirect economic losses). They show that future changes in the distribution of disasters have the potential to generate large amplification ratios and thus very large economic effects if disaster magnitudes exceed a certain threshold. Moreover, a few papers explore the fiscal impact of weather-related disasters on the basis of case studies (Heipertz and Nickel 2008; lis and Nickel 2010). Heipertz and Nickel (2008) conclude that the total effect (including the direct and indirect impact) of extreme weather events on public finances varied between 0.3 to 1.1 percent of GDP. Lis and Nickel (2010) assess the impact of large-scale extreme weather events on changes in public budgets. They found that developing countries face a much larger effect on changes in budget balances following an extreme weather event than advanced economies.

Most of the existing empirical literature focus on the broader categories of natural disasters and its direct and indirect impacts. The empirical literature on the short run effects of natural disasters reports inconclusive results. Raddatz (2007) is one of the early papers attempted to estimate the effect of external shocks (including natural disasters) on short run output dynamics in developing countries. Using a Panel-VAR, he concludes that natural disasters have an adverse short run impact on output dynamics. In addition to the adverse short run effect estimated by Raddatz (2007) and

Felbermayr and Gröschl (2014), Noy (2009) describes some of the structural and institutional characteristics (literacy rate, better institutions, higher per capita income, higher degree of openness to trade, etc.) that compound the short run adverse negative effect. Subsequently, Raddatz (2009) extended the investigation on the short and long run impact of various types of natural disasters on countries in different income groups. He concludes that smaller and poorer states are more vulnerable, especially to climatic events, and that most of the output cost of climatic events occurs during the year of the disaster.

The empirical literature on the long run effects of natural disasters is scant and yields inconclusive results as well. Hochrainer (2009) uses autoregressive integrated moving average models to identify the mechanisms through which natural disasters affect GDP. He studies the counterfactual versus the observed GDP and then assesses disasters impacts as a function of hazard, exposure of assets, and vulnerability. By comparing the counterfactuals with GDP in medium-term (up to five years after the disaster), he finds that natural disasters on average lead to significant negative consequences in the case of large shocks. Loayza et al. (2012) reached the same conclusion applying panel GMM estimation. Cavallo et al. (2013) also implement a comparative event study approach to construct an appropriate counterfactual to see what would have happened to the path of GDP in the absence of a natural disaster and to compare the counterfactual with the actual path observed by building a synthetic control group of other untreated countries. They find no evidence of any significant long run effect of large natural disasters.

In light of the scarcity of studies combining weather-related and health disasters on the one hand and economic growth on the other hand, and the compounded effect of these disasters on the growth of MENA economies, this study comes to value. Our paper is the first to address this gap in the literature by comparatively estimating both the short and long run growth impacts of weather-related 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-related and health disaster economic costs and, importantly, report on potential mitigation strategies. Second, our findings will quantify and compare the impact of weather-related to health disasters and thus enable governments to adjust their macroeconomic policies efficiently and maintain growth sustainability while smoothing out these disasters. Such analysis is timely in view of the current successive waves of weather-related 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 economic growth of MENA economies, we argue that weather-related disasters are no less relevant. Hence, we compare the growth impacts of weather-related 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-related and health disasters. We also hypothesize that growth stabilizers can be used to mitigate the magnitude of effects that follow disasters.

Specifically, we seek to answer four research questions. (1) What is the estimated instantaneous and long-term impact of weather-related and health disasters on the economic growth of MENA countries? (2) How do the magnitude and persistence of the impacts of health disasters compare to weather-related ones? (3) Are MENA economies ready to shoulder the costs of weather-related and health disasters by depending on domestic resources and policies or is external finance also needed? (4) Can MENA countries use their sovereign wealth funds (SWFs) as a mitigation measure in the face of weather-related and health disasters?

To answer these research questions and capture the endogenous response of macroeconomic policy to the weather-related and health disasters, we construct a balanced panel dataset. The dataset merges economic growth (outcomes of interest) with the incidence and estimated damage of weather-related and health disasters and determinants of growth. The data, described below, covers 21 MENA countries1 over the period 1980-2021. We provide the summary statistics of the data used in the Appendix (Table A.1).

2.1 Weather-related and health disasters

Our primary measures for natural disasters are (1) the categorical occurrence of weather-related and health disasters; (2) the incidence of weather-related and health disasters; (3) the economic damages[2] (in US$) of weather-related disasters; and (4) the estimated people affected by health

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[1] 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.

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

disasters. Information on weather-related 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).[3] The EM-DAT reports the number of people killed or injured or rendered homeless and the estimated monetary damage. A disaster is defined as an incident meeting any of the following criteria: (1) 10 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-related disasters include the following three 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-related and health disasters on economic growth depends on the magnitude of disasters, we standardize our disaster measures of the (3) weather-related disasters damage in US$ and the (4) 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 & 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 the categorical occurrence of weather-related and health disasters and (2) as a binary dummy indicator of disaster occurrence.

