Risk Selection in Natural Disaster Insurance - the Case of France*

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Abstract

It is widely recognized that "market failure" prevents efficient risk sharing in natural disaster insurance. As a consequence, many countries adopted institutional frameworks involving public-private "partnerships". We define risk selection as a situation where private companies pass insurance of high risk agents on to the public sector. We argue that this is a potentially important issue in such partnerships, illustrating our concerns with the case of France. We build a simple model that incorporates the main features of the system, such as the risk independent premium rate and the existence of a state reinsurer. We show that in our model, risk selection is likely to be present in equilibrium and discuss the policy options available. We find that the "stylized facts" of the French system correspond to our results. Additionally, the policies implemented by the government correspond to policies characterized to reduce the potential of risk selection.

Key words: Risk selection, property insurance, reinsurance, France.

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1 Introduction

"Market failure" in natural disaster insurance is widely recognized. In a recent paper, Gollier (2005) discusses aspects that lead to a breakdown of efficient risk sharing, such as, among other, the existence of asymmetric information, limited liability of insurance companies and the suboptimal possibility of time diversification of insurers as reasons. The recommended policy options include in most cases some sort of public sector intervention. Particularly interesting are the ideas that "[t]he existence of extensive bankruptcy costs on financial markets implies that catastrophe risks cannot be insured without the government playing the role of reinsurer of last resort." (p. 11) and that "...the state may be in a better situation to organize time diversification." (p. 16). Both statements indicate an active role of the public sector in disaster insurance.

This is indeed the case. Von Ungern (2004) discusses natural disaster insurance in five European countries (England, Spain, France, Switzerland and Germany). The scope of public intervention ranges from "laissez-faire" in England to state owned monopoly in Spain and parts of Switzerland, via the abolition of state monopolies in Germany and public reinsurance in France. In the USA, natural disaster insurance is in part provided by the Federal Emergency Management Agency (FEMA) through its National Flood Insurance Program (NFIP).

Based on the widespread consensus that some sort of public-private partnership is optimal to deal with the issues of market failure in natural disaster insurance, we argue that "risk selection" is a potentially harmful concern, with significant financial consequences for the taxpayer. *We define risk selection as a situation where private companies are able to pass insurance of high risk agents to the public part of the private-public partnership.*[1] Actually, such behaviour is quite intuitive for profit maximizing firms, which have all the incentives to use a particular institutional framework to their advantage.

Risk selection can arise in situations where the public sector provides insurance for agents the private insurers do not want to cover, or where the public sector provides reinsurance. In a situation were existing natural disaster insurance schemes are or have been under financial distress (e.g. France, US) and, additionally, many countries do not have an adequate system of protection

[1] Our definition is similar to the one used by the World Health Organization, applied to a context of public sector participation. "(A) process whereby an insurer tries to attract people with a lower-than-average expected risk ...and deter those with a higher-than-average expected risk in order to increase profits; the process can be explicit or covert" (`www.euro.who.int`). We do not use the term adverse selection, since this is generally associated with asymmetric information in the litterature. We think that asymmetric information is not fundamentally important for natural disaster insurance and abstract from this in our model.

against the financial and economic consequences of natural disasters,[2] the call for reforms of existing, or implementation of new, institutional frameworks for natural disaster insurance is evident.

In order to demonstrate the potential for risk selection and its significant financial implications we consider the French system of natural disaster insurance ("assurance catastrophe naturelle"). This institutional setup is sometimes praised as a *successful* public-private partnership (see e.g. Michel Kerjan (2001) or Gollier (2005)), and is likely to be considered as a potential example to reform existing disaster insurance systems in other countries or as the guideline to create new systems.

To illustrate the potential weaknesses of the French system, we build a simple model that captures the essential features of the institutional setup, such as a unique (and risk independent) premium rate across the country and the existence of a publicly owned reinsurance company. We show that risk selection is a likely equilibrium outcome under this setup, leading to a financially untenable situation for the reinsurance company. We then explore the possible policy alternatives within the model to deal with risk selection, including premium increases and limiting the degree of reinsurance. We next compare the predictions of our model with the observed developments of the French system since its creation in 1982/83. We find that the French system exhibits the main characteristics of the equilibrium outcome described in our model, and that the policy reactions of the authorities are very similar to the ones our model suggests as the ones that might be used to reduce the degree of risk selection. We then provide an outlook of the future sustainability of the system. We conclude that risk selection is likely to continue to be an important issue within the French system. The system already needed to be refinanced at a substantial cost to the taxpayer and it seems likely that the same might reoccur again in the (not so distant) future.

The role of the public sector in the provision of natural disaster insurance has been recognized as early as the 1970's (e.g Kunreuther, 1974). Jaffee and Russell (1997) argue that, despite the potential to increase private sector participation in natural disaster insurance, the "government will continue to be an essential player in catastrophe insurance markets". Lewis and Murdock (1996) discuss the reinsurance of natural disasters, indicating that the public sector can exploit intertemporal diversification to complement the private insurance market. A point similar to the one outlined by Gollier (2005). Rather than contributing to this direction of research, we take the role of the public sector as given and analyze potential consequences in terms of risk selection.

