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For Whom the Bell Tolls: Climate Change and Income Inequality

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For Whom the Bell Tolls: Climate Change and Inequality

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Abstract

Climate change is the defining challenge of our time with complex and evolving dynamics. The effects of climate change on economic output and financial stability have received considerable attention, but there has been much less focus on the relationship between climate change and income inequality. In this paper, we provide new evidence on the association between climate change and income inequality, using a large panel of 158 countries during the period 1955–2019. We find that an increase in climate change vulnerability is positively associated with rising income inequality. More interestingly, splitting the sample into country groups reveals a considerable contrast in the impact of climate change on income inequality. While climate change vulnerability has no statistically significant effect on income distribution in advanced economies, the coefficient on climate change vulnerability is seven times greater and statistically highly significant in the case of developing countries due largely to weaker capacity for climate change adaptation and mitigation.

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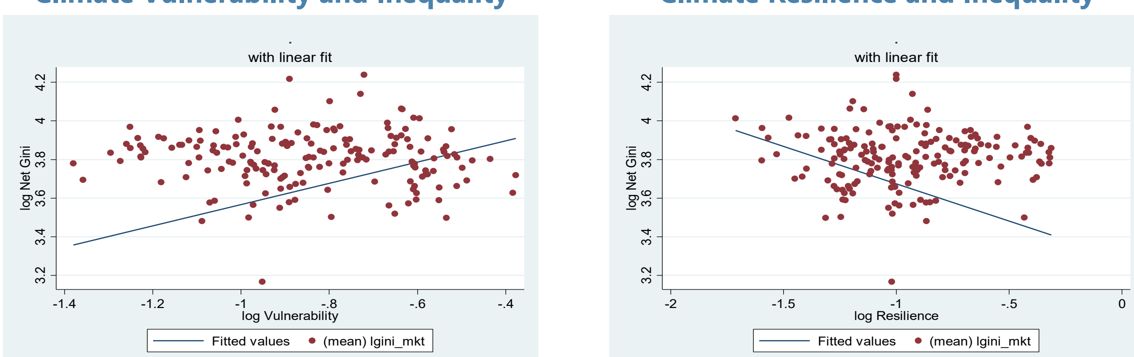
I. INTRODUCTION

Climate change is the defining challenge of our time with complex and evolving dynamics.[2] The global annual average surface temperature has already increased by about 1.1 degrees Celsius (°C) compared with the preindustrial average during 1850–1900, amplifying the frequency and severity of climate shocks across the world. These extreme weather events are projected to intensify over the next century, as the global mean temperature increase by as much as 4°C over the next century (IPCC 2007, 2014, 2019; 2021; Stern 2007). The economic consequences of climate change—ranging from financial and fiscal stability to long-run growth prospects and income distribution—will be felt across the world, but the extent of potential vulnerability depends on the size and composition of economies, the resilience of institutions and physical infrastructure, and the capacity for mitigation and adaption to climate change.

While the effects of climate change on economic output and financial stability have received considerable attention, there has been much less focus on the relationship between climate change and income inequality. This is particularly important in view of the rise of wealth and income inequality in most of the world over the past three decades in spite of sustained economic growth and poverty reduction. Looking forward, climate change could undermine poverty eradication efforts, disproportionately hit the poorest regions, and worsen income inequality within countries (World Bank, 2020).[3] There is indeed evidence that global warming

Figure 1. Climate Change and Income Inequality (2019)

Climate Vulnerability and Inequality | **Climate Resilience and Inequality**



Source: SWIID; ND-GAIN; authors' calculations. (Note: This figure presents the climate vulnerability and resilience indices that are not adjusted for the level of real GDP per capita).

[2] Climate refers to a distribution of weather outcomes for a given location, and climate change describes environmental shifts in the distribution of weather outcomes toward extremes.

[3] This study estimates that climate change could push an additional 68 to 135 million people into poverty by 2030. These projections are consistent with evidence from household-level studies showing that Hurricane Mitch wiped out 18 percent of the assets of the poorest quintile in Honduras compared to only 3 percent for the richest quintile, which translate into unequal reductions in consumption (Morris and others, 2002; Rentschler, 2013). Likewise, in Jamaica, households who lived in better constructed housing—a proxy for wealth—have greater ability to smooth consumption after tropical storms (Henry, Spencer, and Strobl, 2019).

has already exacerbated global income inequality since the 1960s, with temperature changes enriching "cool" countries in the north while weighing down economic growth in "hot" countries in the south (Tol *et al*., 2004; Diffenbaugh and Burke, 2019).

The conceptual framework for examining the relationship between climate change and income distribution is a reflection of deep structural changes—akin to globalization, technological progress, and demographic trends. How institutions and policy choices respond to climate change is critical for determining both pre- and after-tax income inequality. First, some countries (and households) are more exposed to threats associated with climate change than wealthier counterparts due partly to the skewed geographic and sectoral distribution of economic activity and climate-related risks. Second, climate shocks tend to cause a greater loss of income and wealth in lower-income countries (and among poorer households). Third, some countries (and households) have lesser capacity and financial resources to respond and adapt to climate shocks. As captured in Figure 1, these underlying factors as of 2019 form a negative feedback loop in which the poor are more likely to experience climate shocks and lose a greater fraction of income and wealth.

The objective of this paper is therefore to shed new light on how climate change influences income inequality within a broad panel of 158 countries during the period 1995–2019.[4] We utilize a new dataset of climate change vulnerability (and resilience) developed by the Notre Dame Global Adaptation Institute (ND-GAIN) and employ alternative estimation methodologies including a standard panel regression analysis and a panel vector autoregression (VAR) model to analyze the evolution of income inequality to shocks in climate change. We find that an increase in climate vulnerability is positively associated with rising income inequality, after controlling for economic and demographic factors. More interestingly, we split the sample into country groups and detect a considerable contrast in how climate change affects income inequality. While climate vulnerability has no statistically significant effect on the distribution of income in advanced economies, the coefficient on climate vulnerability is seven times greater and statistically highly significant in developing countries, which tend to have weaker capacity to adapt to and mitigate the consequences of climate change. On the other hand, our analysis indicates that an increase in climate resilience is associated with lower income inequality, but this effect is subject to a higher degree of uncertainty. These findings are robust with alternative estimation methods and measures of income inequality.

[4] Risks associated with climate change can be decomposed into two categories—physical risks and transition risks. Physical risks refer to the potential for losses as climate-related events disrupt business operations, destroy capital, and interrupt economic activity. Transition risks, on the other hand, refer to the potential for losses resulting from a shift in policy such as moving toward a lower-carbon economy, consumer sentiment, and technological innovation that will affect the value of certain assets and liabilities. This paper focuses on countries' exposure to physical risks that correspond to the potential economic and financial losses caused by climate change. However, it should be noted that transition risks related to the process of adjusting toward a low-carbon economy, such as stranded asset exposures in the financial system, can also amount to a sizable burden.

The econometric evidence presented in this paper has direct policy implications, especially for developing countries that are relatively more vulnerable to risks associated with climate change. While climate change is an inevitable reality, the negative coefficient on climate resilience shows that even most vulnerable countries can address the threat climate change poses to economic growth and income distribution by (i) implementing inclusive development policies that are consistent with climate mitigation and adaptation objectives; (ii) improving social safety nets and access to healthcare that increase the poor's ability to cope with climate shocks; (iii) enhancing physical resilience through smart infrastructure investments; (iv) strengthening financial resilience with better insurance and financial products; and (v) expanding the economy's production frontier through reforms designed for higher productivity growth and greater economic diversification.

The remainder of this paper is organized as follows. Section II provides an overview of the related literature. Section III describes the data used in the empirical analysis. Section IV introduces the salient features of our econometric strategy. Section V presents the empirical results, including a series of robustness checks. Finally, Section VI offers concluding remarks with policy implications.

II. A Brief Overview of the Literature

This paper brings together two extensive strands of the literature: determinants of income inequality and the macroeconomic impact of climate change. The literature on income inequality spawns from the seminal paper by Kuznets (1955) who surmises that a country's income distribution becomes less egalitarian as its level of economic development increases, and that growth brings about more equality only after the level of income per capita reaches a certain threshold. This suggests an inverted U-shaped curve in income distribution, with economic growth resulting in relatively more inequality in the initial stages of development but greater equality at advanced stages. Greenwood and Jovanovic (1990), Banerjee and Newman (1993), Galor and Zeira (1993), Perotti (1993), and Barro (2000) find a positive correlation between growth and income inequality in a cross-section of international data. This hypothesis, however, is challenged by other studies. Adelman and Robinson (1989), Anand and Kanbur (1993), and Ravallion (1995), among others, show that there is no empirical support for Kuznets' conjecture.