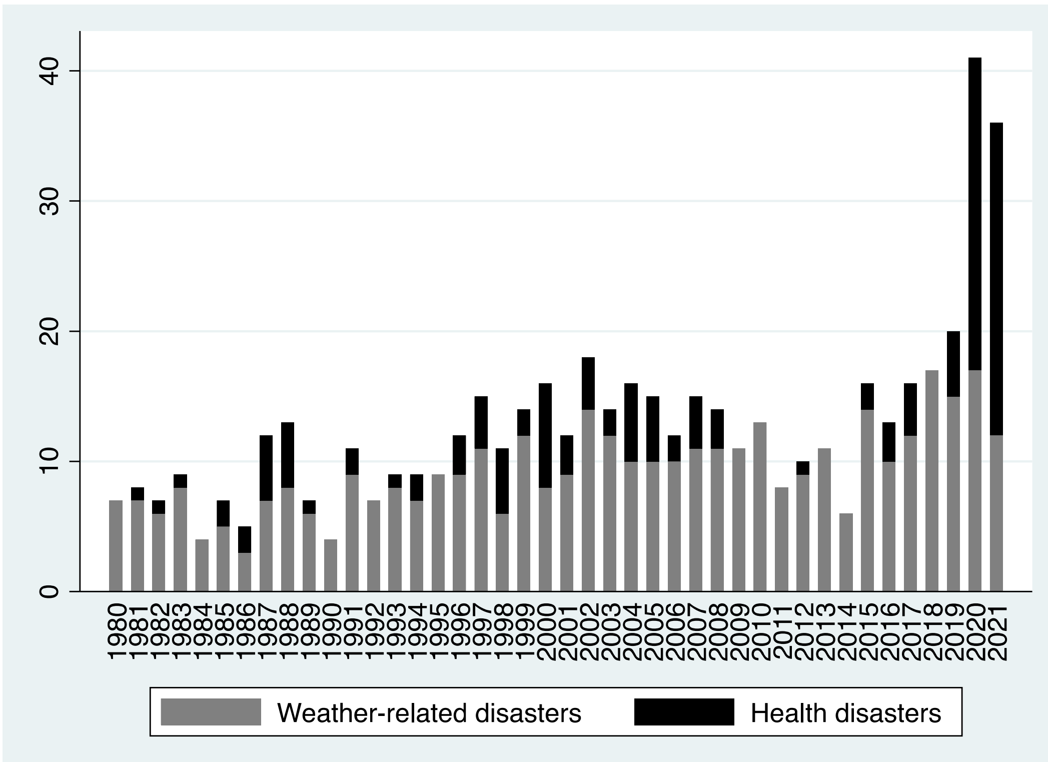
Figure 1 illustrates how weather-related and health disasters evolved over time in MENA, denoting an upward trend. In 2020 alone, the number of weather and health disasters combined amounted

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

to 42 incidents, with weather-related and health contributing almost 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 1980-2021. This proportion will change significantly after accounting for the total affected by COVID-19 in the EM-DAT.

FIGURE 1

Occurrence of weather-related and health disasters in MENA (1980-2021)



Authors' calculations based on EM-DAT.

2.2 Macroeconomic and institutional factors

We exploit a comprehensive data set of macroeconomic fundamentals covering the period 1980 to 2021. Our main dependent variable is annual GDP growth rate and is obtained from the World Bank (WB) World Development Indicators (WDI). We include a comprehensive set of growth predictors ($X_{i,t}$) and potential mitigators ($Z_{i,t}$) in our analyses: (1) population growth, to control for country-size effect; (2) trade, as a share of GDP, as a proxy for openness; (3) real interest rate; (4) domestic credit provided by the financial sector, as a share of GDP, as a proxy for the financial system; (5) gross capital formation, as a share of GDP; (6) foreign direct investment, as a share of

GDP; (7) inflation, consumer prices (annual percentage); (8) current account balance, as a share of GDP; (9) Military expenditures, as a share of GDP, a measure of the effect of political instability and the involvement of military in government on economic activity; (10) secondary school enrollment (percentage from gross) and illiteracy rate, as a proxy for human capital; (11) oil prices, given its influence on the 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; general government final consumption expenditure, as a share of GDP; (12) SWFs, both stabilization and development ones, which we anticipate to play a robust stabilizing role against growth decline during disasters; (13) net official development assistance (ODA), as a proxy of external financing; (14) Government health expenditures, as a share of GDP; (15) government effectiveness index, as a proxy for institutional strength; (16) CO_2 emissions (metric tons per capita), as a proxy for environmental quality; and (17) capital account openness index, as a proxy for the degree of financial openness.

These variables are obtained from the WB WDI, the WB Worldwide Governance Indicators (WGI), and the International Monetary Fund (IMF) International Financial Statistics (IFS).

