# Disaster Risk, Social Vulnerability and Economic Development

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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.

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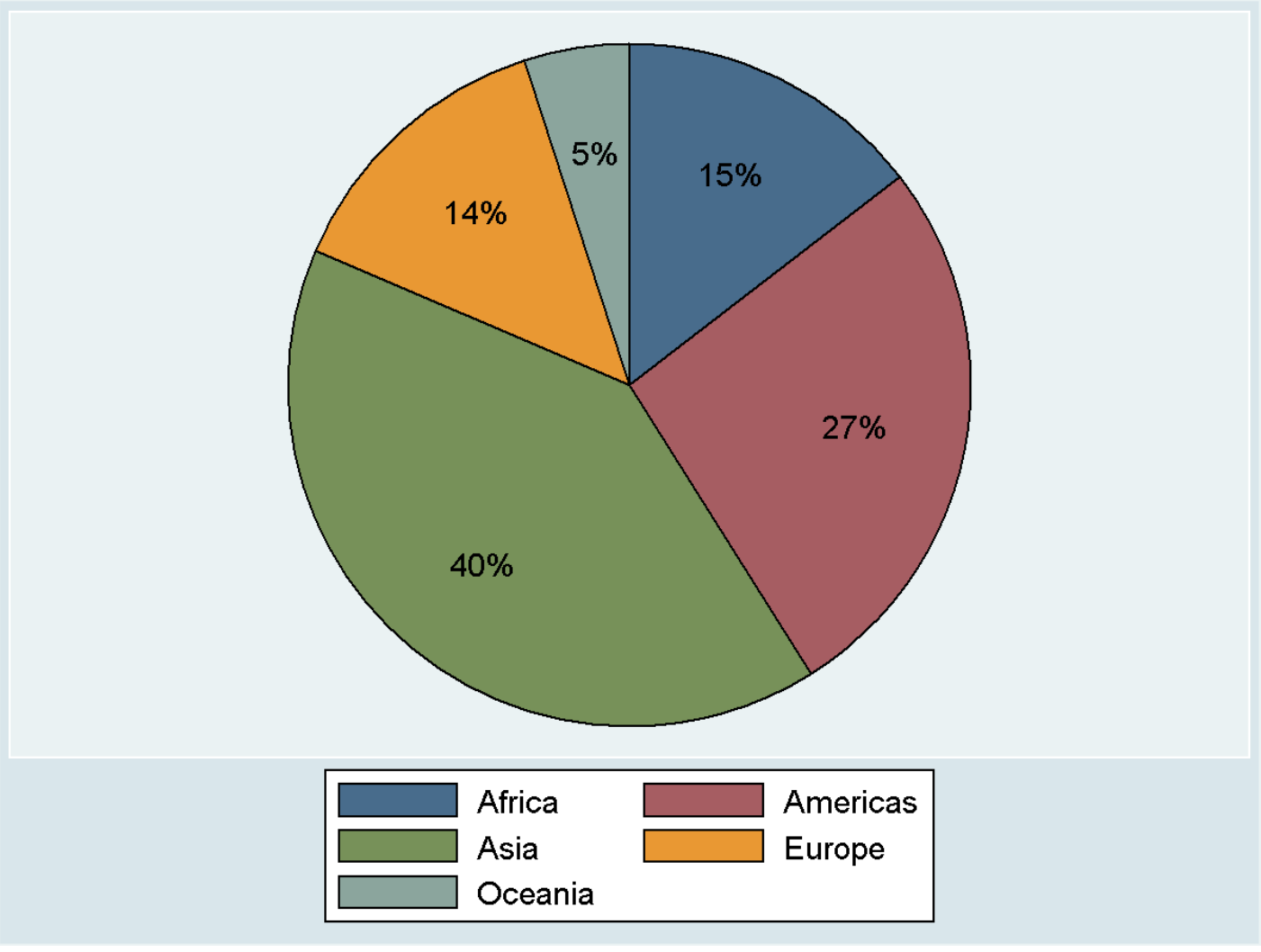
# Climate Disasters Affect All Regions of the World



# Disasters: Natural or Un-Natural?

- World Bank publication (2010) Go!
- 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]
  1. 10 or more people reported killed
  2. 100 or more people reported affected
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# Focus on Climate-Related Disasters

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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# Research Objectives

