Coping With Disaster: 
The Impact of Hurricanes on 
International Financial Flows, 
1970-2001

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Motivation

- Disasters cause huge human and economic losses 
  - From 1970-2001, disasters caused: 
    - 2.7 million deaths 
    - $955 billion in damages 

- Individual disasters can have huge tolls 
  - 1970 hurricane in Bangladesh killed 300,000 
  - 1998 hurricane in Honduras caused damage equal to 38% of GDP 

- A large fraction of world population is exposed to disasters 
  - 39% of world population is in countries where disaster damages were at least 3% of GDP in some year between 1970 and 2001
The economics of disasters: a research agenda

- How much damage do disasters cause?

- How well do countries recover economic losses from disasters?

- What are disasters’ short- and long-run consequences?
  - Economic performance
  - Public finance
  - Politics, intra- and interstate conflict
  - International migration

- What is the relationship between environmental risk and the distribution of world population, GDP, institutions?

Key question in this paper

- How well do countries cope with the aftermath of disasters?

- In particular, how well do international financial flows buffer economic losses from disasters?
  - Focus on net inflows of:
    - official development assistance (ODA)
    - migrants’ remittances
    - sovereign debt
    - foreign direct investment (FDI)
Relation to existing research

- Existing work on risk sharing and consumption smoothing
  - Internationally: little evidence of international sharing of consumption risk
  - At the household level: some evidence of risk-sharing, but not full insurance

- This paper's contribution: examine responses of international risk-coping mechanisms to specific country-level shocks
  - approach mainly used so far in household-level studies

- Little research on disasters, which may be of independent interest

Summary

- Examine impact of disaster damage on international financial flows
  - Instrument for disaster damage with hurricane events

- Remittances, net lending, and FDI respond positively and rapidly to disaster damage (within 1 year)

- ODA responds positively, with a lag (~2 years)

- Replacement rate of disaster damages by inflows from these sources is ~0.8 (within 4 years)
  - Cannot reject null that replacement rate is 1

- OLS results strikingly different: no effect of damage on international flows
Hurricanes in context

- Hurricanes are one of the most common and destructive types of disasters (Table 1)
- Between 1970 and 2001, “wind storms” caused:
  - 611,000 deaths
  - $278 billion in damages

Losses by type of disaster

Table 1: Human losses and damages from natural disasters worldwide 1970-2001

<table>
<thead>
<tr>
<th>Type of disaster</th>
<th>Killed (000s)</th>
<th>Injured (000s)</th>
<th>Damage (1995 US$, 000s)</th>
<th>% of total damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought</td>
<td>877</td>
<td>0</td>
<td>59,865,474</td>
<td>6.27%</td>
</tr>
<tr>
<td>Wind storm</td>
<td>611</td>
<td>517</td>
<td>278,302,633</td>
<td>29.13%</td>
</tr>
<tr>
<td>Earthquake</td>
<td>573</td>
<td>1,086</td>
<td>299,814,937</td>
<td>31.38%</td>
</tr>
<tr>
<td>Flood</td>
<td>206</td>
<td>945</td>
<td>251,450,119</td>
<td>26.32%</td>
</tr>
<tr>
<td>Famine</td>
<td>205</td>
<td>0</td>
<td>71,798</td>
<td>0.01%</td>
</tr>
<tr>
<td>Epidemic</td>
<td>147</td>
<td>80</td>
<td>1,450</td>
<td>0.00%</td>
</tr>
<tr>
<td>Volcano</td>
<td>26</td>
<td>8</td>
<td>5,514,201</td>
<td>0.58%</td>
</tr>
<tr>
<td>Earth slide</td>
<td>24</td>
<td>8</td>
<td>4,289,094</td>
<td>0.45%</td>
</tr>
<tr>
<td>Extreme temperature</td>
<td>17</td>
<td>6</td>
<td>27,589,390</td>
<td>2.89%</td>
</tr>
<tr>
<td>Wave / Surge</td>
<td>3</td>
<td>1</td>
<td>4,659</td>
<td>0.00%</td>
</tr>
<tr>
<td>Wild fire</td>
<td>1</td>
<td>2</td>
<td>28,139,750</td>
<td>2.95%</td>
</tr>
<tr>
<td>Insect infestation</td>
<td>0</td>
<td>0</td>
<td>251,002</td>
<td>0.03%</td>
</tr>
<tr>
<td>Total</td>
<td>2,690</td>
<td>2,652</td>
<td>955,294,507</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
What are hurricanes?

