Income Inequality Impacts of Extreme Weather Events and Disasters

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地球温暖化に伴う苛酷な異常気象や大規模自然災害がもたらす損失を過去のデータから解析すると、貧困国や途上国では低所得層ほど深刻な打撃を受けやすいことがわかった。

Abstract

This paper examined the effect of natural disasters on income inequality using panel data of 124 countries, covering the period 1986 to 2015. The fixed effects model was used in the analysis. It was found that for low and lower middle-income countries, the occurrence of natural disasters increased income inequality (measured in terms of the Gini coefficient). Meanwhile, for high income countries, the study found evidence that natural disasters reduces inequality.

Keywords income inequality, disasters

Introduction

The study of natural disasters has reached the interest of economists in recent years because of the enormous economic and social consequences associated with these events. Focus of research has been on assessing impacts, valuing damages, and identifying factors and policy options that maximizes social welfare or leads to the minimization of their economic costs. The topic is all the more relevant because the turn of the new millennium showed a peak in the occurrence of natural hazards. Moreover, there is a dire prediction that extreme weather events associated with typhoons, floods, heat waves, and droughts may increase in frequency and intensity as a consequence of global climate change (Intergovernmental Panel on Climate Change 2013).

On a micro-level, exposure to these natural hazards can lead to the loss and destruction of properties, damage to agriculture and aquaculture, income losses, displacement, morbidity and deaths. On a macro-level, it may lead to slower economic growth, production inefficiencies, massive migration, increase in poverty, and direct monetary losses. An insurance company, Swiss Re, estimated that the total economic losses that the global economy sustained from both man-made and natural disasters have reached USD 306 billion in 2017, about 60% higher than the estimated losses the prior year (Swiss Re 2017). This is despite the fact that the frequency of disaster occurrence actually declined from 348 events in 2016 to 291 events in 2017 (CRED, D. Guha-Sapir n.d.).

Based on the Centre for Research and Epidemiology of Disasters (CRED) database, about 14,441 natural disaster events occurred from 1900 to 2017 all over the world. Majority of these disaster events were experienced in Asia (40%), followed by Americas (25%), Africa (18%), Europe (12%) and Oceania (5%).

Although much has been understood about the nature of the economic and social costs of natural disasters, for instance, how it affects economic productivity, economic growth, and even migration, studies on the income distribution impacts of disasters and extreme weather are still very limited. It is the goal of this research paper to contribute to the limited literature on the subject matter through an empirical study using

cross-national panel data. Specifically, the paper aims to determine whether natural disasters and extreme weather experience significantly contributes to income inequality. The study employed a panel regression analysis using a fixed effects error correction model. The Driscoll/Kray Standard Errors were used as basis for testing the individual hypothesis of whether natural disaster experiences are statistically significant determinants of the income Gini coefficient of selected countries. The study made use of an unbalanced panel data of 124 countries covering a maximum period of 30 years (1986 to 2015).

Review of Literature

Although studies on the interaction between disasters and income are quite extensive, studies on the relationship between disasters and inequality are still quite limited. Studies that looked into the inequality impacts of weather extremes or disasters are mostly confined to a local level or within country level of analysis and only a few have utilized cross-national panel data. Most of the studies were from a developing country setting, and the findings are quite diverse.

A study conducted in the Philippines by Datt & Hoogeveen (2000) employed regression analysis to look into the effect of El Niño and other economic shocks on consumption, poverty and inequality in the Philippines using data from the 1997/98 Annual Poverty Indicators Survey. The study found that the El Niño phenomenon played a major role in predicting consumption and income, and that it had a regressive impact on inequality. The authors attributed this to the different levels of vulnerability among households. Some are more resilient to shocks, while others are less so. It was found that ownership of land made households more susceptible to El Niño.

Bayani-Arias and Palanca-Tan (2017) used data from the 2009 and 2012 Philippine Family Income and Expenditure Survey (FIES) to conduct decomposition analysis of the provincial income and expenditure Theil inequality index grouped according to exposure to typhoons. It was found that the group with the highest exposure to typhoons experienced worsening of both income and expenditure inequality, while the group with the least exposure showed no change in expenditure inequality and an improvement in income equality. The study works under the premise that different households have different attributes, different adaptive capacities, and therefore different vulnerabilities and thus extreme weather will have varying impacts on their income and consumption, thereby worsening inequality.