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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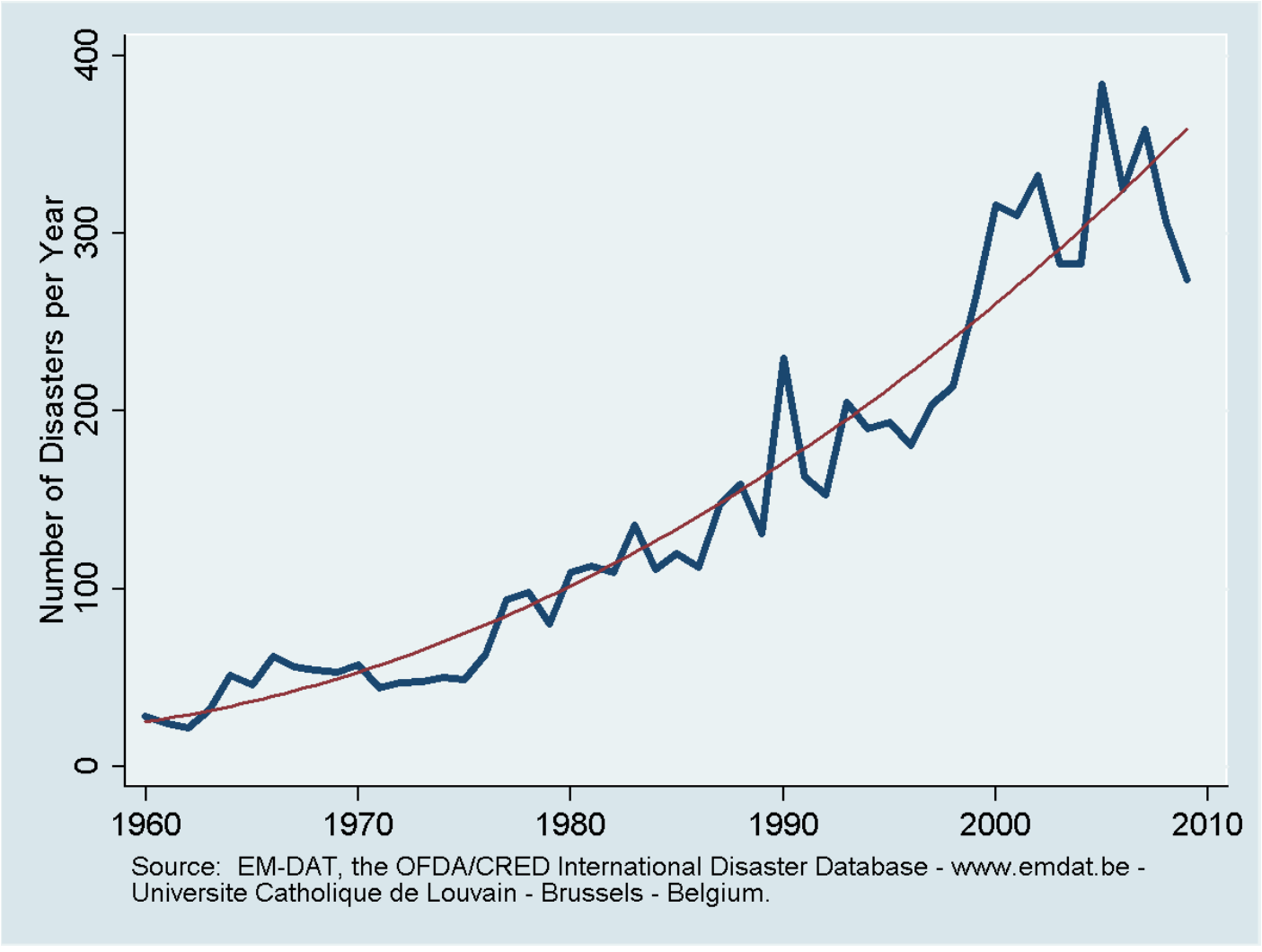
# Disasters Have Been Reported with Greater Frequency



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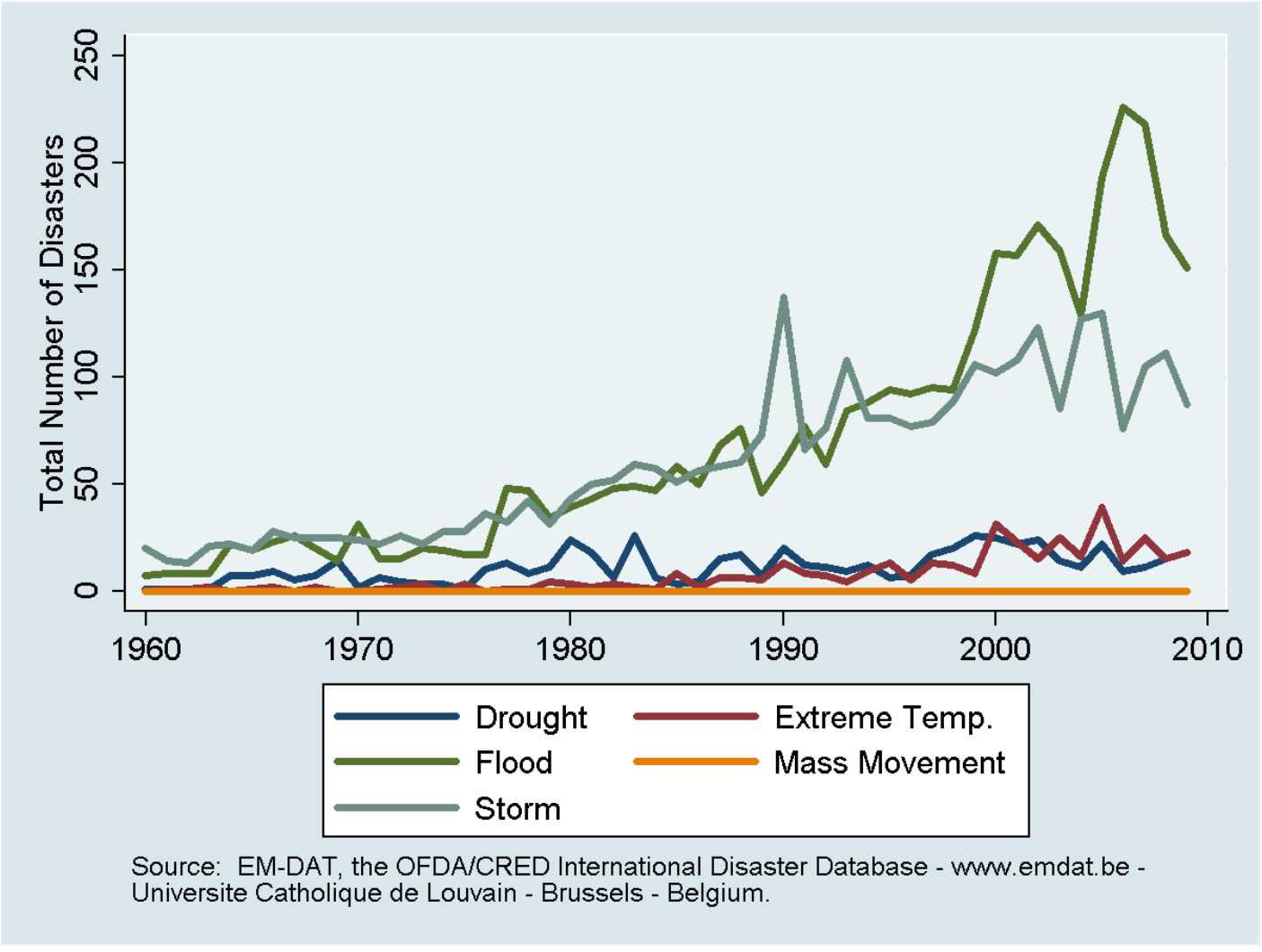
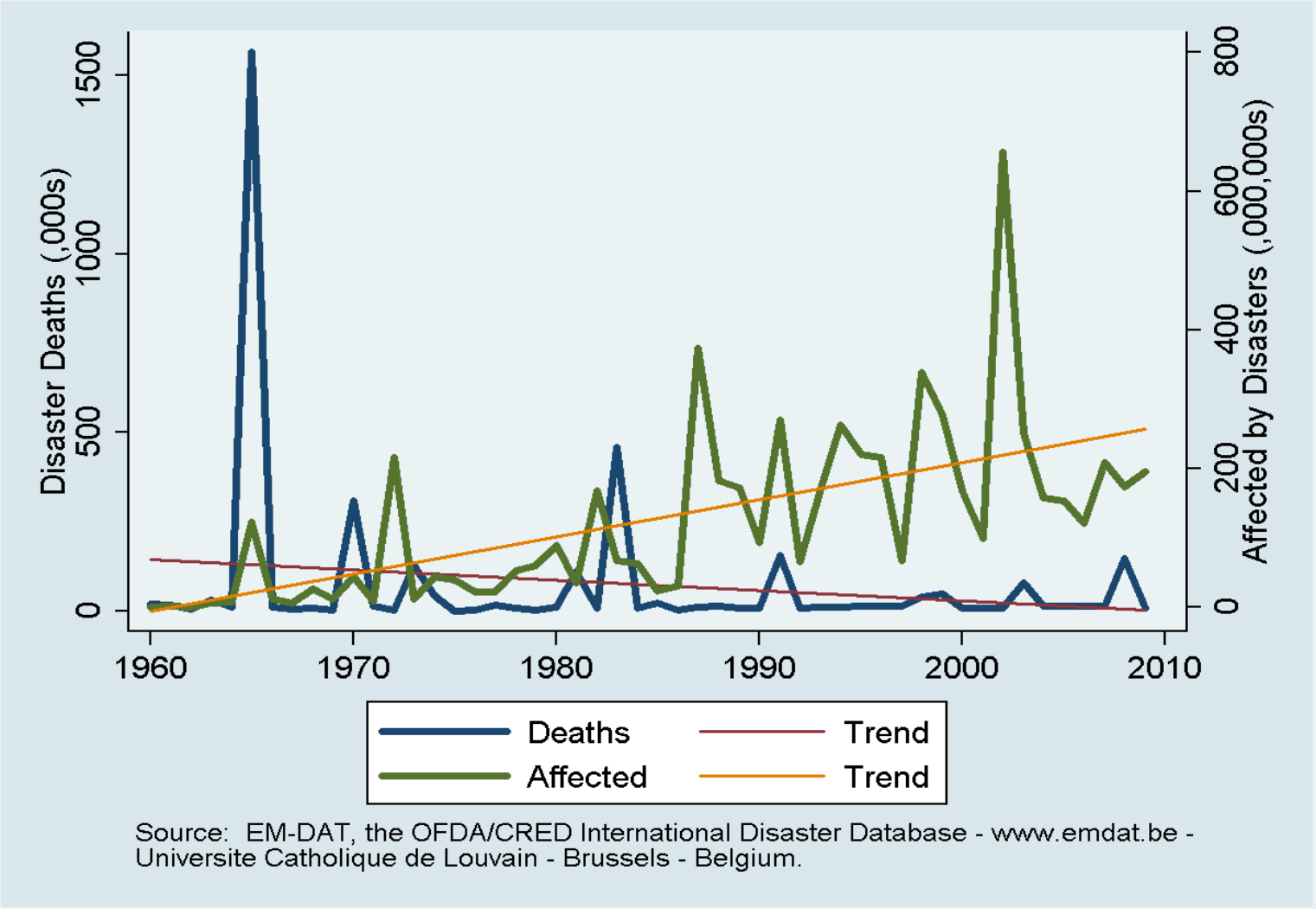



