Disaster Risk, Social Vulnerability and Economic Development

Patrick S. Ward

International Center for Climate Governance

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Introduction

- Disasters represent a significant threat to humankind because they have the potential to have significant and sudden impacts on societies.
- Climate change is expected to increase the frequency and intensity of many types of climate-related disasters.

Since 1960 there have been:
- 8,035 climate-related disasters reported
- 3.5 million deaths associated to climate-related disasters
- 6.1 billion persons affected by climate-related disasters
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Climate Disasters Affect All Regions of the World

- Africa: 40%
- Americas: 27%
- Asia: 14%
- Europe: 15%
- Oceania: 5%
Disasters: Natural or Un-Natural?

- World Bank publication (2010)
- Are disasters natural or un-natural?
  - There is a perceived lack of control over these events
    - “Acts of God”
  - While there are natural events that precipitate disasters, the death and destruction result from human acts of omission and commission
Distinction Between Hazards and Disasters

Hazard
“extreme natural event which may affect different places singly or in combination...at different times.”

Disaster
“when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid.”

Source: Blaikie et al. (1994)
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Center for the Research on the Epidemiology of Disasters (CRED) definition:

- “A situation or event which overwhelms local capacity necessitating a request to national or international level for external assistance.”\(^1\)

Criteria for characterizing an event as a disaster:\(^2\)

- 10 or more people reported killed
- 100 or more people reported affected
- Declaration of a state of emergency
- A call for international assistance

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We focus on climate-related disasters in this paper:

- Droughts
- Extreme Temperatures (both extreme heat and extreme cold)
- Floods
- Wet mass movements (e.g., landslides or mudslides)
- Storms (both tropical storms and localized convective storms)
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Our purpose in this paper is twofold:

Objective #1
Consider the “un-natural” determinants of disasters: What factors contribute to a hazard becoming a disaster?

Objective #2
Consider the effects of socio-economic factors on social vulnerability: How do social, economic, and political factors affect social outcomes in the event of a disaster?
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Disasters Have Been Reported with Greater Frequency

Source: EM-DAT, the OFDA/CRED International Disaster Database - www.emdat.be - Universite Catholique de Louvain - Brussels - Belgium.
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Declining Mortality, Rising Morbidity

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Increasing Disaster Frequency

What explains the increasing frequency of climate disasters?

- Unreliable historical data (may understate true disaster frequencies from the past)
- Changing national boundaries (e.g., break-ups of the Soviet Union and Yugoslavia)
- Systematic variations in reliability
  - Improved transportation infrastructure
  - Improved telecommunication infrastructure
  - Increased international cooperation
  - Political regime switching
- Changing climate
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What explains the declining number of deaths and the rising number of persons affected?

- **Declining death tolls:**
  - Advances in physical infrastructure
  - Advances in medical technology

- **Rising numbers of persons affected:**
  - Lower mortality
  - Population growth (e.g., Strömberg, 2007)
  - Increasing disaster frequency
Trends in Social Outcomes of Disasters

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Explaining Disaster Occurrence
Disasters arise from the intersection of natural hazards and vulnerable societies.
Disasters:

\[ D_{jt}^* = f(H_{jt}^*(E_j), X_{jt}) \]

- **\( D_{jt}^* \): Disaster**
  - Unobserved
  - Observe \( D_{jt} = \begin{cases} 1 & \text{if } D_{jt}^* \geq D \\ 0 & \text{Otherwise} \end{cases} \)
  - \( D \) is as defined by CRED
- **\( H_{jt}^* \): Hazard (unobserved)**
- **\( E_j \): Exposure (presumably constant)**
- **\( X_{jt} \): Un-natural factors conditioning disasters**

What are the “un-natural” factors conditioning disasters?
- Adaptive capacity (i.e., income)?
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Are Wealthier Countries Less Likely to Experience Disasters?

Source: EM-DAT, the OFDA/CRED International Disaster Database - www.emdat.be - Université Catholique de Louvain - Brussels - Belgium.
Previous Research

- **Schelling (1992):**
  - Suggests the best defense against climate change for many developing countries is continued economic development.

- **United Nations Development Programme (2004):**
  - Economic development can “intervene in the translation of physical exposure into natural disasters”, but good development strategies are crucial.

- **Kahn (2005):**
  - Income does not affect the probability that a country experiences a disaster.

