Natural Disasters: Exposure and Underinsurance

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Natural disasters and insurance

- Considerable and growing impact of natural disasters on national economies (several percents of GDP)
- The national output decrease subsequent to natural disasters is mainly driven by the uninsured losses (Von Peter et al., 2012). Insurance enables a partial transfer of catastrophic risk to foreign actors (reinsurers)
- But still low levels of insurance coverage, in particular in many developing countries and developing small island states, most of them being highly exposed to natural disasters

Latin America and the Caribbean

- Concurrence of exposure and low insurance take-up rate is striking in many developing countries and developing small island states
- In particular : Latin America and the Caribbean form one of the world's most disaster-prone areas (damages exceeding 50% of GDP) and have the lowest levels of insurance coverage, even behind Africa. The insurance take-up rate is particularly low among households

A common explanation : a limited supply of insurance

Insurance supply is particularly limited, mainly due to

- unavailable or unaffordable reinsurance
- limited standardized information on risk exposure

In practice

- Supply of coverage for governmental expenditures remains limited despite recent advances (Caribbean Catastrophe Risk Insurance Facility, issuance of catastrophe bonds by Mexican government)
- Supply for households is limited and fragile (Montserrat) ; high insurance premiums

The exception of the French overseas departments

The French overseas departments provide a rare example of a well-developed supply of natural disasters insurance in Latin America, the Caribbean and other exposed small island countries

The French system of natural disasters insurance

- Coverage of dwellings against natural disasters is mandatorily included in comprehensive home insurance
- Premium for natural disasters amounts to 12% of the premium for other risks

In 2006 only half of households living in the French overseas departments had purchased home insurance, which includes coverage against natural disasters, for their primary residence

Approach and data

- When one uses a structural approach, this broad and regulated supply of coverage makes it possible to analyze the determinants of insurance coverage on the demand side

- I have built a unique household-level micro-database combining detailed information about the insured and the uninsured : 2006 French Household Budget survey (INSEE) & GASPAR database (French Ministry of Ecology)

Contributions

1. Providing demand-side explanations for the low insurance take-up rate in disaster-prone areas and comparing their magnitude

- Main explanations are
  - NOT the insurance price (low price elasticity of insurance demand)
  - the uninsurable housing
  - likely the anticipation of financial assistance : *charity hazard*
- Neighbors' insurance choices impact individual insurance decisions through
  - neighborhood eligibility for assistance
  - peer effects
- Existing insurance obligations (*de facto* for homeowners with outstanding loans and *de jure* for French tenants) are operant

Contributions (cont'd)

2. Measuring the impact of regulation on insurers' pricing behavior

The French government

- provides an unlimited guarantee to one reinsurer
- in return, regulates the scope and the price of natural disasters coverage

Beyond strict regulation, the attractive and non-actuarially-based reinsurance policies offered by this reinsurer provide little incentive for insurers to price natural risks

Model of home insurance market equilibrium

In the line of Pauly (1974) or Rothschild and Stiglitz (1976)

- Assumption : insurers offer a single, standard policy with full coverage
- Supply equation explains the offered insurance premium (price) : insurers' expected profit is zero
- Demand equation explains the probability of purchasing insurance (quantity) : comparison by households between their expected utility with and without insurance. Depends on the insurance price

