Drought and Retribution: Evidence from a Large Scale Rainfall Index Insurance in Mexico

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University of Washington
Weather and socioeconomic consequences

• Strong relationship between weather fluctuations and income has long been recognized (Wolpin 1982, Paxson 1992)

• Short-term weather shocks can affect long-term health outcomes (Rose, 1999; Hoddinott & Kinsey 2001, Maccini & Yang 2009)

• Rain fluctuations and civil war analyzed by Edward Miguel, Satyanath and Sergenti (2004) and Miguel & Satyanath (2010).

• Links to famines summarized in Chantarat et al. (2007)

• Lack of tools to insure against weather lead to an underinvestment in ag sector

• Uncertainty & Risk Aversion $\rightarrow$ underinvestment (Morduch 1995, Rosenzweig & Binswanger 1993)
Advantages of WII

• Advantage over traditional harvest loss insurance
  – Simple to implement: indemnity if index exceeds threshold
  – Avoids information problems: adverse selection & moral hazard
  – Stabilizes ‘disaster relief funds’
Main Contributions

• First empirical paper on large scale WII studying

(1) Farmers Behavior

• Yields

• Risk management strategies

• Income (Expenditures as robustness)

(2) Cost benefit Analysis from farmers perspective

(3) Cost efficiency analysis from gov. perspective with respect to subsidies on WII
Challenges with WII (1)

• Expensive to Start
  – Public Provision by NGOs, World Bank, etc. necessary

• “Basis risk“ problem

• Low take-up rates, Xavier Giné et al.

• Debate among development agencies:
  o Bill & Melinda Gates Foundation stopped supporting WII
Challenges with WII (2)

• Unintended Consequences (Fuchs & Wolff, 2011):
  – Disincentive to invest in irrigation technology
  – Monocropping $\rightarrow$ environmental externalities
  – General Equilibrium effects: Indemnity payment can inflate food prices at the expense of uninsured poor
Features of Mexican WII

- 80% of catastrophic losses in Mexico due to droughts
- Four crops insured (maize, barley, sorghum, beans)
- 81% of insured area is grown by maize
- Farmers do not enroll, but WII 100% subsidized by govt.
- Roll out since 2003 from 5 to 656 counties in 2008
2003: 108,000 ha insured in 5 counties in Guanajuato
2004: 250,000 ha insured in 41 counties: extension to Puebla
2006 1.4 million hectares
Weather Index Insurance (WII)

Weather Insurance Thresholds and Actual Rainfall
County Apaseo el Alto, Guanajuato (2007)

Seeding  Flowering  Harvest

Note: Threshold information, both time period and levels, were obtained from PACC data. Rainfall information was obtained from daily rainfall information from the National Water Commission (CNA).
Weather Index Insurance (WII)

Weather Insurance Thresholds and Actual Rainfall
County Leon, Guanajuato (2005)

Note: Threshold information, both time period and levels, were obtained from PACC data. Rainfall information was obtained from daily rainfall information from the National Water Commission (CNA).
Assembly of Six Datasets

• WII administrative data (2003-2008)
  – By county and crop: Weather stations used, insured area, premiums paid, value of insured production, indemnity payments

• County level agricultural production dataset (2002-2008)
  – Over 270 species: area by crop, production in tons

• Daily rainfall and temp data (1990-2008) for all weather station


• Full census of gov. supported farmers: farm size, crops produced, type of ownership

• National Population Council: Marginality Poverty Index
Identification

• Exploit variation over time and across space due to rollout

• Panel of 2,337 counties from 2002 to 2008

• Difference in Difference Strategy with
  – County fixed effects
  – Year fixed effects

\[
\ln(Y_{ict}) = \alpha_c + \beta_1 \text{RainDev}_{ct} + \beta_2 \text{TempDev}_{ct} + \gamma \text{Insurance}_{ct} + \\
+ \sum_{t=1}^{T} \delta_t \text{Year}_t + \mu X_{ct} + \tau H_{ict} + \varepsilon_{ict}
\]
### Results: Effects on Log Maize Productivity