Looking beyond the Kuznets curve, there is extensive evidence indicating that macroeconomic instability tends to depress income growth for the poor and, thereby, leads to greater income inequality (Datt and Ravallion, 1998; Ferreira *et al.*, 2007). Another intensely debated issue is the role of globalization, which has many dimensions including greater openness to foreign trade and investment. From a theoretical point of view, the impact of trade openness on income inequality depends on factor endowments—countries with higher (lower) levels of human capital experience increases (decreases) in inequality. In the empirical literature, however, some scholars, such as Dollar and Kraay (2004), argue that globalization benefits the poor, while others, such as Barro (2000), show that greater openness leads to an increase in inequality, especially in countries with higher income levels. Similarly, the relationship between foreign direct investment (FDI) and income inequality is extensively investigated and found to be positive. While Evans and Timberlake (1980) argue that dependence on FDI tends to exacerbate income inequality by altering the occupational structure of developing economies and producing both a highly-paid elite and large groups of marginalized workers, Alderson and Nielson (1999) show an inverted U-shaped relationship between income inequality and the stock of FDI per capita.

Financial development tends to affect income distribution by enhancing human capital accumulation, improving the access to capital for entrepreneurial activity, and changing the sectoral composition of employment (Beck and others, 2007; Demirguc-Kunt and Levine, 2009). Most of the empirical literature reaches the conclusion that financial development lowers income inequality in the long term (Galor and Zeira, 1993; Banerjee and Newman, 1993; Clarke and others, 2006), except at the very early stages of development (Greenwood and Jovanovic, 1990). However, because the distribution of capital income is significantly more unequal than the distribution of labor income, the concentration of wealth could worsen income inequality over time (Rajan and Zingales, 2003; McKenzie and Woodruff, 2006; Rajan, 2010).

The literature also focuses on the relationship between demographic and social characteristics and income inequality. Population growth is found to be critical, mainly through its effect on the demographic composition. First, while an increase in the supply of unskilled young workers may depress income growth (Alderson and Nielsen, 1999), an increase in the share of the population older than 65 years tends to worsen income inequality (Deaton and Paxson, 1997). Second, as pointed out by Kuznets (1955), the urbanization process becomes decisive, especially in the initial stage of economic development, because the evolution from an agrarian economy to industrialization leads to significant income disparities between and within rural and urban areas. Third, education forms a vital link between the pace and quality of growth and income distribution, although the relationship is not straightforward. Although cross-country studies indicate that a higher level of educational attainment brings about greater equality in the distribution of income, the type, quality, and distribution of education result in an intricate effect on income inequality, particularly in connection with skill-biased technological change (Barro, 2000; Checci, 2000).

Institutional factors and political regimes tend to influence the distribution of income within countries. Democratic systems, for example, are expected to be more equal than autocratic regimes, since democracy may enable income redistribution through various policy channels. Rodrik (1999) shows that countries with democratic governance are associated with greater income equality, while other studies find that authoritarian systems result in greater income inequality (Muller, 1988; Burkhart, 1997). Similarly, Gradstein and Milanovic (2004) conclude that the process of democratization leads to greater income redistribution and hence lower income inequality. However, the literature is not conclusive on this issue. There are studies that find a positive relationship between democracy and income inequality (Huber, 2005) as well as between the process of democratization and income inequality in a panel of OECD countries (Dreher and Gaston, 2008). While democratization can facilitate income redistribution, economic liberalization and the emergence of the private sector may result in greater income inequality by altering the sectoral composition of economic activity and changing the returns to capital and skills. In particular, a number of studies finds that privatization during transition from central planning to market economy worsens income inequality (Bandelj and Mahutga, 2010; Grimalda and others, 2010; Cevik and Correa-Caro, 2020b).

The literature has also focused on the role of fiscal policy in shaping income distribution. As shown by the large variation in net income inequality across countries, fiscal policy can influence income distribution through the level and progressivity of taxation and expenditure policies (Musgrave, 1959; Feenberg and Poterba 1993; Auten and Carroll 1999; Benabou 2000; Muinelo-Gallo and Roca-Sagales 2011; Woo and others, 2017). Well-targeted public spending can improve income distribution by providing greater equality of access to education and health care, thereby redistributing ownership of the factors of production. Taxation plays an important role in attaining greater equity in the distribution of income through the progressivity of the tax system and by generating sufficient revenues to fund public spending on social programs. Although Bird and Zolt (2005) present that taxation, especially of the top earning bracket, as an obstacle to growth and an ineffective tool for fiscal redistribution, Bastagli *et al*. (2012) show that direct income taxes and cash transfer schemes reduced the average Gini coefficient by about one-third in Organization for Economic Co-operation and Development (OECD) countries during the period 1985–2005. Cevik and Correa-Caro (2020a; 2020b) show that the redistributive impact of fiscal policy is statistically insignificant and taxation and government spending appear to have the opposing effects on income inequality in emerging market economies.

There is a growing literature on economic and financial effects of climate change.[5] Starting with Nordhaus (1991; 1992) and Cline (1992), aggregate damage functions have become a mainstay of analyzing the climate-economy nexus. Although identifying the impact of annual variation in climatic conditions remains a challenging empirical task, Gallup, Sachs, and Mellinger (1999), Nordhaus (2006), and Dell, Jones, and Olken (2012) find that higher temperatures result in a significant reduction in economic growth in developing countries. Burke, Hsiang, and Miguel (2015) confirm this finding and conclude that an increase in temperature would have a greater damage in countries that are concentrated in geographic areas with hotter climates. Using expanded datasets, Acevedo and others (2018), Burke and Tanutama (2019) and Kahn and others (2019) show that the long-term macroeconomic impact of weather anomalies is uneven across countries and that economic growth responds nonlinearly to temperature. In a related vein, it is widely documented that climate change by increasing the frequency and severity of natural disasters affects economic development (Loyaza *et al*., 2012; Noy, 2009; Raddatz, 2009; Skidmore and Toya, 2002; Rasmussen, 2004), reduces the accumulation of human capital (Cuaresma, 2010) and worsens a country´s trade balance (Gassebner, Keck, and Teh, 2010).

More recently, Cevik and Jalles (2020; 2021; 2022) show that climate change has significant effects on government bond yields and spreads, the probability of sovereign debt default, especially in developing countries, and sovereign credit ratings. In a similar vein, Bansal *et al*. (2016) and IMF (2020) find that the risk of climate change—as proxied by temperature rises—has a negative effect on asset valuations, while Bernstein and others (2019) show that real estate

[5] Tol (2018) provides a recent overview of this expanding literature.

exposed to the physical risk of sea level rise sell at a discount relative to otherwise similar unexposed properties. Likewise, focusing on the U.S., Painter (2020) find that counties more likely to be affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds compared to counties unlikely to be affected by climate change.

Few studies, however, look at the empirical relationship between climate change and income inequality. Analyzing the impact of climate change on income distribution across countries, Tol *et al*. (2004) and Diffenbaugh and Burke (2019) find that low-income countries tend to become poorer due to geographical and institutional constraints to adapt. With regards to the impact of climate change on income disparities within countries, Islam and Winkel (2017) characterize the relationship as a vicious cycle, whereby initial inequality causes disadvantaged households to experience a disproportionate burden of the adverse effects of climate change, resulting in greater subsequent inequality in income distribution.

III. Data Overview

The empirical analysis covers a large set of 158 countries over the period 1995–2019, utilizing an unbalanced panel dataset of annual observations.[6] The data on income equality as measured by the Gini index is drawn from the Standardized World Income Inequality Database (Solt, 2009; 2020).[7] The SWIID dataset provides standardized Gini coefficients to measure income inequality according to market and net outcomes, and thus allows the comparison of income disparities before and after redistribution by taxation and transfers over time. We use both the market and net income Gini indices, with high coverage across countries and over time, in the estimations.[8]

The main explanatory variables of interest are climate change vulnerability and resilience as measured by the ND-GAIN indices, which capture a country's overall susceptibility to climate-related disruptions and capacity to deal with the consequences of climate change, respectively.[9] The composite indices are based on 45 indicators, of which 36 variables contributing to the vulnerability score and 9 variables constituting the resilience score. Vulnerability refers to "a country's exposure, sensitivity, and capacity to adapt to the impacts of climate change" and comprise indicators of six life-supporting sectors—food, water, health, ecosystem services, human habitat and infrastructure. Since the ND-GAIN climate vulnerability index tends to be correlated with macroeconomic variables, such as real GDP per capita, we use a version of the index adjusted for the level of income. This GDP-adjusted climate vulnerability index is calculated

[6] The list of countries is presented in Appendix Table A1.

[7] We use the v9.1 version of the SWIID dataset, which is available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/LM4OWF

[8] There are some concerns over the reliability of SWIID's imputed estimates in data-poor regions (Ferreira *et al*., 2015; Jenkins, 2015), but it is based on the Luxembourg Income Study (LIS) and continues to be the most comprehensive dataset int terms of country coverage and time dimension.

[9] Chen *et al*. (2015) provides a detailed presentation of the methodology and data sources for the ND-GAIN database, which is available at https://gain.nd.edu/. In Appendix Table A2, we present a summary of the composition of the ND-GAIN climate vulnerability and resilience indices,

by subtracting a country's measured climate vulnerability from its expected value based on the regression of climate vulnerability and real GDP.[10] As a result, the correlation between the GDP-adjusted climate vulnerability index and real GDP per capita becomes statistically insignificant.