3. Methodology

3.1 Estimating weather and health disaster impacts

3.1.1 Static longitudinal specification

Building on the literature spanning economic growth reaction functions (among others, Barro and Sala-i-Martin (2003), and Mankiw et al. (1992)), and natural disasters (among others, Noy (2009), Felbermayr and Gröschl (2014), and El-Shal, Mohieldin, and Moustafa (2022)), we propose a two-way fixed-effects model to estimate the causal impact of weather-related and health disasters on economic growth. For each country i at year t, the following parsimonious specification is estimated four times, once for each of our weather-related and health impact indicators of interest:

$$g_{i,t} = \gamma_0 + \gamma_1 g_{i,t-1} + \gamma_2 X_{i,t} + \gamma_3 D_{i,t} + \eta_i + \tau_t + \epsilon_{it} \qquad (1)$$

The dependent variable $g_{i,t}$ is the annual GDP growth for country i at time t. $g_{i,t-1}$ is the GDP growth lag. $X_{i,t}$ denotes the vector of determinants pertinent to economic, institutional, political, and demographic and other controls. $D_{i,t}$ stands for the weather-related and health disasters variables. 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-related disasters damage in US$ 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 a categorical indicator counting the number of disasters for each year to examine whether this alters our results[4]. η_i and τ_t are sets of country- and year-fixed effects, respectively. γ_{0i} is a country-specific intercept and ϵ_{it} is a random and normally distributed disturbance term.

γ_3 represents the short run coefficient of weather-related and health disasters variable. Following a voluminous growth literature (among others, Barro and Sala-i-Martin (2003), and Mankiw et al. (1992)), the relevant long run coefficient of weather-related and health disasters variable is then defined as follows:

$$\gamma_3^{\mathrm{LR}} = \frac{\gamma_3}{(1-\gamma_1)} \tag{2}$$

where γ_1 is the coefficient on the lagged dependent variable ($g_{i,t-1}$).

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-related and/or health disasters over our estimated time period is under-estimated as weather-related and/or health disasters 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 yield too conservative estimates. 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

[4] 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.

of the disasters they have experienced up to then. Ignoring this effect implies that our conservative estimates are more likely not to detect an effect of disasters. But in fact, our model 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-related and health disasters on economic growth is immediate. The majority of empirical research makes this assumption about the impact of natural disasters in general (Botzen et al., 2019). But in this study, we hypothesize that the long-run effects of disasters on the growth of MENA economies are not to be underestimated. We propose a *parsimonious* long-term dynamic specification to allow for the possibility of disaster 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 growth be it measured by real GDP growth rate. The long-term dynamic specification is as follows.

$$g_{i,t} = \gamma_{0i} + \alpha g_{i,t-1} + \gamma_1 X'_{i,t} + \beta_1 X'_{i,t-1} + \gamma_2 D_{i,t} + \beta_2 D_{i,t-1} + \epsilon_{it} \quad (3)$$

According to this specification, γ_2 estimates the immediate short-run impact of a weather-related or health disaster on economic growth. The long-run impact begins after a one-year lag and is given by

$$\frac{\gamma_2+\beta_2}{1-\alpha}, \quad (4)$$

where α captures the persistence of the adjustment process, specifically the total adjustment of the budget balance following a weather-related or health disaster.

In equation (3), 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, estimation of equation (3) by fixed effects models will yield biased and inconsistent estimates, especially with relatively limited time periods (Blundell et al., 2000; Cameron & Trivedi, 2005; Wooldridge, 2002). To address these concerns, we use the two-step

Arellano-Bond GMM estimator to estimate equation (3). 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 growth 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 and, plus these fixed effects, 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 (3), we have the following moment conditions:

$$E[(\epsilon_{i,t} - \epsilon_{i,t-1})X_{i,t-k}] = 0, \ \ E[\epsilon_{i,t}(X_{i,t-k} - X_{i,t-k-1})] = 0 \qquad (5)$$

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 mis-measurement in the exogenous disaster variables. We assume that the remainder of the current and lagged explanatory variables in equation (3) 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 & Bond, 1991; Blundell & 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 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 economic, institutional, political, and demographic factors of MENA countries, struck by weather-related and health disasters, mitigate disaster-induced change in growth. We explore the effectiveness of a battery of factors in determining countries' ability to mitigate disaster impacts on growth. We additionally include an explanatory variable, $Z_{i,t}$, denoting various growth 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 growth depends on the 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:

$$g_{i,t} = \gamma_{0i} + \alpha g_{i,t-1} + \gamma_1 X'_{i,t} + \gamma_2 D_{i,t} + \gamma_3 \left(D_{i,t} \,.\, Z_{i,t}\right) + \gamma_4 Z_{i,t} + \eta_i + \tau_t + \epsilon_{it} \qquad (6)$$

The coefficient of interest (γ_3) measures the marginal effect of each mitigator on the disaster-induced change in growth.

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 correlation between mitigator and growth. γ_4 measures the effect of a mitigator on growth in the case of no disaster occurrence.