<table>
<thead>
<tr>
<th>FE Specs</th>
<th>Presence</th>
<th>Coverage</th>
<th>Presence</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WII</td>
<td>0.057*/(0.030)</td>
<td>0.064*/(0.036)</td>
<td>0.050*/(0.029)</td>
<td>0.067*/(0.034)</td>
</tr>
<tr>
<td>Rain Dev</td>
<td>0.088***/(0.026)</td>
<td>0.088***/(0.026)</td>
<td>0.068***/(0.02)</td>
<td>0.068***/(0.021)</td>
</tr>
<tr>
<td>Temp Dev</td>
<td>-0.49**/(0.187)</td>
<td>-0.49**/(0.19)</td>
<td>-0.41**/(0.19)</td>
<td>-0.40**/(0.18)</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td>1.58**/(0.59)</td>
<td>1.59**/(0.59)</td>
</tr>
<tr>
<td>Small Prod.</td>
<td></td>
<td></td>
<td>0.17/(0.62)</td>
<td>0.17/(0.62)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.382***/(0.004)</td>
<td>0.385***/(0.003)</td>
<td>0.233/(0.612)</td>
<td>0.241/(0.611)</td>
</tr>
<tr>
<td>Observations.</td>
<td>14,791</td>
<td>14,791</td>
<td>14,791</td>
<td>14,791</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.008</td>
<td>0.008</td>
<td>0.029</td>
<td>0.029</td>
</tr>
<tr>
<td>County FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Year FE</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
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</tr>
</tbody>
</table>

*Note: The table includes the coefficients and standard errors for each variable in the model. The symbols * and ** indicate statistical significance at the 10% and 5% levels, respectively.*
## Results: Effects on Log Maize Cultivated Hectares

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### Question Model Data Results Implications

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</tr>
</thead>
<tbody>
<tr>
<td>WII</td>
<td>-0.044**/(0.021)</td>
<td>-0.124***/(0.034)</td>
<td>-0.023/(0.02)</td>
<td>-0.068**/(0.03)</td>
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<tr>
<td>Rain Dev</td>
<td>0.00/(0.018)</td>
<td>0.00/(0.017)</td>
<td>-0.002/(0.013)</td>
<td>-0.0015/(0.01)</td>
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<tr>
<td>Temp Dev</td>
<td>-0.035/(0.139)</td>
<td>-0.043/(0.136)</td>
<td>0.038/(0.11)</td>
<td>0.032/(0.11)</td>
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<td>-0.34/(0.47)</td>
<td>-0.34/(0.47)</td>
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<td>-4.46***/(0.72)</td>
<td>-4.5***/(0.72)</td>
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<td>Constant</td>
<td>7.20***/(0.003)</td>
<td>7.21***/(0.003)</td>
<td>12.53***/(0.71)</td>
<td>12.54***/(0.71)</td>
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<tr>
<td>Observations</td>
<td>14,791</td>
<td>14,791</td>
<td>14,791</td>
<td>14,791</td>
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<tr>
<td>R-squared</td>
<td>0.002</td>
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</tr>
<tr>
<td>Year FE</td>
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<td>NO</td>
<td>YES</td>
<td>YES</td>
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</table>

### Conclusions
# Results: Effects on Real Log Per Capita(adult equivalent) Household Income

Drought and Retribution: Evidence from a large scale Rainfall-Indexed Insurance Program in Mexico

<table>
<thead>
<tr>
<th>Question</th>
<th>Model</th>
<th>Data</th>
<th>Results</th>
<th>Implications</th>
<th>Conclusions</th>
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### FE Specs

