Effects of Education on Climate Risk Vulnerability in the Philippines: Evidence from Regional Panel Data

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The effects of climate change are being felt disproportionately in the world's poorest countries and among those groups of people least able to cope. The Philippines, being a storm-lashed nation, is one country having high climate change vulnerability and low climate change resilience. A number of researches have suggested investments on adaptation which place strong emphasis on reducing vulnerability to climate change. Focusing on climate change vulnerability in the Philippines, this study examines the effect of one particular type of government intervention: increasing the level of education. In this study, the effect of education on vulnerability to climate change is examined in a regional panel data analysis using official Philippine statistics from the Natural Disaster Risk Reduction and Management Council (NDRRMC), Labor Force Survey (LFS), National Statistical Coordination Board (NSCB). Using the fixed-effects Poisson (FEP) regression model, the study establishes that at the community level, the number of employed college graduates is a significant factor that reduces climate risk vulnerability (measured by number of deaths from natural disasters), controlling for other factors such as number of disasters, gross regional domestic product (GRDP), and population size.

Keywords: *Vulnerability, Resilience, Panel Data, Fixed-effects Poisson model*

1. Introduction

The Earth's climate is changing as a result of greenhouse gases caused by human activities. This climate change is a serious threat to environmental sustainability, and the evidence is overwhelming. Solar radiation coming from the sun passes through the atmosphere and hits the Earth's surface. The Earth is warmed by this radiation, and in response radiates infrared. Most infrared radiation escapes into outer space. Some of the infrared radiation is trapped by the greenhouse gases, and this keeps the Earth warm enough to support life. Without the greenhouse gases, the Earth would be 50°C warmer than its present temperature. However, the increasing concentration of greenhouse gases will result in a warming of the climate. The relationship between temperature and amount of CO_2 in the atmosphere is very strong. Recent sharp increases in global temperatures since 1850 have been unprecedented in the past millennium, and most of the warming observed in the past 50 years is due to human activities.

An important report describing climate trends and projections in the Philippines, entitled *Climate Change in the Philippines*, was drafted by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). It is well worth mentioning some of the results here: In the Philippines, an increase of 0.648 °C in mean temperature anomalies from 1951 to 2010 has been observed, giving an average increase of 0.0108 °C per year. Furthermore, mean temperatures in all areas in the Philippines are expected to rise by 0.9 °C to 1.1 °C in 2020 and by 1.8 °C to 2.2 °C in 2050. Largest temperature increase is projected during the summer (March, April and May) season. The analysis of trends of extreme daily temperatures and extreme daily rainfall indicate significant increase in number of hot days but decrease of cool nights. Although trends of increases or decreases in extreme daily rainfall are not as yet statistically significant, there have been changes in extreme rain events in certain areas in the Philippines (PAGASA, 2011).

The United Nations Framework Convention on Climate Change (UNFCCC), the main vehicle for promoting international responses to climate change, has made its first step towards achieving the goal through the Kyoto protocol. Under Article 3.1 of the Kyoto protocol, parties in aggregate agree to reduce their overall greenhouse gas emissions to at least 5% below the 1990 levels.

Among the effects of climate change are rising ocean levels due to thermal expansion of seawater, large-scale extinctions of vulnerable species, and distribution and abundance of disease vectors. In addition, climate change will also lead to more pronounced differences in water availability between regions, higher temperatures, changes in agricultural productivity, damages on marine ecosystems, and, perhaps most relevant to this study, increased natural hazards (Sachs, 2008).

One important review of the multiple and complex effects of climate change is *The Economics of Climate Change: The Stern Review*. In this comprehensive study, Stern (2007) estimates that "if we do not act, the overall cost would be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. On the other hand, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year."

Adaptation to climate change (that is, taking appropriate steps to build resilience and minimize costs) is essential since climate change occurring in the next two or three decades is already irreversible. Adaptation will be crucial in reducing vulnerability to climate change and is the only way to cope with impacts that are inevitable over the next few decades. This study focuses on the effect of one particular type of adaptation: education.

The need for investment in education as a form of adaptation is mentioned in Stern's review. He suggests investing in human capital as one of the ways to promote adaptation. Investing in health and education, according to Stern, raises the effectiveness of explaining to communities and individuals how their climate is changing and why and how they should adapt in ways which effectively integrate climate risks into the development process. Better information on climate change and more accurate weather forecasting are the interventions needed in both the developed and developing countries.