Simultaneous estimation of the two equations based on maximum likelihood

Risk structure

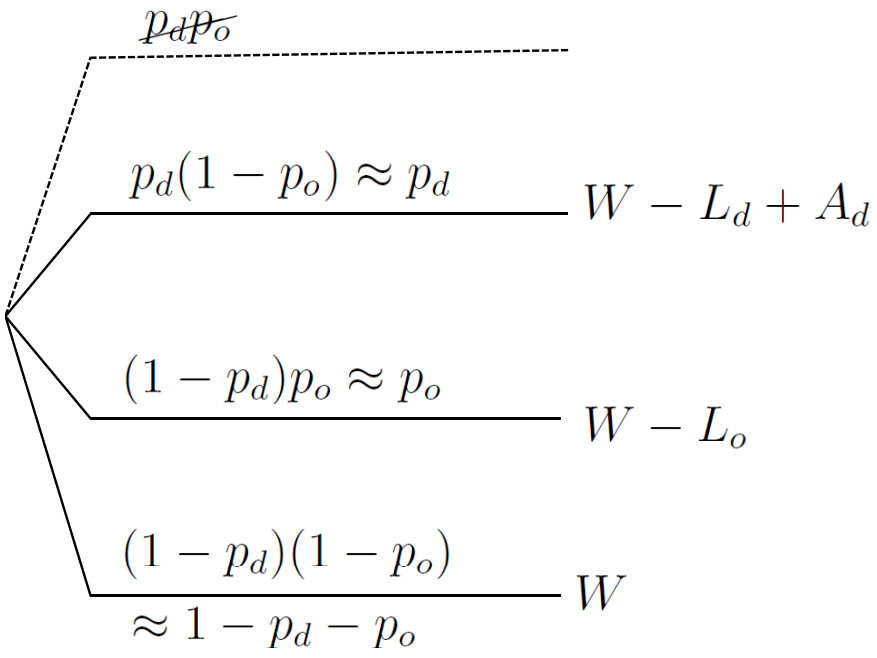
Natural disasters

- Probability p_d
- Loss L_d
- Assistance A_d for the uninsured after a disaster. Net loss for the uninsured : $L_d - A_d$

Ordinary risks

- Probability p_o
- Loss L_o

Ordinary risks and natural disasters are assumed to be independent



Households' risk perception is potentially biased : $\tilde{p}_o \neq p_o$, $\tilde{p}_d \neq p_d$, $\tilde{L}_d \neq L_d$

Supply equation

- $\pi = c(EL_o + EL_d)$
- $EL_o = p_o L_o$
  $EL_d = p_d \min\left(\pi_d, \frac{L_d}{2}\right) + k\pi_d = (p_d + k)\pi_d$
- $\left.\begin{array}{l} \pi = \pi_d + \pi_o \\ \pi_d = r\pi_o \end{array}\right\} \Rightarrow \pi = \frac{1+r}{r}\pi_d$

$$\Rightarrow \log(\pi) = \log(cp_o L_o) - \log\left(1 - ck\frac{r}{1+r} - cp_d\frac{r}{1+r}\right)$$

Supply specification

- $\log(\pi) = \log(cp_o L_o) - \log\left(1 - ck\frac{r}{1+r} - cp_d\frac{r}{1+r}\right)$
- $L_o = lY^y N^n(1 - \tau O_t),\ \tau \geq 0$
- $p_d = pR,\ p \geq 0$
- Error : assessment error ϵ by the insurer (normal distribution)

Supply equation

$$\text{if } \alpha_i = 1, \log(\pi_i) = \log(c_\pi) + y\log(Y_i) + n\log(N_i) + \log(1 - \tau O_{ti}) - \log(1 - \boldsymbol{\kappa} - \rho R_i) + \sigma\epsilon_i$$

$$\text{if } \alpha_i = 0,\ \pi_i = 0$$

c_π, $1 - \kappa$ and ρ cannot be simultaneously identified
$c_\pi = cp_o l$ and $\rho = cpr/(1 + r)$ are estimated
$\boldsymbol{\kappa} = ckr/(1 + r)$ is calibrated

Supply estimation

$$\text{if } \alpha_i = 1,\ \log(\pi_i) = \log(c_\pi) + y\log(Y_i) + n\log(N_i) + \log(1 - \tau O_{ti}) - \log(1 - \boldsymbol{\kappa} - \rho R_i) + \sigma\epsilon_i$$

$$\text{if } \alpha_i = 0,\ \pi_i = 0$$

Supply equation

Coefficient	Estimate
c_π	2.4***
y	0.22**
n	0.32**
τ	0.29**
ρ	0.056**
σ	0.61**
($\boldsymbol{\kappa}$	0.088)

Note : ** : (Pr > |t value|)< 0.0001 ; * : (Pr > |t value|)< 0.05

Source : 2006 French Household Budget survey and GASPAR database. 2,809 obs.