4. Results and discussion

We estimate the costs of weather shock events in terms of growth and highlights the channels through which weather conditions affect the macroeconomy. The analysis offers evidence on how various policies and country characteristics influence the sensitivity of growth to weather variations, using both empirical analysis and model simulations, and presents case studies of climate-proofing infrastructure as an adaptation strategy through a dynamic general equilibrium model.

4.1 The static impact on GDP growth

We first investigate the parsimonious short and long run impacts of weather-related and health disasters in MENA on GDP growth. Table 1 presents the results of our models in equations (1) and (2) based on the six reported measures of the weather-related and health disasters. The six columns in Table 4.1 represent the following models' estimates: (1) weather-related disasters categorical occurrence; (2) weather-related disasters occurrence dummy; (3) weather-related disasters direct damage measure divided by the previous year's GDP; (4) health disasters categorical occurrence; (5) health disasters occurrence dummy; and (6) number of people affected by health disasters divided by the population size in the year prior to the disaster.

The preliminary results presented in Table 1, without the control variables, points to our main general conclusion. There is significant evidence that the six estimates of weather-related and health disasters are a negative determinant of both the short and long run GDP growth performance in MENA. weather-related and health disasters in MENA are associated with a contraction in the short and long run economic activity of the region by about 1-3 percentage points. The result is consistent with the results of Noy (2009) and Felbermayr and Gröschl (2014) but in contrast with Cavallo et al. (2013) and Raddatz (2007) who show no evidence of an adverse impact of natural disasters on growth dynamics in affected countries.

Next, we examine specifications that also include other control variables commonly found in the empirical growth literature. Table 2 shows the results of the estimation including additional determinants of growth which are sets of domestic policy, structural, and external factors, as well as country-specific effects and the lagged output growth as explained earlier. For these control variables, our results (Table 2) show again that in line with our parsimonious results (Table 1), there is significant evidence that the six estimates of weather-related and health disasters are a negative determinant of both the short and long run GDP growth performance in MENA. The results also show that a higher lagged economic growth and capital formation and a lower inflation, oil prices, and military expenditures are all significantly associated with higher GDP growth in the MENA region.

Table 1: Parsimonious Fixed effects estimation (1980-2021)

	(1)	(2)	(3)	(4)	(5)	(6)
lagGDPg	0.024	0.023	0.044	0.018	0.019	0.030
	(0.091)	(0.091)	(0.109)	(0.092)	(0.032)	(0.133)
$Occurence_{W}$= 1	-1.793**					
	(0.668)					
$Occurence_{W}$= 2	-0.896					
	(0.778)					
$Occurence_{W}$= 3+	-1.825**					
	(0.876)					
$Dummy_{W}$= 1		-1.606**				
		(0.622)				
$Damage_{W}$			-3.181**			
			(1.459)			
$Damage_{WLR}$			**-3.317****			
$Occurence_{H}$= 1				-1.725*		
				(1.372)		
$Occurence_{H}$= 2				-0.738		
				(0.902)		
$Occurence_{H}$= 3+				0.704		
				(0.786)		
$Dummy_{H}$= 1					-1.447*	
					(0.918)	
$AFFP_{H}$						-0.208*
						(0.102)
$AFFP_{HLR}$						**-0.214***
Constant	4.037***	4.038***	3.960***	3.618***	3.623***	3.587***
	(0.477)	(0.486)	(0.487)	(0.316)	(0.341)	(0.439)
Observations	1,007	1,007	749	1,007	1,007	714
R-squared	0.006	0.005	0.007	0.004	0.003	0.010

Each column represents a separate regression. Standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The LR coefficients are defined as discussed in equation (2).

Table 2: Estimated *static* impact of weather and health disasters on GDP growth (1980-2021)