The greatest challenge in carrying out this intervention is faced by low-income countries, especially the developing countries that face rising sea levels or desertification. Better information on climate change is a priority in these countries, given the very low level of climate information available. Better information should also come with effective communication of this information, especially since poor countries face barriers to free and easy communication. For instance, there are high illiteracy rates in South Asia (46.3%) and in Sub-Saharan Africa (53.2%) compared to 98.7% in the developed countries.

2. Objectives

This study looks at one particular type of adaptation measure: investment in human capital through education. As stated in the introduction, increasing the number of educated individuals in a community makes it easier to explain to individuals that climate is changing. Thus, the study attempts to establish the link between level of education in a region (measured by the number of employed persons who are at least college graduates) and climate risk vulnerability (measured by the number of deaths due to natural disasters). Once this link is established, we can say that education is a proper tool for adaptation.

The study also looks at the distribution of college graduates in the labor force by sex, and studies its effect on number of deaths, examining whether there is a difference in the effects of number male college graduates and female college graduates on climate risk. The reason why the authors have decided to include this information is that some studies (e.g., Lutz et al., 2008, Lutz et al., 2010) show that differences by sex and by age provide additional explanatory power. As Striessnig et al. (2012) mentions, "past comprehensive research on the effects of the entire educational distribution (i.e. considering the distribution of educational attainment categories by age and sex) for a whole range of issues, going from economic growth to transition to free democracies, has shown that explicit consideration of that distribution has significant additional explanatory power as compared to just taking an average measure of education such as the mean years of schooling." Unfortunately though, data on distribution of college graduates by age bracket is not available in the Labor Force Survey (LFS), making the authors unable to use this distribution as an explanatory variable.

The statistical model used in establishing the relationship between education and climate risk vulnerability is called the fixed-effects Poisson (FEP) regression model, the appropriate model for analyzing panel data where the response variable is a count, introduced by Hausman et al. (1984). The data sets used in the study come from various sources of Philippine statistics, and are arranged in a regional panel. The study includes all 17 Philippine regions, and covers the period from the first quarter of 2003 to the second quarter of 2011 (i.e., data are recorded quarterly). It is with regret that, due to constraints in data, the time frame involved could not be made longer than it is. There are, however, a total of 578 observations, which is sufficient for panel data estimation.

The study also controls for the effect of other factors on number of deaths. These factors are number of natural disasters, population, and gross regional domestic product (GRDP). It is expected that an increase in number of natural disasters is associated with an increase in number of deaths. Moreover, an area with higher population should have a higher death toll when faced with a natural calamity. Of interest also is whether income, measured as GRDP, has an effect on number of deaths.

3. Review of Related Literature

The cause of anthropogenic climate change is the increasing concentration of greenhouse gases such as carbon dioxide (CO_2), water vapor, methane, and nitrous oxide in the atmosphere. Greenhouse gases are transparent to incoming ultraviolet (short wavelength) radiation from the sun which passes through the atmosphere and warms the surface of the Earth. Infrared (long wavelength) radiation is then given off. Most of the infrared radiation escapes into outer space, but some of it is trapped by greenhouse gases, thereby warming the Earth.

Stern (2007) notes that the warming effect due to all greenhouse gases emitted by human activities is now equivalent to around 430 ppm (parts per million) of CO_2 and rising at around 2.3 ppm per year. Current levels of greenhouse gases are higher now than at any time in at least the past 650,000 years. Furthermore, over the past four decades, global temperatures have risen at around 0.2^{o}C, bringing the global mean temperature to perhaps its warmest level in around 12,000 years. All of the ten warmest years on record have occurred since 1990.

The complex effects of climate change have been studied by the Intergovernmental Panel on Climate Change Fourth Assessment Round (IPCC

AR4), and also by Stern (2007). These effects, summarized below, will be suffered more by the developing countries than the developed ones.

The strongest impact of climate change is in the distribution of water. Climate change will alter patterns of water availability by intensifying the water cycle. In many areas, drought and floods will become more severe. There will be more rain in areas of high latitude, and less rain in the dry subtropics, and uncertain but probably substantial changes in tropical areas. Hotter land surface temperatures induce more powerful evaporation and hence become more intense rainfall, with increased risk of flash flooding. Melting glaciers and loss of its mountain snow increases flood risk during the wet season and threatens dry season water supplies to one-sixth of the world's population.