The ND-GAIN climate resilience index, on the other hand, assesses capacity for adaptation and covers three areas—economic, governance and social readiness—with nine indicators.[11] Although we also use the GDP-adjusted climate resilience index, it is important to acknowledge that the ND-GAIN climate resilience index incorporates governance and social indicators that are not directly related to climate change. Therefore, we present estimations including the resilience index as a point of reference in the empirical analysis, not for causal inference.

Figure 2 shows the time profile between 1995 and 2019 and box-whisker plots for both the climate vulnerability and resilience indices for the entire sample and income group, respectively. The ND-GAIN indices show considerable deterioration in climate vulnerability and resilience in recent years, with significant heterogeneity across countries. For example, while the mean value of climate resilience is 0.44 over the sample period, it varies between a minimum of 0.24 and a maximum of 0.70. Climate resilience exhibits even greater variation between a minimum of 0.12 and a maximum of 0.81, with a mean value of 40.7 over the period 1995–2019. It is also clear from the data that advanced economies are much less vulnerable to climate change than developing countries. This is also true when we focus on climate resilience, in which emerging market economies and low-income countries score significantly worse than advanced economies. It is important to highlight that the time-series variation in the ND-GAIN indices reflect the changes in countries' levels of vulnerability and resilience (which are not necessarily forward-looking), not from the changes in the projected vulnerability and resilience to physical risks associated with climate change.

Aggregate pictures, however, hide marked heterogeneity across countries that should not go unnoticed. Figure 3a compares climate vulnerability in 1995 with that in 2019. We can see that Canada, Australia, some parts of South America and Asia improved the situation, while Sub-Saharan Africa remained relatively unchanged over the past two decades. In Figure 3b, we do the same for climate resilience. It is interesting to observe a slight deterioration in the case of the U.S. and in some countries in Sub-Saharan Africa, but improvements in Europe, Russia and other parts of Southeast Asia as well as South America.

We include conventional determinants of income inequality as control variables: real GDP per capita, real GDP growth, consumer price inflation, unemployment rate, terms-of-trade index, trade openness, financial development, population, age dependency, corruption, which are assembled

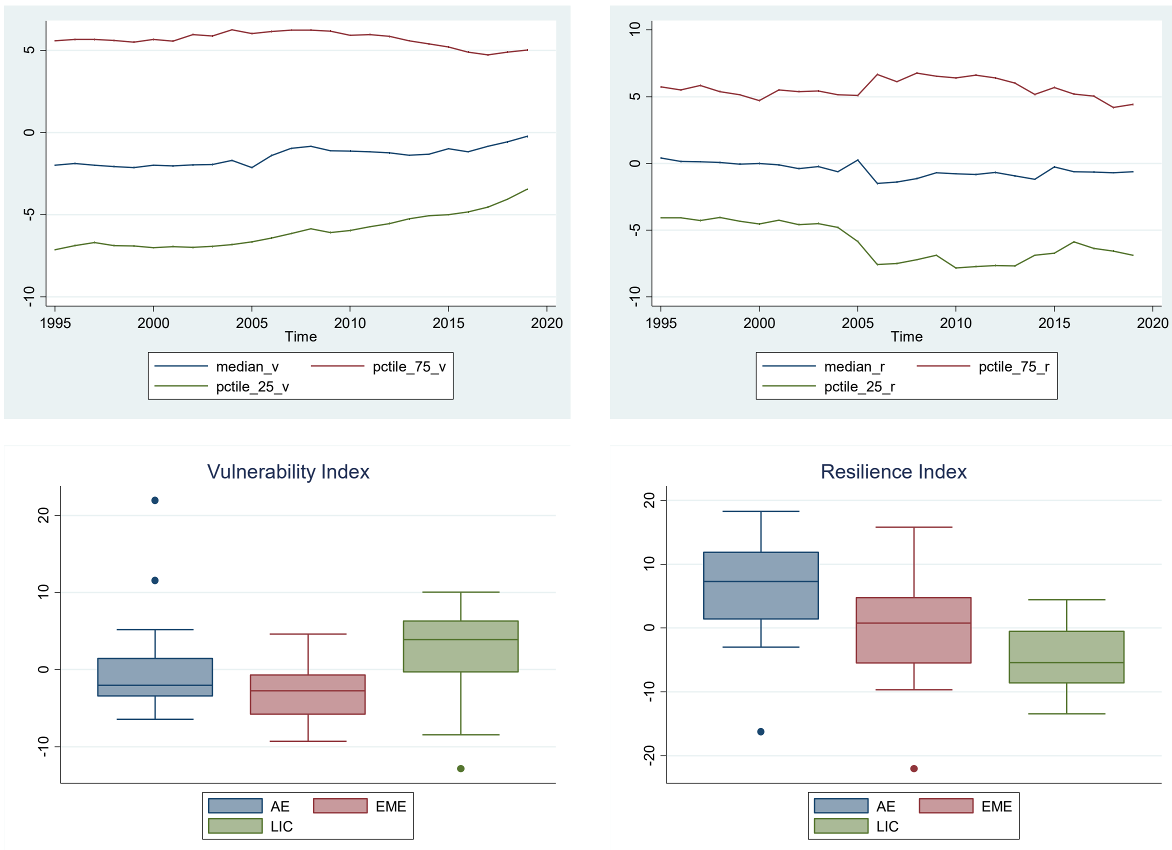
[10] Positive values reflect lower vulnerability than expected, given certain level of GDP per capita. For ease of interpretation with multiplied the GDP-adjusted vulnerability index by -1, so that higher values correspond to higher vulnerability.

[11] The ND-GAIN database refers to this series as "readiness" for climate change, which we use as a measure of resilience against climate change. In this context, it should also be noted that the ND-GAIN indices do not reflect fiscal insurance schemes for natural disasters that may occur due to climate change.

from the IMF's International Financial Statistics (IFS) and World Economic Outlook (WEO) databases, and the World Bank's World Development Indicators (WDI) database. There is a significant degree of dispersion across countries in terms of climate vulnerability and resilience as well as macroeconomic performance, as presented in Appendix Table A3.

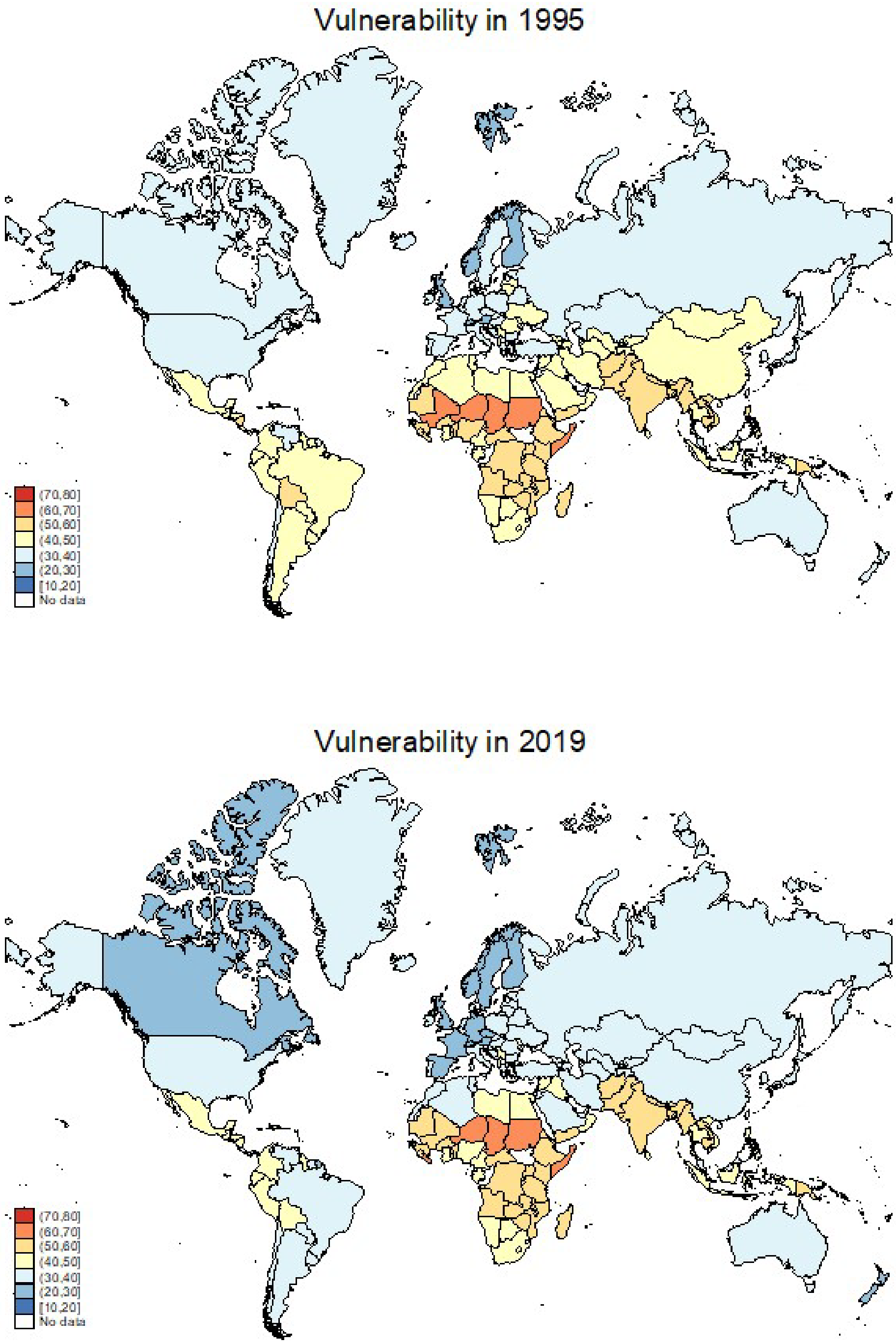
Figure 2. Climate Change Vulnerability and Resilience

