ISSN 2385-0825

SAPIENZA UNIVERSITÀ DI ROMA

ANNALI DEL DIPARTIMENTO DI METODI E MODELLI PER L'ECONOMIA, IL TERRITORIO E LA FINANZA

Perspectives on Behavioural Sciences

2015

Pàtron Editore Bologna

SAPIENZA - UNIVERSITÀ DI ROMA

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2015

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ISBN: 978-88-555-3333-1 ISSN: 2385-0825

PÀTRON EDITORE
Bologna 2015

PÀTRON Editore - Via Badini, 12
Quarto Inferiore, 40057 Granarolo dell'Emilia (BO)
Tel. 051.767003
Fax 051.768252
E-mail: info@patroneditore.com
http//www.patroneditore.com
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Stampa: Rabbi s.r.l., Bologna per conto di Pàtron editore, dicembre 2015.

ISBN 978-88-555-3333-1

9 788855 533331

€ 38.00

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ANOMALOUS DEMAND AND SUPPLY IN CAT RISKS INSURANCE MARKET

Abstract: Insurance is a classical tool to hedge against risks. Thanks to the law of large numbers, it pools funds from a large number of similar exposures to pay for the losses incurred by somehow. The theory tells us that all risk-adverse people is willing to buy insurance if the premium is actuarially fair or even if the price of the coverage is greater than the expected loss. However, what happens in the insurance market of catastrophic risks is completely different: demands for cat covers, subscribed voluntarily, are rare. Paying a premium for a risk with low probability but high loss, even if it is fair, is considered an overprotection. This is probably due to incomplete information. This irrationality in the demand does not allow insurance firms to reach the critical mass, necessary to define the right capital allocation. This is one of the reasons why cat covers are not so widespread in the insurance market. In the present paper, we investigate the anomalous behaviour of demand and supply for cat policies and we study some possible solutions. We focus on the Italian flood risks insurance market and we illustrate the critical aspects of the evaluation and rate making process under an actuarial point of view.

Keywords: Anomalous behaviours, Demand and Supply, Insurance market, Catastrophic risks, Pricing and Hedging.

1. Introduction

For cat risks or catastrophic risks we mean the occurrence of damaging events having a low probability of occurrence but a high severity. In this paper, we refer in particular to cat risks caused by natural hazards environmental (e.g. earthquakes, tsunamis,

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volcanic eruptions) and extreme weather conditions (floods, hurricanes, tornadoes).

In recent decades, these risks have grown dramatically and it becomes increasingly urgent to provide for their appropriate evaluation and hedging. Considering insurance as a risk mitigation tool, it is therefore curious to know that many cat insurance covers are available for companies, including multi-risks policies, but not for private consumers, with few exceptions.

In Italy, the insurance supply for companies is wide and solid and the demand is subsidized by the allowed premium tax-deduction. Coverage is provided for direct damage to the building and contents (goods and equipment) or personal injuries as well as for indirect damages, i.e. economic losses due to the interruption of the activity (loss of profit, fixed costs, bad advertising).

A different scenario appears in the insurance market for private consumers, and not only in Italy.

Anomalous behaviours of demand generate anomalous behaviours of supply which in turn discourage demand and activate a vicious circle undermining the very existence of the market.

In the paper, we show that the anomalies are mainly due to incomplete information on cat risks and we explain that the evaluation problem of these risks is at the same time cause and consequence of such incompleteness.

Under an actuarial point of view, the individual fair premium for a generic risk is given by the expected value of the individual claim resulting from the occurrence of the risk. In actuarial practice, this premium is estimated by calculating the total damage recorded on a group of independent risks subject to the same source of uncertainty (say belonging to the same risk class) and dividing it equally among them.

The mutual principle of solidarity underlying the insurance system is embodied in the above mentioned estimation. Its fairness is the result of a compromise between two conflicting goals: in order to ensure the accuracy of the estimated premium, the risk class should be as large as possible but at the same time, in order to differentiate between risk of different quality, the risk class should be as small and homogeneous as possible.

The lack and/or the heterogeneity of the statistical and historical data caused by the irrationality of the insurance market for cat risks and their own nature of extreme and rare risks are therefore the principal reasons of the failure of the classical statistical approach to their rate making.

In the present paper, we study some possible solutions to the evaluation and pricing problem of cat covers. We refer in particular to the Italian f lood risks insurance market that, more than any other and nowadays more than in the past, suffers the absence of governmental regulation and the difficulties of rate making.