Climate change will also affect food production. Food production is sensitive to climate change because crop yields depend in large part on prevailing climate conditions. In tropical regions, even small amounts of warming will results in large declines in yield. Higher temperatures are likely to become increasingly damaging to crops, as droughts intensify and critical temperature thresholds for crop production are reached more often.

Health is another increasing concern. Climate change will increase worldwide deaths from malnutrition and heat stress. Vector-borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place. The World Health Organization (WHO) estimates that climate change is already responsible for over 150,000 deaths each year through the rising incidence of diarrhea, malaria and malnutrition, particularly in Africa and other developing nations.

Moreover, climate change is likely to occur too rapidly for many species to adapt. One study estimates that around 15-40% of species face extinction with 2 ^{o}C of warming. Warming of the 20th century has already directly affected ecosystems.

One effect of climate change which definitely hits hard on the Philippines is rising sea levels. The rise of sea levels increases coastal flooding, raises costs of coastal protection, leads to loss of wet lands and coastal erosion, and will increase saltwater intrusion into surface and groundwater. In addition, it will increase the amount of land lost and people displaced due to permanent inundation. Homes of tens of millions more people are likely to be affected by flooding from coastal storm surges with rising sea levels. People in South and East Asia will be most vulnerable, along with those living on the coast of Africa and on small islands.

Coastal zones are especially vulnerable to natural fluctuations making these areas sensitive to climate change. There are two major reasons for their vulnerability: the land elevations are low, so natural disasters are easily caused by any rise in sea level, storm waves, storm surges and tsunamis; and many coastal zones have high population density or high levels of economic activity, so that disasters which break through protection systems cause huge damage (Nobuoka and Murakami, 2011).

The report of working group II of the IPCC AR4 addresses six concerns regarding coastal zones and climate change:

- Coasts are experiencing the adverse consequences of hazards related to climate and sea level.
- Coasts will be exposed to increasing risks, including coastal erosion, over coming decades due to climate change and sea level rise.
- The impact of climate change on coasts is exacerbated by increasing human-induced pressures.
- Adaptation of the coasts of developing countries will be more challenging than for coasts of developed countries, due to constraints on adaptive capacity.
- Adaptation costs for vulnerable coasts are much less than the costs of inaction.
- The unavoidability of sea-level rise, even in the longer term, frequently conflicts with present-day human development patterns and trends.

The Philippines will also be affected by the rise in number of extreme events. Sachs (2008) observes that it is generally expected that extreme weather events are likely to intensify as a result of warmer temperatures. While the overall frequency of hurricanes might not change, the energy released seems to be increasing and therefore the frequency of major hurricanes seems to be on the rise. Flooding and droughts are both likely to increase in some parts of the planet. Hupper (2006) cites the Southeast Asia tsunami and Kashmir earthquake as illustrations of the vulnerability of developing countries, resulting in terrible death tolls, great suffering, and whole communities being destroyed.

There are two approaches to handling the issue of climate change: one is to remove the causes of the change and the other is to adjust to the adverse effects. These responses are referred to as mitigation and adaptation measures, respectively (Tamura and Mimura, 2011). Mitigation strategies to reduce greenhouse gas emissions and their role in climate change include energy conservation, development of alternative energy and forest protection and afforestation programs. In contrast adaptation serves to adjust human and natural systems, on the assumption of ongoing climate change e.g. disaster prevention, changes in cultivated plant species, and breeding new plant varieties (Tamura and Mimura, 2011). As already mentioned, this study focuses on education as an adaptation strategy.

The idea for undertaking this study came from Striessnig et al. (2013), which, to the authors' knowledge, is the only other study which analyzes the relationship between education and climate risk vulnerability. Their study runs a panel regression involving 125 countries over 5- and 10-year intervals between 1980 and 2010. The logarithm of number of deaths per 1000 population is used as response variable, while the education component of the Human Development

Index (HDI) is used a measure of education. The main conclusion of their study is that education as an investment in the adaptive capacity has to be seen as a new policy focus. Striessnig provides the rationale for education's being an important adaptation strategy: "Better education typically implies better access to relevant information, such as early warnings for tropical storms, or seasonal prediction of drought. Second, there is evidence that education also enhances cognitive skills and willingness to change risky behavior while at the same time extending the planning horizon."