	(1)	(2)	(3)	(4)	(5)	(6)
Lag GDPg	0.093*	0.093*	0.089*	0.091*	0.092*	0.084*
	(0.052)	(0.052)	(0.052)	(0.055)	(0.055)	(0.060)
Openness	0.006	0.006	0.007	0.004	0.005	-0.001
	(0.012)	(0.012)	(0.015)	(0.013)	(0.013)	(0.014)
Population	0.416	0.421	0.383	0.410	0.410	0.452
	(0.273)	(0.271)	(0.282)	(0.274)	(0.273)	(0.310)
Inflation	-0.071	-0.070	-0.089**	-0.071	-0.072*	-0.088*
	(0.043)	(0.043)	(0.033)	(0.042)	(0.042)	(0.048)
Interest rate	-0.050	-0.051	-0.082	-0.051	-0.052	-0.064
	(0.049)	(0.048)	(0.060)	(0.048)	(0.048)	(0.063)
Domestic credit	0.017	0.018	0.014	0.017	0.017	0.014
	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)
Gross capital formation	0.060	0.062	0.078*	0.066*	0.065*	0.069
	(0.036)	(0.036)	(0.043)	(0.038)	(0.037)	(0.044)
Foreign direct investment	0.088	0.085	0.093	0.095	0.091	0.108
	(0.059)	(0.058)	(0.059)	(0.059)	(0.059)	(0.063)
Current account	0.001	0.001	0.001	0.001	0.001	0.002
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
School enrollment	-0.023	-0.025	-0.017	-0.024	-0.025	-0.029
	(0.031)	(0.030)	(0.027)	(0.031)	(0.031)	(0.025)
Oil Price	-0.015	-0.014	-0.022*	-0.016	-0.016	-0.021*
	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)	(0.011)
Military expenditure	-0.432***	-0.427***	-0.441***	-0.423**	-0.421**	-0.420***
	(0.151)	(0.150)	(0.138)	(0.152)	(0.152)	(0.140)
$Occurence_W$= 1	-1.291**					
	(0.588)					
$Occurence_W$= 2	0.344					
	(0.614)					
$Occurence_W$= 3+	-2.036**					
	(0.904)					
$Dummy_W$= 1		-1.076**				
		(0.512)				
$Damage_W$			-1.979**			
			(0.798)			
$Damage_{WLR}$			**-2.172****			
$Occurence_H$= 1				-2.584**		
				(0.997)		
$Occurence_H$= 2				-0.346		
				(1.000)		
$Occurence_H$= 3+				-1.216		
				(1.120)		
$Dummy_H$= 1					-2.065**	
					(0.845)	
$AFFP_H$						-0.332**
						(0.159)
$AFFP_{HLR}$						**-0.362****
Constant	4.167*	4.135*	3.885	4.113*	4.114*	4.802**
	(2.146)	(2.116)	(2.306)	(2.150)	(2.158)	(2.153)
Observations	696	696	524	696	696	479
R-squared	0.142	0.135	0.149	0.142	0.139	0.189

Each column represents a separate regression. Standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The LR coefficients are defined as discussed in equation (2).

These consistent and robust results of Tables 1 and 2 eliminate any suspicious that the way we constructed the damage and total affected variables created any endogeneity problem. The converted disaster measures (both dummy and categorical) yield the same results.

4.2 The dynamic impact on GDP growth

Table 3 lists the results of estimating the long-run dynamic specification of equation (3) for MENA countries; these are the two-step system GMM estimates. We include lags of both dependent and independent variables, precisely GDP growth, and disaster measures. 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 GDP growth, indicating how each parameter is calculated.

Significant contemporaneous and long-run effects of weather-related and health disasters are observed for the dummy measures of the disasters. Specifically, we estimate that the occurrence of weather-related and health disasters decreases GDP growth by about 9.8, and 12.4 percentage points immediately in MENA (Table 3). These effects are significant, but the magnitude of the reported long-run effects is much larger, standing at about 11.7, and 22.3 percentage points, respectively, after a year (Table 4). These findings reflect how both weather-related and health disasters are hindering MENA's efforts in sustaining high-growth path trajectory. As in Skidmore and Toya (2002), the human capital cost has an impact on the long run growth specifications. On the other hand, the reason for the short run impact of a disaster is caused mostly by damage to the capital stock, to delivery and transportation systems, and other infrastructure.

Diagnostic tests. As the employed GMM method relies on IVs, we test the validity of the used instruments. For this purpose, the Hansen test for over-identified restrictions is reported in Table 3, with the null hypothesis being that the used instruments are valid. As shown in Table 3, we fail to reject the null hypothesis, verifying that the instruments are valid. We also report the Arellano-Bond autoregressive (AR) test for autocorrelation of the residuals in Table 3. Failing to reject the null hypothesis suggests that the differenced residuals do not exhibit significant AR(2) behavior.

TABLE 3: Estimated *dynamic* impact of weather and health disasters on GDP growth (1980-2021)