- **Strömberg (2007):**
  - Wealthier countries are no less likely to experience a disaster than poor countries.
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Previous Research

- **Wheeler (2011):**
  - Other factors are potentially confounding disaster data
  - Attempts to impute climate change effects should take these confounding factors into consideration
  - Controlling for these confounding factors, individuals in wealthy countries are less likely to be affected by disasters than those in poor countries.
Institutional Quality as a Confounding Variable

Recall CRED criteria for classifying an event as a disaster:

1. 10 or more people killed
2. 100 or more people affected
   - Disasters must be reported
     - Citizens must have a voice
     - Freedom of the press to discuss the hazard and its impact
     - Strong regulatory environment
3. Call for international assistance
   - Country must be engaged in the international community
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Kaufmann, Kraay & Mastruzzi Governance Indicators

- Voice and accountability
- Political stability and absence of violence/terrorism
- Government effectiveness
- Regulatory quality
- Rule of law
- Control of corruption

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- Factor weights computed using principal components analysis (PCA)
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Are Wealthier Countries Less Likely to Suffer Disasters?

Empirical model:
Panel Probit Model

\[ \text{Prob}(D_{ijt} = 1) = \Phi(E_j, Y_{jt}, IQ_{jt}, t, \nu_i) \]

- \( \text{Prob}(D_{ijt} = 1) \): Probability of disaster type \( i \) occurring in country \( j \) in year \( t \)
- \( E_j \): Time-invariant characteristics capturing hazard exposure for country \( j \) (geography, land area, etc.)
- \( Y_{jt} \): Time-varying real per capita income for country \( j \) (lagged)
- \( IQ_{jt} \): Potentially time-varying institutional characteristics for country \( j \)
- \( \nu_i \): Country-specific random effect error component
- \( \Phi(\cdot) \): Normal cumulative distribution function
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- \(\Phi(\cdot)\): Normal cumulative distribution function
# Random Effects Panel Probit Results

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<tr>
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<th>Any Disaster</th>
<th>Drought</th>
<th>Extreme Temperatures</th>
<th>Flood</th>
<th>Wet Mass Movement</th>
<th>Storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>−2.325**</td>
<td>−1.425**</td>
<td>−7.175***</td>
<td>−3.019***</td>
<td>−7.258***</td>
<td>−4.139***</td>
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<tr>
<td>ln(Real Per Capit GDP)</td>
<td>−0.185***</td>
<td>−0.203***</td>
<td>0.083</td>
<td>−0.233***</td>
<td>0.192**</td>
<td>−0.140</td>
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<tr>
<td></td>
<td>(−2.938)</td>
<td>(−3.464)</td>
<td>(0.738)</td>
<td>(−3.511)</td>
<td>(2.019)</td>
<td>(−1.588)</td>
</tr>
<tr>
<td>Quality of Institutions</td>
<td>0.078**</td>
<td>−0.011</td>
<td>−0.039</td>
<td>0.110***</td>
<td>−0.165**</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>(2.001)</td>
<td>(−0.280)</td>
<td>(−0.547)</td>
<td>(2.636)</td>
<td>(−2.432)</td>
<td>(1.021)</td>
</tr>
<tr>
<td>Elevation</td>
<td>0.119</td>
<td>−0.088</td>
<td>0.065</td>
<td>0.133</td>
<td>0.853***</td>
<td>−0.119</td>
</tr>
<tr>
<td></td>
<td>(1.196)</td>
<td>(−1.022)</td>
<td>(0.466)</td>
<td>(1.328)</td>
<td>(6.111)</td>
<td>(−0.838)</td>
</tr>
<tr>
<td>Abs. Value of Latitude</td>
<td>−0.015**</td>
<td>−0.009*</td>
<td>0.013</td>
<td>−0.018***</td>
<td>−0.032***</td>
<td>0.019**</td>
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<tr>
<td></td>
<td>(−2.360)</td>
<td>(−1.732)</td>
<td>(1.282)</td>
<td>(−2.778)</td>
<td>(−3.367)</td>
<td>(2.047)</td>
</tr>
<tr>
<td>Population Near Ice-Free Coast</td>
<td>0.221</td>
<td>−0.034</td>
<td>0.086</td>
<td>0.458</td>
<td>1.272**</td>
<td>0.658</td>
</tr>
<tr>
<td></td>
<td>(0.611)</td>
<td>(−0.114)</td>
<td>(0.151)</td>
<td>(1.273)</td>
<td>(2.118)</td>
<td>(1.269)</td>
</tr>
<tr>
<td>Land Near Ice-Free Coast</td>
<td>0.711*</td>
<td>0.117</td>
<td>0.438</td>
<td>0.154</td>
<td>−0.344</td>
<td>0.366</td>
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<tr>
<td></td>
<td>(1.893)</td>
<td>(0.360)</td>
<td>(0.781)</td>
<td>(0.413)</td>
<td>(−0.544)</td>
<td>(0.688)</td>
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<tr>
<td>ln(Land Area)</td>
<td>0.342***</td>
<td>0.157***</td>
<td>0.272***</td>
<td>0.356***</td>
<td>0.411***</td>
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<td>(10.022)</td>
<td>(5.439)</td>
<td>(5.131)</td>
<td>(10.227)</td>
<td>(7.411)</td>
<td>(5.926)</td>
</tr>
</tbody>
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<thead>
<tr>
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<th>#Obs</th>
<th>#Groups</th>
<th>Log-Likelihood</th>
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<td>3,867</td>
<td>146</td>
<td>−2,002.271</td>
</tr>
<tr>
<td>Drought</td>
<td>3,867</td>
<td>146</td>
<td>−1,097.367</td>
</tr>
<tr>
<td>Extreme</td>
<td>2,973</td>
<td>113</td>
<td>−670.544</td>
</tr>
<tr>
<td>Temperatures</td>
<td>3,867</td>
<td>146</td>
<td>−1,879.707</td>
</tr>
<tr>
<td>Flood</td>
<td>3,867</td>
<td>146</td>
<td>−694.051</td>
</tr>
<tr>
<td>Wet Mass</td>
<td>3,867</td>
<td>146</td>
<td>−1,410.356</td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
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</tr>
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<td>Storm</td>
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* p < 0.10, ** p < 0.05, *** p < 0.01
## Disaster Risk Ranking: Top 10 Most At-Risk