The United Nations Children's Fund (UNICEF) says the same thing about the vulnerability of children to climate risk: "Providing children with empowering and relevant education on disasters and climate change in a child-friendly school environment can reduce their vulnerability to risk while contributing to sustainable development for their communities. Educating girls and women is one of the best ways of strengthening community adaptation to climate change, as shown by recent studies."

Striessnig et al. (2013) also mentions other development indicators that have been found to correlate significantly with losses from climate hazards. Among them are income, population density, access to drinking water, female fertility, and a number of indicators of good governance and public corruption. This study also controls for the effects of number of natural disasters, gross regional domestic product (GRDP), and population size.

4. Methodology

4.1 Discussion of the panel data model

To collect panel data (also known as longitudinal data), the same cross sections (e.g. individuals, families, firms, cities, states, or whatever) are followed, or attempted to follow, across time. In the study's case, we follow the different regions through each quarter, starting from the first quarter of 2003 to the second quarter of 2011. The researchers had initially planned on using the fixed-effects (FE) model for panel data, the model commonly used for panel data analysis. The fixed-effects model for panel data is given by:

$$y_{it} = \alpha_i + X_{it}\beta + u_{it}, \quad i = 1,2,\ldots,17, \quad t = 1,2,\ldots,34 \tag{1}$$

In here, y_{it} represents the number of deaths from natural disasters for the i^{th} region at time t, where i = 1,2,…,17 (17 regions) and t = 1,2,…,34 (34 quarters included). The vector X_{it} represents the explanatory variables, β is a vector of coefficients, α_i represents the region-specific and unobservable fixed effect, and u_{it} is random error term assumed to be normally distributed with mean 0 and constant variance σ_u^2 (Wooldridge, 2003).

The researchers found this model inappropriate because of the relatively large percentage of observations with zero values for the dependent variable. These observations correspond to those regions which experienced no natural disaster, or just very few minor disasters that do not result in casualties. Even those regions which are in the usual path of natural disasters do not experience casualties the whole year. Thus, the count of number of deaths is still zero for those quarters where no natural disaster has occurred.

Even though model (1) did show some logical results, the authors had to abandon this model to reflect the discrete nature of the response variable (which counts the number of deaths). The model adopted by the researchers is the fixed-effects Poisson (FEP) model for panel data, developed by Hausman et al. (1984). The basic Poisson probability specification is:

$$\Pr\left(n_{it}\right) = f\left(n_{it}\right) = \frac{e^{-\lambda_{it}} \lambda_{it}^{n_{it}}}{n_{it}!} \tag{2}$$

In the paper's application, the subscript i represents the regions and t represents the time periods, n_{it} represents the number of deaths from natural disasters in the i^{th} region at time t. We make the following specification:

$$\log \lambda_{it} = X_{it}\beta \tag{3}$$

We see that λ_{it} is a deterministic function of X_{it} and the randomness in the model comes from the Poisson specification for n_{it}.

4.2 Estimation Procedure

The log likelihood for N regions and T time periods for this Poisson specification is:

$$L\left(\beta\right) = \sum_{i=1}^{N}\sum_{t=1}^{T}\left[n_{it}! - e^{X_{it}\beta} + n_{it}X_{it}\beta\right] \tag{4}$$

The gradient and Hessian take the forms

$$\frac{\partial L}{\partial \beta} = \sum\sum\left[X_{it}^{'}\left(n_{it} - e^{X_{it}\beta}\right)\right] \tag{5}$$

$$\frac{\partial^2 L}{\partial \beta \partial \beta^{'}} = \sum\sum\left[-\left(X_{it}^{'}X_{it}\right)e^{X_{it}\beta}\right] \tag{6}$$

As Hausman et al. (1984) observes, the first order conditions indicate that β can be estimated either by an iterative nonlinear weighted least squares method with $(n_{it}-\lambda_{it})$ as the residual or by a maximum likelihood (ML) program. The Hessian demonstrates that the likelihood function is globally concave as long as X is of full column rank and $e^{X_{it}\beta}$ does not go to zero for all X_{it}. With a globally concave likelihood function, a wide choice of ML algorithms can be used. In the applications of Hausman et al. (1984), convergence to the global maximum was always rapid. The variance matrix of the asymptotic distribution of $V(\beta)$ is calculated from the Hessian matrix evaluated at $\hat{\beta}$.