Home insurance : premium and budget weight

	Mean	Lower quartile	Upper quartile
Uninsured households			
Premium (€ 2006)	231	187	274
Annual income (€ 2006)	15,735	7,756	20,236
Budget weight	2.1%	1.2%	2.6%
Insured households			
Premium (€ 2006)	254	118	300
Annual income (€ 2006)	30,217	13,974	40,222
Budget weight	1.4%	0.5%	1.4%

Source : 2006 French Household Budget survey and GASPAR database. 2,809 obs.

Demand equation and specification

- $\alpha = 1 \Leftrightarrow \; EU|_{\alpha=1} \geq EU|_{\alpha=0}$
- $EU|_{\alpha=1} = U(W - \pi)$
- $EU|_{\alpha=0} = \tilde{p}_o U(W - L_o) + \tilde{p}_d U(W - \tilde{L}_d + \tilde{A}_d) + (1 - \tilde{p}_o - \tilde{p}_d) U(W)$
  $= U(W) - \tilde{p}_o[U(W) - U(W - L_o)] - \tilde{p}_d[U(W) - U(W - \tilde{L}_d + \tilde{A}_d)]$
- Losses. $\tilde{L}_d = \beta L_o$
- Loss probabilities. $\tilde{p}_o[U(W) - U(W - L_o)]$ and $\tilde{p}_d[U(W) - U(W - L_d + \tilde{A}_d)]$ are fundamentally linked
  $\Rightarrow (\tilde{p}_o, \tilde{p}_d, \beta)$ cannot be simultaneously identified
  $\boldsymbol{\tilde{p}_o}$ and $\boldsymbol{\beta}$ are calibrated

Charity hazard

- No proxy for expected assistance. I build a test for the presence of charity hazard based on the impact of past sinistrality

- As the number S of past disasters increases, two opposite effects on insurance demand
  - increase of the probability $\tilde{p}_d(S)$ of natural disasters : $\uparrow$ demand
  - increase of the expected assistance $\tilde{A}_d(S)$: $\downarrow$ demand

  "summarized" in the weight $q_d(S)$
  $EU|_{\alpha=0} = U(W) - \tilde{p}_o[U(W) - U(W - L_o)] - q_d(S)[U(W) - U(W - \beta L_o)]$

- Test : charity hazard only if the second effect exceeds the first one, i.e. only if $\frac{\partial q_d}{\partial S} \leq 0$

- Perception bias or uncontrolled differences in risk aversion could not imply $\frac{\partial q_d}{\partial S} \leq 0$

Demand equation and specification (cont'd)

- Neighborhood eligibility for assistance. The more an individual is surrounded by people without insurance, the less need he/she has to purchase insurance since the political power of the uninsured grows : $\tilde{A}_d(S, E(Z_{\text{aid}})) \Rightarrow q_d = (q + \theta E(Z_{\text{aid}}))S$

- Peer effects. Social norms impact the decision to purchase insurance : $E(Z_{\text{peer},i})$

- Place of birth. Dummies B_m and B_a born in metropolitan France or abroad, respectively

- Uninsurable housing. Houses still under construction (H_c), houses without hot water (H_w), houses without drainage (H_d), houses without toilets inside the house (H_t)

- Insurance obligations. For tenants (O_t) and for homeowners with outstanding loans (O_l). Robustness when sample excludes them or the model is estimated for tenants only

- Selection bias. $\nu\epsilon$, where ϵ is the hazard attached to the insurance premium

- Error. Assessment error η made by households (normal distribution)

- Utility function. $U(W) = W^{1-\lambda}/(1-\lambda)$. Here $U(W) = \log(W)$ ($\lambda \to 1$). Robust for $\lambda = 2$ or $\lambda = 3$

- Wealth. Households' holdings (observed annual income is assumed to be constant over time until the death of the reference person). Results are robust when using the holdings (discount rates of 4% until 30 years and 2% beyond (Gollier, 2007), 10% (Andersen et al., 2008) or 20%) or the annual income

Identifying variables

- Variables. Houses still under construction (H_c) and without drainage (H_d). Overidentified model. Compatible identifying variables

- Interpretation. Houses still under construction or without drainage have a lower probability of being insured but, once a house is covered, the price of its coverage does not depend on these characteristics.