In Mozambique, Silva, et al. (2015) conducted a study that relates weather patterns associated with near normal rainfall, tropical cyclones and flooding, and drought to changes in inequality and polarization. The study utilized 2005 and 2008 National Agricultural Survey and conducted decomposition analyses of the Gini index and Duclos-Esteban-Ray (DER) polarization index. Silva et al. (2015) found that weather shocks can exacerbate existing economic income and divisions within societies, but they also found that in some cases inequality and polarization can decline after an extreme event.

Reardon & Taylor (1996) examined the impacts of an agroclimatic shock on income inequality in Burkina Faso. The study applied income-source decompositions of the Gini coefficient and the Foster-Greer-Thorbecke (FGT) poverty index before and after a severe drought. The study used survey data collected by ICRISAT from farm households in the period 1983/84 and 1984/85. The authors noted that the inequality impacts of a weather shock depend on the extent to which incomes are diversified and on the costs of diversifying income in response to the shock. They found that off-farm income increases inequality and fails to shield poor households against agro-climatic shocks.

In Ethiopia, Thiede (2014) used the 2005 and 2011 Ethiopia Demographic and Health Survey to determine the impact of drought on livestock inequality index using the triple difference approach. Thiede (2014) found that rainfall deficits have an equalizing effect on the livestock inequality within some Ethiopian communities, although the results vary from region to region. On the other hand, the estimated effects of rainfall deficits on asset inequality within communities are non-significant.

Keerthiratne and Tol (2017) examined the effects of

natural disasters (in terms of the percentage of the population affected) on the district level Gini Coefficient and Theil index in Sri Lanka. The study applied various regression models including panel fixed effects estimator, Ordinary Least Squares regression and system GMM estimators. The study found that contemporaneous natural disasters and their immediate lags decrease district level income inequality, but they have no significant effects on expenditure inequality. Moreover, the study found that natural disasters seem to worsen seasonal and agricultural income inequality while having an equalizing effect on non-seasonal and non-agricultural income. They explained that natural disasters reduced income inequality because those with higher income suffers higher damages from natural disasters than the poor. Those with lower income are able to easily diversify their income sources in the aftermath of disasters (Keerthiratne and Tol 2017).

A study conducted in the United States looked into the income inequality effects of hurricane Katrina (Shaughnessy, White and Brendler 2010). The study predicted the impacts by constructing Lorenz Curves and estimating Gini coefficients from three income density functions particularly the Lognormal density function, Log-logistic density function, and the Singh-Maddala density function pre- and post- Katrina. The study found that inequality in New Orleans declined after Katrina, but it was not clear in the paper what possible mechanisms were responsible for this phenomenon.

In contrast, a study conducted in Vietnam found that natural disasters seem to worsen expenditure and income inequality (Bui, et al. 2014). The study used data from the 2008 Vietnam Household Living Standard Survey and applied regression analysis corrected for fixed effects and endogeneity bias.

Yamamura (2013) examined the effects of natural disaster frequency on the country level Gini coefficient utilizing panel data of 86 countries covering the period 1965 to 2004. The fixed effects regression model was used wherein the dependent variable was the change in the Gini coefficient from past to current year, while the explanatory variables include the Gini coefficient of the previous year, current and past disaster frequency (lagged 3 periods), GDP per capita, and land size. In addition, an Ordinary Least Squares regression model was also undertaken which included the following control variables: institutional conditions, legal origin and socio-economic heterogeneity, ethnic and religious heterogeneities, and geographical dummies representing Asia, Africa, South America. Results of the study showed that natural disasters widened income inequality in the short term; but the effect seem to disappear in the medium term. Yamamura attributed these findings to the possibility that governments attempt to attenuate the impacts of disasters by means of redistribution in subsequent years. Hence, the recovery will also be accompanied by the reduction of income inequality.

Methodology

In this study, a framework was developed to explain the link between natural disaster exposure and inequality. It is hypothesized that natural disasters have a direct effect on the relative incomes of the different sectors and also have an indirect effect via change in relative demand and consequently, relative factor prices.

The model considers a two sector economy comprised of a weather vulnerable sector (V) and a non-vulnerable sector (N), both of which are utilizing two inputs, skilled labor (S) and unskilled labor (U). It is assumed that the vulnerable sector is intensive in the use of unskilled labor, while the non-vulnerable sector is intensive in the use of skilled labor. The above is a plausible assumption because informal, traditional, and agriculture-based industries which are considered more vulnerable to weather shocks rely more on unskilled laborers than on skilled laborers.

