Earthquake Risk Management: A Case Study for an Italian Region

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Abstract

Italy is a country exposed to a number of major natural hazards, but the regulatory framework for risk management has not been yet fully established. As an example, a law for integrating insurance in the overall risk management process was only proposed in the late 1997: this opened a debate, which has not yet been concluded by a legislative act. Therefore policy options are still open to investigations on resource allocation in prevention and mitigation, and in measures for risk burden sharing. This paper gives a brief overview on earthquake losses in Italy in the last century, how they have been compensated and on new legislative proposals. To investigate possible policy options, a case study for the Tuscany region has been developed. For this region, indeed, models and data from a previous study were made available by the Institute for Research on Seismic Risk (IRSS) of the Italian National Research Council (CNR). The IIASA spatial-dynamic, stochastic optimization model that takes into account the complexities and dependencies of catastrophic risks has been customized to explicitly incorporate the geological characteristics of the region and its seismic hazards, as well as the vulnerability of the built environment. The model is shown to be able to analyze multiple policy options for developing insurance as a mitigation measure, and their effects on insurance premium and reserve funds. In a next working phase the interplay between investments in physical mitigation (retrofitting) and risk-sharing measures will be investigated.

1. Introduction

Italy is a country exposed to a number of major natural hazards, but the regulatory framework for risk management has not been yet fully established. Measures were mostly reactive to severe events, and essentially devoted to manage the emergencies and to implement a generally long lasting reconstruction process supported by the government. Rather recent events (e.g. the devastating Irpinia 1980 earthquake) demonstrated the lack of preparedness of the country to cope with natural disasters. This earthquake was however the occasion for strengthening the efforts to create a new approach to civil protection, which resulted in the new legislative framework of 1990 and 1992 [1,2] and the recent creation of the National Agency for Civil Protection [3].

There is still a lack for incentives for retrofitting and mitigation. As an example, a law for integrating insurance in the overall risk management process was only proposed in the late 1997: this opened a debate, which has not yet been concluded by a legislative act. Therefore policy options are still open to investigations on resource allocation in prevention and mitigation, and in measures for risk burden sharing.

This paper approaches option analysis for an integrated catastrophe risk management. For sake of simplicity the work has started analyzing the earthquake risk, it could be easily

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extended to cover multiple risks in the same study region. The paper gives a brief overview on earthquake losses in Italy in the last century, how they have been compensated and on new legislative proposals. Policy options have been analyzed in a case study for the Tuscany region. For this region, indeed, models and data from a previous study were made available by the Institute for Research on Seismic Risk (IRSS) of the Italian National Research Council (CNR) [4]. The IIASA spatial-dynamic, stochastic optimization model that takes into account the complexities and dependencies of catastrophic risks [5 to 10] has been customized to explicitly incorporate the geological characteristics of the region and its seismic hazards, as well as the vulnerability of the built environment. The model, which was already tested in an application to the Irkutsk region in Russia [11], is now shown to be able to analyze multiple policy options for developing insurance as a mitigation measure, and their effects on insurance premium and reserve funds.

The results obtained have to be considered as preliminary ones and this paper as an extended summary.

In a next working phase the interplay between investments in physical mitigation (retrofitting) and risk-sharing measures will be investigated.

2. Earthquake risks in Italy

Table 1. shows a time history of major earthquake events in Italy in this century, involving more than 100 casualties. Certain earthquakes of comparable intensities but resulting in smaller human losses have not been included. The number of deaths in the 1908 Calabria /Messina (Sicily) is impressive: the event was followed by a sea-surge.

The dimensions of the earthquake risk can be summarized according to [13] as:

- human lives: larger than 120,000 deaths in the last century;
- losses: ~120 000 billions lire (~ 63 billions ECU) in the last 20 years;
- ~64% of the buildings constructed before seismic classification of the country;
- 23 millions people exposed;
- cultural heritage threatened.

As already mentioned the 1980 Irpinia event was a landmark in raising awareness and developing a policy for preparedness and mitigation. The extension of the involved territory was almost equivalent to a country such as Belgium. The severity of the losses appeared to be no longer acceptable with respects to the technological status of the country.