  Business practices indicate that most of the time insurers check building quality once a loss has occurred, before paying compensation ; this check and its consequences can easily be anticipated by the concerned households who will not buy insurance

Demand estimation

$$\alpha_i = 1 \Leftrightarrow [\log(W_i - \pi_i) - \log(W_i)] + \tilde{\boldsymbol{p}}_{\boldsymbol{o}}[\log(W_i) - \log(W_i - L_{oi})]$$
$$+[qS_i + \theta E(Z_{\text{aid},i})S_i][\log(W_i) - \log(W_i - \beta L_{oi})] + o_t O_{ti} + o_l O_{li}$$
$$+h_c H_{ci} + h_w H_{wi} + h_d H_{di} + h_t H_{ti} + \delta E(Z_{\text{peer},i}) + b_m B_{mi} + b_a B_{ai} + \nu\epsilon_i + \eta_i \geq 0$$

Demand equation

Coefficient	Estimate	Coefficient	Estimate
q	-0.065**	h_d	-0.50**
θ	0.095**	h_t	-0.70*
δ	0.67**	o_t	0.34**
b_m	0.77**	o_l	0.83**
b_a	-0.53**	ν	0.41**
h_c	-0.71*	($\tilde{\boldsymbol{p}}_{\boldsymbol{o}}$	0.075)
h_w	-0.85**	(β	15)

Note : ** : (Pr > |t value|)< 0.0001 ; * : (Pr > |t value|)< 0.05

$\tilde{\boldsymbol{p}}_{\boldsymbol{o}}$ and $\boldsymbol{\beta}$ are calibrated at 0.075 and 15, respectively

Source : 2006 French Household Budget survey & GASPAR database. 2,809 obs.

Determinants of demand and their magnitude

Assumption	Insured households
Place of birth	
$B_m = 1$	71%
$B_a = 1$	29%
Municipal insurance rate	
Municipal insurance rate = 0.75	
via neighborhood eligibility only	0.49
via peer effects only	0.65
Uninsurable housing	
$H_c = 1$	19%
$H_w = 1$	13%
$H_d = 1$	36%
$H_t = 1$	19%
Insurance obligations	
$O_t = 1$	60%
$O_l = 1$	72%

Note : the initial percentage of insured households is 48%.

Source : 2006 French Household Budget survey and GASPAR database. [illegible] bs.

Price and income elasticities of demand for home and flood insurance

Line of insurance and place	Definition of demand	Price elasticity	Income elasticity	Citation
Home insurance				
French overseas departments	(PP)	$-5 \cdot 10^{-4}$	0.10	Current study
Florida	(FA)	-1.08	0.06	Grace et al. (2004)
New York	(FA)	-0.86	-0.03	
National flood insurance				
Unites States	(PP)	-0.11	1.40	Browne and Hoyt (2000)
Unites States	(FA)	-1.00	1.51	

Caption : insurance demand is defined by the percentage of purchased policies (PP) in the population / the face amount (FA) of coverage

Price elasticity : when the premium increases by 50%, the number of households that are willing to purchase insurance decreases by only 0.2%

Income elasticity : comparable order of magnitude. Income decreases absolute risk aversion but increases need for coverage

Could other phenomena explain that $\frac{\partial q_d}{\partial S} \leq 0$?

- Perception biases
- Correlation between risk aversion and past sinistrality

Variable	Correlation value
Age	0.060*
Gender (women)	0.068**
Place of birth (metropolitan France)	-0.0032
Insured automobile	-0.0053
Comprehensive automobile coverage	0.029

Note : ** : (Pr > |r|)< 0.0001 ; * : (Pr > |r|)< 0.05