Suppose a disaster or weather shock occurs, the vulnerable sector is expected to suffer a greater decline in their output than the non-vulnerable sector, given the same weather shock. Consequently, those employed in the vulnerable sector will earn lower average incomes than those employed in the non-vulnerable sector.

From the premise that the vulnerable sector is more intensive in the use of unskilled laborers which now has a lower average income than skilled laborers because of the disaster, this will result in the widening of income

gap and hence can lead to the worsening of inequality.

For the indirect impact, since output from the two sectors are expected to decline due to the disaster shock, aggregate output and income of the economy will also decline. When income declines, demand for both "vulnerable" and "non-vulnerable goods" will also decline. Depending on the relative importance of the two goods in the consumption process, the relative demand for the goods can change, and consequently, so will the relative output price.

According to the Stolper-Samuelson theorem, if relative output price changes, so will the relative factor price. The theorem predicts that if the relative price of the skilled labor-intensive good increases, the relative wage of skilled workers will also increase. On the other hand, if the relative price of the unskilled labor-intensive good increases, the relative wage of unskilled workers will increase.

How relative output price changes will depend upon the relative importance of each good in domestic demand. If the marginal propensity to consume (mpc) for the vulnerable good is greater than the *mpc* for the non-vulnerable good, there will be a greater decline in the demand for the vulnerable good, and hence the relative price of the vulnerable good in terms of the non-vulnerable good will decline (i.e. the absolute price of the vulnerable good will decline more than the absolute price of the "non-vulnerable good). This will lead to a lower returns (wages) to the factor (unskilled labor) used intensively in the production of the vulnerable good and consequently will worsen inequality.

On the other hand, if the *mpc* for the non-vulnerable good is higher than that for the vulnerable good, there will be a greater decline in the demand for the non-vulnerable good, and hence will result in a lower relative price for the non-vulnerable good. The factor used intensively in this sector (skilled labor) will earn lower returns, and hence equality may improve.

The link between relative wages (ω) and the Gini coefficient is presented below. The Gini coefficient is computed through the Lorenz curve. It is equal to the area between the Lorenz curve and the uniform distribution line divided by the area under the uniform distribution line.

Equation 1

$$G = \left(\frac{U}{U+S}\right) - \left(\frac{1}{1+\frac{S}{U}\frac{\omega_S}{\omega_U}}\right)$$

Following Goderis & Malone (2011), the measure of income inequality can be represented as a ratio of total wage income earned by skilled workers over total wage income earned by unskilled workers.

Equation 2

$$I = \frac{S}{U}\frac{\omega_s}{\omega_u}$$

Substituting equation 2 into equation 1 yields,

Equation 3

$$G = \frac{U}{U+S} - \frac{1}{1+I}$$

G then is shown to be a non-linear increasing function of *I*. Hence, an increase in exposure to weather and disaster shocks which increases the relative wage of skilled versus unskilled, increases the inequality ratio I, and consequently increases G. However, if such weather shock reduces the relative wage of unskilled workers, the inequality ratio *I* will decline, consequently reducing G.

The present study hypothesizes that high income countries and low income countries will experience different inequality impacts from disasters. The direct impact of disasters is expected to be inequality-increasing in the immediate-term for both high and low income countries as the localized impacts will have a disproportionate impact on affected areas/sectors. However, the indirect impact will differ depending on a country's income category. This arises from the premise that rich countries have a higher propensity to consume skilled labor-intensive goods while poor countries have a higher propensity to consume unskilled labor-intensive goods. Following this assumption, it is hypothesized that as natural disaster exposure increases and aggregate

income declines, the relative demand for unskilled labor-intensive goods will decline in the poor country, causing the relative wage of unskilled labor to decline, hence worsening inequality. For the rich country, however, as the natural disaster exposure increases and aggregate income declines, the relative demand for skilled labor-intensive goods will decline, causing the relative wage of skilled labor to decline, hence improving equality.