2. Anomalous behaviour of demand and supply for cat covers

The demand and supply for insurance is mainly based on the expected utility theory: as long as people are risk adverse, they will prefer to pay a premium greater than the expected value of losses.

However, "irrational" behaviours of demand and supply may occur because of incomplete and asymmetric information in the pricing process.

A typical example on a macroeconomic point of view is the "adverse selection" behaviour. In insurance, the premium is determined averaging on a collective basis. As a consequence, price and individual risk aversion being equal, riskier contracts become more likely to be selected and this may generate a dangerous spiral of rising prices.

Another example of anomalous behaviour is due to the "moral hazard" which occurs when, after purchasing an insurance, the policy holders behave in a more risky manner. This causes negative consequences that the insurer must take into account in the pricing policy.

In the insurance market of catastrophic risks, empirical studies show further kinds of anomalous behaviours and consequent suboptimal economic decisions.

Individuals seem to prefer uncertain losses to actuarially equivalent certain ones, even with low administrative costs or governmental subsidies. In other words, paying a premium for a risk with low probability but high loss, even if it is fair, is considered an overprotection (Kunreuther, Pauly, 2004).

Another irrational behaviour is that individuals are more often interested in buying an insurance coverage after a disaster, rather than before it, even if the premium is unfair. As a matter of fact, the empirical evidence shows a positive relationship between the disaster occurrence and the voluntary subscription of insurance products after the event. The diffusion of cat insurance covers following a disaster shows a trend similar to the one of a product life cycle after an innovation: immediately after the event, we observe a rapid growth in the subscription rate followed by a period of stationarity culminating in the saturation of the market.

Anomalous is also the choice of many individuals to cancel their insurance coverage after maintaining it for several years without a claim. It is irrational to consider the subscribed policy as a medium-short term investment or to consider it as a waste of funds because the damage risk remains the same even after a long period of no catastrophes.

At the mean time, after a disaster, the fear of the insurers to be involved in a new financial loss will cause an overestimation of the probability of a catastrophic event with significant impacts on supply. The empirical evidence shows a substantial rate increase after a large loss from a catastrophe or a restriction in the supply of the cat coverage for that specific risk.

It also happens that, after some years without serious losses, the insurance market will offer underpriced cat covers.

The anomalous behaviour of demand does not allow the creation of a sufficiently large number of individuals with the same risk exposure which is necessary for appropriate risk pooling and hedging supply. On the other hand, an anomalous behaviour of supply further discourages demand.

This generates a vicious cycle that prevents a proper development of the private insurance market against catastrophic risks.

3. The Italian flood risks insurance market

One of the main reasons of the anomalous behaviours illustrated in the previous section is the difficulty to find information for calculating the probability of suffering a disaster and incurring in a large financial loss.

On one hand, this causes huge differences among the premiums of different insurance companies which do not allow market efficiency and produce a general misperception of the individual risk.

On the other side, the costs of information search result in higher administrative and transactional costs and, as a consequence, in higher premium thus making the policies on cat risks even less attractive.

The anomalies in demand and supply are also driven by the idea that someone else, in particular the Government, will take on the entire loss associated to the disaster.

Even if the governmental payments are a little portion of the damage suffered or if they are not guaranteed at all, this mechanism creates a substantial failure in the insurance market, reducing the incentive to manage risk and to buy a cat coverage.

Solving the problem becomes therefore a typical "Samaritan's Dilemma" (Kunreuther, Pauly, McMorrow, 2013).

In order to protect individuals from the risk of enormous losses, different kinds of coverage solutions (from mandatory to voluntarily ones) have been adopted from Governments of all developed countries.

In Italy, several proposals have been discussed for developing a more efficient cat insurance model and creating a public-private system of protection of natural disasters.

At present, however, there are no organic laws nor a partnership between the public and private sectors. Individuals and businesses still continue to count on government aids for recovery and it explains why private insurance covering natural catastrophes has never fully developed and is infrequent.

This is especially true for flood risks insurance.

According to the analysis of Munich Re (2014), despite more than 6 millions of Italian citizens live in earth-prone areas or flooding risk area, the rate of coverage penetration is low: only 5% for individuals versus 75% for the industrial sector, covering devices, machineries and installations.

Besides, insurers operating in Italy do not offer specific cat covers. The disaster risk is considered as one of the warranties the insured can voluntarily add in the policy bought to protect property or family.