4.3 Robust covariance matrix

The Poisson model restricts the conditional variance to be equal to the conditional mean. However, there is a possibility that data are *overdispersed*. That is, the variance may exceed the mean. Unless count data are equidispersed, the usual Poisson MLE standard errors may be wrong. In econometrics, the standard correction is to generalize White's heteroskedasticity-robust standard errors from ordinary least squares (OLS) to Poisson. White (1980) introduced the following robust estimator:

$$v\left(\hat{\beta}_j\right) = \frac{\sum_{i=1}^{n} \hat{r}_{ij}^2 \hat{u}_i^2}{SSR_J^2} \tag{7}$$

where $\hat{r}_{ij}$ is the i^{th} residual obtained by regressing x_j on all other independent variables and SSR_j is the sum of squared residuals from this regression. The square-root of the above quantity is called the heteroskedasticity-robust standard error. Such standard error corrections must be made for overdispersed data, in which case the uncorrected t-statistics are much larger than the corrected t-statistics. It is worth mentioning that in computing the value of the t-statistic, the value of the parameter estimate does not change, only the standard error does. As the sample size increases the distribution of the robust t-statistics resembles the t-distribution more closely.

5. Variable Definitions and Data Sets

5.1 Response variable: number of deaths due to natural disasters

Data on number of deaths due to natural disasters were obtained from the Natural Disaster Risk Reduction and Management Council (NDRRMC). The data are available monthly and by region. The natural disasters include only tropical depressions, typhoons, and supertyphoons. Unfortunately, the data do not include other natural disasters like earthquakes.

5.2 Determinants of number of deaths from natural disasters

Education

The main explanatory variable for this study is education, measured as number of employed persons (in thousands) who are at least college graduates. Data on this variable were obtained from the Labor Force Survey (LFS), administered quarterly by the National Statistics Office (NSO). The data set is available by region and also by sex. The disaggregation by sex is used by the authors because of studies which claim that distributions by sex and age have significant explanatory power. Unfortunately, distribution by age for our measure of education is not available in the quarterly report of the LFS.

Number of natural disasters

The dataset on number of natural disasters was also obtained from the NDRRMC, and includes only tropical depressions, typhoons, and supertyphoons. Data are available by area of the disaster, and the disaster is counted for all regions affected. In order to estimate the effect of education on number of deaths from natural disasters, the study has to control for number of natural disasters, which measures a region's exposure to natural disasters.

Population size

The dataset on population by region was obtained from the Philippine Statistical Yearbook of the National Statistical Coordination Board (NSCB). For certain time periods, projections were done to estimate the population. These projections, although not exactly linear, are approximately linear. The inclusion of population size in the model is due studies (e.g. Huppert and Sparks, 2006) which link population with natural hazards.

Gross regional domestic product per capita

Data on real gross regional domestic product (GRDP) per capita were also obtained from the Philippine Statistical Yearbook of the NSCB. GRDP is a measure of economic activity of the regional economy. The inclusion of GRDP as an explanatory variable is to address the question of whether income matters more than education in reducing a country's disaster death count. Rebasing was done on the GRDP series to measure the GRDP in real terms. The base year used is 1985.

6. Results and Discussions

Figure 1 presents the total number of natural disasters by region for the entire period included in the study. Relatively few disasters have hit the Mindanao regions. The top five regions most frequently affected by natural disasters (Cagayan Valley, Ilocos Region, CAR, Central Luzon, and Bicol Region) are all in mainland Luzon. According to PAGASA's climate projections, extreme rainfall is projected to increase further in Luzon and Visayas, the places already much-exposed to natural disasters.

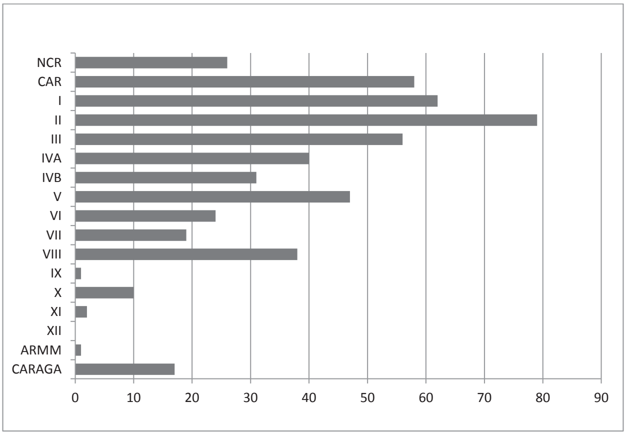

Figure 1. Total Number of Natural Disasters: 2003-2011

The total number of deaths from natural disasters is shown by region in Figure 2. The figure shows that it is Bicol Region which suffers the most number of deaths, followed by Southern Luzon and Eastern Visayas. The regions with the fewest number of deaths are in Mindanao, the same regions least frequently visited by natural disasters.