The rather recent Umbria-Marche Earthquake, which started with a first shake on 26/9/97, is characteristic for losses in the Appenines mountain region of Italy, since the urban structure is typical of many cities located in the seismically hazardous regions of central and southern Italy. Two-thirds of the buildings were built in traditional masonry (mainly stonework) more than 60 years ago. Furthermore, it is a region with an enormous cultural heritage.

Table.1 Major Earthquakes in Italy in the last century [12]

Year	area	MCS intensity	deaths	injuries
1906	Calabria	X	557	~2,000
1907	Calabria	IX	167	~90
1908	Calabria/ Messina	XI	85,926	14,138
1910	Irpinia	IX	~50	many
1914	Etna (Vulcan)	X	~69	115
1915	Fucino	XI	32,610	many
1919	Mugello	IX	~100	~400
1920	Lunigiana/ Garfagnana	X	171	~650
1930	Irpinia	X	1,778	4,264
1968	Belice	X	231	623
1976	Friuli*	IX-X	965	~3,000
1980	Irpinia* - Basilicata	IX-X	2,914	10,000

Tuscany

* Certain events of comparable intensity but with lesser human losses have not been included.

The data presented in the following for this Umbria- Marche event are derived from official information of the Civil Protection Department (DPC) [13] after four months from the first event, which has been followed, even recently, by a series of shakes of significant importance.
In the quoted period 3,300 shakes followed the first one: ten out these had intensities larger than VI (MCS). 10,100 rescue operators were involved. The number of people assisted ranged from 13,500 on the first day to 38,000 after the violent shakes on mid October.

Table.2: Damages and losses of the Umbria-Marche Earthquake

	Umbria	Marche	Total
Number of Damaged Public and Historical Buildings	1,178	948	2,126
Number of Damaged Private Buildings and Activities	16,082	10,617	26,699
Number of homeless people	18,276	7,194	25,470
Private Buildings + Activities* Losses in MECU	1490	2010	3500
Further activities and Agriculture	180	390	570
Public buildings	150	590	740
State Buildings and Roads			130
Cultural heritage	140	410	550
Total Losses in	1960	3400	5490

* excluding Agriculture

Even if the number of victims was relatively small (10), very serious damages to the cultural heritage, public infrastructures and activities were suffered. The collapse of part of the cupola of the San Francesco Basilica in Assisi showed the problems of employing new technologies for restoration of old monuments: wood (subjected to fire risk) had been substituted in the roof with reinforced concrete.

3. Compensation, Reconstruction and Insurance

Insurance for losses from natural disasters is practically negligible in Italy, even because people are expecting governmental aids. As an example after the Umbria-Marche earthquake, according to the Law (61/98) for the reconstruction (after a microzonation), the public intervention for the reconstruction will cover 100% of the cost of structures and recovering of the external façades (for preserving the historical characters of towns and villages). Internal components and other direct losses will be partially compensated according to social conditions of families involved.

Since earthquakes are only a subset of all hazards costs in Italy, it has been calculated the state expenditures for natural disasters exceed 3 billions EUROs/ year [12].

Few resources are then available for ex-ante mitigation measures, to be devoted to incentives for retrofitting and therefore human lives saving, and to protect the cultural heritage, which is a duty to the whole national community.

Therefore within the Design of Law 2793: “Measures for the stabilization of the public finance”, 1998, it was originally included a proposal intended by the government to reduce the impact of natural disaster to the Italian budget.[2]

The proposal, approaching the French system, can be summarized as follows (Article 31bis - Measures related to insurance against natural catastrophes):