Climate Vulnerability | **Climate Resilience**



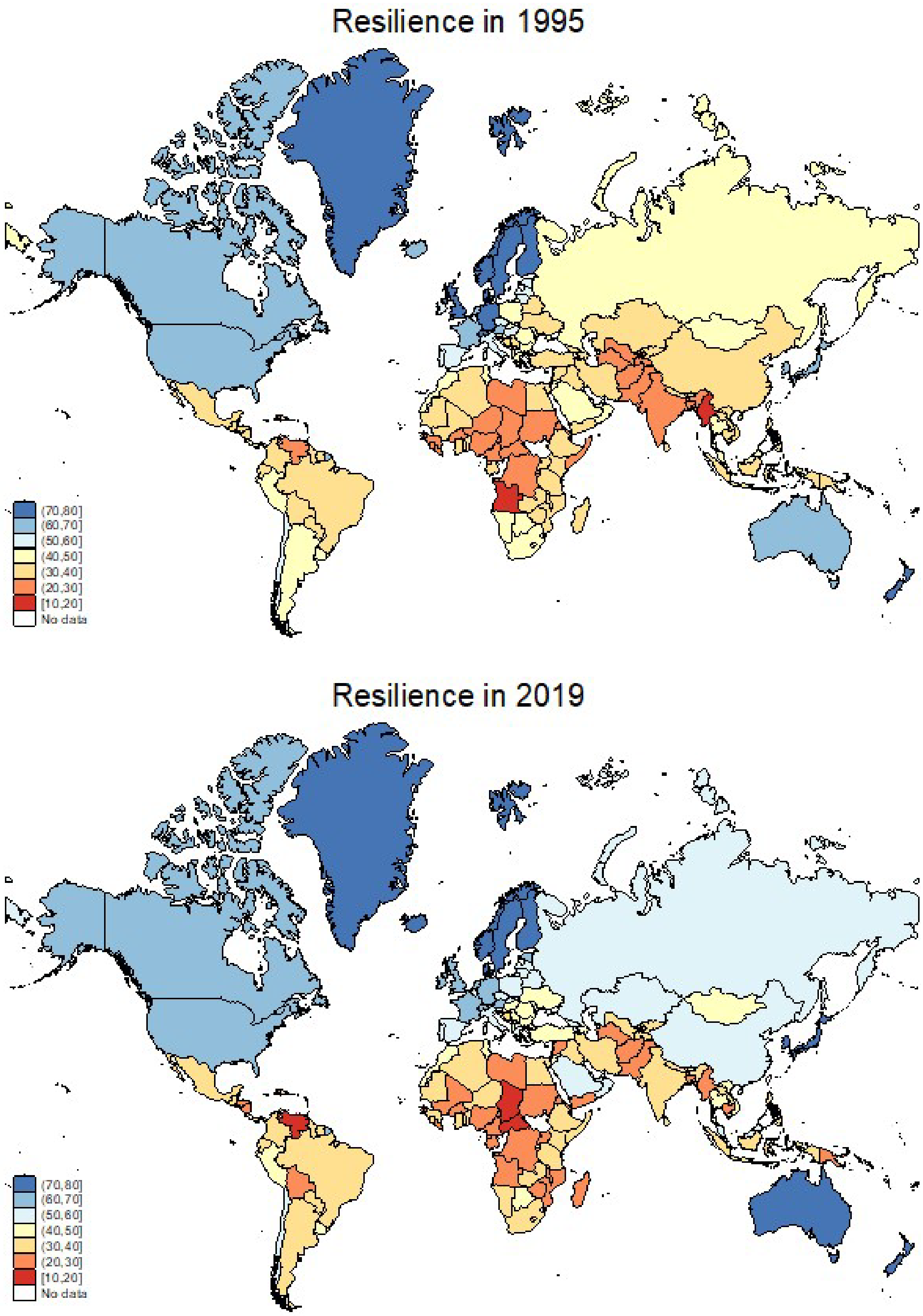
Source: ND-GAIN; authors' calculations. This figure presents the climate vulnerability and resilience indices that are adjusted for the level of real GDP per capita.

Figure 3a. Climate Vulnerability Across the World in 1995 vs. 2019



Note: color scheme for less (blue) to more vulnerable to climate change (red).
Source: ND-GAIN; authors' calculation. This figure presents the climate vulnerability index that is not adjusted for the level of real GDP per capita.

Figure 3b. Climate Resilience Across the World in 1995 vs. 2019



Note: color scheme for less (red) to more resilient to climate change (blue).

Source: ND-GAIN; authors' calculations. This figure presents the climate resilience index that is not adjusted for the level of real GDP per capita.

IV. EMPRICAL METHODOLOGY AND RESULTS

Drawing on the existing literature, we explore the empirical relationship between climate change and income inequality, while controlling for conventional determinants of income disparities, in a panel setting according to the following baseline regression model:

$$Gini_{it} = \beta Climate_{it} + \gamma X_{i,t} + +\eta_i + \mu_t + \varepsilon_{it} \quad (1)$$

where $Gini_{it}$ denotes income inequality as measured by alternative Gini coefficients; $Climate_{it}$ represents the measures of climate vulnerability and resilience; X_{it} is a vector of control variables including real GDP per capita, real GDP growth, consumer price inflation, terms-of-trade index, trade openness, age dependency, population, and population density, the quality of institutions. The η_i and μ_t coefficients denote the time-invariant country-specific effects and the time effects controlling for common shocks that may affect inequality across all countries in a given year, respectively. $\varepsilon_{i,t}$ is an error term. To account for possible heteroskedasticity, robust standard errors are clustered at the country level.

We then move on to a dynamic modelling exercise and estimate a panel VAR model to analyze the response of income inequality to climate shocks controlling for real GDP growth and consumer price inflation. This approach allows us to take into consideration country-level heterogeneity in estimating the evolution of income disparities and also has an important advantage over standard panel models in that all variables are assumed to endogenous and interdependent. Accordingly, a first-order VAR model is defined in the following form:

$$Y_{i,t} = \Gamma_0 + \Gamma(L)Y_{i,t} + v_i + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ is a vector of endogenous variables, Γ_0 is a vector of constants, $\Gamma(L)$ is a matrix polynomial in the lag operator, v_i is a matrix of country-specific fixed effects and $\varepsilon_{i,t}$ is a vector of error terms. The correlation between fixed effects and regressors due to lags of the dependent variables implies that the mean-differencing procedure creates biased coefficients (Holtz-Eakin *et al.*, 1988). This drawback is solved using the Helmert transformation[12] and estimating a system in first differences by GMM using the lags of the regressors as instruments. With regards to impulse-response functions (IRFs), given that the variance-covariance matrix of the error terms may not be diagonal, we follow the Cholesky decomposition and plot IRFs with 90 percent confidence bands.

Table 1 presents our baseline estimation results of equation (1), where the dependent variable is the Gini coefficient and the static fixed-effects model is estimated for the full sample of countries during the period 1995–2019. There is a consistent relationship between climate change and measures of income inequality across all specifications. First, an increase in climate vulnerability is associated with a statistically significant deterioration in income inequality. The coefficient of climate vulnerability is positive at the 1 percent level of significance, thereby implying that an

[12] This is a forward mean-differencing approach that removes only the mean of all future observations available for each country-year. In our model, the number of regressors is equal to the number of instruments.

increase in climate vulnerability leads to an increase in income inequality. This effect is even stronger when income disparities are gauged by the net Gini coefficient after redistribution by taxation and transfers, which is the most preferred measure of income inequality in the literature as it takes into account the impact of fiscal policies. Accordingly, a one percentage point increase in climate vulnerability is associated with a deterioration of 1.5 percent in income inequality. Second, an increase in climate resilience is related to an improvement in income distribution, but this effect is significant only for the gross Gini coefficient, after controlling for common factors. This finding is not surprising, in our view, given that the ND-GAIN resilience index incorporates some institutional and social variables that we account for in the regression models. All in all, these results strongly support that climate vulnerability is closely associated with rising income inequality within our sample of countries during the period 1995–2019.