It is in health insurance that risk selection has been discussed to a certain extent. Newhouse (1996) presents a good early survey of the main issues in the

[2] A situation that was dramatically illustrated by the 2004 Tsunami-earthquake in South-east Asia, or, for that matter, by 2005 hurricane "Katrina" in the United States.

health insurance market both from a theoretical and an empirical perspective. More recently, some empirical papers have attempted to assess whether risk selection is indeed present in health insurance or not. The evidence seems to be mixed: On the one hand, Polsky and Nicholson (2004) "find no evidence that HMO plans attract a disproportionate share of low-risk enrollees". On the other hand, Nicholson *et. al.* find risk selection for employer-sponsored plans (Nicholson et al., 2004). Shen and Ellis (2002), using simulation methods, find that risk selection can remain profitable for insurers even after the implementation of risk-adjustment formulas, while Lehmann and Zweifel (2003) document that risk selection partly explains the cost advantages of HMOs.

The reminder of this paper considers the case of the natural disaster insurance in France. We first outline and discuss the institutional framework implemented by the French government, discussing the main changes to the system since its inception. We next build a simple model to evaluate this framework. We then compare the model's outcome to the actual situation in France and conclude with an outlook on the future of this particular insurance scheme.

2 The Case of France

2.1 The institutional framework

Natural disaster insurance was introduced in France in 1982 as a reaction to a severe flood a few months earlier. The term "natural disaster" ("catastrophe naturelle") is not defined in the law creating the system.[3] A commission, formed of representatives of the Ministries of Interior, Finance and Environment, has to decide whether a given occurrence is deemed a natural disaster and hence makes claimants eligible for reimbursement. The conditions of insurance (in particular premium rates and excesses) are fixed by decree and uniform across the country. Insurance is compulsory, presumably to reduce problems of adverse selection among property owners. Similarly, all insurance companies offering (other types of) property insurance in a specific area are obliged to include protection against natural disasters. Premium rates are defined as a percentage of other property insurance premiums (in particular fire), while excesses (for non-commercial buildings) are fixed per contract and

[3] The description below is drawn from von Ungern (2004). The author also provides a more in depth description of the natural disaster insurance in France. Additional information was obtained from a letter by the CEO of the public reinsurer to a private insurer dated in October 1996 (CCR, 1996). The letter is written in French, any translations in this paper have been done by the authors, which are not certified translators. Copies of this letter can be obtained from the authors upon request.

per event.[4]

An important institutional feature of the system is the existence of a publicly owned reinsurance company, the Caisse Centrale de Réassurance (CCR). Reinsurance is not compulsory, and insurers are free to contract with other, private, reinsurance companies. Reinsurance with the state reinsurance company is, however, potentially attractive, both because the reinsurance premiums charged are low and because it can offer unlimited cover (it is covered by a state guarantee). Insurance companies that decide to reinsure with the public reinsurer are offered two types of contracts; proportional contracts (for a given percentage of premium income the reinsurance company covers a given percentage of claims) and stop-loss contracts (the reinsurance company covers all claims that exceed a given multiple of annual premium income).

The initial conditions of insurance were the following: The premium rate was set at 5.5% of the basic housing insurance contract, and excesses for a residential structure were FF 800. The basic CCR conditions were: for proportional contracts insurers could choose any rate of reinsurance between 40% and 90%. Stop-loss contracts were only offered to insurers that also participated in the proportional contract. Conditions for the stop-loss contracts were negotiated on a case by case basis. Furthermore, the CCR offered a commission for administrative expenses to the private insurers of 24% of the reinsured premium income.

2.2 The main changes to the system since its creation

There have been four major changes to the system since its creation in 1982.

In 1983, i.e. just one year after its creation, the premium rates for buildings were increased by more than 50% (from 5.5% to 9%). At the same time the excesses were also revised upwards (from FF800 to FF1500).

In 1990 the French overseas districts (Départements Outre Mer, DOM) were included in the natural disaster insurance scheme, i.e. insurers had to provide disaster insurance if they wanted to operate in the DOM. The private insurers accepted this introduction only under the condition that these territories could be reinsured separately from the mainland portfolio. The legislator and the CCR accepted this condition.

[4] One could argue that it is impossible to treat the natural disaster insurance “market” independently from other housing insurance, since these contracts are sold together. We would argue that this is not the case. It is easily conceivable that losses in the natural disaster segment drive an insurer out of a particular region, even if premium income from this segment is relatively small. Imagine a region where the basic housing insurance is delivered in a competitive market with no returns to scale. Clearly, an insurer would opt not to provide insurance in a situation where the disaster insurance incurrs losses, even if the fraction of premium income from this segment is small.

In 1996, after its reserves had dwindled to less than €300 million (2 billion FF), the CCR substantially revised its reinsurance conditions. The range for the proportional reinsurance rate was reduced to a rate between 40% (minimum unchanged) and 60% (maximum reduced by 30 percentage points). The minimum retention rate for the insurers in the proportional reinsurance cover was thus increased from 10% to 40%. For insurers with a high share of industrial risks, the maximum rate was further limited to 40%, i.e. their compulsory retention rate was fixed at 60%. The possibilities to obtain stop-loss cover were also reduced. The minimum loss for the insurer before the stop-loss could come into play was increased to equal 100% of the insurers **total** (gross) premium income. For small insurers or insurers with a bad risk portfolio (mainly industrial risks or risks in the DOM (Guadeloupe, Martinique)), the minimum excess was even higher. Finally, the commission to cover administrative costs varied, according to the historic claims/premium ratio of the insurers, between 18% and 24%.