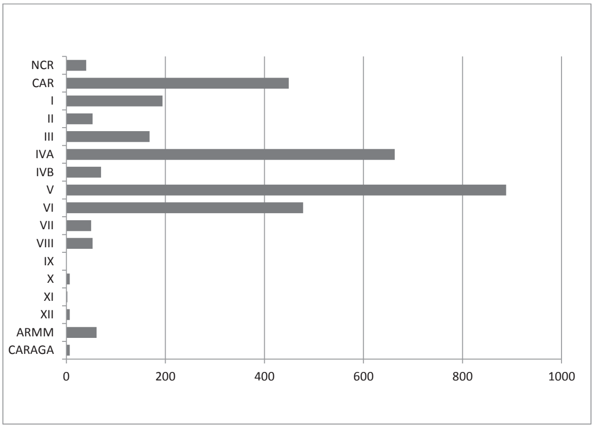

Figure 2. Total Deaths from Natural Disasters: 2003Q1-2011Q2

Figure 3 shows the number of college graduates in the Philippines who are employed. The graph shows that there is a steady, increasing, and nearly deterministic linear trend whose dynamics does not change so much. Although the national trend in education seems unchanging, different regions display different trends in education.

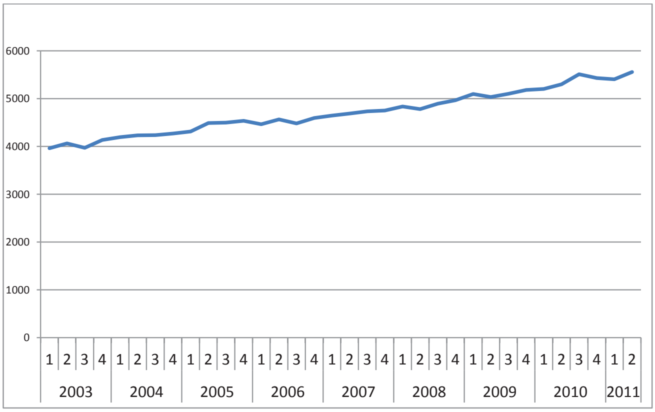

Figure 3. Number of College Graduates (in thousands) who are Employed

Figure 4 below breaks figure 3 down by sex. The trends in number of employed male and female college graduates are the same as that of all employed college graduates. In fact, there is a high degree of correlation between employed male and female college graduates, making it improper to include both variables simultaneously in the model, as this would lead to multicollinearity.

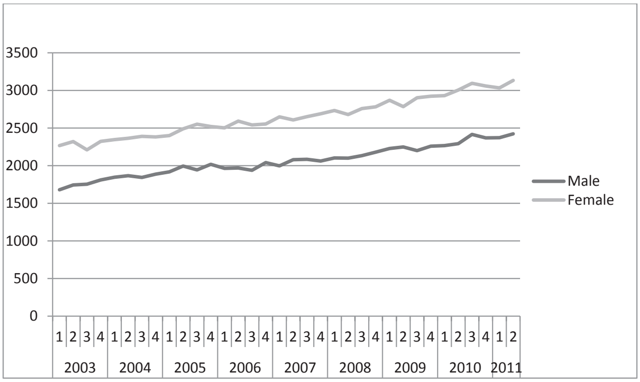

Figure 4. Number of Male and Female Employed College Graduates

Figure 5 below gives the number of employed college graduates by region for the last quarter included in the study (2nd quarter of 2011). As expected, it is NCR which has the highest number of employed college graduates, followed by Region IV-A (CALABARZON) and Region III (Central Luzon), while it is the regions in Mindanao which have the fewest number of employed college graduates.