Table 1. Climate Change and Income Inequality—Baseline Results

Specification	(1)	(2)	(3)	(4)
Dep.Var	Gross Gini	Net Gini	Gross Gini	Net Gini
Ln(vulnerability) (t-1)			0.012***	0.015***
			(0.003)	(0.004)
Ln(resilience) (t-1)	-0.003***	-0.002		
	(0.001)	(0.001)		
Ln(rgdppc) (t-1)	-0.028***	-0.008	0.030***	0.027***
	(0.011)	(0.012)	(0.009)	(0.009)
growth (t-1)	-0.008	0.033	0.003	0.005
	(0.026)	(0.031)	(0.019)	(0.018)
inflation (t-1)	-0.005	-0.002	-0.000	0.001
	(0.010)	(0.012)	(0.004)	(0.003)
trade (t-1)	0.005	0.012*	-0.001	0.000
	(0.005)	(0.007)	(0.003)	(0.004)
Ln(tot) (t-1)	-0.042***	-0.041***	-0.005	-0.008*
	(0.005)	(0.006)	(0.004)	(0.004)
age_ratio (t-1)	0.127***	0.172***	0.011	0.025
	(0.028)	(0.035)	(0.023)	(0.021)
Ln(pop) (t-1)	-0.529***	-0.703***	-0.001	-0.210*
	(0.131)	(0.156)	(0.094)	(0.127)
Ln(pop_den) (t-1)	0.488***	0.689***	-0.008	0.203
	(0.135)	(0.161)	(0.096)	(0.128)
Fixed effects	Yes	Yes	Yes	Yes
Observations	1,241	1,241	874	874
R-squared	0.975	0.987	0.986	0.989

Note: The dependent variable is income inequality as measured by gross and net Gini coefficient and identified in the second row. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively. A constant is included in each regression, but not shown in the table. Robust standard errors are reported in parenthesis.

We divide the full sample of countries into income groups—advanced and developing—and document these results in Table 2. This disaggregation reveals a striking contrast in the impact of climate change on income inequality in economies with differing levels of economic development. While climate vulnerability has no statistically significant effect on income distribution in advanced economies, its impact is statistically and economically significant in the case of developing countries. With net income inequality as the dependent variable, the coefficient on climate vulnerability is seven times greater and statistically significant at the 1 percent level for the sample of developing countries due largely to weaker capacity to adapt to and mitigate the consequences of climate change. This might also reflect low variation of climate vulnerability among advanced countries compared to developing countries over the sample period, but it also indicates that the impact of future climate change will likely be much greater in developing countries even as advanced economies become more vulnerable too. We also estimate the models using the subcomponents of climate vulnerability and resilience indices to attain a more nuanced picture, which is presented in Appendix Tables A4 and A5 for gross and net Gini coefficients respectively.

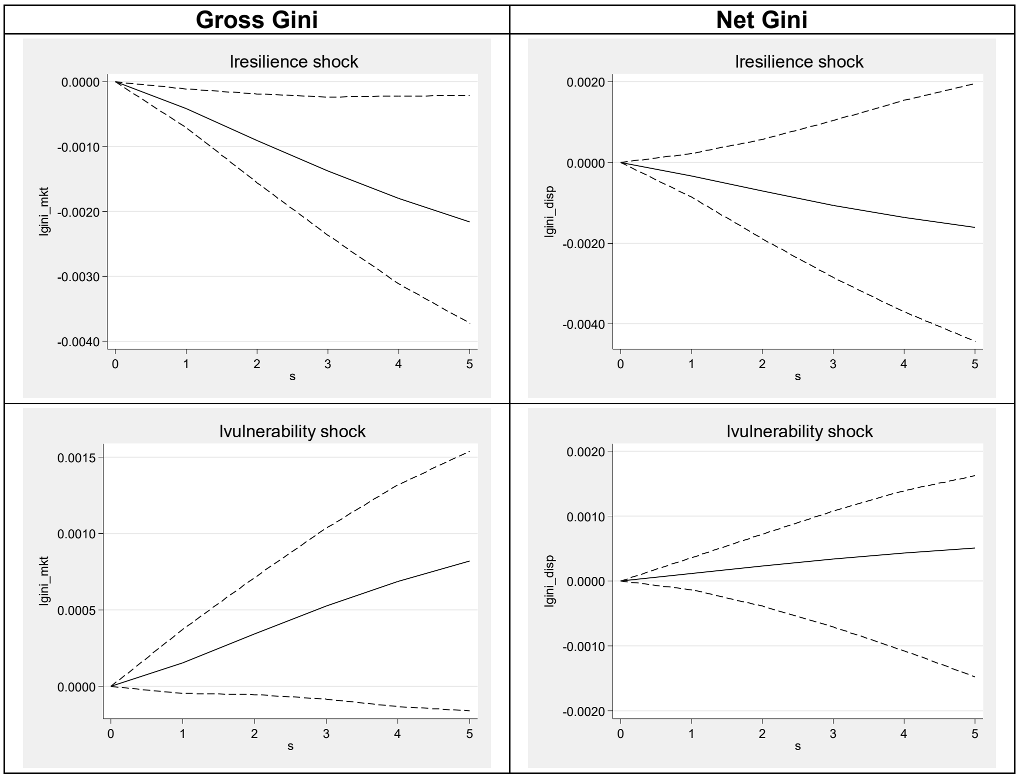
Table 2. Climate Change and Income Inequality—Country Groups

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep.Var	Gross Gini	Net Gini	Gross Gini	Net Gini	Gross Gini	Net Gini	Gross Gini	Net Gini
Income group	Advanced				Developing			
Ln(vulnerability) (t-1)			0.002	0.002			0.011***	0.014***
			(0.002)	(0.002)			(0.004)	(0.004)
Ln(resilience) (t-1)	-0.005**	-0.003			-0.000	0.000		
	(0.002)	(0.002)			(0.001)	(0.001)		
Ln(rgdppc) (t-1)	-0.064***	-0.026	-0.033	-0.061	0.027*	0.044**	0.040***	0.039***
	(0.017)	(0.018)	(0.042)	(0.063)	(0.014)	(0.017)	(0.010)	(0.010)
growth (t-1)	0.027	0.130***	0.056*	0.056	-0.029	-0.040	-0.003	-0.007
	(0.037)	(0.046)	(0.032)	(0.038)	(0.034)	(0.040)	(0.021)	(0.019)
inflation (t-1)	0.038	0.056	-0.072	0.249*	-0.021	-0.019	0.001	0.003
	(0.074)	(0.082)	(0.120)	(0.149)	(0.016)	(0.018)	(0.004)	(0.003)
trade (t-1)	-0.018***	-0.028***	0.014**	0.004	0.024***	0.048***	-0.009**	-0.009**
	(0.007)	(0.008)	(0.007)	(0.009)	(0.007)	(0.010)	(0.004)	(0.004)
Ln(tot) (t-1)	-0.033***	-0.016	0.081	0.067	-0.032***	-0.040***	-0.004	-0.007*
	(0.009)	(0.011)	(0.052)	(0.095)	(0.005)	(0.008)	(0.004)	(0.004)
age_ratio (t-1)	0.139*	0.170*	0.068	0.229	-0.037	0.040	-0.009	0.002
	(0.076)	(0.087)	(0.312)	(0.476)	(0.029)	(0.037)	(0.022)	(0.021)
Ln(pop) (t-1)	-0.553***	-0.769***	-1.679*	-3.085**	0.561*	0.711*	0.364***	0.348***
	(0.161)	(0.184)	(0.882)	(1.329)	(0.296)	(0.422)	(0.112)	(0.119)
Ln(pop_den) (t-1)	0.429**	0.670***	1.766*	3.437**	-0.574*	-0.701*	-0.369***	-0.354***
	(0.171)	(0.194)	(1.054)	(1.633)	(0.293)	(0.419)	(0.112)	(0.118)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	561	561	59	59	680	680	815	815
R-squared	0.962	0.975	0.997	0.999	0.983	0.984	0.986	0.986

Note: The dependent variable is income inequality as measured by gross and net Gini coefficient and identified in the second row. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively. A constant is included in each regression, but not shown in the table. Robust standard errors are reported in parenthesis.

Regression models are indicative but also limited at the same time. We complement our previous analysis by using a panel VAR approach, which allows not only for examining the correlation between climate change and income inequality, but also exploring the dynamic relationship between these variables over time. The estimated panel VAR is used to simulate orthogonalized IRFs to a one-standard deviation shock to measures of climate change. In Figure 4, the cumulative IRFs from a one standard deviation shock, together with their 90 percent confidence bands, display the impact of climate change (vulnerability and resilience) shocks, while controlling for economic growth and inflation. These dynamic effects on income inequality as measured by gross and net Gini coefficients follow similar patterns observed in the static regression analysis. A one standard deviation shock to climate vulnerability (or resilience) leads to an immediate increase (decline) in income inequality and the observed positive effect continues to grow in magnitude over time.

Figure 4. Panel VAR IRFs



Note: IRF displayed in solid black line. 90 percent confidence bands are shown as discontinued black lines.