In spite of these changes the CCR was virtually bankrupt by the end of the year 1999 (see discussion below). The resulting financial injection by the government was accompanied by a major financial reorganisation.

The premium rate was increased by one third (from 9% to 12%) and their excesses were multiplied by a factor of (approximately) 2.[5] The commission for administrative costs has been entirely abolished. The rate of proportional reinsurance was fixed at 50%, i.e. the maximal and minimal rates are now equal.

If the insurance companies wish to continue obtaining separate cover for their risks situated in the DOM, they can do so only at the cost of accepting a substantial excess (1600% of annual premium income) on those risks.

2.3 The financial evolution of the system

We next turn to the financial evolution of the disaster insurance system in France.

Table 1 presents financial information of the system in its first 20 years of existence. The first column of data presents the industry claims/premium (C/P) ratio. Over the period 1982-2001 the average C/P ratio was 58%, with important yearly variation due to the infrequent occurrence of natural disasters.

The second column gives an estimate of the overall profitability (including capital income) of the system. The methodology used for this computation is detailed in Appendix A1. Accumulated system-wide profits over the first 20 years are estimated at roughly 7.2 billion €.

[5] The factor is less than 2 for damage due to floodings, and more than 6 for damage due to subsidence.

Column three shows the rate of reinsurance of the private insurers. One can observe the important drop in the rate of reinsurance from above 80% at the beginning of the system to 40% (the lowest the CCR would allow, while still offering stop-loss contracts) by the end of the 1990's. Note that the final increase in the rate of reinsurance was the introduction of the unique rate of 50% by the reinsurer.[6]

Finally, columns four and five indicate information on the financial evolution of the CCR, presenting the ceded premium income and the evolution of reserves of the public reinsurer. We come back to the interpretation of this evolution in Section 4.

We will first build a simple model of this institutional framework. We want to include the main elements of the French system, while still keep the model analytically tractable. These elements are:

1. A premium rate that is independent of risk, modeled via a uniform rate across the country.

2. Existence of a single (publicly owned) reinsurance company.

3. Insurers can, but need not, contract reinsurance.

We shall not explicitly model the stop-loss contracts, since in our (highly symmetric) model, their introduction would not add any substantial new insights. We discuss these contracts in Section 4 as well.

3 A simple model

Consider a simple model of a country with two regions of equal size $i \in [H; L]$. A region has a stock of $\mathcal{H}$ houses, each of (normalized) value 1. We assume that a region is subdivided into a finite number of counties, each with housing stock $\mathcal{M}$. A county can be affected by damage, which destroys the county completely (damage value $= \mathcal{M}$). Damage occurrence for each county in region i is assumed to follow a binomial distribution with the probability of damage equal to p_i. We assume that damage occurrence is independent both among counties and among regions. Hence, for each region the expected damage is $\mathcal{H}p_i$. Regions differ only in the respective probability of an event occurring, with the H-region having a higher probability of damage than the L-region ($p_H > p_L$).

Housing insurance is compulsory, and its price is fixed at rate θ independent of p_i. The insurance service is provided by identical insurers in a competitive

[6]The reason why the rate of reinsurance is not exactly equal to 50% is due to the fact that the figures include insurance/reinsurance of minor items such as vehicles, which are not subject to the 50%-rule.

market. Therefore, the market outcome in the model will be determined by symmetric, free-entry equilibrium. Whenever an insurer j decides to offer service in a particular region i, its market share will be given by $1/N_i$, where N_i is the number of insurers active in the region.[7]

There exists a single reinsurance company which offers proportional contracts to the market in all regions.[8] Reinsurance is voluntary, and each insurer can decide on the fraction of the portfolio that it wants to reinsure. We denote by $r_j \in [0,1]$ the rate of retention for insurer j.[9] Note that an insurer can reinsure only its entire portfolio and therefore can choose **only one** level of r_j, even when active in both regions.

The premium income from the fraction of the portfolio that is reinsured is divided as follows. The insurer keeps a percentage γ to cover administrative costs and passes on $(1-\gamma)$ to the reinsurance company. For the remaining portfolio, the insurer keeps the entire premium income. The reinsurer covers the fraction $(1-r_j)$ of claims payments. In terms of a particular house in region i, revenue for insurer j from signing a natural disaster insurance contract can be expressed by the following random variable:

$$Rev_j\left(i\right) = \left\{ \begin{array}{c} \theta\gamma + r_j\theta(1-\gamma) \\ \theta\gamma + r_j\left[\theta(1-\gamma)-1\right] \end{array} \right. \; with\, prob. \; \begin{array}{c} (1-p_i) \\ p_i \end{array}$$

The insurer is certain to obtain $\theta\gamma$ for each house it has under contract. Further, with probability $(1-p_i)$ the house does not suffer a damage. The insurer then receives the remaining premium income for the fraction of retained risks (r_j). With probability p_i the house is destroyed (damage value equals 1) and "net revenue" to the insurer is the fraction of remaining premium income minus the fraction of damage that the insurance company bears.