Source: EM-DAT, the OFDA/CRED International Disaster Database - www.emdat.be - Universite Catholique de Louvain - Brussels - Belgium.

# 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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# Trends in Social Outcomes of Disasters

What explains the declining number of deaths and the rising number of persons affected?

- Declining death tolls:
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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 $D_{jt} = \begin{cases} 1 & \text{if } D^*_{jt} \geq \underline{D} \\ 0 & \text{Otherwise} \end{cases}$
  - $\underline{D}$ 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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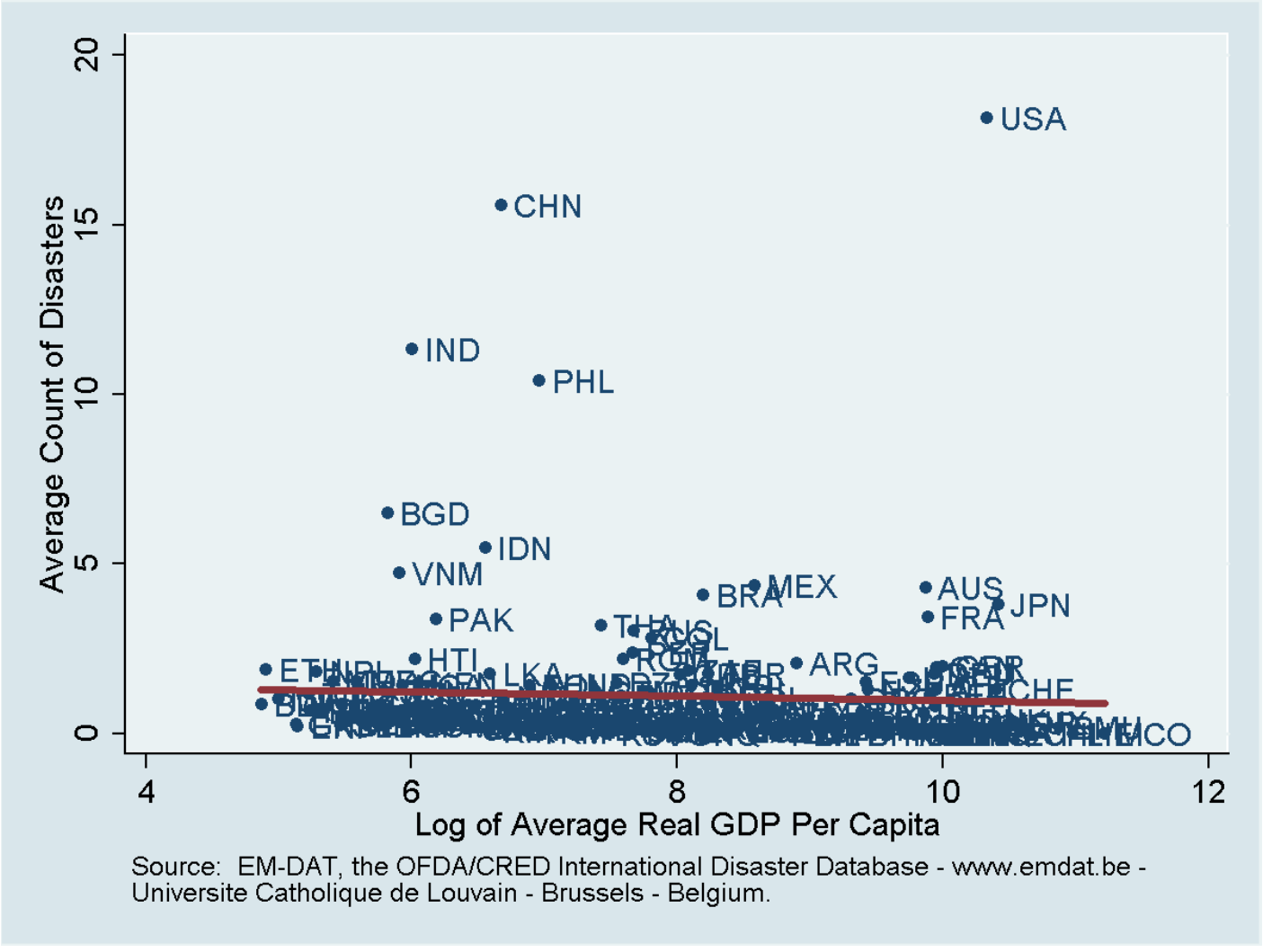
# Are Wealthier Countries Less Likely to Experience Disasters?