V. CONCLUSION

Climate change has become an existential threat to the world economy like no other, with complex and evolving dynamics that remain a source of great uncertainty. There is a growing body of literature on the economic consequences of climate change, but research on the link between climate change and income inequality remains limited. Building on our previous contributions, this paper aims to fill another gap in the literature by focusing in the impact of climate change on income distribution in a large set of 158 countries over the period 1995–2019.

Empirical results show that climate change vulnerability has adverse effects on income inequality, after controlling for conventional economic and demographic factors. An increase of one percentage point in climate vulnerability leads to an increase of 1.5 percent in income inequality. Furthermore, we split the sample into country groups and detect a considerable contrast in how climate change affects income inequality. While climate vulnerability has no statistically significant effect on the distribution of income in advanced economies, the coefficient on climate vulnerability is seven times greater and statistically highly significant in developing countries, which tend to have weaker capacity to adapt to and mitigate the consequences of climate change. On the other hand, an increase in climate resilience is associated with lower income inequality but this effect is not statistically significant at conventional levels when income inequality measured by the net Gini coefficient.

Our econometric findings have direct policy implications, especially for developing countries that are relatively more vulnerable to risks associated with climate change. While climate change is already an inevitable reality, the positive (and negative) coefficient on climate vulnerability (and resilience) shows that even most vulnerable countries can address the threat climate change poses to income distribution by (i) implementing inclusive development policies that are consistent with climate mitigation and adaptation objectives; (ii) improving social safety nets and access to healthcare that increase the poor's ability to cope with climate shocks[13]; (iii) enhancing physical resilience through smart infrastructure investments; (iv) strengthening financial resilience with better insurance and financial products; and (v) expanding the economy's production frontier through reforms designed for higher productivity growth and greater economic diversification.

The impact on income inequality should be explicitly take into account in the design of climate change mitigation and adaption policies. Using traditional cost-benefit calculations to select investments for climate change adaption, for example, is likely to favor the wealthy at the expense of the poor. That is because the poor tend to live in marginalized regions and neighborhoods that are more vulnerable to the consequences of climate change. Likewise, climate change mitigation policies, such as the introduction of a carbon tax and the removal of fossil-fuel subsidies, should be designed for equitably and compensate poor households for energy price increases through direct cash transfers. Therefore, only an explicit consideration of income inequality in policymaking would protect the most vulnerable segments of the population and help address discrepancies in a fair manner.

[13] For example, governments can provide well-targeted cash transfers assistance to the most vulnerable segments of the society when natural disasters occur.

Appendix Table A1. List of Countries

Africa: South Africa, Angola, Botswana, Burundi, Cameroon, Cabo Verde, Central African Republic, Chad, Comoros, Congo, Rep., Congo, Dem. Rep., Benin, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, The, Ghana, Guinea-Bissau, Guinea, Cote d'Ivoire, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Niger, Nigeria, Zimbabwe, Rwanda, Sao Tome and Principe, Seychelles, Senegal, Sierra Leone, Namibia, Eswatini, Tanzania, Togo, Uganda, Burkina Faso, Zambia

Americas: United States, Canada, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela, RB, Antigua and Barbuda, Bahamas, The, Barbados, Dominica, Grenada, Guyana, , Belize, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the , Grenadines, Suriname, Trinidad and Tobago

Asia: Bangladesh ,Bhutan, Brunei Darussalam, Myanmar, Cambodia, Sri Lanka, India, Indonesia, Timor-Leste, Lao PDR, Malaysia, Maldives, Nepal, Palau, Philippines, Thailand, Vietnam, Solomon , Islands, Fiji, Kiribati, Vanuatu, Papua New Guinea, Samoa, Tonga, Marshall Islands, Micronesia, Tuvalu, China, Mongolia

Europe: United Kingdom, Austria, Belgium, Denmark, France, Germany, San Marino, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Finland, Greece, Iceland, Ireland, Malta, Portugal, Spain, Turkey, Cyprus, Israel, Belarus, Albania, Bulgaria, , Moldova, Russian Federation, Ukraine, Czech Republic, Slovak Republic, Estonia, Latvia, Serbia, Montenegro, Hungary, Lithuania, Croatia, Slovenia, North Macedonia, Bosnia and Herzegovina, , Poland, Romania

Middle East and Central Asia: Bahrain, Iran, Islamic Rep., Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Egypt, Arab Rep., Yemen, Rep., Afghanistan, Pakistan, Djibouti, Algeria, Libya, Mauritania, Morocco, Sudan, Tunisia, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan

Appendix Table A2. Components of ND-GAIN Indices

Climate Vulnerability

The climate vulnerability index measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change by considering six life-supporting sectors: food, water, health, ecosystem service, human habitat, and infrastructure.

> *Exposure:* Degree to which a system is exposed to significant climate change from a biophysical perspective. It is a component of vulnerability independent of socio economic context. Exposure indicators are projected impacts for the coming decades and are therefore invariant overtime in ND-GAIN.
>
> *Sensitivity:* Extent to which a country is dependent upon a sector negatively affected by climate hazard, or the proportion of the population particularly susceptible to a climate change hazard. A country's sensitivity can vary over time.
>
> *Adaptive capacity:* Availability of social resources for sector-specific adaptation. In some cases, these capacities reflect sustainable adaptation solutions. In other cases, they reflect capacities to put newer, more sustainable adaptations into place. Adaptive capacity also varies over time.

Climate Resilience

The climate reslience index measures a country’s ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall readiness by considering three components: economic readiness, governance readiness, and social readiness.

> *Economic:* Captures the ability of a country's business environment to accept investment that could be applied to adaptation that reduces vulnerability (reduces sensitivity and improves adaptive capacity).
>
> *Governance:* Captures the institutional factors that enhance application of investment for adaptation.
>
> *Social:* Captures the factors such as social inequality, ICT infrastructure, education and innovation that enhance the mobility of investment and promote adaptation actions.

Appendix Table A3. Summary Statistics

Variable	Obs.	Mean	Std.Dev	Min.	Max.
Gini_market (gross)	3210	45.80	6.32	22.4	70.1
Gini_disposable (net)	3210	38.86	8.34	21.8	66.4
Climate Resilience	4500	0.40	0.13	0.12	0.81
Climate Vulnerability	4500	0.44	0.09	0.24	0.70
Ln(Real GDP per capita)	4352	8.42	1.43	5.33	11.56
Real GDP growth	4175	0.037	0.05	-0.96	0.92
Inflation	4117	0.10	0.82	-0.18	41.45
Trade	4116	0.85	0.49	0.0002	4.37
Ln(terms-of-trade)	3968	4.69	0.28	3.06	6.12
Age dependency ratio	4442	0.63	0.19	0.157	1.15
Ln(population)	4492	15.71	1.93	10.64	21.05
Ln(population density)	4495	4.11	1.37	0.39	8.99

Table A4. Climate Vulnerability and Resilience and Income Inequality (Market)—Decomposing by Sector

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. Var.	Resilience by sector			Vulnerability by sector					
Regressors	Economic	Governance	Social	Ecosystems	Food	Habitat	Health	Infrastructure	Water
Ln(rgdppc) (t-1)	0.001	-0.009	0.006	0.000	0.001	-0.002	0.001	0.005	0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
growth (t-1)	-0.013	-0.014	-0.014	-0.014	-0.012	-0.017	-0.012	-0.007	-0.019
	(0.016)	(0.015)	(0.015)	(0.017)	(0.016)	(0.017)	(0.016)	(0.019)	(0.017)
inflation (t-1)	-0.004	0.006	-0.011***	-0.004	-0.004	-0.007	-0.004	-0.004	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
trade (t-1)	0.012***	0.012***	0.016***	0.013***	0.012***	0.013***	0.012***	0.017***	0.012***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Ln(tot) (t-1)	-0.025***	-0.026***	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***	-0.023***	-0.025***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
age_ratio (t-1)	0.199***	0.196***	0.136***	0.200***	0.200***	0.157***	0.199***	0.237***	0.199***
	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)	(0.020)	(0.019)	(0.022)	(0.020)
Ln(pop) (t-1)	-0.019	-0.049	-0.008	-0.036	-0.021	0.011	-0.029	0.015	-0.025
	(0.170)	(0.165)	(0.151)	(0.170)	(0.169)	(0.165)	(0.171)	(0.166)	(0.166)
Ln(pop_den) (t-1)	0.031	0.065	0.010	0.047	0.032	-0.001	0.041	0.024	0.028
	(0.171)	(0.166)	(0.152)	(0.171)	(0.170)	(0.166)	(0.172)	(0.167)	(0.167)
Ln(resilience_econ) (t-1)	0.002								
	(0.003)								
Ln(resilience_gov) (t-1)		0.037***							
		(0.008)							
Ln(resilience_soc) (t-1)			-0.077***						
			(0.008)						
Ln(vulnerability_ecosystems) (t-1)				-0.047					
				(0.031)					
Ln(vulnerability_food) (t-1)					0.006				
					(0.011)				
Ln(vulnerability_habitat (t-1)						0.127***			
						(0.012)			
Ln(vulnerability_health) (t-1)							-0.007		
							(0.005)		
Ln(vulnerability_infrastructure) (t-1)								0.095***	
								(0.018)	
Ln(vulnerability_water) (t-1)									0.083***
									(0.022)
Observations	2,348	2,322	2,339	2,327	2,348	2,348	2,348	2,037	2,249
R-squared	0.975	0.976	0.977	0.975	0.975	0.976	0.975	0.977	0.975