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<th>Presence</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WII</td>
<td>0.118***/(0.03)</td>
<td>0.128***/(0.04)</td>
<td>0.075**/(0.04)</td>
<td>0.077*/(0.04)</td>
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<tr>
<td>Log(M.Yield)</td>
<td>0.34/(0.02)</td>
<td>0.037*/(0.02)</td>
<td>0.003/(0.04)</td>
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<tr>
<td>Private</td>
<td>-0.013/(0.37)</td>
<td>0.007/(0.37)</td>
<td>0.43/(2.13)</td>
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<tr>
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<td>-2.03***/(0.55)</td>
<td>-2.01***/(0.54)</td>
<td>-0.024/(0.02)</td>
<td>-0.030/(0.02)</td>
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<tr>
<td>RainDev</td>
<td>0.064/(0.07)</td>
<td>0.068/(0.07)</td>
<td>0.102**/(0.05)</td>
<td>0.104**/(0.05)</td>
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<tr>
<td>Procampo</td>
<td>0.001***/(0.00)</td>
<td>0.001***/(0.00)</td>
<td>0.001***/(0.00)</td>
<td>0.001***/(0.00)</td>
</tr>
<tr>
<td>OPORT.</td>
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<td>-0.002***/(0.00)</td>
<td>-0.001***/(0.00)</td>
<td>-0.001***/(0.00)</td>
</tr>
<tr>
<td>Education Yrs</td>
<td>0.068***/(0.01)</td>
<td>0.068**/(0.01)</td>
<td>0.058***/(0.002)</td>
<td>0.057***/(0.01)</td>
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<tr>
<td>Constant</td>
<td>8.83***/(0.53)</td>
<td>8.82***/(0.52)</td>
<td>8.76***/(0.97)</td>
<td>8.78***/(0.97)</td>
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<tr>
<td>Obs</td>
<td>34,440</td>
<td>34,440</td>
<td>34,440</td>
<td>34,440</td>
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<tr>
<td>R-squared</td>
<td>0.17</td>
<td>0.168</td>
<td>0.36</td>
<td>0.359</td>
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<tr>
<td>County FE</td>
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<tr>
<td>Year FE</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
## Results: Effects on Real Log Per Capita (adult equivalent) Household Expenditure

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### FE Specs

<table>
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<tr>
<th>FE Specs</th>
<th>Presence</th>
<th>Coverage</th>
<th>Presence</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WII</td>
<td>0.076**/(0.03)</td>
<td>0.085**/(0.04)</td>
<td>0.078**/(0.03)</td>
<td>0.085*/(0.04)</td>
</tr>
<tr>
<td>Log(M.Yield)</td>
<td>0.039*/(0.02)</td>
<td>0.041**/(0.02)</td>
<td>-0.085**/(0.04)</td>
<td>-0.086**/(0.04)</td>
</tr>
<tr>
<td>Private</td>
<td>0.010/(0.38)</td>
<td>0.023/(0.37)</td>
<td>1.023/(2.68)</td>
<td>1.18/(2.75)</td>
</tr>
<tr>
<td>Small Prod</td>
<td>-1.52***/(0.57)</td>
<td>-1.51***/(0.57)</td>
<td>-1.41**/(0.68)</td>
<td>-1.48***/(0.68)</td>
</tr>
<tr>
<td>RainDev</td>
<td>0.08/(0.07)</td>
<td>0.083/(0.07)</td>
<td>0.113**/(0.05)</td>
<td>0.116**/(0.05)</td>
</tr>
<tr>
<td>Procampo</td>
<td>0.0003***/(0.00)</td>
<td>0.0004***/(0.0)</td>
<td>0.001***/(0.0)</td>
<td>0.001***/(0.00)</td>
</tr>
<tr>
<td>OPORT.</td>
<td>-0.002***/(0.00)</td>
<td>-0.002***/(0.00)</td>
<td>-0.001***/(0.00)</td>
<td>-0.001***/(0.00)</td>
</tr>
<tr>
<td>Education</td>
<td>0.064***/(0.01)</td>
<td>0.064***/(0.01)</td>
<td>0.058***/(0.01)</td>
<td>0.058***/(0.003)</td>
</tr>
<tr>
<td>Constant</td>
<td>8.30***/(0.55)</td>
<td>8.29***/(0.54)</td>
<td>8.25***/(0.99)</td>
<td>8.28***/(1.01)</td>
</tr>
</tbody>
</table>