- Par. 1 states that, in mandatory way, fire insurance policies shall include coverage of losses from earthquakes and other natural disasters. A possible exemption layer shall not exceed 25% of the compensation. (This has to be put in relation with the provisions in Par. 5).
- Par. 2 states that the fire policies already existing should be integrated within 6 months from the enforcement date of the law. For this the insurance companies may ask for integration of the premium, and if this is not agreed among the parties the policies must be cancelled. (either all or nothing).
- Par. 3 obliges insurance companies to create reserves, also by reinsurance on the international market for a value estimated up to ~3 billion EUROs a year. (For catastrophe events exceeding this value the Companies are assumed to not be able to face with. The scheme, however, would allow the State to trust in a buffer of reinsurance coverage of about 3 billion EUROs/y, i.e. the sum, which on average the State has paid in the past for all the catastrophe events).
- Par. 4. The state tax on the policy is equal to 12.5% instead of the usual 22.5%. The incomes derived to the state will remain the same since the premium will be higher –but taxes will not aggravate the cost of the new policy to the citizens. The additional cost for the premium for catastrophe risk was calculated to be 0.4 - 0.6%o. This could mean that an integrated policy might cost 100 - 125% more than a fire policy for a same coverage.

[2] This was in the urgency of matching the Maastrict criteria for EU. It should be hoped that once insurance would reduce the compensation costs, resources be found for "prevention".

- Par. 5. Buildings damaged by natural catastrophes are eligible for possible public compensation within the limit of the exemption at Par. 1. If not covered by insurance, the compensation will be within a maximum to be decided on a case by case basis and established by a decree of the finance minister. (*In this way* - explained the proposal - *the private citizen has an incentive to purchase insurance, and the state will save because it would only intervene in the 25% exemption layer. One can also expect other saving since private compensation might be faster and therefore the reconstruction also be faster, decreasing the costs for the state to provide provisional dwellings to homeless people)*
- Par. 6 The insurance premiums can be deducted from the personal tax for low income layers until a maximum of ~ 500 Euro (US$ 550).
- Par. 7. The aspects related to the reinsurance from catastrophe losses will be regulated by a subsequent decree by the Ministry of Industry: forms of both private and public negotiations might be foreseen

However the original proposal was withdrawn: subsequent proposals of laws do not have changed the main elements, but probably decreased certain incentives. In practice, at the moment insurance is not yet an element of the risk management policy.

4. The case study

As Figure 1 shows: Tuscany earthquake hazards are similar to those in Umbria and Marche Regions. They however interest a smaller fractional area of the region. The Lunigiana - Garfagnana area and the Mugello were interested by severe earthquakes in the past (see Table 1). The hazards are much less severe of other regions: the choice was determined by the availability of data.