• Severe storms that originate over tropical waters
  - Sustained winds >74 mph (119 kph)
  - Also known as typhoons, tropical cyclones

• Architecture of hurricanes (see figure):
  - "Eye", 20-30 mi. in diameter
  - Spiral arms of storm clouds, 60-900 mi. in diameter
  - Hurricane force winds near eye

• Damage due to hurricanes
  - Storm surge (rise of sea level from 4-18+ feet)
  - Strong winds
  - Flooding

Hurricane Mitch

Data on hurricanes

- Sources:
  - NOAA Tropical Prediction Center
  - Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center

- Hurricane “best tracks”: positions (latitude and longitude) of hurricane eyes at 6-hourly intervals, with wind speed and barometric pressure data (see figures)
  - Incorporate information from reconnaissance aircraft, ships, and satellites
  - Highest quality data is from 1960s to present

Example of hurricane best tracks

Western North Pacific best tracks, 1985

Hurricane best tracks worldwide, 1949-2001

Sources: Hurricane best track databases of the NOAA Tropical Prediction Center and the Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center; processed using ArcGIS software.

Hurricane event definitions

- Best tracks overlaid with world map using GIS software to create hurricane event variables (at country-year level):
  - Number of hurricane landfalls: hurricane eye crosses a country’s borders
  - Number of hurricane near-landfalls: hurricane eye passes within 100 miles of a country’s borders
### Top hurricane countries

**Countries with the most hurricane landfalls, 1970-2001**

<table>
<thead>
<tr>
<th>Country</th>
<th>Landfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines</td>
<td>90</td>
</tr>
<tr>
<td>China</td>
<td>86</td>
</tr>
<tr>
<td>Japan</td>
<td>62</td>
</tr>
<tr>
<td>Mexico</td>
<td>47</td>
</tr>
<tr>
<td>United States</td>
<td>40</td>
</tr>
<tr>
<td>Australia</td>
<td>39</td>
</tr>
<tr>
<td>Vietnam</td>
<td>34</td>
</tr>
<tr>
<td>India</td>
<td>23</td>
</tr>
<tr>
<td>Madagascar</td>
<td>16</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>9</td>
</tr>
</tbody>
</table>

**“Small” countries with the most hurricane landfalls, 1970-2001**

<table>
<thead>
<tr>
<th>Country</th>
<th>Landfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanuatu</td>
<td>9</td>
</tr>
<tr>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>Bahamas, The</td>
<td>5</td>
</tr>
<tr>
<td>Guam</td>
<td>5</td>
</tr>
<tr>
<td>Fiji</td>
<td>5</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>4</td>
</tr>
<tr>
<td>Haiti</td>
<td>3</td>
</tr>
<tr>
<td>Belize</td>
<td>3</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>2</td>
</tr>
<tr>
<td>Virgin Islands (U.S.)</td>
<td>2</td>
</tr>
</tbody>
</table>

### Other data

- **Country-year observations, 1970-2001**
- **Dependent variables (all as fractions of GDP):**
  - Transfers: official development assistance (ODA), migrants’ remittances
  - Lending: net financial flows (sovereign debt)
  - Asset sales: FDI, portfolio investment
  - From World Development Indicators, IMF Balance of Payments Statistics