In this study, secondary data collected and published by reputable international agencies were used in the analysis. For the inequality variable, the study used the Standardized World Income Inequality Database (Solt 2008). The mean of the market Gini coefficient was used. This is the estimate of the Gini index of inequality in "equivalized" (square root scale) household pre-tax and pre-transfer income. For the disaster/extreme weather variable, the source of data is the Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Events Database (EM-DAT) (CRED, D. Guha-Sapir n.d.). The indicator used is the frequency of occurrence of natural disasters. According to CRED, for a disaster to be included in the database any one of the following criteria must be fulfilled: ten (10) or more people reported killed; hundred (100) or more people reported affected; declaration of a state of emergency; and call for international assistance. In addition, several control variables were also included: Real GDP per capita (*GDP*) and its square; trade openness (*Trade*) which is measured as the total value of export and import as a percentage of GDP; and total land area (*Land*).

The initial dataset, which contains 192 countries, has a high number of missing data. Countries that have less than 10 years of observations were then dropped arriving at a final dataset of 124 countries covering the period 1986 to 2015. All in all, there were 21 low-income countries, 35 lower middle-income countries, 34 upper middle-income countries, and 34 high income countries.

The study used panel data regression techniques to estimate the effect of natural disasters on inequality. All estimations were done using the Stata 12 Statistical Package. The regression models used in the study is given in equation 4 and equation 5.

Equation 4

$$Gini_{it} = \alpha + \beta_1 Gini_{it-1} + \beta_2 Disaster_{it-1} + \beta_3 Disaster_{it-2} + \beta_4 Disaster_{it-3} + \beta_5 Disaster_{it-4} + \beta_6 Disaster_{it-5} + \beta_7 GDP_{it} + \beta_8 GDP^2{}_{it} + \beta_9 Trade_{it} + \beta_{10} Land_{it} + \gamma DCountry'_{it} + \delta DYear'_{it} + \mu_i + \lambda_t + v_{it}$$

Equation 5

$$Gini_{it} - Gini_{it-1} = \alpha + \beta_1 Disaster_{it-1} + \beta_2 Disaster_{it-2} + \beta_3 Disaster_{it-3} + \beta_4 Disaster_{it-4} + \beta_5 Disaster_{it-5} + \beta_6 GDP_{it} + \beta_7 GDP^2{}_{it} + \beta_8 Trade_{it} + \beta_9 Land_{it} + \gamma DCountry'_{it} + \delta DYear'_{it} + \mu_i + \lambda_t + v_{it}$$

Because different income levels are expected to sustain different inequality impacts from disasters, two separate regressions were undertaken, one for the low and lower middle income countries sub-sample, and another for the upper middle and high-income countries sub-sample.

Results and Discussion

The study's main hypothesis is that natural disaster occurrence has a different effect on income inequality depending on the income categorization of countries. For lower income countries the expected relationship is positive. As the frequency of natural disasters increases, the Gini coefficient also increases which means that income inequality worsens. For higher income countries, the expected relationship may be positive or negative depending on which mechanism is stronger, whether the direct impact or the indirect impact. As mentioned, two separate regressions were undertaken, one for low and lower middle-income countries (denoted as Group Low), and another for upper middle and high-income countries (denoted as Group High).

The diagnostic tests employed (Table 1) revealed that the fixed effects model is appropriate rather than the pooled OLS or the random effects model. For the Group High, the Wald-test of joint significance rejects the null hypothesis that the dummy variables for all years are

equal to zero. However, individual test of significance shows that not all the coefficients for these time dummies were statistically significant. Hence, both the one-way fixed effects model and the two-way fixed effects model are presented in the analysis. On the other hand, for Group Low, the analysis failed to reject the null hypothesis that the year dummies are not jointly equal to zero at 5% level of significance. However, since the p-value is still less than 0.10, both the one-way fixed effects and the two-way fixed effects specifications were still presented.

Table 1. Summary of the diagnostic tests used in panel regression analysis

Diagnostic Test	Group Low	Group High
Wald joint test of significance for country dummies (FE versus OLS)	0.000	0.000
Wald joint test of significance for year dummies (one-way versus two-way)	0.060	0.008
Hausman test (FE versus RE)	0.005	0.000
Pesaran's test of cross-sectional independence for one-way FE model	0.021	0.555
Pesaran's test of cross-sectional independencefor two-way FE model	0.873	0.192
Modified Wald test for group-wise heteroscedasticity For one-way FE model	0.000	0.000
Modified Wald test for group-wise heteroscedasticity For two-way FE model	0.000	0.000
Wooldridge test for autocorrelation in panel data	0.000	0.000

The p-value of 0.021 in the Pesaran's test indicates the presence of cross-sectional dependence in the one-way FE model for the lower income group sub-sample. Meanwhile, the null hypothesis of weak cross-sectional dependence was rejected for the two-way FE model for the Group Low sub-sample and all specifications for the Group High sub-sample. Meanwhile, the results of the modified Wald test and Wooldridge test denote the presence of heteroskedasticity and first order autocorrelation for all specifications. Because of the presence of cross-sectional dependence, heteroscedasticity, and first order autocorrelation, the standard errors by Driscoll/Kray were used in the analysis.