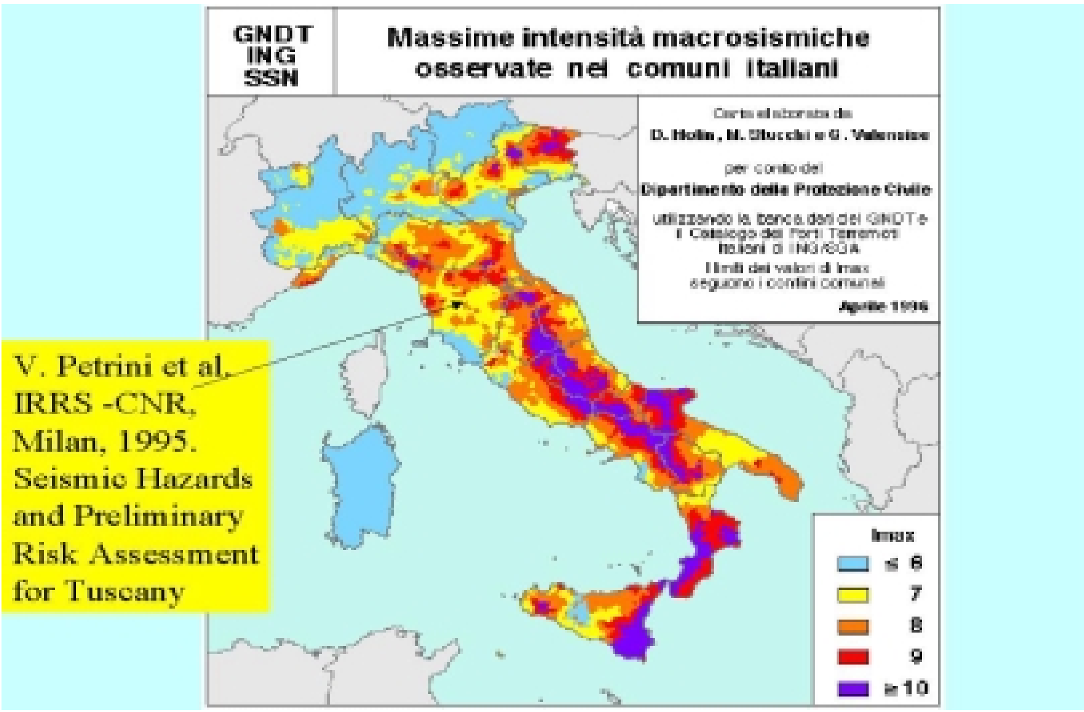

Figure 1: Seismic Hazards in Italy

In order to apply the IIASA methodology, from the basic data in Ref. [4], a catastrophe generator has been created, based on the Gütenberg – Richter law and on the attenuation characteristics of the region, see Figure 2.

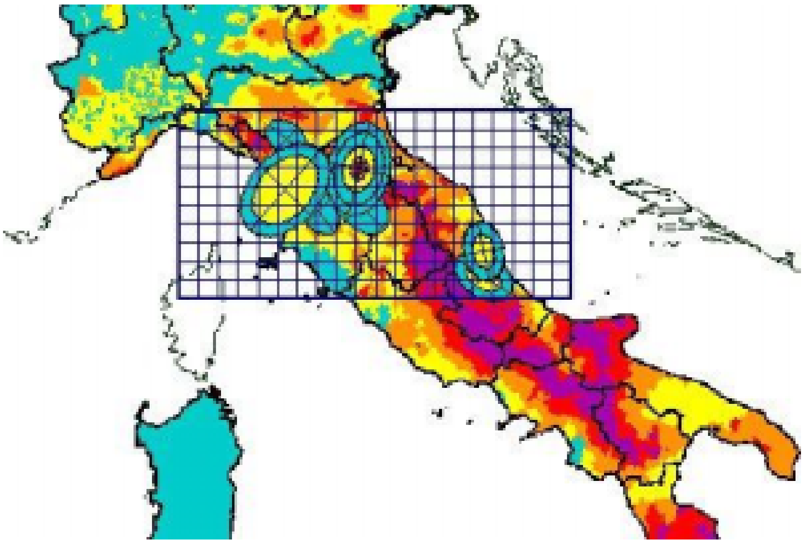

Figure 2: IIASA earthquake generator[3]

For each generated earthquake, the losses are calculated by relations fitted from Petrini's data [4] , magnitude $\rightarrow$ intensities $\rightarrow$ accelerations (average in each municipality, even if it would have been possible to consider amplification factors: microzonation).
Data on vulnerability of buildings were available as a function of the type of the building (masonry or reinforced concrete), year of construction and state of maintenance. The kind of vulnerability indices is exemplified in Figure 3.

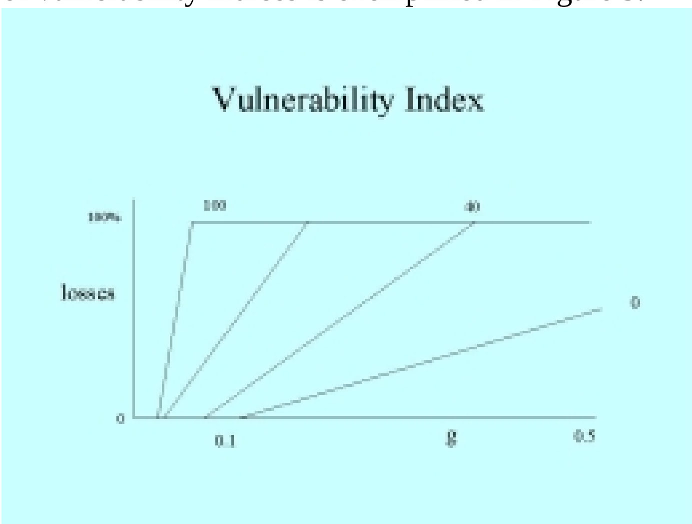

Figure 3: Examples of Vulnerability Indices [4]

[3] Unpublished and still in progress work by S. Baranov, B. Digas et al.