- **Independent variable:**
  - Disaster losses as fraction of GDP
  - From *EM-DAT: the CRED/OFDA International Disaster Database*, Center for Research on the Epidemiology of Disasters (Université Catholique de Louvain)
    - Include direct losses (to property, crops) and indirect losses (reductions in economic activity)
    - Primary sources: governments, UN, NGOs, insurance companies, research institutes, media
    - Most reliable from late 1960s
Econometric issues

- Reverse causation: when inflows turn out to be (or expected to be) small, damage reports may be exaggerated

- Omitted variables: third factors (e.g., government breakdown, economic decline) could lead to high damages and low inflows

- Classical measurement error

- **Approach**: instrument for damages with hurricane events constructed from meteorological data

First- and second-stage regression equations

- Impact of hurricanes as share of GDP will vary by country’s physical size

- First stage equation:

\[
DAM_t = 
\begin{align*}
\beta_0 + \beta_1 H_{it} + \beta_2 Q_{it} + \beta_3 Q_{it} + \beta_4 Q_{it} + \beta_5 Q_{it} + \beta_6 Q_{it} + \beta_7 Q_{it} + \beta_8 Q_{it} + \\
\eta_i + \epsilon_{it}
\end{align*}
\]

- Second stage (IV) equation:

\[
Y_{it} = 
\begin{align*}
\beta_0 + \beta_1 DAM_{it} + \beta_2 DAM_{it} + \beta_3 DAM_{it} + \beta_4 DAM_{it} + \\
\eta_i + \epsilon_{it}
\end{align*}
\]

- Hypothesis tests:
  - Are responses of flows \((\beta_{11}, \beta_{12}, \ldots)\) nonzero?
  - Can we reject the null that total replacement rate is 1? (sum of all \(\beta\) across all flows and years \(t\) to \(t-4\))
First stage estimates

Table 5: Impact of hurricanes on disaster damage, 1970-2001
(Fixed effects OLS estimates, first stage of IV regression)

Sample: Observations with data on official development assistance as fraction of GDP.

Dependent variable: Disaster damage as fraction of GDP

Year | Current | 1 year before | 2 years before | 3 years before | 4 years before
--- | --- | --- | --- | --- | ---
Hurricane landfalls | 0.0206 | -0.0056 | 0.0097 | -0.0111 | -0.0100
| (0.0138) | (0.0076) | (0.0090) | (0.0092) | (0.0086)
Hurricane landfalls * Small-Medium Land Area | 0.0041 | 0.1115 | 0.0167 | 0.0425 | 0.0222
| (0.0197) | (0.1058) | (0.0245) | (0.0226) | (0.0256)
Hurricane landfalls * Medium-Large Land Area | -0.0191 | 0.0062 | -0.0034 | 0.0114 | 0.0102
| (0.0137) | (0.0078) | (0.0087) | (0.0097) | (0.0086)
Hurricane landfalls * Large Land Area | -0.0205 | 0.0881 | -0.0043 | 0.0114 | 0.0080
| (0.0137) | (0.0085) | (0.0069) | (0.0091) | (0.0080)
Hurricane near-landfalls | 0.0397 | -0.0092 | -0.0049 | 0.0030 | -0.0028
| (0.0223) | (0.0138) | (0.0080) | (0.0084) | (0.0122)
Hurricane near-landfalls * Small-Medium Land Area | -0.0139 | -0.0091 | -0.0018 | -0.0101 | 0.0056
| (0.0253) | (0.0163) | (0.0109) | (0.0104) | (0.0226)
Hurricane near-landfalls * Medium-Large Land Area | -0.0392 | 0.0110 | 0.0039 | -0.0054 | 0.0024
| (0.0227) | (0.0143) | (0.0084) | (0.0086) | (0.0129)
Hurricane near-landfalls * Large Land Area | -0.0385 | 0.0092 | 0.0028 | -0.0041 | 0.0028
| (0.0223) | (0.0139) | (0.0087) | (0.0087) | (0.0124)

F-statistic: joint significance of all hurricane variables 22.77
P-value 0.0000

Num. of obs. 3,369
R-squared 0.2

IV estimates

Panel B: Instrumental variables regressions

Instrumental variables for disaster damage: hurricane landfalls, hurricane near-landfalls, and interactions with country size categories, 0 to 4 years before (see Table 5 for first stage results).