As explained by the National Association of Insurance Companies (Ania) in a recent position paper (ANIA, 2015), the offer of flood protection is largely absent for private homes because of the risk of adverse selection of the portfolio, i.e. the risk that the demand for policies is concentrated in areas close to the waterways or limited to ground floors or basements.

Furthermore, the rate making process is difficult because it is necessary to distinguish different situations and consequences of floods and also because the modest size of the premium on homes does not allow to use experts' ex-ante evaluations to census the risks and mitigate them by means of effective preventive measures.

Note in this regard that the case of floods is different from that of earthquakes. While for earthquakes the risk areas are long known and homogeneous, the magnitude of floods hazard may change frequently in relation to various factors (changes in urban planning, maintenance and efficiency of the systems used to channel and dispose of the water) or may be significantly different even for very close areas.

Finally, the companies do not have an established and internationally shared modelling for "retail" risk and this hinders reinsurance.

We think that the cat insurance market will efficiently work only when the Italian Government will be able to take ex-ante measures instead of providing low-interest loans to aid the recovery process after the declaration of the state of emergency following the disaster.

In practice, the Italian Government should assume the responsibility to regulate the insurance and reinsurance private market for cat risks and allow the creation of a public-private system of protection.

It should make the necessary works of maintenance and defense of the territory to mitigate the risks and provide financial incentives for individuals who decide voluntarily to purchase cat covers or establish mandatory coverages.

It should however be able to ensure the correct relationship between risk and premiums by providing accurate information to understand the magnitude of the potential loss and to build and select cat policies.

So, the pricing continues to be the main problem to be solved.

4. Critical aspects of evaluation and pricing

Under an actuarial point of view, the pricing of a given insurance contract i requires the evaluation of the aggregate claim distribution, i.e. the distribution of the following random variable:

$$X_i = \sum_{j=0}^{N_i} U_{ij} \quad (1)$$

where N_i is the random number of claims occurring in a year and U_{ij} the random indemnity of the j-th claim for contract i, with $U_{i0} = 0$. Notice that the random variables U_{ij} depends on the severity random variables D_{ij} according to the contractual terms. Actually, $U_{ij} = \varphi_i(D_{ij})$.

The fair premium is the expected value of equation (1).

By assuming the independence and the identical distribution of U_{ij} as well as their independence of N_i, the fair premium of each contract i is in particular given by:

$$P_i = E[X_i] = E[N_i]E[U_i] \quad (2)$$

being $U_{ij} = U_i$, $\forall j$.

In actuarial practice, the premium (2) is estimated by means of the damage ratio for the risk class of contract i, i.e. the average indemnity paid in a year for each contract belonging to the same risk class of the contract i. Actually, we have:

$$P_i \approx Q_i = \frac{c_i}{r_i} \quad (3)$$

where c_i is the total amount of indemnities paid in a year for the risks belonging to the class of contract i and r_i is the number of contracts in the class.

By multiplying and dividing equation (3) by the number of claims n_i occurred in the class, we obtain:

$$Q_i = \frac{n_i}{r_i}\frac{c_i}{n_i} = \frac{n_i}{r_i}\overline{c_i} \quad (4)$$

where the first factor is the average number of claims and is considered an estimation of the expected value of N_i in equation (2), while the second factor is the average cost for individual claim and is considered an estimation of the expected value of U_i.

Notice however that Q_i can be considered a good estimation of the fair premium only if r_i is sufficiently large and the risks of the class are sufficiently homogeneous as well as independent.

Unfortunately, these conditions do not occur for cat risks because of the lack of statistical information and historical data or the lack of homogeneity among the collected information characterizing them.

It follows that the number of observations for homogeneous risk classes is limited. Besides, contracts belonging to the same risk class are not independent since the catastrophic event can hit them simultaneously.

As a consequence, the statistical approach used for pricing traditional forms of risk cannot be applied in the case of cat risks.

In order to extend the applicability of equation (4) to floods risks, Ania with the help of Cima Research Foundation (a non-profit organization committed to the support of scientific research in environmental monitoring) is studying the possibility of enlarging the statistical basis of computation by means of joint coverages against earthquake and flood risks.

Given the absence of empirical correlation between the two risks, we think that the proposal of a joint coverage can certainly be useful for the risks diversification and the consequent rates reduction.

However, a better solution for the pricing is to return to use a probabilistic approach by applying equation (2) or, more generally, by calculating the expected value of equation (1).