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<td>Ethiopia</td>
<td>Russia</td>
<td>India</td>
<td>China</td>
</tr>
<tr>
<td>2</td>
<td>United States</td>
<td>China</td>
<td>India</td>
<td>Indonesia</td>
<td>Indonesia</td>
</tr>
<tr>
<td>3</td>
<td>Indonesia</td>
<td>Indonesia</td>
<td>Pakistan</td>
<td>China</td>
<td>Peru</td>
</tr>
<tr>
<td>4</td>
<td>Canada</td>
<td>Mozambique</td>
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<td>Brazil</td>
</tr>
<tr>
<td>5</td>
<td>China</td>
<td>Tanzania</td>
<td>Ukraine</td>
<td>Australia</td>
<td>Tajikistan</td>
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<td>Nepal</td>
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<td>Vietnam</td>
<td>Uganda</td>
<td>Italy</td>
<td>Sri Lanka</td>
<td>Mexico</td>
</tr>
<tr>
<td>10</td>
<td>Malaysia</td>
<td>Zambia</td>
<td>Belarus</td>
<td>United States</td>
<td>Kyrgyzstan</td>
</tr>
</tbody>
</table>

(China: China, India: India, Pakistan: Pakistan, Russia: Russia, Brazil: Brazil, Tajikistan: Tajikistan, Nepal: Nepal, Iran: Iran, Mexico: Mexico, Indonesia: Indonesia, Kyrgyzstan: Kyrgyzstan, Australia: Australia)
Disaster Risk and Social Vulnerability

Country-specific measures of disaster risk and social vulnerability:

- Disaster risk: average predicted probability of experiencing a disaster
- Social vulnerability: average societal footprint of disasters
  1. Deaths per 1,000 people in the (lagged) population
  2. Persons affected per 1,000 people in the (lagged) population

Is there a relationship between disaster risk and social vulnerability?
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Disaster Risk and Deaths

![Graph showing the relationship between average predicted probability of disaster and logarithm of deaths per 1,000 people.]
Disaster Risk and Affected Persons
Pressure and Release Model

Blaikie et al. (1994) introduced a conceptual model to explain society’s vulnerability to disasters:

- Tracks the progression of vulnerability from root causes to unsafe conditions
- Disasters lie at the complex interaction of two opposing forces:
  - Natural hazard
  - Vulnerable society
Pressure and Release Model

THE PROGRESSION OF VULNERABILITY

1. ROOT CAUSES
   - Limited access to
     - Power
     - Structures
     - Resources
   - Ideologies
     - Political systems
     - Economic systems

2. DYNAMIC PRESSURES
   - Lack of
     - Local institutions
     - Training
     - Appropriate skills
     - Local investments
     - Local markets
     - Press freedom
     - Ethical standards in public life
   - Macro Forces
     - Rapid population growth
     - Rapid urbanization
     - Arms expenditure
     - Debt repayment schedules
     - Deforestation
     - Decline in soil productivity