# 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):
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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
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Kaufmann, Kraay & Mastruzzi Governance Indicators

- Voice and accountability
- Political stability and absence of violence/terrorism
- Government effectiveness
- Regulatory quality
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## Institutional Quality Index

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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)
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# Random Effects Panel Probit Results

| | Any Disaster | Drought | Extreme Temperatures | Flood | Wet Mass Movement | Storm |
|---|---|---|---|---|---|---|
| Constant | −2.325*** | −1.425** | −7.175*** | −3.019*** | −7.258*** | −4.139*** |
| | (−3.329) | (−2.214) | (−6.581) | (−4.219) | (−6.847) | (−4.249) |
| ln(Real Per Capita GDP) | −0.185*** | −0.203*** | 0.083 | −0.233*** | 0.192** | −0.140 |
| | (−2.938) | (−3.464) | (0.738) | (−3.511) | (2.019) | (−1.588) |
| Quality of Institutions | 0.078** | −0.011 | −0.039 | 0.110*** | −0.165** | 0.058 |
| | (2.001) | (−0.280) | (−0.547) | (2.636) | (−2.432) | (1.021) |
| Elevation | 0.119 | −0.088 | 0.065 | 0.133 | 0.853*** | −0.119 |
| | (1.196) | (−1.022) | (0.466) | (1.328) | (6.111) | (−0.838) |
| Abs. Value of Latitude | −0.015** | −0.009* | 0.013 | −0.018*** | −0.032*** | 0.019** |
| | (−2.360) | (−1.732) | (1.282) | (−2.778) | (−3.367) | (2.047) |
| Population Near Ice-Free Coast | 0.221 | −0.034 | 0.086 | 0.458 | 1.272** | 0.658 |
| | (0.611) | (−0.114) | (0.151) | (1.273) | (2.118) | (1.269) |
| Land Near Ice-Free Coast | 0.711* | 0.117 | 0.438 | 0.154 | −0.344 | 0.366 |
| | (1.893) | (0.360) | (0.781) | (0.413) | (−0.544) | (0.688) |
| ln(Land Area) | 0.342*** | 0.157*** | 0.272*** | 0.356*** | 0.411*** | 0.283*** |
| | (10.022) | (5.439) | (5.131) | (10.227) | (7.411) | (5.926) |
| #Obs | 3,867 | 3,867 | 2,973 | 3,867 | 3,867 | 3,867 |
| #Groups | 146 | 146 | 113 | 146 | 146 | 146 |
| Log-Likelihood | −2,002.271 | −1,097.367 | −670.544 | −1,879.707 | −694.051 | −1,410.356 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# Disaster Risk Ranking: Top 10 Most At-Risk

| | Any Disaster | Drought | Extreme Temperature | Flood | Mass Movement | Storm |
|---|---|---|---|---|---|---|
| 1 | India | Ethiopia | Russia | India | China | Canada |
| 2 | United States | China | India | Indonesia | Indonesia | United States |
| 3 | Indonesia | Indonesia | Pakistan | China | Peru | China |
| 4 | Canada | Mozambique | Canada | Russia | Brazil | India |
| 5 | China | Tanzania | Ukraine | Australia | Tajikistan | Japan |
| 6 | Australia | Kenya | United States | Brazil | India | Mongolia |
| 7 | Sri Lanka | Madagascar | France | Pakistan | Nepal | Russia |
| 8 | Russia | Sudan | Poland | Vietnam | Malaysia | France |
| 9 | Vietnam | Uganda | Italy | Sri Lanka | Mexico | Indonesia |
| 10 | Malaysia | Zambia | Belarus | United States | Kyrgyzstan | 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
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Is there a relationship between disaster risk and social vulnerability?

