Natural Disasters: Exposure and Underinsurance

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Work in Progress

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Natural disasters and insurance

- Considerable and growing impact of natural disasters on national economies (several percents of GDP)
- Macroeconomic value of risk transfer to insurance markets. Insurance enables a partial transfer of catastrophic risk to foreign actors (reinsurers)
- But still low levels of insurance coverage

Latin America and the Caribbean

- Concurrence of exposure and underinsurance 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 (for example, in Mexico in 1998, less than 1% of houses had disaster insurance coverage)

A common explanation : a limited supply of insurance

Developing countries : insurance supply is particularly limited (microinsurance provides very partial coverage), mainly due to

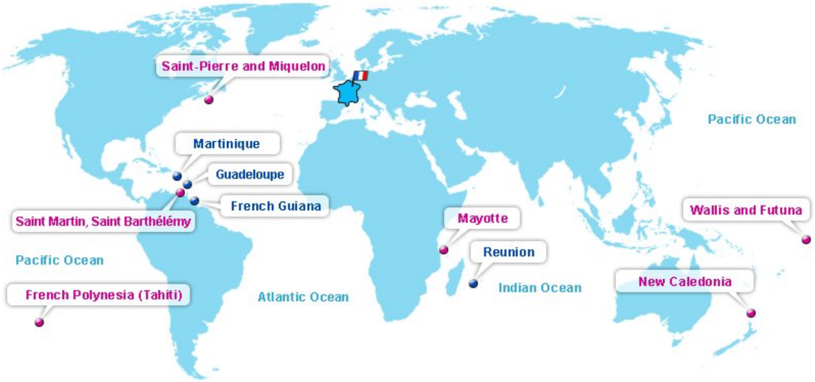
- unavailable or unaffordable reinsurance
- limited standardized information on risk exposure

Latin America and the Caribbean

- 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 natural experiment 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
- Created in 1982 ; instituted initially for metropolitan France. Extended to the French overseas departments in the state of emergency following Hurricane Hugo (Guadeloupe, 1989).

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

Contributions

1. Providing demand-side explanations for underinsurance in disaster-prone areas

- Standard explanations for underinsurance (perception biases, insurance price) are excluded
- Main explanations are
  - uninsurable housing
  - anticipation of financial assistance : *charity hazard*
- Neighbors' insurance choices impact individual insurance decisions through
  - peer effects
  - neighborhood eligibility for assistance
- 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

Contributions (cont'd)

3. Specification and estimation of a theoretical insurance model (Abel (1986), Pauly (1974) and Rothschild and Stiglitz (1976)), which had not been previously tested

A unique household-level micro-database combining detailed information about the insured and the uninsured has been built to estimate this model : 2006 French Household Budget survey (INSEE) & GASPAR database (French Ministry of Ecology)

Model of home insurance market equilibrium

Insurers are assumed to offer a single, standard policy with full coverage

Structural model (Abel (1986), Pauly (1974), Rothschild and Stiglitz (1976))

- 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

Estimation is based on maximum likelihood (method used by labor economists (Laroque and Salanié, 2002))

Risk structure

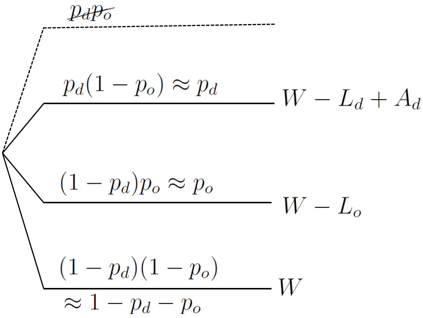
Natural disasters

- 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

- $\log(\pi) = \log(cp_o L_o) - \log\left(1 - ck\frac{r}{1+r} - cp_d\frac{r}{1+r}\right)$
- $L_o = lY^y N^n(1-\tau O_t),\ \tau \geq 0$
- $p_d = pR,\ p \geq 0$
- Hazard : 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

- $\alpha = 1 \Leftrightarrow \; EU|_{\alpha=1} \geq EU|_{\alpha=0}$
- $EU|_{\alpha=1} = U(W - \pi)$
- $$\begin{aligned} EU|_{\alpha=0} &= \tilde{p}_o U(W - L_o) + \tilde{p}_d U(W - \tilde{L}_d + \tilde{A}_d) + (1 - \tilde{p}_o - \tilde{p}_d) U(W) \\ &= U(W) - \tilde{p}_o [U(W) - U(W - L_o)] - \tilde{p}_d [U(W) - U(W - \tilde{L}_d + \tilde{A}_d)] \end{aligned}$$

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

- Losses. $\tilde{L}_d = \beta L_o$

- Identification. $\tilde{p}_o[U(W) - U(W - L_o)]$ 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

Learning from past disasters

- Number S of past natural disasters (from 1990 to 2006) has a dual impact : $\tilde{p}_d(S)$ and $\tilde{A}_d(S)$. No proxy for aid

- As the number of past disasters increases, utility loss effect (ULE) + charity hazard effect (CHE)

$$\Rightarrow \alpha = 1 \Leftrightarrow \begin{array}{l} [\log(W-\pi) - \log(W)] + \tilde{p}_o[\log(W) - \log(W - L_o)] \\ +q_d(S, E(Z_{\text{aid}}))[\log(W) - \log(W - \beta L_o)] + ... \geq 0 \end{array}$$

$$\frac{\partial q_d}{\partial S} \leq 0 \Rightarrow |\text{CHE}| \geq \text{ULE} \Rightarrow \frac{\partial \tilde{A}_d}{\partial S} \geq 0$$

- 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*
Sex (women)	0.068**
Insured automobile	-0.0053
Comprehensive automobile coverage	0.029

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

- 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 : $\tilde{A}_d(S, E(Z_{\text{aid}})) \Rightarrow q_d = (q + \theta E(Z_{\text{aid}}))S$

Demand equation and specification (cont'd)

- Peer effects. Social norms impact the decision to purchase insurance : $E(Z_{\text{peer},i}) = \frac{\sum_{j \in J_{\text{peer}}, j \neq i} \alpha(j)}{\text{card}(J_{\text{peer}})-1}$
- Initial peer effects. 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

- Wealth. Households' holdings (observed annual income is assumed to be constant over time until the death of the reference person). Discount rates recommended by Gollier (2007). Robust when using annual income

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

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

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

Demand estimation

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

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 β 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	Percentage of insured households
Place of birth	
$B_m = 1$	71%
$B_a = 1$	29%
Municipal insurance rate	
Municipal insurance rate = 0.75	
via peer effects only	0.65
via aid eligibility only	0.49
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. 2,80

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.
New York	(FA)	-0.86	-0.03	(2004)
National flood insurance				
Unites States	(PP)	-0.11	1.40	Browne and
Unites States	(FA)	-1.00	1.51	Hoyt (2000)

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 decreases but increases need for coverage

Discussion

To what extent is charity hazard an issue ? After all, "a catastrophe fund is de-facto "mandatory insurance"" (Raschky and Weck-Hannemann, 2007)

Ex post assistance ≈ ex ante insurance subsidy ? No ! See Coate (1995)

- Ex post assistance by the State and local authorities is inefficient : there is no reason to expect that people who provide assistance will choose the optimal level of assistance ; the uninsured can free-ride between different channels
- No incentive for prevention measures

\+ Distortion of the fiscal system

How can charity hazard be reduced ? Regulatory incentives for home insurance purchase ?