| Obs.   | 34,440 | 34,440 | 34,440 | 34,440 |
| R-squared | 0.156 | 0.156 | 0.347 | 0.347 |
| County FE | NO    | NO    | YES   | YES   |
| Year FE  | NO    | NO    | YES   | YES   |
Results: WII causes

• Yield increases by 7.6%
  – 1% of maize producers have > 20 hcts, but own 11% of total land share of maize → point estimate of 6.7% translates in average treatment effect on the treated (TOT) = 7.6%

• Rural farm household income increases by 8%
  → Suggests positive spillover effects of WII on firm productivity

• WII literature provides possible explanations
  – Multiplying effects: WII increases access to credit markets (Barnett, Barrett & Skees, 2008)
  – Alleviation of risk constraints (Boucher, Carter & Guirkinger, 2008)

• Additionally we find increase in diversification:
  – Maize area decreases by 8%, freeing up land for potentially more profitable crops. With 270 crops difficult...some vegetables significant at 10% level.
Potential Threats to Estimation

• Estimates biased if insured and uninsured counties are different
  – i.e. land quality differs
  – County fixed effects will deal with time invariant unobserved differences

• Non-random weather-station placement
  – Weather stations were located and built by ‘Conagua’ long before WII (25 years window)

• Estimates biased if rollout selective:
  – We test for Ashenfelter Dip and Placebo regressions

• Farmers may not trust the government, thus not change behavior
  – 2009 Impact Evaluation Survey: almost 100% of farmer know about program and 80% have high WTP \( \Rightarrow \) estimates would be lower bound
WII successfully passes CBA from Farmers Perspective

- **Benefits**: yield increases $\rightarrow$ farmer gains $52.44/ha
- **Cost** of premium = $11.90/ha
- **Benefit / Cost Ratio** = 440%
- **Calculations based on**
  - Average farm produces 3 ha of maize
  - Average yield conditional on not being treated: 3 tons/ha
  - Average maize price/ton = $230

- Irrigation technology increases yields by 300%
- What is cost of irrigation?
WII successfully passes CBA from Farmers Perspective

• **Benefits:** yield increases → farmer gains $52.44/ha
• **Cost** of premium = $11.90/ha
• Benefit / Cost Ratio = 440%
• **Calculations based on**
  – Average farm produces 3 ha of maize
  – Average yield conditional on not being treated: 3 tons/ha
  – Average maize price/ton = $230

• **Caveat:**
  – Irrigation increases yields by 300%
  – What is cost of irrigation?
Cost Efficiency Analysis

• Government of Mexico pays very high premium: 16.07% of value of crop insured

• We estimate “Expected loss” to be 8.04% of value of insured land
  – By using county specific thresholds in the periods of seeding/Flowering/harvesting & daily rainfall data from 1990-2008

• **Premium** driven by 3 components (Mahul and Stutely 2010):
  1. Expected loss (frequency and loss severity)
  2. Expense load: compensates administrative & operating costs
  3. Catastrophe load: compensates “risk bearing”

• Basix: Premium was 9.2% (was considered high by Gruschynski & Jaisinghani, 2009)
Conclusion

• WII rapidly increasing in the last decade, but debate whether WII is effective

• This is first paper to empirically study large scale WII on farmers behavior

• Consistent with theory:
  – Yields increases (7.6%)
  – Income increases (8%) → positive spillover effects

• Mechanism of multipliers
  – Relaxed credit constraint
  – Maize area sowed decreases and substituted by likely more profitable crops

• From individual farmers perspective WII passes CBA

• From society perspective, our analysis hints that government likely overpays
• Thank you!