All the ~300 municipalities of the region have been considered: for each municipality, number and types of buildings, and number of built cubic-meters were available according to the 1991 census.
The loss generator resulted in the number of cubic-meters destroyed after each simulated earthquake. The economical loss was considered equal to the cost of reconstruction:

Monetary unit = cost of construction of 1 cubic meter.

A simulation over a 50years period resulted in an average annual damage in the region of about 25 000 monetary units.
As described in the quoted IIASA publications, the methodology would allow the analyst to consider:

- the clustering of events in time in a particular region
- the time sequence of previous events and losses, as well as the resulting policy measures (e.g. the status of preparedness and response, the dependency of property values on their degradation or restoration status);
- cascading effects (earthquake → landslide→ dam-failure → flood → technological accident);
- dependency among losses and claims for different policies (life, estate, car, employment, business interruption etc.), and at different locations.

In this application, the first exercise consisted in calculating premiums for insurance according to the different policy option, as in Text Box.1

Policy Options

Option 1: Premiums calculated based on the average damage over all municipalities

Option 2: Location-specific premiums calculated based on average damage in the location -" risk based"

Option 3: Premiums calculated according to stochastic optimization procedure "minimizing insurance exposure and minimizing risk of premium overpayment.

Text Box. 1: Policy Options for Earthquake Insurance

Option 1 would correspond to the spirit of the Italian law proposal, where the burden is equally distributed over all the population (even because different natural risks may affect different districts). In some way all citizens are "equal" with respects to the natural catastrophes. For a discussion about efficiency and equity see [4].
For this option the annual premium for each location would be ~ 0.08 (x 1000 monetary units).[4]