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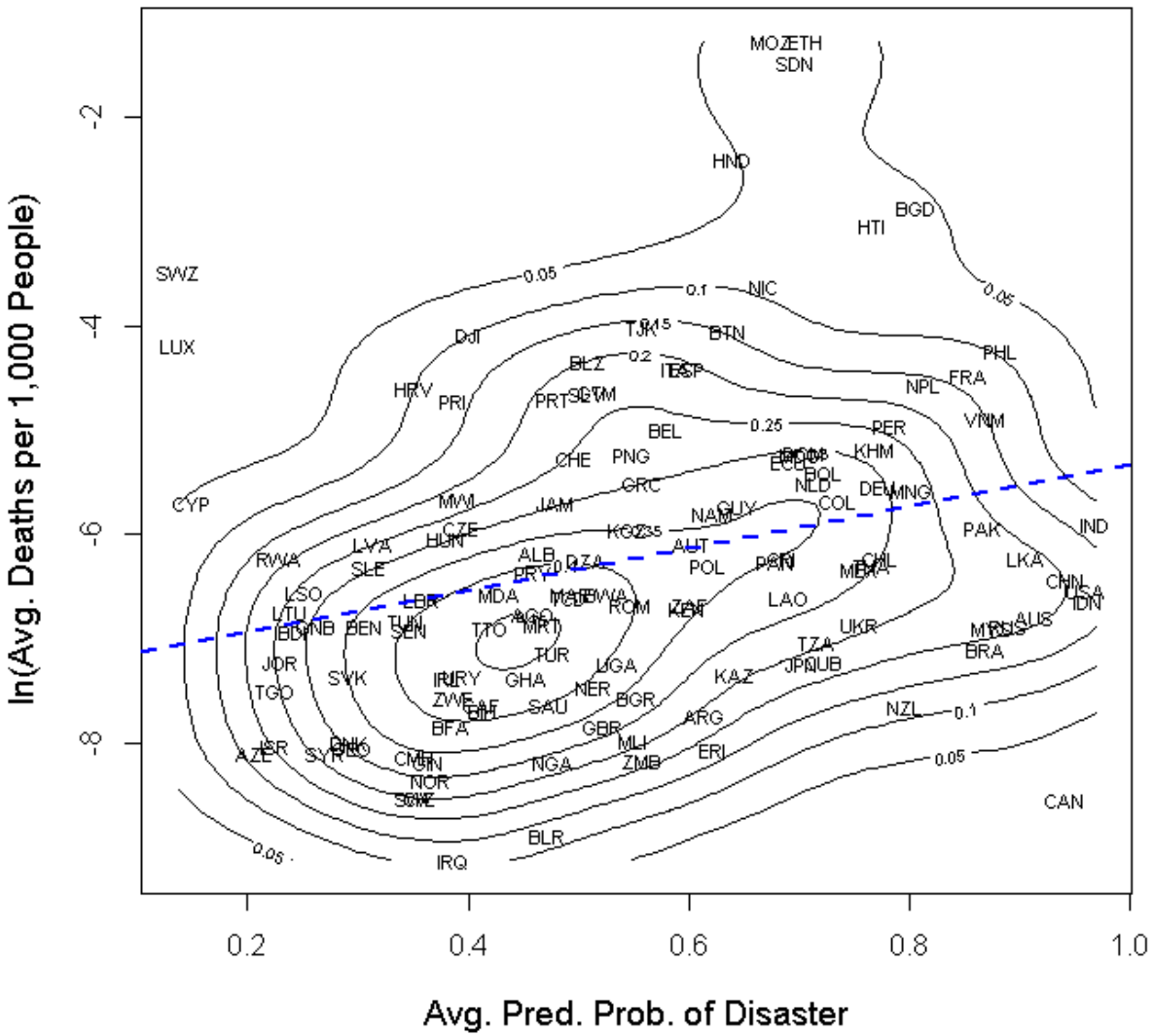
# Disaster Risk and Deaths

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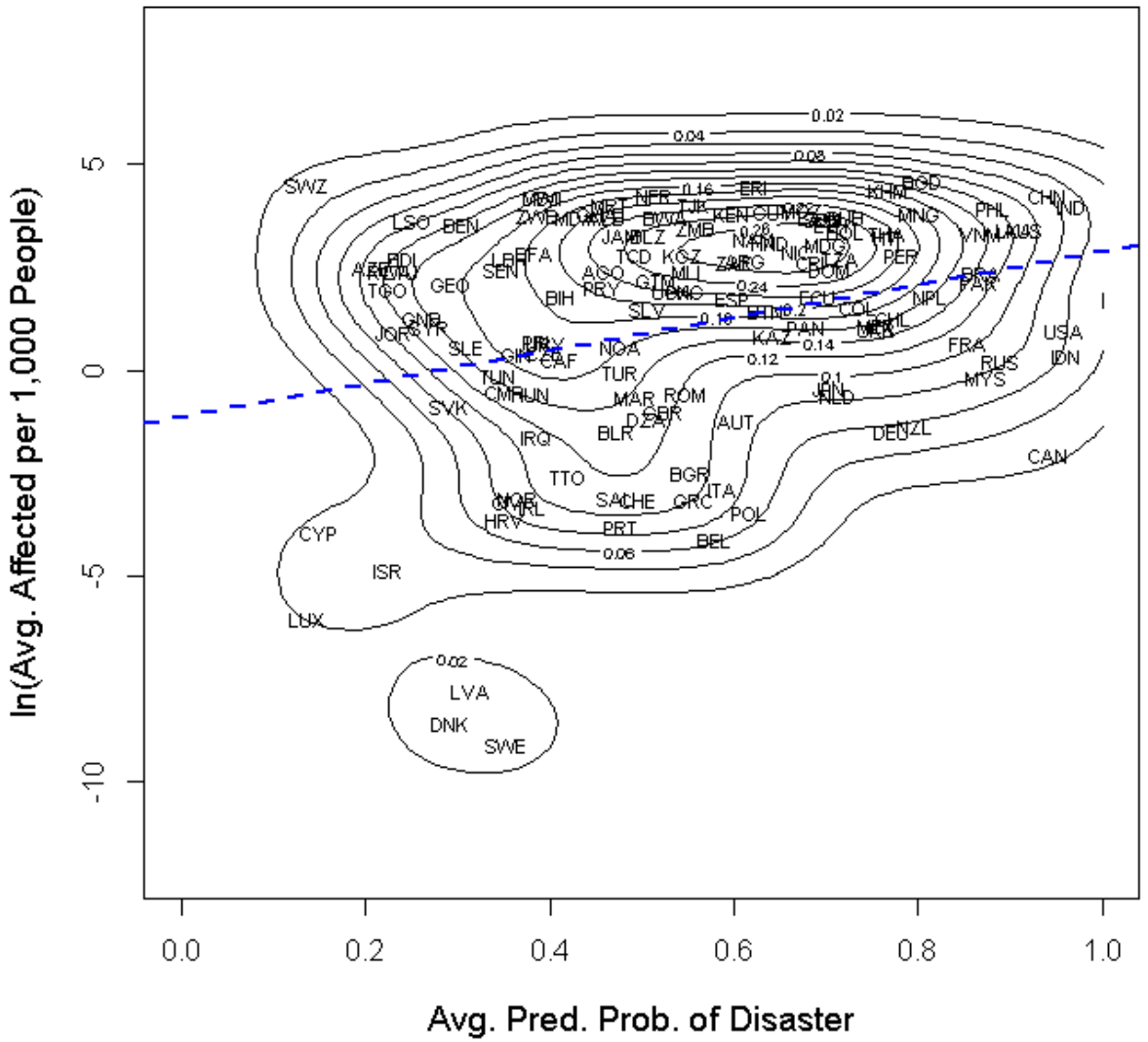
# Disaster Risk and Affected Persons