For the direct insurers all costs other than claims payments are assumed to be fixed. We consider two types of fixed costs. A region specific fixed cost (f) and a country specific fixed cost (F). F represents the fact that some costs, such as setting up a countrywide representation, must be incurred independently of the number of regions covered. Other fixed costs, such as local branch activities, are specific to a particular region. For simplicity we assume that regional fixed costs (f) are the same in both regions.[10] The country specific fixed cost (F) plays a crucial role in this model. Without it, there would be no incentive for an insurer to serve both regions. In fact, in the absence of F and under a competitive insurance market characterized by

[7] We work with free-entry equilibria to make the model simple. A high N in the model represents the substantial profits earned by the French insurers (see discussion below).

[8] This is an exact model of the proportional reinsurance cover the CCR offered prior to 2001.

[9] Hence $(1-r_j)$ is the fraction of the portfolio that is reinsured.

[10] One could argue that administrative costs in the H-regions are higher since there will be, on average, more cases to evaluate and forms to fill out. We abstract from this.

free entry, each individual insurer will seek a homogeneous risk portfolio in order to choose an optimal rate of retention. Only through the introduction of country fixed costs might an insurer actually want to provide service in both regions in our model.

Insurers are risk averse. Insurer j's expected utility is given by

$$E\left[u\left(\pi_j\right)\right] = E\left[\pi_j\right] - \frac{\lambda}{2} Var\left[\pi_j\right],$$

where π_j is profit of insurer j, and λ is the parameter of risk aversion.

Additionally to the rate of retention, each insurer can decide where to be active. We distinguish two types of insurers: A *specialist (insurer)* serves only one specific region, while a *generalist (insurer)* serves both regions. Expressions for expected profits and its variance are

$$E\left[\pi_j\right] = \frac{\mathcal{H}}{N_i}\left[\theta\gamma + r_j\left(\theta\left(1-\gamma\right) - p_i\right)\right] - f - F, \tag{1a}$$

$$Var\left[\pi_j\right] = r_j^2 \frac{\mathcal{H}}{N_i} p_i\left(1 - p_i\right), \tag{1b}$$

for specialists; and

$$E\left[\pi_j\right] = \left\{ \begin{array}{c} \frac{\mathcal{H}}{N_L}\left[\theta\gamma + r_j\left(\theta\left(1-\gamma\right) - p_L\right)\right] \\ +\frac{\mathcal{H}}{N_H}\left[\theta\gamma + r_j\left(\theta\left(1-\gamma\right) - p_H\right)\right] - 2f - F, \end{array} \right. \tag{2a}$$

$$Var\left[\pi_j\right] = r_j^2 \left[\frac{\mathcal{H}}{N_L} p_L\left(1-p_L\right) + \frac{\mathcal{H}}{N_H} p_H\left(1-p_H\right)\right], \tag{2b}$$

for generalists. Given the two types of insurers, three equilibrium characterizations are possible: all insurers are specialists $\Longrightarrow$ a *specialist equilibrium* (SE); all insurers are generalists $\Longrightarrow$ a *generalist equilibrium* (GE); both specialists and generalists coexist $\Longrightarrow$ a *hybrid equilibrium* (HE).

Insurers maximize expected utility, while free-entry determines the number of active insurers such that expected utility is zero. Since there is no asymmetric information in the model, the equilibrium concept used is Nash equilibrium. Even though this model setup seems to us to be as simple as possible, it is not possible to obtain useful analytic expressions for the equilibrium conditions for hybrid equilibria. For this reason we restrict the rest of our analysis to "specialist" and "generalist" equilibria. For each equilibrium candidate we calculate the conditions such that deviation (D) is not profitable. Note that the set of possible deviations is not very large. Retiring from the market is never a profitable deviation, since equilibria are characterized by zero expected utility. Deviation strategies are defined by entering or retiring from a particular region choosing the optimal rate of retention. Equilibrium conditions, as well as the expression for the equilibrium rate of retention and number of insurers, are given in Table 2, where we have introduced notation for the the "risk-adjusted unitary profit" for insurer j in region i

$$\omega_{ij} = \left[\theta\gamma + r_j\left[\theta\left(1-\gamma\right) - p_i\right] - \frac{\lambda}{2}\left(r_j\right)^2 p_i\left(1-p_i\right)\right]. \tag{3}$$

Figure 1, below, illustrates the equilibrium conditions for a set of specific parameter values in the θ-p_H space.[11] The shaded areas correspond to the areas of generalist equilibria with interior rates of retention and the case of specialist equilibria with full reinsurance in the high probability region. The line *GE cond* represents situations where the generalist equilibrium condition holds with equality; the line *SE cond* represents situations where the specialist equilibrium conditions holds, while the third line represent points where $r_H = 0$. The graph illustrates that the area of GE exists only for low levels of the premium rate or for small differences in damage probabilities across regions, while the (particular) specialist equilibrium occurs for high differences in damage probabilities. This characterizes the fundamental trade-off in the model: for small probability differences, the incentive to distribute the country fixed cost between two regions prevails (generalist insurers), while for larger differences the incentive to optimally set the rate of retention dominates (specialist insurers). Note that in the remaining areas of the graph other equilibrium characterizations would apply (such as hybrid equilibria or specialist equilibria with an interior rate of retention also in the H-region).[12] Moving north-east in the graph implies thus the following: either some (or all) insurers decide to become specialists, or the premium rate is sufficiently high such that $r_j = 1$ for all insurers.[13]

We are now in the position to analyze the problem of risk selection within the model. Risk selection affects the situation of the reinsurance company. It may end up with a disproportionate share of risks from the high probability region in its portfolio. We can define a simple measure of the degree of risk selection in our case: the number of high risks divided by the number of low risks that are reinsured. In our model this measure is

[11] Without loss of generality we define p_H and p_L in terms of a mean preserving spread $\overline{p} = \frac{p_H + p_L}{2}$, which implies that high values of p_H correspond to large differences in the damage probabilities between the regions. We assume θ to be at least actuarially fair.