The Fisher-type panel unit root test failed to strongly reject the hypothesis that all panels for the Gini coefficient contain no unit roots. To address this, two specifications of the FE model were used in the analysis. One specification contains the lag of the Gini coefficient as an explanatory variable, while the second uses the first difference of the Gini coefficient as the dependent variable. The variable natural disaster occurrence was found to be stationary using the same test.

The result of the panel regression analysis show that for Group Low, natural disasters have a worsening impact on inequality (Table 2). The coefficients, however, were found to be statistically significant only for disasters lagged three years to disasters lagged five. In the one-way fixed effects model with the level Gini coefficient as the dependent variable, the estimated impact of disasters lagged three years was modest at 0.011. This means that a one unit increase in disaster three years prior increases the Gini coefficient by 0.011 Gini points, cet. par. The other specifications, particularly the two-way FE with level Gini as dependent variable, as well as the one-way and two-way FE with first differenced Gini as the dependent variable, had very similar results. The coefficient for natural disasters lagged three periods, ranges from 0.011 to 0.014, while for the natural disaster variable lagged four periods was about 0.11. Meanwhile, the natural disaster variable lagged five periods had an estimated coefficient that ranges between 0.008 and 0.010. The results suggest that the magnitude of the impact seems to wane over the years.

For the control variables, real GDP per capita, trade openness, and land endowment were found to be statistically significant in the one-way FE models for the low and lower-middle income group. The signs and values of the coefficients are consistent for all specifications.

The study found a U-shape relationship between real per capita GDP and inequality. This was determined by

Table 2. Results of the panel regression analysis for Group Low (low and lower middle-income countries)

	Gini		D.Gini	
	One-way FE	Two-way FE	One-way FE	Two-Way FE
Gini				
L1.	.995***	.988***		
Natural disaster				
L1.	.006	.009	.006	.009
L2.	.006	.009	.006	.009
L3.	.011*	.014*	.011*	.014*
L4.	.011*	.012*	.011*	.011*
L5.	.010*	.010*	.009*	.008*
Real per capita GDP	-.001**	-.000	-.001**	-.000
Real per capita GDP squared	6.5e-08*	-4.1e-10	6.4e-08*	2.9e-09
Trade openness	-.002*	-.001	-.002*	-0.001
Land area	1.2e-06	7.4e-07	8.1e-07**	-7.9e-10
* p<0.05; ** p<0.01; *** p<0.001				

taking the first and second order partial derivative of the equation with respect to the variable real per capita GDP. This result is consistent with Bahmani-Oksooee, Hegerty, & Wilmeth (2008) and Angeles-Castro (2006). Inequality may decline as the economy expands because expansion increases the demand for workers. And with fixed supply of labor, firms would then eventually hire down along the line of workers towards the less skilled and less preferred laborers. This increases the probability of finding employment, as well as increases wage rates in the lower strata, which then reduces inequality (Treas 1983). This relationship, however, is in effect only up to a certain level of income. Further expansion may eventually lead to the worsening of inequality as growth encourages technological advancements which increase productivity and the wage premium of skilled workers, which will then increase inequality.

Furthermore, trade openness was found to have an equalizing effect on the income of low and lower middle-income countries. The coefficient of the variable was significant for the one-way FE specifications of the model. The coefficient estimates of -0.002 suggests that as the share of total exports and imports to GDP increases by one percentage point, the Gini coefficient declines by about 0.002 cet. par. Theory relating trade openness with inequality points to an ambiguous relationship between the two, depending on the factor endowment of countries as well as the degree of technology transfer facilitated by trade. The result seems to conform to the theory that for lower income countries, trade openness tends to reduce income inequality. Lower income countries are relatively more abundant with unskilled labor. Therefore, they will tend to export more of the good that are intensive with the use of unskilled labor. Opening up to trade will increase the relative demand for the unskilled-labor intensive good produced by the local economy because of the expansion of market opportunities offered by the world market. This will lead to an increase in the relative demand for unskilled labor, and consequently increases their relative factor earnings, thereby reducing inequality.