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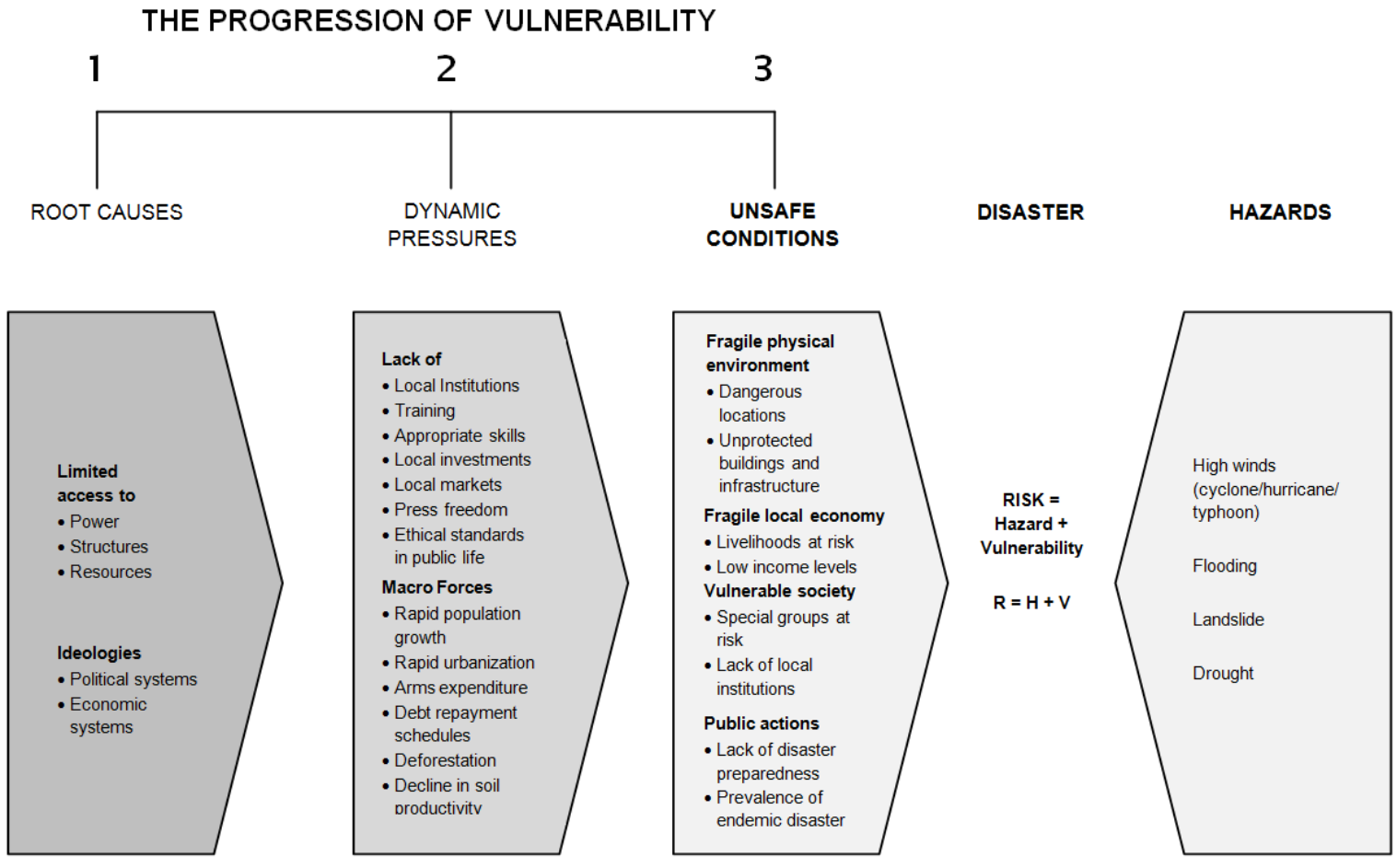
# Pressure and Release Model

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




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)
  - Economic ideologies (openness to trade)

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  - Economic ideologies (openness to trade)

# 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

$$\ln\left(\frac{Affected_{it}+1}{Population_{it}/1,000}\right) = x'_{it}\beta + z'_i\gamma + \delta t + \nu_i + u_{it}$$