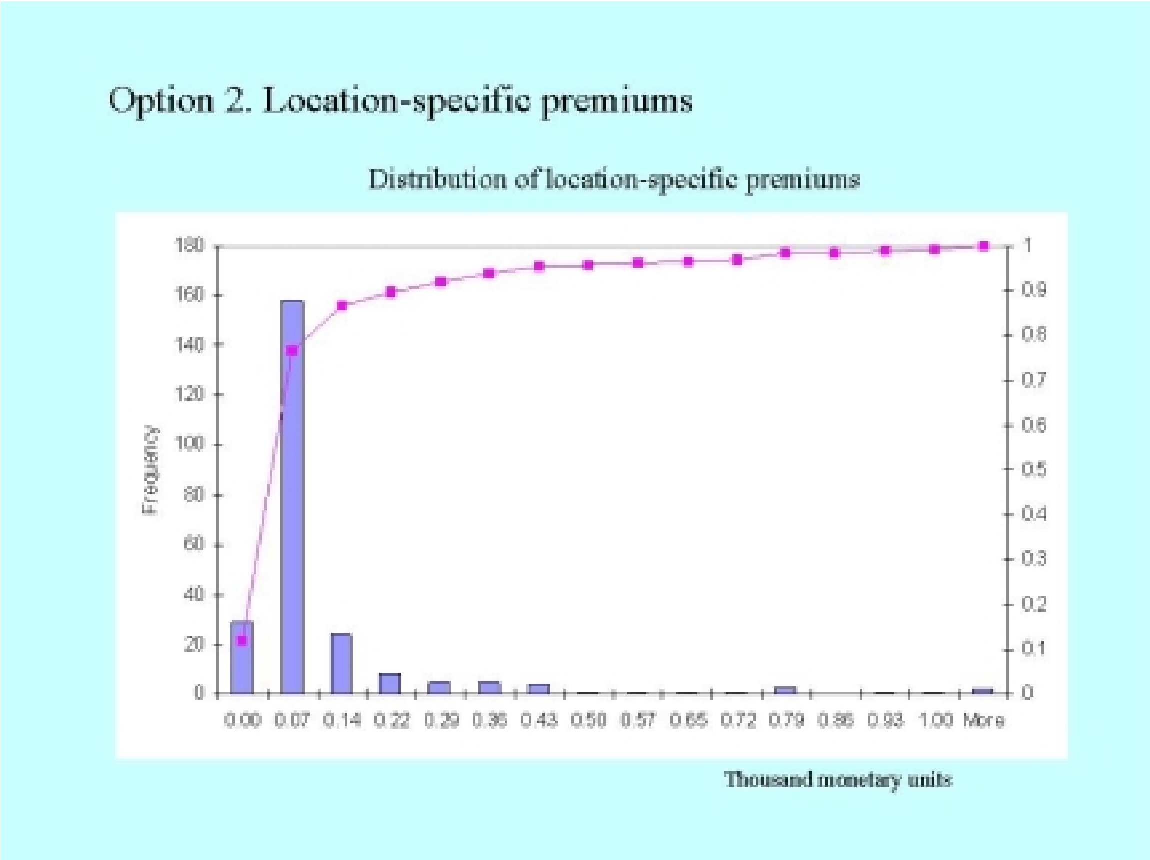

Figure 4 . Histogram of premium distribution

Figure 4. shows the distribution of premiums when calculated according to the risk at the particular municipalities. The ordinates represent the number of municipalities at a given premium.
Figure 5. shows the distribution of reserves after 50 years simulation. At a low probability there is the risk of "bankruptcy": the reserve is negative up to - 130 000 monetary units, both for Option 1 and 2.
Figure 6 and 7 show the distribution of premiums and reserves (the exposure is considerably less: Figure 7) for Option 3, for which premiums were calculated by stochastic optimization procedures. At the same time the optimization maximized insurance stability and minimized risk of premium overpayments (in the most exposed municipalities premiums are smaller: Figure 6).

[4] this should still be divided by the number of buildings/ dwelling units in each location to get the household premium