Dependent variables (net flows, as fraction of GDP)

<table>
<thead>
<tr>
<th>Official development assistance</th>
<th>Financial flows</th>
<th>Remittances</th>
<th>Foreign direct investment</th>
<th>Portfolio investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage as fraction of GDP:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In current year</td>
<td>0.065</td>
<td>0.083</td>
<td>0.179</td>
<td>0.171</td>
</tr>
<tr>
<td>(0.047)</td>
<td>(0.043)</td>
<td>(0.053)</td>
<td>(0.066)**</td>
<td>(0.043)</td>
</tr>
<tr>
<td>1 year before</td>
<td>0.069</td>
<td>0.073</td>
<td>0.092</td>
<td>0.102</td>
</tr>
<tr>
<td>(0.065)</td>
<td>(0.029)**</td>
<td>(0.032)**</td>
<td>(0.083)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>2 years before</td>
<td>0.196</td>
<td>0.056</td>
<td>0.057</td>
<td>-0.064</td>
</tr>
<tr>
<td>(0.077)**</td>
<td>(0.044)</td>
<td>(0.054)</td>
<td>(0.053)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>3 years before</td>
<td>0.083</td>
<td>0.096</td>
<td>0.04</td>
<td>-0.017</td>
</tr>
<tr>
<td>(0.065)</td>
<td>(0.043)</td>
<td>(0.069)</td>
<td>(0.047)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>4 years before</td>
<td>0.079</td>
<td>-0.045</td>
<td>-0.009</td>
<td>-0.092</td>
</tr>
<tr>
<td>(0.085)</td>
<td>(0.057)</td>
<td>(0.078)</td>
<td>(0.057)</td>
<td>(0.031)</td>
</tr>
</tbody>
</table>

Country fixed effects | Y | Y | Y | Y | Y |
Year fixed effects | Y | Y | Y | Y | Y |
Country-specific linear time trend | Y | Y | Y | Y | Y |

Num. of obs. 3,369

20

* significant at 10%; ** significant at 5%; *** significant at 1%
### Table 6: Impact of disaster damage on international financial flows, 1970-2001

#### Panel A: Ordinary least squares regressions

<table>
<thead>
<tr>
<th>Dependent variables (net flows, as fraction of GDP):</th>
<th>Official development assistance</th>
<th>Financial flows</th>
<th>Remittances</th>
<th>Foreign direct investment</th>
<th>Portfolio investment</th>
</tr>
</thead>
</table>

- **Damage as fraction of GDP:**
  - In current year: 0.012 (0.008), 0.008 (0.008), 0.001 (0.002), 0.007 (0.006), -0.003 (0.003)
  - 1 year before: 0.012 (0.010), 0.011 (0.010), 0.003 (0.004), 0.018 (0.008)**, -0.002 (0.003)
  - 2 years before: 0.001 (0.014), 0.01 (0.009), -0.003 (0.005), 0.021 (0.006)**, 0.001 (0.002)
  - 3 years before: 0.009 (0.007), 0.008 (0.007), 0.001 (0.004), 0.02 (0.009)**, -0.001 (0.002)
  - 4 years before: 0.006 (0.004), 0.005 (0.003), -0.007 (0.003)**, 0.011 (0.003)**, 0 (0.002)

- **Country fixed effects:** Y Y Y Y Y
- **Year fixed effects:** Y Y Y Y Y
- **Country-specific linear time trend:** Y Y Y Y Y
- **Num. obs.:** 3,369 2,841 2,559 3,135 3,121
- **R-squared:** 0.85 0.39 0.96 0.75 0.38