Table A5. Climate Vulnerability and Resilience and Income Inequality (Disposable)—Decomposing by Sector

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. Var.	Resilience by sector			Vulnerability by sector					
Regressors	Economic	Governance	Social	ecosystems	Food	Habitat	Health	Infrastructure	Water
Ln(rgdppc) (t-1)	0.014*	0.002	0.019**	0.012	0.015**	0.009	0.013*	0.018**	0.017**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.009)	(0.008)
growth (t-1)	0.014	0.013	0.013	0.013	0.018	0.007	0.014	0.026	0.008
	(0.018)	(0.017)	(0.016)	(0.018)	(0.018)	(0.018)	(0.018)	(0.021)	(0.018)
inflation (t-1)	0.003	0.013***	-0.006	0.003	0.002	-0.002	0.002	0.004	0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
trade (t-1)	0.013***	0.012***	0.017***	0.013***	0.013***	0.014***	0.013***	0.018***	0.013***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
Ln(tot) (t-1)	-0.027***	-0.029***	-0.027***	-0.027***	-0.027***	-0.028***	-0.027***	-0.025***	-0.028***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
age_ratio (t-1)	0.235***	0.229***	0.159***	0.232***	0.232***	0.171***	0.233***	0.281***	0.236***
	(0.021)	(0.021)	(0.020)	(0.022)	(0.021)	(0.022)	(0.021)	(0.026)	(0.022)
Ln(pop) (t-1)	-0.058	-0.088	-0.041	-0.079	-0.054	-0.009	-0.060	-0.019	-0.060
	(0.213)	(0.208)	(0.190)	(0.213)	(0.209)	(0.206)	(0.214)	(0.212)	(0.210)
Ln(pop_den) (t-1)	0.084	0.121	0.058	0.108	0.083	0.037	0.088	0.072	0.083
	(0.214)	(0.209)	(0.191)	(0.214)	(0.211)	(0.207)	(0.215)	(0.214)	(0.211)
Ln(resilience_econ) (t-1)	-0.001								
	(0.003)								
Ln(resilience_gov) (t-1)		0.042***							
		(0.008)							
Ln(resilience_soc) (t-1)			-0.089***						
			(0.009)						
Ln(vulnerability_ecosystems) (t-1)				-0.074**					
				(0.035)					
Ln(vulnerability_food) (t-1)					0.037***				
					(0.012)				
Ln(vulnerability_habitat (t-1)						0.184***			
						(0.027)			
Ln(vulnerability_health) (t-1)							-0.003		
							(0.006)		
Ln(vulnerability_infrastructure) (t-1)								0.098***	
								(0.021)	
Ln(vulnerability_water) (t-1)									0.068***
									(0.026)
Observations	2,348	2,322	2,339	2,327	2,348	2,348	2,348	2,037	2,249
R-squared	0.987	0.988	0.988	0.987	0.987	0.988	0.987	0.987	0.987

REFERENCES

Acevedo, S., M. Mrkaic, N. Novta, E. Pugacheva, and P. Topalova (2018) "The Effects of Weather Shocks on Economic Activity: What Are the Channels of Impact?" IMF Working Paper No. 18/144 (Washington, DC: International Monetary Fund).

Adelman, I., and S. Robinson (1989) "Income Distribution and Development," in *Handbook of Development Economics*, edited by H. Chenery and T. Srinivasan (Amsterdam: North-Holland).

Alderson, A., and F. Nielsen (1999) "Income Inequality, Development, and Dependence," *American Sociological Review*, Vol. 64, pp. 606–631.

Anand, S., and S. Kanbur (1993) "Inequality and Development: A Critique," *Journal of Development Economics*, Vol. 41, pp. 19–43.

Auten, G., and R. Carroll (1999) "The Effects of Income Taxes on Household Income," *Review of Economics and Statistics*, Vol. 81, pp. 681–693.

Banerjee, A., and A. Newman (1993) "Occupational Choice and the Process of Development," *Journal of Political Economy*, Vol. 101, pp. 274–298.

Barro, R. (2000) "Inequality and Growth in a Panel of Countries," *Journal of Economic Growth*, Vol. 5, pp. 5–32.

Bandelj, N., and M. Mahutga (2010) "How Socioeconomic Changes Shape Income Inequality in Post-Socialist Europe," *Social Forces*, Vol. 88, pp. 2133–2161.

Bansal, R., D. Kiku, and M. Ochoa (2016) "Price of Long-Run Temperature Shifts in Capital Markets," NBER Working Paper No. 22529 (Cambridge, MA: National Bureau of Economic Research).

Bastagli, F., D. Coady, and S. Gupta (2012) "Income Inequality and Fiscal Policy," IMF Staff Discussion Note No. 12/08 (Washington, DC: International Monetary Fund).

Beck, T., A. Demirguc-Kunt, and R. Levine (2007) "Finance, Inequality and the Poor," *Journal of Economic Growth*, Vol. 12, pp. 27–49.

Benabou, R. (1997) "Inequality and Growth," *NBER Macroeconomic Annual* (Cambridge, MA: National Bureau of Economic Research).

Benabou, R. (2000) "Unequal Societies: Income Distribution and the Social Contract," *American Economic Review*, Vol. 90, pp. 96–129.

Berg, A., and J. Ostry (2011) "Inequality and Unsustainable Growth: Two Sides of the Same Coin?" IMF Staff Discussion Note No. 11/08 (Washington, DC: International Monetary Fund).

Bernstein, A., M. Gustafson, and R. Lewis (2019) "Disaster on the Horizon: The Price Effect of Sea Level Rise," *Journal of Financial Economics*, Vol. 134, pp. 253–272.

Bird, R., and E. Zolt (2005) "Redistribution via Taxation: The Limited Role of the Personal Income Tax in Developing Countries," *UCLA Law Review*, Vol. 52, pp. 1–71.

Birdsall, N., and J. Nellis (2003) "Winners and Losers: Assessing the Distributional Impact of Privatization," *World Development*, Vol. 31, pp. 1617–1633.

Buchanan, M., S. Kulp, L. Cushing, R. Morello-Frosch, T. Nedwick, and B. Strauss (2020) “Sea Level Rise and Coastal Flooding Threaten Affordable Housing,” *Environmental Research Letters* Vol. 15, pp. 124020.

Burke, M., and V. Tanutama (2019) “Climatic Constraints on Aggregate Economic Output,” NBER Working Paper No. 25779 (Cambridge, MA: National Bureau of Economic Research).

Burke, M., S. Hsiang, and E. Miguel (2015) “Global Nonlinear Effect of Temperature on Economic Production,” *Nature*, Vol. 527, pp. 235–239.

Burke, M., S. Hsiang, and E. Miguel (2015) "Climate and Conflict." Annual Review of Economics, Vol. 7, pp. 577–617.

Cevik, S., and C. Correa-Caro (2020a) “Growing (Un)equal: Fiscal Policy and Income Inequality in China and BRIC+” *Journal of the Asia Pacific Economy*, Vol. 25, pp. 634–653.

Cevik, S., and C. Correa-Caro (2020b) “Taking Down the Wall: Transition and Inequality,” Review of Development Economics, Vol. 24, pp. 238–253.

Cevik, S., and J. Jalles (2020) “Feeling the Heat: Climate Shocks and Credit Ratings,” IMF Working Paper No. 20/286 (Washington, DC: International Monetary Fund).

Cevik, S., and J. Jalles (2021) “An Apocalypse Foretold: Climate Shocks and Sovereign Defaults,” *Open Economies Review*, Vol. 33, pp. 89–108.

Cevik, S., and J. Jalles (2022) “This Changes Everything: Climate Shocks and Sovereign Bonds,” *Energy Economics*, Vol. 107, 105856.

Checci, D. (2000) “Does Educational Achievement Help to Explain Income Inequality,” UNU-WIDER Research Paper No. 2000/208 (Helsinki: United Nations University- World Institute for Development Economics Research).

Chen, C., I. Noble, J. Hellmann, J. Coffee, M. Murillo, and N. Chawla (2015) *University of Notre Dame Global Adaptation Index Technical Report* (Notre Dame, IN: University of Notre Dame).

Clarke, G., L. Xu, and H. Zou (2006) “Finance and Income Inequality: What Do the Data Tell Us?” *Southern Economic Journal*, Vol. 72, pp. 578–596.

Cline, W. (1992) *The Economics of Global Warming* (New York: New York University Press).

Datt, G., and M. Ravaillion (1998) “Farm Productivity and Rural Poverty in India,” *Journal of Development Studies*, Vol. 34, pp. 62–85.