3. UNSAFE CONDITIONS
   - Fragile physical environment
     - Dangerous locations
     - Unprotected buildings and infrastructure
   - Fragile local economy
     - Livelihoods at risk
     - Low income levels
   - Vulnerable society
     - Special groups at risk
     - Lack of local institutions
   - Public actions
     - Lack of disaster preparedness
     - Prevalence of endemic disaster

RISK = Hazard + Vulnerability
R = H + V

4. DISASTER

5. HAZARDS
   - High winds (cyclone/hurricane/typhoon)
   - Flooding
   - Landslide
   - Drought

Source: Blaikie et al. (1994, modified to incorporate only climate-related hazards).
Root Causes, Dynamic Pressures and Unsafe Conditions

- **Unsafe Conditions:**
  - Low incomes (real per capita income)
  - Physical infrastructure (telephones per 1,000 people)
  - Marginalized groups (dependency ratio and ethnic fractionalization)

- **Dynamic Pressures:**
  - Population pressures (population density and urban population)

- **Root Causes:**
  - Political institutions and ideologies (institutional quality)
  - Limited access to power (Gini coefficient on income inequality)
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Testing the Pressure and Release Model

Empirical Models:

Model #1

\[
\ln \left( \frac{Deaths_{it} + 1}{Population_{it}/1,000} \right) = x'_{it}\beta + z'_{i}\gamma + \delta t + \nu_i + u_{it}
\]

Model #2

\[
\ln \left( \frac{Affected_{it} + 1}{Population_{it}/1,000} \right) = x'_{it}\beta + z'_{i}\gamma + \delta t + \nu_i + u_{it}
\]
Testing the Pressure and Release Model

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\]
Testing the Pressure and Release Model

<table>
<thead>
<tr>
<th></th>
<th>ln(Deaths Population/1,000)</th>
<th>ln(Affected Population/1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>−9.054***</td>
<td>3.126</td>
</tr>
<tr>
<td></td>
<td>(−2.821)</td>
<td>(0.337)</td>
</tr>
<tr>
<td>ln(Real GDP per capita)</td>
<td>−0.363***</td>
<td>−0.822***</td>
</tr>
<tr>
<td></td>
<td>(−2.835)</td>
<td>(−2.614)</td>
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<tr>
<td>ln(Dependency)</td>
<td>1.985*</td>
<td>1.624</td>
</tr>
<tr>
<td></td>
<td>(2.520)</td>
<td>(0.782)</td>
</tr>
<tr>
<td>ln(Physicians per 1,000)</td>
<td>0.372***</td>
<td>0.466</td>
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<tr>
<td></td>
<td>(3.178)</td>
<td>(1.545)</td>
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<tr>
<td>Population near coast (%)</td>
<td>0.406*</td>
<td>1.341**</td>
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<tr>
<td></td>
<td>(1.708)</td>
<td>(2.299)</td>
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<tr>
<td>ln(Population density)</td>
<td>0.165***</td>
<td>−0.404***</td>
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<tr>
<td></td>
<td>(2.828)</td>
<td>(−2.811)</td>
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<tr>
<td>ln(Urban population)</td>
<td>−0.308***</td>
<td>−0.241</td>
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<tr>
<td></td>
<td>(−4.520)</td>
<td>(−1.351)</td>
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<tr>
<td>Income inequality</td>
<td>0.016**</td>
<td>0.043**</td>
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<tr>
<td></td>
<td>(2.030)</td>
<td>(1.929)</td>
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<tr>
<td>Fractionalization</td>
<td>−0.405</td>
<td>−1.624*</td>
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<tr>
<td></td>
<td>(−1.182)</td>
<td>(−1.835)</td>
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<tr>
<td>Time trend</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Disaster count controls</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td># Obs</td>
<td>1,477</td>
<td>1,477</td>
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<tr>
<td># Groups</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>R²: Within</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>R²: Between</td>
<td>0.40</td>
<td>0.62</td>
</tr>
<tr>
<td>R²: Overall</td>
<td>0.23</td>
<td>0.35</td>
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After controlling for factors that affect disaster reporting, wealthier countries are less likely to suffer disasters than poor countries. This contrasts with several high-profile studies that fail to control for factors influencing disaster reporting. Confounding variables: time, institutional quality, greater populations at risk. There is a positive relationship between disaster risk and social vulnerability. Higher disaster risk is correlated with greater social disaster outcomes.
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- Conditional on a disaster occurring:
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Thank you!

patrick.ward@cmcc.it
Natural Hazards, UnNatural Disasters

The Economics of Effective Prevention