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| | $\ln\left(\frac{\text{Deaths}}{\text{Population}/1{,}000}\right)$ | $\ln\left(\frac{\text{Affected}}{\text{Population}/1{,}000}\right)$ |
|---|---|---|
| Constant | $-9.054^{***}$ | 3.126 |
| | $(-2.821)$ | (0.337) |
| ln(Real GDP per capita) | $-0.363^{***}$ | $-0.822^{***}$ |
| | $(-2.835)$ | $(-2.614)$ |
| ln(Dependency) | $1.985^{*}$ | 1.624 |
| | (2.520) | (0.782) |
| ln(Physicians per 1,000) | $0.372^{***}$ | 0.466 |
| | (3.178) | (1.545) |
| Population near coast (%) | $0.406^{*}$ | $1.341^{**}$ |
| | (1.708) | (2.299) |
| ln(Population density) | $0.165^{***}$ | $-0.404^{***}$ |
| | (2.828) | $(-2.811)$ |
| ln(Urban population) | $-0.308^{***}$ | $-0.241$ |
| | $(-4.520)$ | $(-1.351)$ |
| Income inequality | $0.016^{**}$ | $0.043^{**}$ |
| | (2.030) | (1.929) |
| Fractionalization | $-0.405$ | $-1.624^{*}$ |
| | $(-1.182)$ | $(-1.835)$ |
| Time trend | Yes | Yes |
| Disaster count controls | Yes | Yes |
| # Obs | 1,477 | 1,477 |
| # Groups | 98 | 98 |
| $R^2$: Within | 0.08 | 0.09 |
| $R^2$: Between | 0.40 | 0.62 |
| $R^2$: Overall | 0.23 | 0.35 |

# Concluding Remarks

- 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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- Our results support many of the hypotheses of the Pressure and Release Model
- Conditional on a disaster occurring:
  - Wealthier countries are less vulnerable than poorer countries
  - Countries with relatively larger *vulnerable* population segments are more vulnerable
  - More urban societies are less vulnerable than autocratic societies
  - More ethnically heterogeneous societies are less vulnerable than ethnically homogeneous societies
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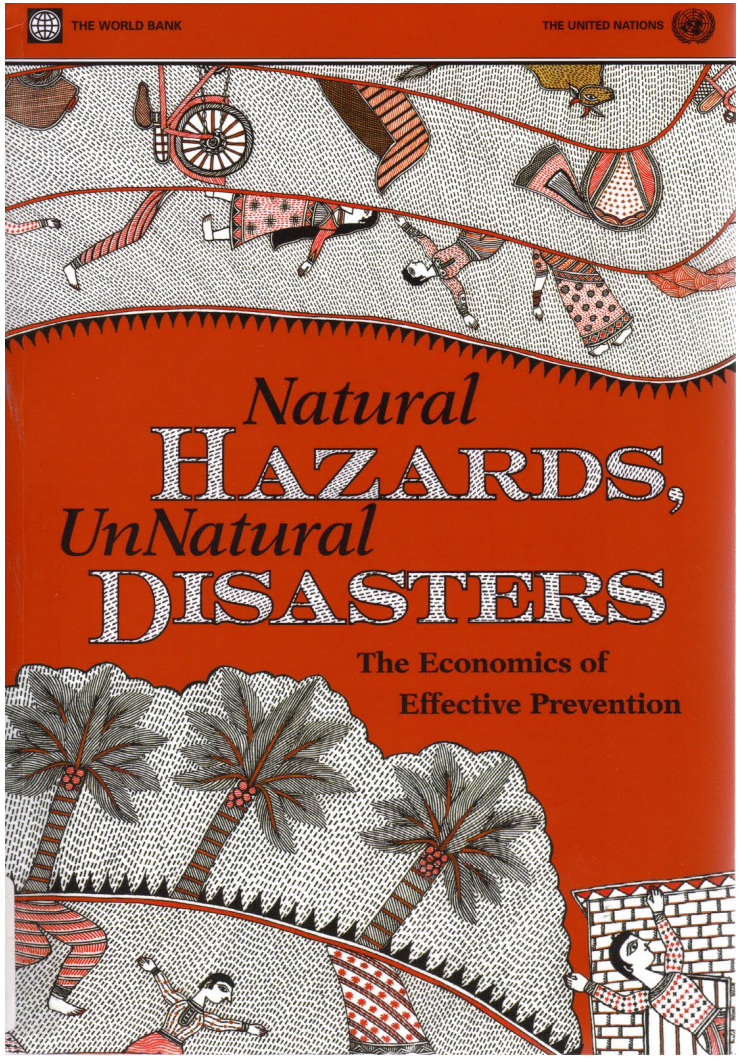
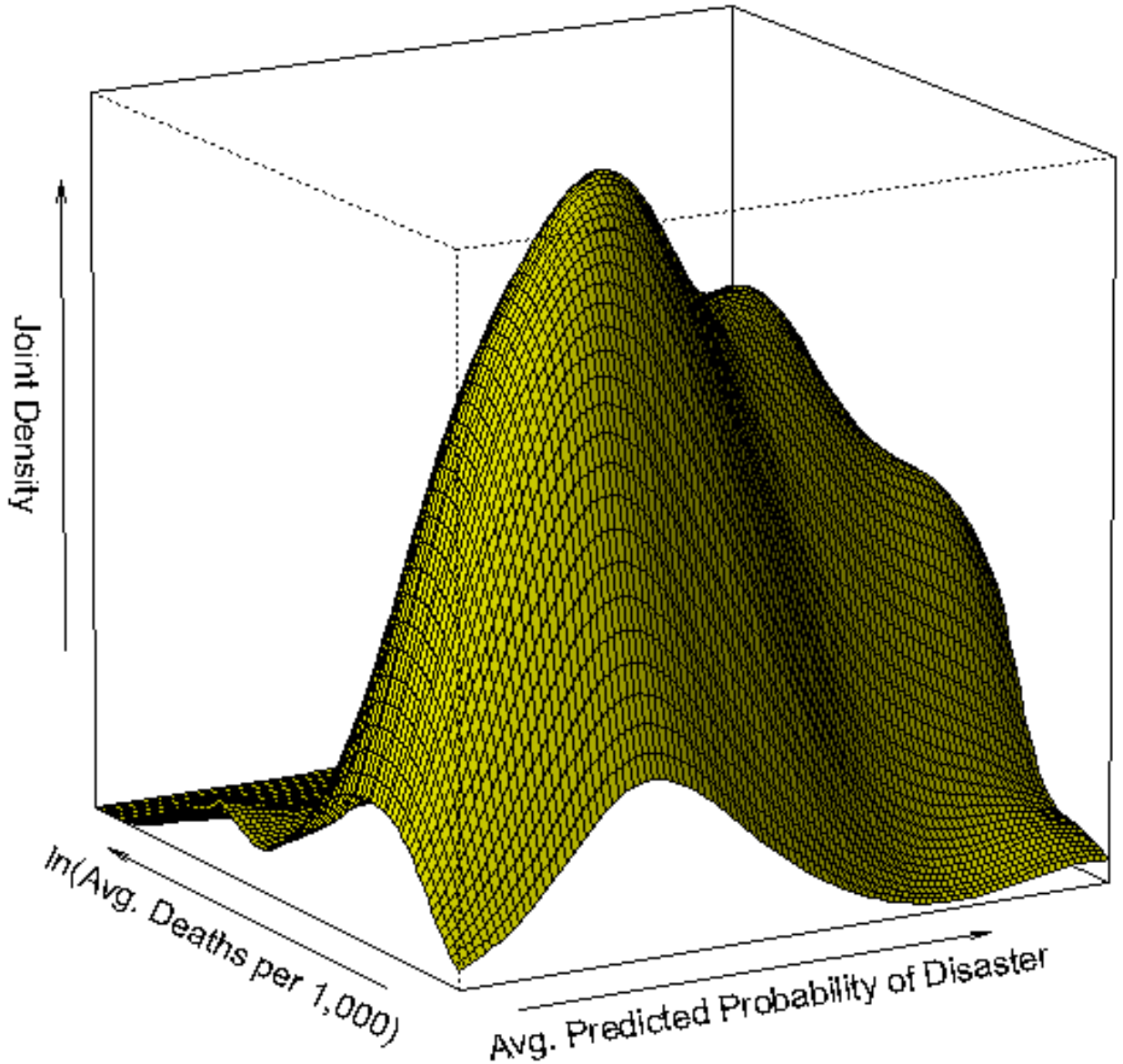
# Thank you!