[12] Indeed, our model satisfies the conditions of Proposition 8.D.3 of Mas-Colell, Whinston and Green (1995) implying existence of a pure strategy equilibrium.

[13] Jametti and von Ungern (2004) analyze, in a similar model with a linear utility function, the effect of an increase in the premium rate on the equilibrium outcome. They show that a discrete increase in θ leads either to a situation with more insurers operating as specialists or all insurers fully retaining their risks.

$$\rho = \frac{(1 - r_H)\frac{N_{SH}}{N_{SH}+N_G} + (1 - r_G)\frac{N_G}{N_{SH}+N_G}}{(1 - r_L)\frac{N_{SL}}{N_{SL}+N_G} + (1 - r_G)\frac{N_G}{N_{SL}+N_G}}, \tag{4}$$

where N_{SH} represents the number of specialists in the high probability region, etc.

The numerator consists of a weighted average of the rate of reinsurance in the H-region of specialists $(1 - r_H)$ and generalists $(1 - r_G)$, weighted by the percentage of insurers of each type in this region. The denominator is the equivalent expression for the L-region. A value of $\rho = 1$ implies that the reinsurer has a balanced portfolio (the same percentage of reinsurance in both regions. Values of $\rho > 1$ imply a certain degree of risk selection.[14] "Full risk selection", a situation where the reinsurer only reinsures risks from the H-region implies a value of $\rho = \infty$.

We are also interested in the expression for the expected profits of the reinsurer. For this we assume that the reinsurer does not incur costs other than the claims payments. Expected profits are then given by

$$\pi_R = \sum_i \sum_j \frac{N_{ij}}{N_{iS} + N_{iG}} \mathcal{H}(1 - r_{ij})\left[\theta(1 - \gamma) - p_i\right]. \tag{5}$$

For example, in the case of a generalist equilibrium this expression reduces to

$$\pi_R = \mathcal{H}(1 - r_G)\left[(\theta(1 - \gamma) - p_L) + (\theta(1 - \gamma) - p_H)\right].$$

Figure 2 takes up our example of generalist and specialist equilibrium areas and illustrates the outcome in terms of our measure of risk selection (ρ) and expected profits of the reinsurer (π_R), for premium rates that are at least actuarially fair.

Quite naturally, in the case of a generalist equilibrium, there is no risk selection. However, it must be noted that an important part of the area is in situations where the reinsurance company is not financially viable. Indeed, the vertical line indicates points where $(\theta(1 - \gamma) - p_L) + (\theta(1 - \gamma) - p_H) = 0$, i.e. below this line the reinsurer is not financially viable even in a case where it receives the entire housing portfolio. For the upper left part of the GE-area, π_R can be positive or negative. The intuition behind this result is straightforward. If the premium rate is sufficiently low so that the insurers can make little profit even on the low risks (in excess of the share of premiums they keep to cover their administrative costs) then they will purchase full reinsurance. However, the premium income for the reinsurer might then not be sufficiently high to cover its expected claims payments.

[14] Values of $\rho < 1$ do not occur in equilibrium.

In the case of a specialist equilibrium, there is always a certain degree of risk selection ($\rho > 1$). Specialist insurers in the H-region will have a lower rate of retention (a higher rate of reinsurance) than their counterparts in the L-region. Actually, given our parameter values, the SE-area corresponds to a situation with "full risk selection", where specialists in the H-region fully reinsure and those in the L-region fully retain their risks. In such a situation, the expected profit of the reinsurer must be negative.

Thus, a move north-east in the graph implies a higher degree of risk selection (as long as there is any reinsurance), and this situation might lead to a worsening of the financial situation of the reinsurance company.

In conclusion, risk selection is an important feature of our model unless the country specific fixed costs are very large. It is particularly significant in situations where there are big differences in the damage probabilities across regions.

What would be the policy measures to remedy the situation?

One could argue that risk-dependent premium rates are an easy and immediate solution to risk selection within the model. This might be a somewhat fast conclusion. First of all, risk-dependent premium rates do not imply automatically a generalist equilibrium outcome. It might be that premium rates, although differentiated across regions, are such that insurers still have the incentive to specialize into one region, hence not eliminating the problem of risk selection. Furthermore, significantly higher charges in disaster prone areas might not be politically feasible. In the case of France, the uniform premium rate is a fundamental cornerstone of the system. Changing this feature has not been considered so far.[15]

A uniform increase in the premium rate might not be an adequate solution for two reasons: first, it might actually worsen the problem of risk selection, as a higher premium rate increases the incentive of insurers to specialize into a homogeneous risk portfolio (see Figure 2); second, increasing premium rates, in particular increasing premium rates above actuarially fair rates, comes at a cost to the final customer, who pays an ever higher price for the service.[16] In our model, due to the free-entry assumption, higher premium rates translate into a higher number of insurers in the market, which creates an inefficiency since regional and country fixed costs are multiplied.[17]

[15] More generally, redistribution towards people living in high damage areas seems acceptable to most societies worldwide. Otherwise it would be difficult to explain the significant public and private disaster relief spending. Frame (2001) shows that redistribution towards households in disaster prone areas might be beneficial also to households in safe areas.