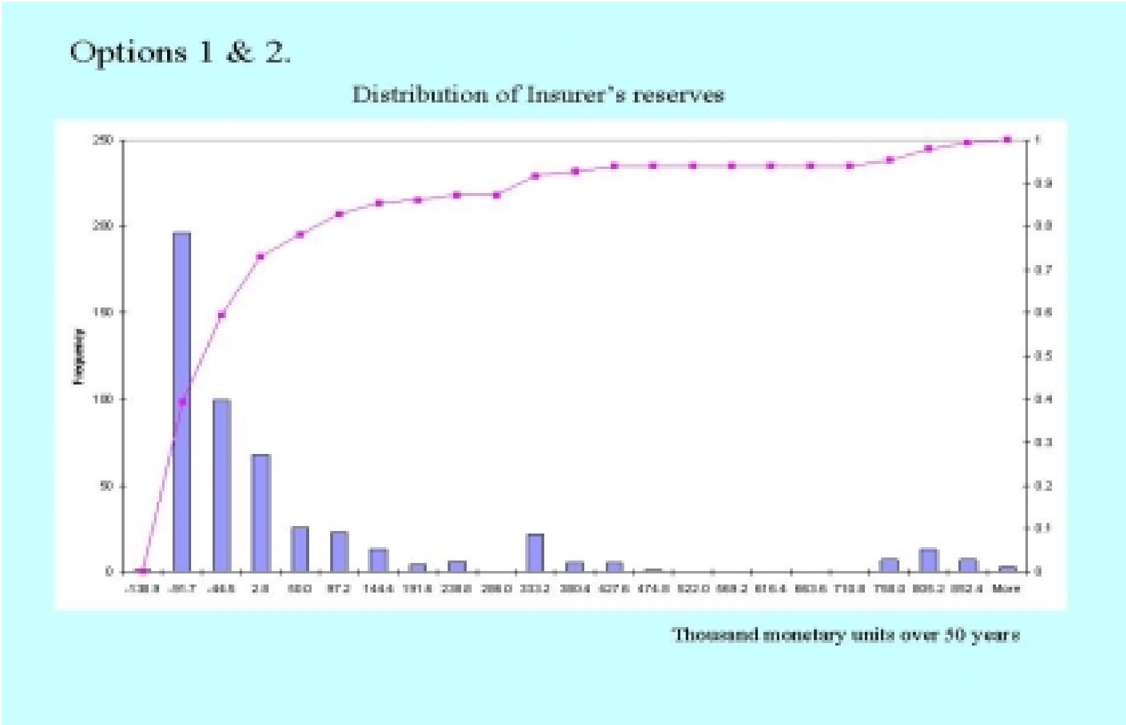

Figure 5. Distribution of Insurer's Reserves for Options 1 and 2.