	Parameter	GMM estimate			
		(1)	(2)	(3)	(4)
Lag GDPg	α	-0.049	0.252	-1.515	3.236
		(0.529)	(0.326)	(1.221)	(2.559)
Disasters					
$Dummy_W$= 1	γ_2	-9.774*			
		(5.583)			
$Dummy_H$= 1			-12.424*		
			(9.221)		
Lag $Dummy_W$= 1	β_2	-2.449			
		(6.303)			
Lag $Dummy_H$= 1			-4.279		
			(19.787)		
$Damage_W$	γ_2			-4.486	
				(5.025)	
$AFFP_H$					7.305
					(7.826)
Lag $Damage_W$	β_2			-4.138	
				(4.449)	
Lag $AFFP_H$					-8.019
					(5.666)
Control Variables					
Openness	γ_{11}	0.517*	0.173**	0.157	0.194
		(0.372)	(0.083)	(0.507)	(0461)
Population	γ_{12}	-6.116	6.410	4.172*	-1.778
		(9.462)	(6.364)	(3.149)	(9.993)
Inflation	γ_{13}	0.424	-0.500*	-0.655	4.855
		(0.599)	(0.334)	(1.646)	(3.531)
Interest rate	γ_{14}	-0.073	0.545**	0.199	0.104
		(0.654)	(0.258)	(0.523)	(0.602)
Domestic credit	γ_{15}	0.095	-0.086	0.068	-0.906
		(0.198)	(0.184)	(0.417)	(0.812)
Gross capital formation	γ_{16}	1.903	-0.449*	1.111	2.760
		(1.786)	(0.286)	(1.223)	(2.224)
Foreign direct investment	γ_{17}	2.387*	1.116*	3.099	2.608*
		(1.678)	(0.643)	(2.932)	(1.976)
Current account	γ_{18}	0.033*	0.010	0.028	0.017
		(0.019)	(0.010)	(0.047)	(0.032)
Military expenditure	γ_{19}	-2.230*		-1.042	-2.241*
		(1.339)		(1.413)	(2.182)
Constant	γ_{0i}	-49.599	33.079	393.036	
		(40.293)	(33.769)	(499.673)	
Arellano-Bond test for AR(2) in 1st	z-statistic	-0.83	0.33	-1.33	-0.24
differences	Pr > z =	0.408	0.742	0.184	0.807
Hansen difference test	χ^2	0.000	0.000	0.000	0.000
	Pr > χ^2 =	1.000	1.000	1.000	1.000
Number of countries		21	21	21	21
Number of observations		663	796	401	364

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 10%, 5%, and 1% levels, respectively.

TABLE 4

Calculated *long-run* impact of weather-related and health disasters on GDP growth from a dynamic model specification

Explanatory variable	Parameter calculation	Long-run effect estimate			
		(1)	(2)	(3)	(4)
Long-run disaster	$(\gamma_2 + \beta_2)/(1-\alpha)$	-11.654*	-22.334**	-3.429*	-5.413*
		(6.687)	(12.949)	(2.251)	(3.465)

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.3 Mitigation policies and strategies

We estimate equation (6) to test whether domestic policy as well as institutional and structural aspects of the MENA economies struck by disasters have any bearing on the magnitude of the growth decline. The coefficient on the interaction of weather-related and health disasters measure and the mitigation variable in equation (6) defines the mitigation effect of these characteristics on the magnitude of the growth impact in Tables 1-4. 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 previously identified impact on the GDP growth of MENA economies. Specifically, we estimate equation (6) to test if openness, stabilization funds, SWFs, domestic credit, illiteracy, government consumption, CO2 emissions, capital account openness, ODA, health expenditures, and institutional strength in MENA countries struck by weather-related and health disasters have any bearing on the magnitude of growth decline.

Ordering the mitigating effects of weather-related disaster growth mitigators in Table 5 by effectiveness, both stabilization and development SWFs come first, with the highest magnitude, as the main mitigator of weather-related disaster effects, surpassing all the other effective mitigators in MENA countries (CO2 emissions, institutional strength, domestic credit, government consumption, and openness). A one percentage point increase in SWFs' holdings can absorb the negative weather disaster effect on growth by more than 720 percentage points. Put simply, the economic growth of MENA countries is unitary elastic to SWFs' holdings in the time of a weather-related disaster. Moustafa and El-Shal (2021) argues that MENA countries with greater SWFs' holdings in the region can use it as a buffer stock against cash outflows during such disasters. CO2 emission comes second in mitigating weather disasters effects. Again, in Table 6, development SWFs come first, with the highest magnitude, as the main mitigator of health disaster effects, surpassing all the other effective mitigators in MENA countries (institutional strength, health expenditures, ODA, and government consumption).

Our findings in Tables 5 and 6 also suggest that domestic policies can partially dampen the adverse effects of weather-related and health disasters. Interacting the level of illiteracy with the weather damage and health occurrence variables yields a negative and significant coefficient, suggesting that affected MENA countries with higher level of human capital experience are guaranteeing less adverse effect on growth. Disasters have both a direct, contemporaneous effect and a long term, indirect effect on human capital. While the direct effects- primarily related to injury, illness and death suffered as a result of the disaster- are relatively straightforward, the indirect effects will depend on human capital long term investment decision. Indeed, higher levels of human capital are effective in mitigating the long-term impacts of disasters on growth.

Additionally, we find that institutional strength is associated with a significant lower macroeconomic cost. The importance of governing institutions can be attributed either to the direct efficiency of the public intervention following the event's onset, or to the indirect impact of an efficient government response in shaping private sector response to the disaster. We also find that a bigger government with higher government consumption and health expenditures and higher level of openness are more able to lower disaster costs. These governments are more able to mobilize more resources for reconstruction and may also be more likely recipients of larger international capital inflows to aid in the reconstruction effort (Yang, 2008; Raddatz, 2007; Cashin et al., 2017).