[16] Jametti and von Ungern (2004) provide an analysis of the cost of service provision in their simpler model.

[17] Indeed from a cost-of-service perspective, our model would imply a single insurer providing the service. In this case, the amount of fixed costs is minimized. One could argue that such a situation might not be politically feasible, although in Spain natural disaster insur-

A more adequate policy mix would consist of two measures: increase the premium rate and make a substantial rate of reinsurance compulsory. The problem of risk selection is created by the possibility of insurers to serve only the low risk customers, buy little reinsurance and make profits on these low risk customers. The model shows that insurers have an incentive to do so. If these insurers are forced to reinsure a substantial part of their portfolio, the cost for them of accepting some high risk customers will fall, and this leads to a reduction in the degree of risk selection (ρ)

4 Discussion

4.1 Does the model apply to the case of France?

We next compare the prediction of our model with the developments of the French natural disaster system as outlined in Section 2. We argue that risk selection is a fundamental flaw that lead to the virtual collapse of the system by the year 2000. Our conjecture is supported by the fact that many of the policy changes outlined in section 2 can easily be interpreted as being designed to reduce the problems of risk selection. Ideally, one would, of course, like to analyse these issues on the basis of individual firm data, in particular to obtain an empirical measure of ρ. Unfortunately, no firm-level data is available, and we have to limit ourselves to the interpretation of system-wide information.

Before turning to the specific aspects of the development of the disaster insurance system it is important to appreciate that the institutional setup, with proportional and stop-loss contracts, implies the CCR will bear most of the cost when a large-scale disaster occurs. If the reinsurer is unable to accumulate sufficient reserves to face "spikes" in damage payments, this will trigger the state guarantee. Hence, the tax payer might end up paying the bill of a large disaster, or a series of large disasters.

Let us turn to the overall performance of the system as indicated in Table 1.

The average claims/premium (C/P) ratio since inception of the system is 58%, which is in line with other segments of the insurance industry. The crucial difference is that within the French system, where natural disaster contracts are an add-on to basic housing insurance contracts, acquisition and administrative costs should be very low. Indeed, von Ungern (2004) presenting data for Spain indicates that the C/P ratio for the period 1971 to 1999 there was of the order of 98%.[18]

ance is (quite successfully) provided by a single public insurance company, the "Consorcio de Compensacion de Seguros" (see von Ungern (2004) for details).

[18] The Spanish "consorcio", while achieving low administrative costs, also benefited from significant interest earnings on their reserves during periods of high inflation. This explains

Despite the system-wide financial viability (estimated accumulated profits of 7.2 billion €), the surplus of the system was not used to keep the public part of the private-public partnership afloat. We can observe that the premium income of the CCR remained fairly stable over time and, more importantly, the reinsurer was never able to accumulate significant reserves. Indeed, the reserves of the CCR were drained from over 500 million € in 1992 to practically zero in 1999. At this point the French government stepped in, refinancing the CCR with approximately 450 million €. In spite of the substantial premium hike in 1999 the CCR's reserves were still only at 427 million € by the end of 2001, i.e. less than the government injection of funds. Thus, the entire surplus of the system landed in the pockets of the private insurers.

How could it come to this situation? In light of our simple model, risk selection is the answer.

A first point to note is the rapid rise in the retention rate of the insures from 17% in 82/83 to 60% in 1990 (see Table 1). Two symptoms would contribute to explaining this development. First, the substantial rise in premium rates in 1984 made a higher retention rate much more attractive. Second, this same rise in premium rates and the accompanying reduction in retention rates made it more expensive to keep high risks on a portfolio of essentially low risks. Specialising on low risk customers, and retaining all risks, or specialising on high risk customers and reinsuring became much more profitable strategies than offering across-the-board service. Note that this is exactly the result of our model, i.e. higher premium rates imply lower rates of reinsurance and might lead to more risk selection. As mentioned, we do not have firm level data to establish whether this is in fact what happened.

Furthermore, the changes in the CCR's reinsurance policies introduced in 1996 and 1999 do give a strong indication that risk selection was in fact a major problem.

The maximum rate of reinsurance was reduced in 1996 and 2000 to end up in a unique rate of 50%. In the year 2000 the premium rates were further increased from 9% to 12%, while the generous commission for administrative costs was abolished.[19] In 1996 the CCR forced higher excesses on the stop-loss contracts, in particular for insurers operating in high damage areas like the DOM. In the year 2000 the CCR introduced important excesses (1600% of premium income) for insurers wishing not to pool their DOM risks with the rest of their portfolio.

All these policies are easily understandable if one accepts risk selection to be a problem in the system. All these policies aim at increasing the amount of low risks in the portfolio of the reinsurer. They are, indeed, in line with our policy discussion in the last section, increase the premium rate and increase

the somewhat suprisingly high C/P ratio.

[19]In Spain the commission paid by the "Consorcio" is 5%.

the rate of reinsurance.

Quite obviously, our model abstracts from various points of reality. It is conceivable to build a much more complex model that explains the outcome in France without relying on risk selection. In the spirit of Occam's razor, we favour our simple and straightforward explanation.