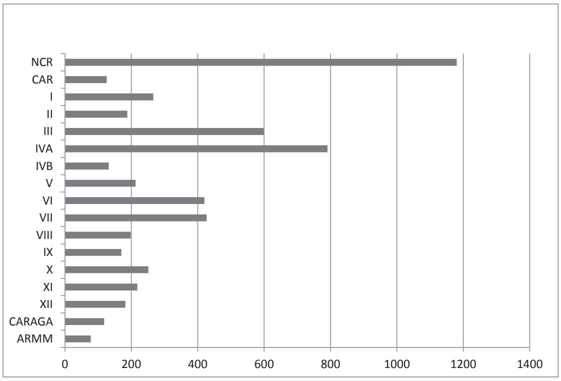

Figure 5. Number of Employed College Graduates by Region: 2011 Q2

As already mentioned, this study looks at the distribution by sex of college graduates. Figure 6 gives the number of male and female college graduates by region. There are more female college graduates than male in all regions except for ARMM. The gap between sexes is closest for Region II and CAR, and widest for Regions IV-A, CARAGA, and V, where there are 51.3%, 48.1%, 42.7% more female than male employed college graduates, respectively.

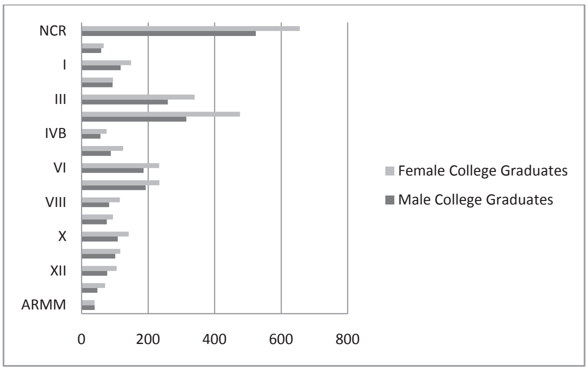

Figure 6. Number of Male and Female College Graduates by Region: 2011Q2

Figure 7 shows the scatterplot between number of deaths from natural disasters and the main explanatory variable of interest, number of employed college graduates. To illuminate the relationship, only disasters with number of deaths less than 50 are included in the scatterplot (the other disasters appear to be outlying observations). A negative relationship between the two variables is at least visible.

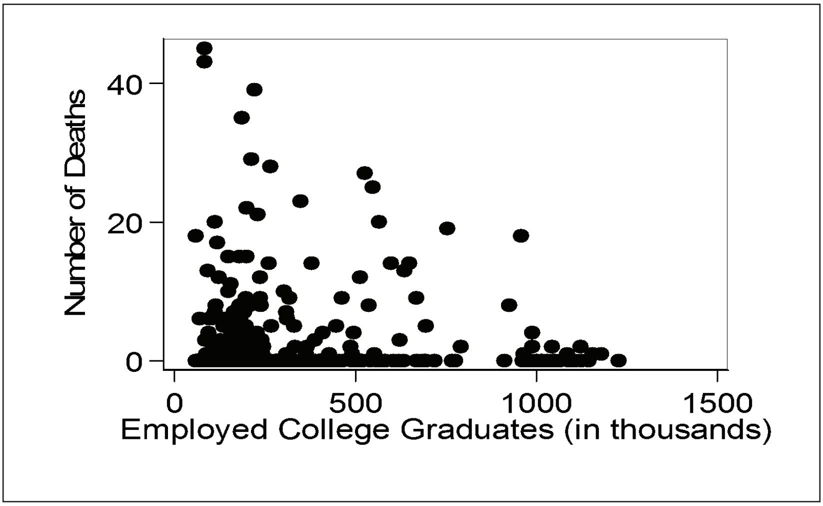

Figure 7. Scatterplot of Number of Employed College Graduates and Number of Deaths

The authors have run three separate models: the first uses number of employed college graduates as a measure of education, the second uses number of employed *male* college graduates, and the third uses employed *female* college graduates. These models will be referred to as models 1, 2, and 3, respectively. Including both employed male and female college graduates simultaneously results in serious multicollinearity (this is expected from the high correlation between the two, as suggested by Figure 7), and is therefore not run as one of the models.

Table 1 gives the results of Model 1. The results show that number of natural disasters, education, and population size all have significant effects on number of deaths from natural disasters. The signs of the coefficients agree with expectations. Although not a significant variable, the sign of the coefficient of GRDP is surprisingly positive, thus seeming to indicate a positive relationship between income and climate risk, a result that is contrary to expectations. The results for the other variables show that an increase of 1000 college graduates brings about a 2% decrease in mean number of deaths from natural disasters, supporting the research hypothesis that education has a significant effect in reducing climate risk vulnerability. Moreover, for every occurrence of a natural disaster, the mean number of deaths is doubled. Lastly, population size also figures as a significant variable affecting climate risk: for every additional one million people in the population, the mean number of deaths increases by 1.9%.