Since insurance, credit, and financial flows all play a role in disaster mitigation, we examine whether financial market conditions matter for the consequences of weather-related and health disasters. We start by examining whether the depth of the financial system matters for disaster costs. We proxy the financial system with the level of domestic credit (Table 5 column 4). We do observe that more domestic credit appears to reduce the costs of weather-related disasters in terms of foregone output growth. We next examine whether the degree of openness of the capital account matters for the output dynamics following health disasters. Yang (2008) finds some evidence of capital flight following disaster events. In light of Yang's observations, MENA countries with open capital accounts seem to experience larger drops in their output growth following disasters.

These findings confirm that domestic resource mobilization (DRM) by MENA countries, rather than external financing, plays a pivotal role in mitigating the negative weather-related and health disaster effects on economic growth. In this case, we can argue that DRM is crucial not only to generate economic stability, growth, and redistribution, but also to strengthen 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.

TABLE 5: Mitigating factors of *weather* disaster effects on GDP growth (1980-2021)

	Openness (1)	Stabilization SWFs (2)	Development SWFs (3)	Domestic credit (4)	Illiteracy (5)	Government consumption (6)	CO2 emissions (7)	Capital account openness (8)	Institutional strength (9)
lagGDPg	0.098	0.158***	0.157***	0.093	0.257*	0.119**	-0.017	0.214***	0.075
	(0.073)	(0.040)	(0.041)	(0.071)	(0.125)	(0.057)	(0.072)	(0.048)	(0.036)
$D_{i,t}$	-0.232*	-0.017***	-0.016***	-0.157**	0.706	-0.020***	-0.309***	0.674***	-1.507*
	(0.117)	(0.002)	(0.003)	(0.056)	(1.534)	(0.001)	(0.058)	(0.099)	(0.516)
$Z_{i,t}$	0.008	-2.353*	-0.203	0.009	-0.058	-0.016**	-3.629	3.429	-0.927
	(0.007)	(1.294)	(1.766)	(0.014)	(0.109)	(0.006)	(6.086)	(3.016)	(0.511)
$D_{i,t} . Z_{i,t}$	0.003*	720.543***	101.228***	0.006**	-0.117*	0.005***	0.710***	-1.006***	0.578**
	(0.002)	(164.291)	(28.793)	(0.002)	(0.056)	(0.000)	(0.161)	(0.150)	(0.155)
Foreign direct investment	0.200*	0.160*	0.153	0.203*	0.635*	0.141**	0.112	0.282***	0.179
	(0.101)	(0.091)	(0.090)	(0.102)	(0.362)	(0.065)	(0.086)	(0.079)	(0.101)
Inflation	-0.101**	-0.094**	-0.095**	-0.105**	0.086	-0.018	-0.025	-0.025	-0.068***
	(0.042)	(0.038)	(0.038)	(0.046)	(0.147)	(0.016)	(0.028)	(0.115)	(0.006)
Openness		0.007	0.007	0.008	-0.020	0.006	-0.003	-0.008	-0.002
		(0.006)	(0.006)	(0.007)	(0.042)	(0.012)	(0.018)	(0.007)	(0.002)
Interest rate	-0.044	-0.036	-0.031	-0.041	0.036	-0.011	-0.049	-0.027	0.107
	(0.033)	(0.031)	(0.031)	(0.032)	(0.060)	(0.044)	(0.037)	(0.066)	(0.059)
Domestic credit	0.010	0.012	0.012		0.019	0.011	-0.001	0.014	-0.009***
	(0.015)	(0.015)	(0.015)		(0.042)	(0.008)	(0.010)	(0.012)	(0.000)
Gross capital formation	0.025	-0.002	-0.002	0.028	-0.071	0.064*	0.111	0.075	-0.039
	(0.053)	(0.047)	(0.048)	(0.052)	(0.095)	(0.037)	(0.071)	(0.095)	(0.051)
Constant	6.260*	0.343	0.360	6.237*	4.731	2.226	16.631	-2.436	3.675
	(3.604)	(2.365)	(2.372)	(3.610)	(6.564)	(2.064)	(10.723)	(2.511)	(3.078)
Observations	627	577	577	627	99	432	412	185	33
R-squared	0.066	0.107	0.106	0.067	0.206	0.071	0.089	0.184	0.624

Each column represents a separate regression. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Year fixed effects are included in all estimations.