As a final point of illustration of the problems of risk selection we quote the communication of the CCR to the private insurers from 1996, when outlining the situation in the DOM: "The logic of the system requires that there should, at the reinsurance level, be some degree of coinsurance between the insurers heavily engaged in the DOM and those that have no contracts in that region. However, the major events like the floodings due to the three hurricanes in 1995 have allowed us to establish, that the CCR has had to cover 98% of the costs, i.e for these events 650 million Francs, as compared to 24 million Francs income in the form of reinsurance premiums. It has thus become necessary to reestablish an equilibrium that is more acceptable to the market as a whole, by raising the excess of the non-proportional reinsurance cover to be born by the insurers" (CCR, 1996).

4.2 An outlook

When trying to assess the efficiency of the system as it now stands, a first point to emphasise is that it is getting more and more costly for the houseowner. As shown, the overall system was economically viable with the premium rates set in 1984. Nevertheless, rates were increased by one third in the year 2000. The houseowners now have to pay considerably more for a lower coverage (higher excesses).

Second, while the CCR's premium income more than doubled from 303 million € in 1999 to 680 million € in 2004 (CCR, 2005) its reserves, after increasing to almost 600 million € in 2002, are currently only slightly over 400 million €. This is nowhere near the amount necessary to cover the reinsurance cost of a major natural disaster.

Finally, it is unclear at what stage a private insurer might decide that it is more profitable to concentrate on the good risks, and stop buying reinsurance cover from the CCR altogether. There is always the possibility to turn to private competitive reinsurance companies. They may be unwilling to offer unlimited reinsurance cover, but it is likely that for a good portfolio they can offer considerably lower costs of reinsurance.

It is thus much less than certain whether the "carrot" of unlimited reinsurance cover will in the long run be sufficient to limit the extent of risk selection and allow the CCR to reinsure a sufficiently large fraction of the low risks the lawmaker intended to subsidise the system.

5 Conclusions

Most insurance schemes currently in use include various degrees of public sector participation. Often, such as in the case of France, institutional setups are praised as public-private partnership. We argue that in such situations careful thought should be given to the issue of risk selection, where we define risk selection as a situation where private insurers "pass on" high damage probability agents to the public part of the partnership.

To illustrate our concerns we analyze the case of the French natural disaster insurance system. We build a simple model to represent the current system and show that, in our model, risk selection is a likely outcome, in particular if there exist significant regional differences in damage probabilities. Policies to remedy this situation focus on achieving a better balanced portfolio for the (public) reinsurer. Observing the evolution of the system in France we find that exactly such policies were implemented, culminating in a refinancing of the reinsurer with approximately 450 million € in 1999. At the same time, premium rates were increased by 33% even though the overall system had been financially viable in its first 20 years of existence.

It is, quite obviously, easily conceivable to build a more complex model that explains the outcome in France without relying on risk selection. In the spirit of Occam's razor we favour our, admittedly simple, explanation of the facts.

Unfortunately we cannot test our hypothesis with individual firm data. Our conclusion is based on system-wide aggregates. A useful extension to this research would be to analyze firm behaviour. Similarly, it would be interesting to consider the potential for risk selection in other institutional settings, such as the one applied currently in the USA.

References

[1] Caisse Centrale de Réassurance (1996): Communication to natural disaster insurance companies.

[2] Caisse Centrale de Réassurance (2003): Natural Disasters in France.

[3] Caisse Centrale de Réassurance (2005): Annual Report.

[4] Frame, David E. (2001): Insurance and community welfare, *Journal of Urban Economics* 49, 267-284.

[5] Gollier, Christian (2005): Some aspects of the economics of catastrophe risk insurance, Chapter 1 in *Catastrophe Risk and Insurance*, OECD publishing.

[6] Kunreuther, Howard (1974): Disaster Insurance: A Tool for Hazard Mitigation, *The Journal of Risk and Insurance* 41(2), 287-303.

[7] IMF (2004): International Financial Statistics Yearbook, Washington.

[8] Jaffee, Dwight M. and Thomas Russell (1997): Catastrophe Insurance, Capital Markets and Uninsurable Risks, *Journal of Risk and Insurance* 64(2), 205-230.

[9] Jametti, Mario and Thomas von Ungern-Sternberg (2004): Disaster insurance or a disastrous insurance - Natural disaster insurance in France, *DEEP Working Paper N°04.12*, Université de Lausanne.

[10] Lehmann, Hansjörg and Peter Zweifel (2003): Innovation and risk selection in deregulated social health insurance, *Journal of Health Economics* 23, 997-1012.

[11] Lewis, Christopher M. and Kevin C. Murdock (1996): The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters, *The Journal of Risk and Insurance* 63(4), 567-597.

[12] Newhouse, Joseph P. (1996): Reimbursing health plans and health providers: efficiency in production versus selection, *Journal of Economic Literature* 34(3), 1236-1263.

[13] Nicholson, Sean *et al.* (2004): The magnitude and nature of risk selection in employer-sponsored health plans, *Health Services Research* 39(6) Part 1, 1817-1838.

[14] Polsky, Daniel and Sean Nicholson (2004): Why are managed care plans less expensive: risk selection, utilization or reimbursement?, *Journal of Risk and Insurance* 71, 21-40.

[15] Shen, Yujing and Randall P. Ellis (2002): How profitable is risk selection? A comparison of four risk adjustment models, *Health Economics* 11, 165-174.