The above mentioned approach requires specific assumptions about the counting distribution and the severity distributions whose formulation still needs for detailed statistical information but it has the advantage of being able to draw on national data bases and to release the evaluation process by the "portfolio experience" of each company.

For simplicity, we can assume that only one catastrophe may occur in a specific area over a year.

Therefore, the counting distribution becomes the indicator of the cat event occurrence in that area (which is the geographical area covered by contract i) in a year and we can formalize it as a Bernoulli random variable with mean value p_{i1}, the probability of occurrence of the cat event for contract i over a year.

Besides, we have only one random variable D_{i1} as random severity and only one random variable $U_{i1} = \varphi_i(D_{i1})$ as related random indemnity.

In the case of floods risks, the probability p_{i1} depends on a variety of meteorological, and geophysical factors, e.g. temperature, frequency and intensity of precipitation, ...

We can use the Extreme Value Theory (EVT) to estimate some of them and we can formalize each of them as a random variable with Generalized Extreme Value (GEV) distribution whose location, scale and shape parameters can be estimated from empirical data by means of the maximum log-likelihood (see Embrechts, Kluppelberg, Mikosch, 1997 for an introduction to EVT; see also Leandri, 2011 for an application to rainfall in Italy).

We can assume that the occurrence of the event depends on the k-th factor F_{ik} only and that the event occurs when the value of this factor exceeds a given value z_{ik}. We can write:

$$p_{i1} = p(F_{ik} > z_{ik}) = 1 - G_{F_{ik}}(z_{ik}) \tag{5}$$

where $G_{F_{ik}}(\cdot)$ is the cumulative distribution function of F_{ik}.

By inverting the GEV distribution, we can also calculate the “return value” of each factor, a.i. the value with a given probability of being exceeded in a year. It can be useful for defining the random severity of the claim as well as for extending the model to the case of repeatability of the claim.

In fact, the factors are dependent and they can simultaneously contribute to the occurrence of the event. Therefore, some difficulties arise for taking into account their joint actions. Further difficulties arise when considering anthropogenic factors, too.

As for the random severity of the claim D_{i1}, it results from the sum of the random damages related to the different elements in the insurance coverage, e.g. damage to buildings, damage to their contents, personal injury.

The main difficulties we encounter when defining this random variable is therefore measuring the vulnerability of each element to the cat event and taking into account their dependence.

In the case of material elements, useful information can be derived from the observations collected on a ZIP code basis. Notice however that using data related to small geographic areas, as ZIP codes, is not suffice to distinguish the different degrees of severity that could affect the same area and to allow the differentiation of the relative premium coverage.

The problem can only partly be overcome using new technologies such as GIS technologies which are able to capture, analyze and manage different types of spatial and geographical information.

They can allow us to distinguish the degree of risk of two properties with the same ZIP code, one located on a hill and the other near a river but they do not help us to price differently two properties which are in the same building, one being a basement apartment and the other a penthouse.

In addition to buildings' localization, for evaluating flood damage (as well as for the earthquake), we have to take into account the hydrological and environmental characteristics of the area and include in the flood risk maps something more than a simple basin proximity.

Therefore, the GIS analysis must be integrated in order to consider eventual drainage congestion, confluence, ground elevation or any kind of disturbance of the natural drainage channels due to human interventions which could cause an increase in vulnerability.

The problem is even more complex in the case of repeatability of the claims or portfolio evaluation (see Cossette, Duchesne, Marceau, 2003).

We will address in future works the details of the proposed mathematical model by taking care of the numerical-statistical and computational aspects, too.

5. Conclusion

Italy is a country with a strong hydrogeological risk because of its morphology and the high density of population. Nevertheless, the insurance market of this risk is not so developed.

In this paper, we illustrate the principal reasons of the inefficiency of the market of cat risks in general and of the Italian market of floods risk in particular. We explain that an integrated public-private system of protection is necessary to overcome the problem. This requires first of all clear and rigorous rules of evaluation and ratemaking.

We show that the calculation of an "experience premium" according to the statistical approach used for the classical forms of risk is not applicable. As a matter of fact, the anomalies of demand and supply for cat coverage and the very nature of extreme and rare risks do not allow the necessary size and homogeneity of the risk classes.

The alternative is to apply the original probabilistic approach. In the paper, we provide a first formalization and we analyze the main critical aspects under an actuarial point of view.

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