TABLE 6: Mitigating factors of *health* disaster effects on GDP growth (1980-2021)

	Development SWFs	Illiteracy	Government consumption	Institutional strength	ODA	Health expenditures
	(1)	(2)	(3)	(4)	(5)	(6)
lagGDPg	0.091	0.153	0.127*	0.150*	0.031	0.182**
	(0.069)	(0.112)	(0.069)	(0.060)	(0.074)	(0.077)
$D_{i,t}$	-1.493	14.558*	-2.375***	-8.343*	-3.948***	-4.329
	(1.066)	(7.085)	(0.816)	(2.705)	(1.027)	(3.041)
$Z_{i,t}$	0.698	0.014	-0.020***	0.292	-0.033	-0.095
	1.498	-0.098	(0.004)	(2.186)	(0.032)	(0.068)
$D_{i,t} . Z_{i,t}$	74.402***	-0.250**	0.040***	2.257*	0.107***	0.191*
	(2.841)	(0.099)	(0.007)	(0.923)	(0.030)	(0.111)
School enrollment	-0.009		-0.031**	-0.047	-0.042	-0.082
	(0.029)		(0.014)	(0.045)	(0.035)	(0.058)
Foreign direct investment	0.143*	0.655**	0.112	0.102***	0.130	0.240**
	(0.071)	(0.295)	(0.076)	(0.008)	(0.094)	(0.085)
Inflation	-0.026*	-0.017	-0.020		-0.044	0.057
	(0.013)	(0.094)	(0.014)		(0.035)	(0.130)
Openness	0.008	-0.021	0.011	0.004	0.014***	0.024
	(0.006)	(0.041)	(0.011)	(0.003)	(0.004)	(0.020)
Interest rate	-0.028	0.029	0.002	0.016		
	(0.026)	(0.061)	(0.031)	(0.022)		
Domestic credit	0.013	0.021	0.010	-0.024	-0.004	0.001
	(0.015)	(0.027)	(0.018)	(0.016)	(0.017)	(0.014)
Gross capital formation	0.099	-0.006	0.054	0.001	0.026	0.090
	(0.088)	(0.082)	(0.045)	(0.038)	(0.046)	(0.094)
Constant	-0.994	1.688	2.024	4.031	5.163**	9.151**
	(2.266)	(9.075)	(1.339)	(7.368)	(2.146)	(4.007)
Observations	793	135	606	66	569	400
R-squared	0.159	0.205	0.087	0.160	0.048	0.181

Each column represents a separate regression. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Year fixed effects are included in all estimations.

5 Conclusion

This study presents novel evidence on the short- and long-run impacts of weather-related and health disasters on economic growth of 21 MENA countries over the period 1980-2021. The aim is to guide future policy formulation and implementation, especially in the time of natural disasters.

Our fixed-effects and GMM results show that both weather-related and health disasters have a significant negative impact on the economic growth of MENA economies. The results show that the occurrence and damage of weather disasters decreases growth, respectively, by ~1.1 and ~2 percentage points instantaneously in MENA countries. The magnitude of the disaster long-run effects is much larger, standing at ~11.7, and ~3.4 percentage points, respectively, after one year. Health disasters occurrence and affected people measures are reducing growth in the short run by ~2 and ~0.3 percentage points, respectively. The magnitude of the disaster long-run effects is much larger, standing at ~22.3, and ~5.4 percentage points, respectively, after one year.

Exploring various mitigating factors of disaster effect, our findings provide pertinent evidence on how MENA countries can strengthen their growth resilience to weather-related and health disasters by mobilizing domestic resources constituting the most effective disaster mitigation strategies. SWFs come first as the most effective mitigator, surpassing the effectiveness of the other significant sources of domestic and external finance in MENA countries.

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

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Appendix A

TABLE A.1

Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP growth					
GDP	1,008	3.487	9.359	-64.047	86.800
lagGDP	1,007	3.491	9.363	-64.047	86.800
Disasters					
Health disaster dummy	1,008	0.136	0.343	0.000	1.000
Weather disaster dummy	1,008	0.390	0.488	0.000	1.000
Weather disaster damage (US$)	750	0.957	18.645	0.000	507.202
Total affected by health disasters	727	-0.375	1.710	-10.975	3.960
Determinants of GDP growth					
Openness	991	75.965	45.659	0.021	628.890
Population growth	1,004	2.910	2.059	-4.533	17.512
Inflation	1,008	13.109	41.224	-16.117	487.200
Interest rate	1,008	6.816	18.943	-46.492	373.216
Domestic credit	928	51.197	40.146	-59.323	232.080
Gross capital formation	974	24.799	9.431	-12.880	61.882
Foreign direct investment	966	1.981	3.615	-13.605	33.566
Current account	948	461.416	263.653	1.000	908.000
School enrolment	996	65.000	29.036	4.217	131.140
Oil prices	1,008	42.498	28.539	12.280	109.450
Military expenditures	759	5.901	5.900	0.051	117.350
Other disaster mitigating factors					
Development SWFs	924	0.014	0.118	0.000	1.000
Stabilization SWFs	924	0.012	0.109	0.000	1.000
Government consumption	621	6.849	29.034	0.000	262.609
ODA	609	9.921	14.561	-0.085	108.263
Health expenditures	418	52.930	18.902	10.182	89.766
Inistitutional strength	89	3.129	0.685	1.500	4.500
Illiteracy	137	19.377	15.482	1.773	69.742
CO2 emissions	617	0.734	0.422	0.080	2.676
Capital account openness	254	0.579	0.288	0.090	1.000