[16] von Ungern-Sternberg, Thomas (2004): Efficient Monopolies - The Limits of Competition in the European Property Insurance Market, *Oxford University Press.*

A Calculation of system surplus

In this appendix we briefly describe our financial performance evaluation of the natural disaster insurance system in France.[20] Data were obtained from the official CCR publications and the IMF International Financial Statistics Yearbook (2004).

We first calculate the per year gross result of disaster insurance as the difference between premium income and claims payments. From this we subtract administrative costs, estimated at 10% of premium income to obtain gross profits of the system. Finally, profits enter the accumulated system surplus with financial returns estimated at the government bond rate of interest.

The claims-premium ratio, the rate of reinsurance and the CCR's reserves are obtained directly from the official publication of the public reinsurer (CCR, various years).

[20] The detailed table of calculations is available from the authors upon request.

Table 1
Financial performance of the system

Year	C / P Ratio (%)	Acc. system surplus (million €)	Rate of reinsurance (%)	CCR premium inc. (million €)	CCR Reserves (million €)
'82/'83	163	-214	83	243	*n.a.*
'84	5	93	75	297	*n.a.*
'85	3	496	75	335	*n.a.*
'86	12	918	73	341	223
'87	36	1,281	52	274	338
'88	52	1,618	41	232	424
'89	46	2,012	51	234	416
'90	99	2,135	43	238	466
'91	42	2,638	40	235	483
'92	77	2,958	38	234	525
'93	116	3,050	41	263	499
'94	48	3,547	41	297	406
'95	91	3,800	45	320	349
'96	83	4,140	39	348	300
'97	53	4,691	40	304	310
'98	50	5,261	40	303	230
'99	88	5,526	40	303	155
'00	33	6,316	48	447	261
'01	32	7,231	47	469	427
'02	*n.a*	*n.a*	*n.a*	515	591
'03	*n.a*	*n.a*	*n.a*	628	340
'04	*n.a*	*n.a*	*n.a*	680	418

Sources: von Ungern (2004) and CCR (2003, 2005). Due to the different years covered by the various sources, not all information is available over the full period.

Table 2
Equilibrium conditions

Equilibrium	Rate of retention	Number of insurers	Eqm. condition
SE	$r_j = \frac{\theta(1-\gamma)-p_i}{\lambda p_i(1-p_i)}$	$N_i = \frac{\mathcal{H}\omega_i}{f+F}$	$f\left[\frac{\mathcal{H}\omega_{LD}}{\mathcal{H}\omega_L+f+F}+\frac{\omega_{HD}}{\omega_H}-2\right]+F\left[\frac{\mathcal{H}\omega_{LD}}{\mathcal{H}\omega_L+f+F}+\frac{\omega_{HD}}{\omega_H}-1\right]<0$
GE	$r_G^* = \frac{\theta(1-\gamma)-p_L+\theta(1-\gamma)-p_H}{\lambda[p_L(1-p_L)+p_H(1-p_H)]}$	$N_G = \frac{\mathcal{H}\omega_G}{2f+F}$	$\frac{\omega_L}{\omega_G}(2f+F)-f-F<0$

Note: The displayed expression for the number of insurers corresponds to an interior solution for the rate of retention. The deviation strategy (D) in the *SE* is to become a generalist, while in the *GE* it is to reduce service to the *L*-region.

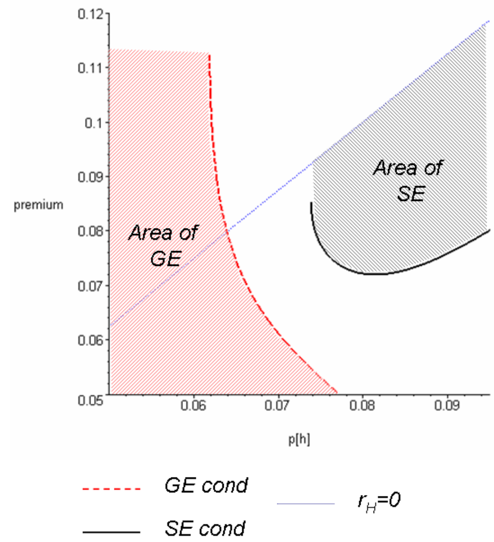

Figure 1: Equilibrium areas for generalist and specialist equilibria.
Parameter values: $\mathcal{H}$=100,000, γ=0.2, f=100, F=200, λ=1.

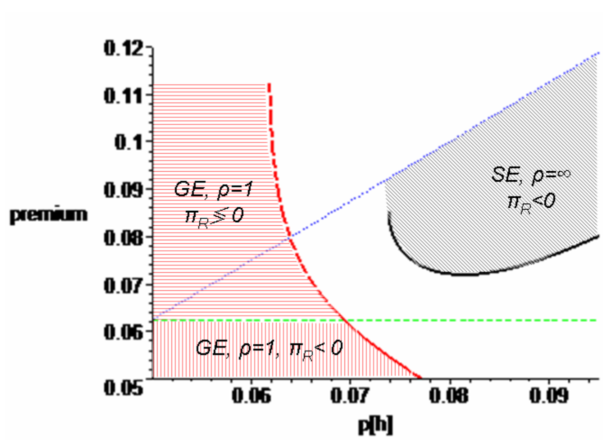

Figure 2: degree of risk selection and profits of reinsurer.

Parameter values as in Figure 1.