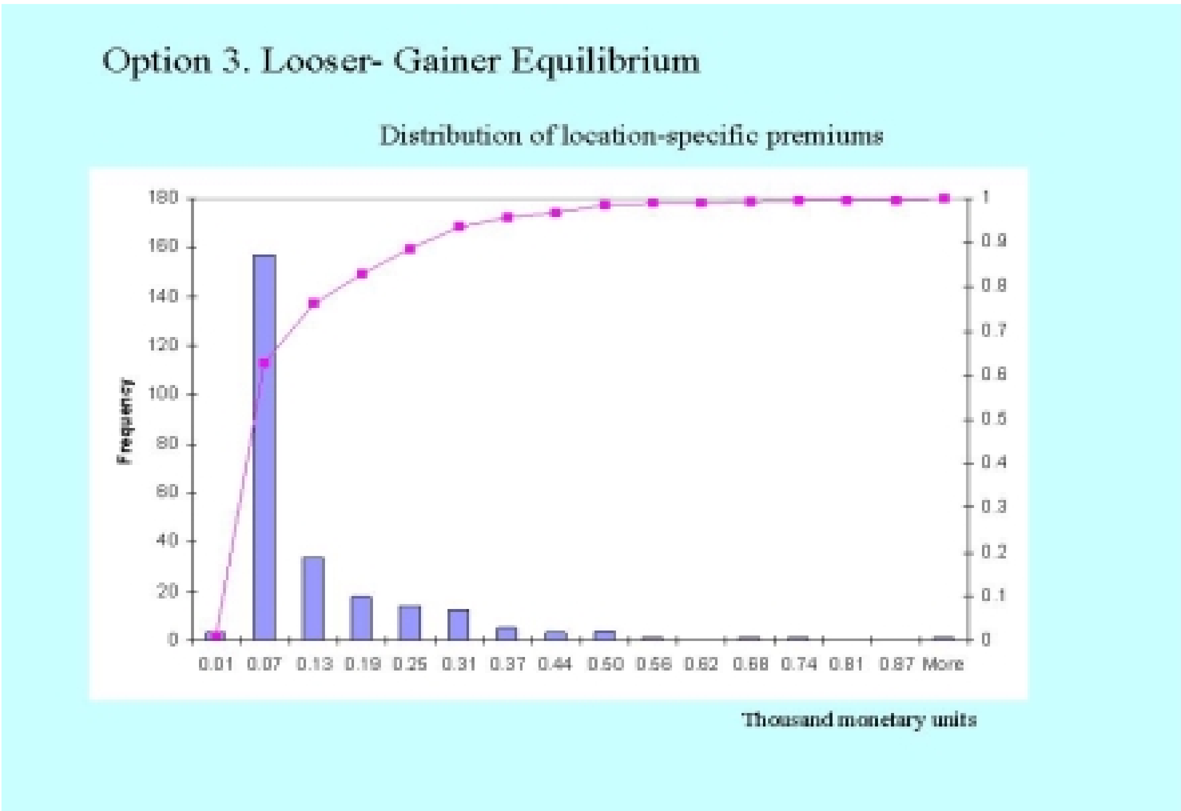

Figure 6. Histogram of premiums when based on gainer-looser equilibrium

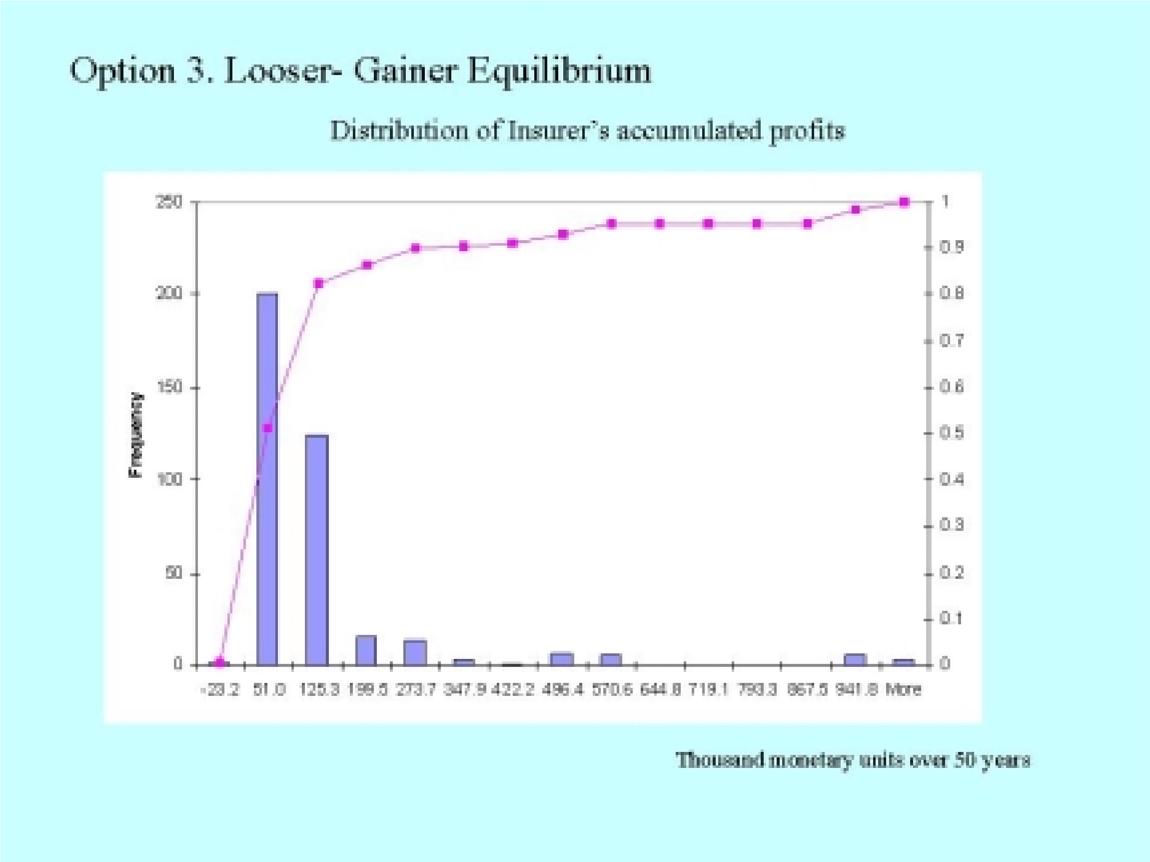

Figure 7: Distribution of Insurer's Reserves for Option 3.

5. Conclusions

A case study based on a comprehensive geographically distributed data set has demonstrated the ability of the methodology developed at IIASA to compare different policy options for risk sharing.

The methodology is able to incorporate any kind of hazard and vulnerability models, and to deal with various kinds of dependencies.

Future work should

- include distributions for vulnerability;
- investigate the trade - off between mitigation /insurance and behavior according to possible incentives to reduce vulnerability. In this case the live savings aspects of retrofitting should be considered;
- determine coverage by introducing behavior of household to buy insurance and or willingness to invest in retrofitting according to risk information;
- introducing dynamics of reconstruction.

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