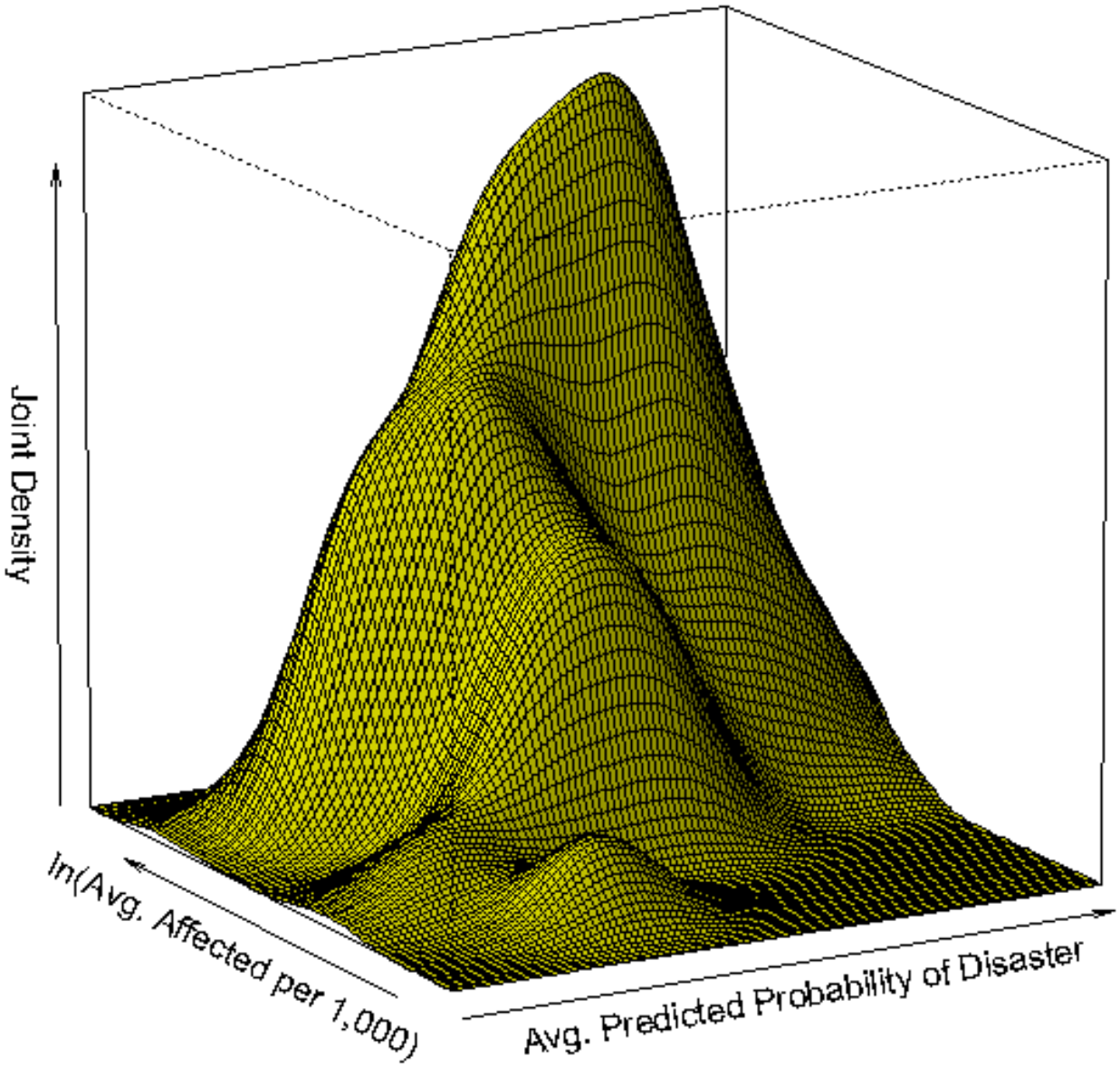
patrick.ward@cmcc.it


THE WORLD BANK
THE UNITED NATIONS
Natural
HAZARDS,
UnNatural
DISASTERS
The Economics of
Effective Prevention

Return


Joint Density
ln(Avg. Deaths per 1,000)
Avg. Predicted Probability of Disaster

Return


Joint Density
ln(Avg. Affected per 1,000)
Avg. Predicted Probability of Disaster

Return