### Table 8: Impact of disaster damage on international financial flows, 1970-2001

#### Instrumental variables estimates, sample with complete data on all four main flows

<table>
<thead>
<tr>
<th>Dependent variables (net flows, as fraction of GDP):</th>
<th>Official development assistance</th>
<th>Financial flows</th>
<th>Remittances</th>
<th>Foreign direct investment</th>
<th>All four flows combined</th>
</tr>
</thead>
</table>

- **Damage as fraction of GDP:**
  - In current year: 0.087 (0.065), 0.016 (0.049), 0.132 (0.073)**, 0.193 (0.062)**, 0.427 (0.187)**
  - 1 year before: 0.03 (0.060), 0.057 (0.048), 0.09 (0.036)**, 0.062 (0.067), 0.259 (0.106)
  - 2 years before: 0.091 (0.052)*, 0.019 (0.037), 0.035 (0.048), -0.063 (0.061), 0.082 (0.094)
  - 3 years before: 0.058 (0.033)*, 0.036 (0.040), 0.014 (0.056), 0.04 (0.065), 0.148 (0.097)
  - 4 years before: -0.001 (0.054), -0.039 (0.060), 0.013 (0.064), -0.026 (0.045), -0.052 (0.145)

- **Country fixed effects:** Y Y Y Y Y
- **Year fixed effects:** Y Y Y Y Y
- **Country-specific linear time trend:** Y Y Y Y Y
- **Num. obs.:** 1,686 1,686 1,686 1,686 1,686
- **Sum of coefficients on all damage variables:** 0.265 (0.187), 0.089 (0.158), 0.284 (0.139)**, 0.206 (0.165), 0.844 (0.415)**

* significant at 10%; ** significant at 5%; *** significant at 1%
In closing

- Replacement rate of disaster damages by inflows from these sources is ~0.8 (within 4 years)
  - Cannot reject null that replacement rate is 1
  - May reflect relative absence of moral hazard problems

- Open questions
  - *Distribution of inflows*: do they reach the most affected? Need micro data
  - *Generalizability*: examine impact of other types of disasters (e.g., earthquakes, floods)
  - *Other outcomes*: GDP growth, political outcomes
### Alternative subsamples

**Table 7: Impact of disaster damage on international financial flows, 1970-2001**  
(IV estimates, alternative subsamples)

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>ODA</th>
<th>Financial flows</th>
<th>Remittances</th>
<th>FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient on damage from:</td>
<td>2 years ago</td>
<td>1 year ago</td>
<td>1 year ago</td>
<td>Current year</td>
</tr>
<tr>
<td>Original sample (estimates from Table 6)</td>
<td>0.196</td>
<td>0.073</td>
<td>0.082</td>
<td>0.171</td>
</tr>
<tr>
<td>Countries with 10 or more observations</td>
<td>0.185</td>
<td>0.073</td>
<td>0.084</td>
<td>0.181</td>
</tr>
<tr>
<td>By land area:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area less than 250,000 sq. km.</td>
<td>0.217</td>
<td>0.072</td>
<td>0.086</td>
<td>0.17</td>
</tr>
<tr>
<td>Land area greater than 250,000 sq. km</td>
<td>-0.079</td>
<td>-0.1</td>
<td>-0.251</td>
<td>0.112</td>
</tr>
<tr>
<td>By development status:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less-industrialized countries</td>
<td>0.196</td>
<td>0.073</td>
<td>0.085</td>
<td>0.181</td>
</tr>
<tr>
<td>Highly industrialized countries</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0.067</td>
<td>0.213</td>
</tr>
</tbody>
</table>

#### Test of violation of exclusion restriction

**Appendix Table 2: Impact of disaster damage on international financial flows, 1970-2001**  
(Instrumental variables estimates, controlling for persons killed and economic growth)

Instrumental variables for disaster damage: hurricane landfalls, hurricane near-landfalls, and interactions with country size categories, 0 to 4 years before (see Table 5 for first stage results).