Deaton, A., and C. Paxson (1997) “The Effects of Economic and Population Growth on National Saving and Inequality,” *Demography*, Vol. 34, pp. 97–114.

Dell, M., B. Jones, and B. Olken (2012) “Temperature Shocks and Economic Growth: Evidence from the Last Half Century,” *American Economic Journal: Macroeconomics*, Vol. 4, pp. 66–95.

Demirguc-Kunt, A., and R. Levine (2009) “Finance and Inequality: Theory and Evidence,” World Bank Policy Research Working Paper No. 4967 (Washington, DC: World Bank).

Diffenbaugh, N., and M. Burke (2019) “Global Warming Has Increased Global Economic Inequality,” *Proceedings of the National Academy of Sciences*, Vol. 116, pp. 9808–9813.

Dreher, A., and N. Gaston (2008) "Has Globalization Increased Inequality?" *Review of International Economics*, Vol. 16, pp. 516–536.

Feenberg, D., and J. Poterba (1993) "Income Inequality and the Incomes of Very High-Income Taxpayers," *Tax Policy and the Economy*, Vol. 7, pp. 145–177.

Ferreira, F., P. Leite, and J. Litchfield (2007) "The Rise and Fall of Brazilian Inequality: 1981–2004" *Macroeconomic Dynamics*, Vol. 12, pp. 1–32.

Ferreira, F., N. Lustig, and D. Teles (2015) "Appraising Cross-National Income Inequality Databases: An Introduction," *Journal of Inequality*, Vol. 13, pp. 497–526.

Galor, O., and J. Zeira (1993) "Income Distribution and Macroeconomics," *Review of Economic Studies*, Vol. 60, pp. 35–52.

Gallup, J., J. Sachs, and A. Mellinger (1999) "Geography and Economic Development," *International Regional Science Review*, Vol. 22, pp. 179–232.

Gassebner, M., A. Keck, and R. Teh (2006) "Shaken, Not Stirred: The Impact of Disasters on International Trade," *Review of International Economics*. Vol. 18, pp. 351–368.

Gradstein, M., and B. Milanovic (2004) "Does Liberté=Egalité? A Survey of the Empirical Links between Democracy and Inequality with Some Evidence on the Transition Economies," *Journal of Economic Surveys*, Vol. 18, pp. 515–537.

Greenwood, J., and B. Jovanovic (1990) "Financial Development, Growth, and the Distribution of Income," *Journal of Political Economy*, Vol. 98, pp. 1076–1107.

Grimalda, G., D. Barlow, and E. Meschi (2010) "Varieties of Capitalisms and Varieties of Performances: Accounting for Inequality in Post-Soviet Union Transition Economies," *International Review of Applied Economics*, Vol. 24, pp. 379–403.

Henry, M., N. Spencer, and E. Strobl (2019) "The Impact of Tropical Storms on Households: Evidence from Panel Data on Consumption," *Oxford Bulletin of Economics and Statistics*, Vol. 22, pp. 179–232.

Holtz-Eakin, D., W. Newey, H.S. Rosen (1988), "Estimating vector autoregressions with panel data", *Econometrica*, Vol. 56, pp. 1371-1396

Im, K., M. Pesaran, and Y. Shin, 2003, "Testing for Unit Roots in Heterogeneous Panels," *Journal of Econometrics*, Vol. 115, pp. 53–74.

Intergovernmental Panel on Climate Change (IPCC) (2007) *Fourth Assessment Report, Intergovernmental Panel on Climate Change* (New York: Cambridge University Press).

Intergovernmental Panel on Climate Change (IPCC) (2014) *Climate Change in 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (New York: Cambridge University Press).

Intergovernmental Panel on Climate Change (IPCC) (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K.

Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. (New York: Cambridge University Press). In Press.

International Monetary Fund (2020) "Physical Risk and Equity Prices," Global Financial Stability Report, Chapter 5 (Washington, DC: International Monetary Fund).

Islam, S., and J. Winkel (2017) "Climate Change and Social Inequality," DESA Working Paper No. 152 (New York: United Nations Department of Economic and Social Affairs).

Kahn, M., K. Mohaddes, R. Ng, M. Pesaran, M. Raissi, and J-C. Yang (2019) "Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis," IMF Working Paper No. 19/215 (Washington, DC: International Monetary Fund).

Jenkins, S., 2015, "World Income Inequality Databases: An Assessment of WIID and SWIID," Journal of Economic Inequality, Vol. 13, pp. 629–671.

Kuznets, S., 1955, "Economic Growth and Income Inequality," American Economic Review, Vol. 45, pp. 1–28.

Loayza, N., E. Olaberria, J. Rigolini, and L. Christiaensen (2012) "Natural Disasters and Growth: Going Beyond the Averages," *World Development*, Vol. 40, pp. 1317–1336.

McKenzie, D., and C. Woodruff, 2006, "Do Entry Costs Provide an Empirical Basis for Poverty Traps? Evidence from Mexican Microenterprises," Economic Development and Cultural Change, Vol. 55, pp. 3–42.

Morris, S., and others (2002) "Hurricane Mitch and the Livelihoods of the Rural Poor in Honduras," *World Development*, Vol. 30, pp. 49–60.

Muinelo-Gallo, L., and O. Roca-Sagales, 2011, "Economic Growth and Inequality: The Role of Fiscal Policies," Australian Economic Papers, Vol. 50, pp. 74–97.

Musgrave, R., 1959, The Theory of Public Finance (New York: McGraw Hill).

Nordhaus, W. (1991) "To Slow or Not to Slow: The Economics of the Greenhouse Effect," *Economic Journal*, Vol. 101, pp. 920–937.

Nordhaus, W. (1992) "An Optimal Transition Path for Controlling Greenhouse Gases," *Science*, Vol. 258, pp. 1315–1319.

Nordhaus, W. (2006) "Geography and Macroeconomics: New Data and New Findings," *Proceedings of the National Academy of Sciences of the United States of America*, 103, 3510–3517.

Noy, Ilan (2009) "The Macroeconomic Consequences of Disasters," *Journal of Development Economics*, Vol. 88, pp. 221–231.

Ostry, J., A. Berg, and C. Tsangarides (2014) "Redistribution, Inequality, and Growth," IMF Staff Discussion Note No. 14/02 (Washington, DC: International Monetary Fund).

Painter, M. (2020) "An Inconvenient Cost: The Effects of Climate Change on Municipal Bonds," *Journal of Financial Economics*, Vol. 135, pp. 468–482.

Perotti, R. (1993) "Political Equilibrium, Income Distribution and Growth," *Review of Economic Studies*, Vol. 60, pp. 755–776.

Raddatz, C. (2009) "The Wrath of God: Macroeconomic Costs of Natural Disasters," Policy Research Working Paper No. 5039 (Washington, DC: World Bank).

Rajan, R. (2010) *Fault Lines: How Hidden Fractures Still Threaten the World Economy* (Princeton, NJ: Princeton University Press).

Rajan, R., and L. Zingales (2003) "The Great Reversals: The Politics of Financial Development in the Twentieth Century," *Journal of Financial Economics*, Vol. 69, pp. 5–50.

Rodrik, D. (1999) "Democracies Pay Higher Wages," *Quarterly Journal of Economics*, Vol. 114, pp. 707–738.

Solt, F. (2009) "Standardizing the World Income Inequality Database," *Social Science Quarterly*, Vol. 90, pp. 231–242.

Solt, F. (2020) "Measuring Income Inequality Across Countries and Over Time: The Standardized World Income Inequality Database," *Social Science Quarterly*, Vol. 101, pp. 1183–1199.

Tridico, P., 2010, "Growth, Inequality and Poverty in Emerging and Transition Economies," Transition Studies Review, Vol. 16, pp. 979–1001.

Rasmussen, T. (2004) "Macroeconomic Implications of Natural Disasters in the Caribbean," IMF Working Paper No. 04/224 (Washington, DC: International Monetary Fund).

Rentschler, J. (2013) "Why Resilience Matters: The Poverty Impacts of Disasters," Policy Research Working Paper No. 6699 (Washington, DC: World Bank).

Skidmore, M., and H. Toya (2002) "Do Natural Disasters Promote Long-Run Growth?" *Economic Inquiry*, Vol. 40, pp. 664–687.

Stern, N. (2007) *The Economics of Climate Change: The Stern Review* (Cambridge: Cambridge University Press).

Tol, R. (2018) "The Economic Impacts of Climate Change," *Review of Environmental Economics and Policy*, Vol. 12, pp. 4–25.

Tol, R., T. Downing, O. Kuik, and J. Smith (2004) "Distributional Aspects of Climate Change Impacts," *Global Environmental Change*, Vol. 14, pp. 259–272.

Woo, J., E. Bova, T. Kinda, and Y. Zhang (2017) "Distributional Consequences of Fiscal Adjustments: What Do the Data Say?" *IMF Economic Review*, Vol. 65, pp. 273–307.

World Bank (2020) *Poverty and Shared Prosperity: Reversals of Fortune* (Washington, DC: World Bank).