Finally, land resource endowment was found to have a significant and positive effect on the Gini coefficient in the one-way FE model with first-differenced Gini as the dependent variable. Land size was included in the model to control for possible scale effects. Land area was used instead of population because population may be endogenous, while the former is exogenous. The estimate suggests that larger countries tend to have higher levels of inequality.

Table 3. Results of the panel regression analysis for Group High (upper middle and high-income countries)

	Gini		D.Gini	
	One-way FE	Two-way FE	One-way FE	Two-Way FE
Gini				
L1.	.999***	.994***		
Natural disaster				
L1.	-.005	-.002	-.005	-.003
L2.	-.011*	-.009	-.011*	-.009
L3.	-.007	-.006	-.007	-.006
L4.	-.006	-.003	-.006	-.003
L5.	-.011*	-.007	-.011*	-.007
Real per capita GDP	-.001***	-1.3e-06	-4.4e-05**	6.2e-07
Real per capita GDP squared	3.8e-10**	1.2e-10	3.7e-10*	8.7e-11
Trade openness	-.003***	-0.001	-.003***	-0.001
Land area	4.3e-07*	2.1e-07	4.1e-07***	8.6e-08

Table 3 above summarizes the regression results for the upper middle and high-income sub-sample (Group High). The coefficients for natural disasters were negative for all specifications. However, the coefficients were statistically significant only for the variable disasters lagged two years and five years for the one-way FE model. The results suggest that disasters have no immediate impact on inequality in upper middle and high-income countries and that disasters have an equality-enhancing effect in the medium term.

The negative relationship between natural disaster occurrence and the Gini coefficient is consistent with the assumption of the study that richer countries have a higher propensity for skilled-labor intensive goods. When disasters reduce aggregate income, relative demand for skilled-labor intensive goods will also decline. This will reduce the relative demand for skilled-labor embodied in the good and consequently reduce their earnings relative to lower paid unskilled-labor, thereby improving inequality.

For the control variables, real GDP per capita and its square, as well as trade openness were statistically significant in the one-way FE models. The estimated coefficients of real GDP per capita and its square also suggest a U-shape relationship with inequality, which is similar to the findings in the lower income sub-sample. Moreover, the coefficients for trade openness and the size of land were also found to be statistically significant in the one way-FE model. The sign of the coefficient was negative for trade, and positive for land area which is similar to the findings for the lower income country group.

Summary and Conclusion

The study examined the impact of natural disasters on income inequality by analyzing data from 124 countries, from 1986 to 2015, using panel regression techniques. Specifically, the one-way and two-way fixed effects models with Driscoll/Kray standard errors were used.

Earlier studies had varying findings on the possible impact of natural disasters on inequality. Some have found a positive relationship implying that natural disasters worsen inequality, while others found a negative relationship, implying that natural disasters are income-equalizing.

Most studies that were reviewed utilized single country data for their analysis. The paper by Yamamura (2013) was the only study found which analyzed inequality impacts using cross-country panel data. The study covered 86 countries covering the period 1965 to 2004. Yamamura (2013) found that natural disasters have widen inequality in the short-term, but this effect

eventually disappears in the medium term. Yamamura's study therefore assumes that the effect of natural disasters will be the same regardless of the level of income of the country. The present study deviates from this notion and conducted separate regressions for low and lower middle-income countries (Group Low) and upper middle and high-income countries (Group High). The results of the fixed effects regression analysis showed that the occurrence of natural disasters has a significant impact on inequality, but the effect was only felt in the medium-term.

The study found evidence that natural disasters tend to worsen inequality in low and lower middle-income countries. This magnifies the urgency of mainstreaming disaster risk reduction and providing safety nets for vulnerable groups in the economy. This may be in the form of skills development, health investments or direct transfers. Moreover, this further amplifies the importance of constructing disaster-resilient infrastructures and promoting disaster-resilient production methods to minimize the social cost of natural disasters.

For upper middle and high-income countries, it was found that natural disasters can be equality-improving in the medium-term. However, this improvement in equality may be due to the reduction in income of those in the high-income strata, instead of the desired scenario that the income of those in the low-income sector is rising and catching up. The implication is that disaster risk reduction should still be a priority in high income countries.

For the control variables, the study found a U-shape relationship between real Gross Domestic Product (GDP) per capita and inequality, while trade had a negative relationship.

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