Table 1. Determinants of Number of Deaths from Natural Disasters

Variable	Coefficient	Robust Std. Error	Z	p-value
Disasters*	0.778032	0.258051	3.02	0.003
College graduates*	-0.0201645	0.0048063	-4.2	<0.001
Population*	0.00000191	0.000000503	3.79	<0.001
GRDP	0.0000713	0.0000703	1.01	0.311

**Significant at 1% level*

Table 2 gives the results of model 2. The effects of natural disasters and population are similar to that of model 1. An increase of one in number of natural disasters multiplies the mean number of deaths by 2.2, while an increase of 1 million in population size of the region is associated with a 1.36% increase in mean number of deaths. The surprising result however is the substantially higher effect of the male education variable. An increase of 1000 male college graduates leads to a 4% decrease in mean number of deaths (twice the decrease compared to number of college graduates taken together).

Table 2. Determinants of Number of Deaths from Natural Disasters, Male College Graduates as Explanatory Variable

Variable	Coefficient	Robust Std. Error	Z	p-value
Disasters*	0.7897123	0.2569203	3.07	0.002
Male College graduates*	-0.0411637	0.0160049	-2.57	0.01
Population	0.00000136	0.000000887	1.53	0.125
GRDP	0.0000849	0.0000918	0.93	0.355

**Significant at 1% level*

Lastly, we show the results of model 3 in table 3, where we study the effect of female education on climate risk. The results for the effects of the explanatory variables are similar to model 1. An increase of 1000 female college graduates leads to a 2.7% decrease in mean number of deaths. This is an indication that education, whether male or female, plays a significant role in reducing climate risk vulnerability. In addition, the estimated model also shows that an increase of one in number of natural disasters leads to a doubling of the mean number of deaths, a result that is almost identical to that of models 1 and 2. Lastly, increasing the population by 1 million people decreases the mean number of deaths by 1.61%. As in the previous two models, GRDP is not significant in explaining number of deaths, hence its coefficient is not interpreted. GRDP loses its explanatory power once we add education and population variables into the model.

Table 3. Determinants of Number of Deaths from Natural Disasters, Female College Graduates as Explanatory Variable

Variable	Coefficient	Robust Std. Error	Z	p-value
Disasters*	0.7629796	0.2523063	3.02	0.002
Female College graduates*	-0.0276168	0.0082201	-3.36	0.001
Population*	0.00000161	0.000000463	3.48	0.001
GRDP	0.0000602	0.0000596	1.01	0.313

**Significant at 1% level*

7. Conclusion

All three models show that education is a significant factor in reducing the number of deaths due to natural disasters, with a reduction of approximately 2% deaths associated with increasing the total number of college graduates in a region by 1000. This provides support to the fact that education is an important adaptation measure since, as Striessnig et al. (2013) argue, better education enhances cognitive skills and the willingness to change risky behavior while extending personal planning horizon.

The inclusion of number of disasters as a control variable in the models is essential in order to measure the partial effect of education. It is of course not surprising that higher frequency of natural disasters causes more deaths. The three models affirm this, and in addition the effect is quantified: An increase of one disaster doubles the mean number of deaths from natural disasters. This effect is roughly the same in all three models.

We can also see that an increase in population results to an increase in number of deaths. Increasing the population by 1 million can increase the mean number of deaths by up to 1.9%. This is consistent with the findings of Huppert et al. (2006), which claims that mankind is becoming more susceptible to natural disasters, largely as a consequence of population growth and globalization. Huppert clearly says that the increased influence of events is due to the ever increasing vulnerability arising from larger populations in high risk locations.

Lastly, the factor GRDP has not been significant in all of the three models. The positive coefficient attached to it is a surprising result. A similar result is seen in the study of Striessnig et al. (2013), where the GDP component of HDI shows no significant additional explanatory power in a model which already includes the educational and life expectancy components of the HDI.

Natural disasters exact far greater economic costs in developing countries like the Philippines than in developed countries. The poorest countries will be especially hard hit by climate change, with millions potentially pushed deeper into poverty. Governments have an important role to play in raising awareness. Moreover, as Stern notes, development itself is key to adaptation. Much adaptation should be an extension of good development practice and reduce vulnerability, one of the steps to do this is to invest in education.

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