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Defining insurance models within climate change european policies

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SUMMARY The paper outlines the role of insurance as a political economic tool that can be used to face the issue of climate change. The magnitude of potential loss, the adverse social and economic consequences for millions of people and considerable fiscal strain imposed on the government budget by weather disasters indicate that governments can benefit significantly from the use of insurance instrument that would seamlessly not only cover damage but also incentivate risk reduction behaviours. Looking at the diversity of existing insurance systems in European countries, natural hazards insurance is examined in terms of private and public involvement, taking into account the EU climate change policies framework. The paper analyses the economic efficiency of different insurance models in relation to the informational imperfections, i.e. adverse selection, moral hazard, and market imperfection, i.e. charity hazard and transaction costs. Moreover, the different models are considered for the way they likely affect incentives to address climate change seeking mechanism to facilitate the mitigation of greenhouse gas emissions, the adaptation to the inevitable impacts of climate change, and the development of climate risk financial management. Conclusive remarks are presented about the possible future development of an European insurance system to find an economic efficient response to natural hazards caused by climate change.

Keywords: climate change, insurance, environmental policy choice

JEL: K32, L51, P16, Q28

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Introduction: insurance as a political economic instrument

On 1 April 2009, the European Commission published a White Paper on adapting to climate change, showing that, despite the economic crisis, climate change remains at the top of the European and international political agendas and that an urgent action is needed to address the future problems deriving from weather-related disasters, as outlined by case scenario provided by the Intergovernmental Panel on Climate Change (IPCC)[1].

Following the previous Green Paper (2007), the White Paper states that Europe has an important role to play in tackling climate change and should maintain the leading role in international efforts to combat climate change, taking into account both the cross-border aspects of disasters and regional differences in risk exposure.

This paper suggests that, to face the increasing consequences of natural catastrophes[2], especially the ones deriving from climate change, environmental policy decision makers should pay more attention to insurance as a political economic instrument to manage risk and limit economic vulnerability.

The benefit from the use of insurance as a political economic instrument is clear from Table 1 that shows the differences between the costliest weather catastrophes and the losses insured in Europe with consequent adverse economic effects for millions of people and considerable fiscal strain imposed on government budgets.

[1] The IPCC is currently starting to outline its Fifth Assessment Report (AR5) which will be finalized in 2014. The new assessment will take into account recent scientific and policy developments and will be organized around a revised set of socio-economic, climate and environmental scenarios.

[2] A "natural catastrophe" relates to natural event that causes damages which exceed the social and economic of coping capacity of a region or nation. For statistical reasons, the definition of natural disaster is often simplified. For example, Munich Re considers a natural event a "major disaster" if fatalities (deaths) exceed ten, personal injuries exceed thirty, and the economic loss caused by the event exceeds 15 millions Euro. For a survey of different concepts and definitions of natural catastrophe: see Mueller (2000).

Table 1 Costliest weather catastrophes in Europe — 1980–2009

Date	Event	Affected area	Losses (€m)*		Deaths
			Insured	Total	
26.12.1999	Winter storm Lothar	Austria, Belgium, France, Germany, Switzerland	5 900	11 500	110
18-20.1.2007	Winter storm Kyrill	Austria, Belgium, Byelarus, Czech Republic, Denmark, France, Germany, Netherlands, Poland, Slovenia, Switzerland, UK, Ukraine	4 500	7 800	49
25-26.1.1990	Winter storm Daria	Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, Norway, Poland, Sweden, UK	4 400	5 900	94
12-20.8.2002	Floods, severe storm	Austria, Czech Republic, Germany, Hungary, Italy, Moldova, Slovakia, Switzerland	3 500	16 800	39
15-16.10.1987	Winter storm 87J	France, Norway, Spain, UK	2 750	3 500	18
27-28.12.1999	Winter storm Martin	France, Spain, Switzerland	2 500	4 100	30
3-4.12.1999	Winter storm Anatol	Denmark, Germany, Latvia, Lithuania, Poland, Russia, Sweden, UK	2 400	3 000	20
25-30.6.2007	Floods, severe storm	UK	2 200	3 000	4
20-23.7.2007	Floods	UK	2 200	3 000	1
7-9.1.2005	Winter storm Erwin	Denmark, Estonia, Finland, Germany, Ireland, Latvia, Lithuania, Norway, Russia, Sweden, UK	2 000	4 500	18

Source: CEA (2009), p. 12

Generally, a political economic instrument facing climate change issue has to cover a wide array of intervention, comprising ex ante interventions (prevention, prepardness, and risk financing) as well as ex post action (compensation, relief, and reconstruction). The existing literature is mainly dedicated to analyse the role of insurance in ex post action providing financial support after events by arranging relief for the occurrence; so the attention is on the implementation of an insurance system that covers the disasters consequences. In this paper we will consider also ex ante action, particularly risk management, mitigation and adaptation.

In fact the insurance industry can act to tackle the consequences of climate change by playing its part in climate change mitigation through the promotion of ways to reduce greenhouse gas emissions. But insurers are also well placed to help society to adapt to the impacts of climate change by promoting the effective limitation and management of risks from extreme climate-related hazards[3].

"The climate-policy community has concluded that the only effective response to climate change requires a combination of loss prevention (adaptation) coupled with emissions reductions (mitigation). Most of the examples from the insurance sector pertain to the latter, but insurers have long been involved in loss prevention as well, which traditionally often takes place at the individual customer level (improved storm

[3] Extreme weather- or climate-related events (in short: "climate risks") are defined as the occurrence of a value of a weather or climate variable above (or, for example in the case of droughts, below) a threshold value near the upper (or lower) ends of the range of observed values of the variable, in accordance with the IPCC SREX (forthcoming 2012).

shutters, fire suppression, etc.). Climate change certainly calls for more of this, but also for prevention at much larger scales, especially for regional defensive infrastructure"[4].
As the European Commission rightly states in the White Paper on adapting to climate change (2009, p. 4) insurance is an instrument for risk-sharing. This function is of great importance for the economy because it allows forward planning with more certainty, covering specific risks that could otherwise threaten business continuity.
In the next paragraph, looking at the diversity of existing insurance systems, natural hazards insurance will be examined in terms of private and public involvement. The following paragraphs defines different insurance models and analyse their economic efficiency in relation to the informational imperfections, i.e. adverse selection, moral hazard, and market imperfection, i.e. charity hazard and transaction costs. In addition, the fifth paragraph looks at the way the different models likely affect incentives to address climate change seeking mechanism to facilitate the mitigation of greenhouse gas emissions, the adaptation to the inevitable impacts of climate change, and the development of climate risk financial management. In conclusion, the actual implementation of the insurance models will be considered looking at the possible future development of an European insurance model to find an economic efficient response to natural hazards caused by climate change.

1. The different insurance systems in reality

Following Abraham (1995), insurance serves three economic functions. The first function is risk transfer: the risk is transferred from a risk-averse individual to the risk-neutral insurer; the second function is risk pooling: by insuring numerous policyholders, the individual's insured "uncertainty" is converted by insurer's "certainty" that such risk would occur to some of its customers; the third function is risk allocation: the price each insured pays should reflect the risk he contributes.
Given the overall outcome of the above mentioned three economic functions, the insurance contracts enhance social welfare while, at the same time, they induce taking cost-justified precautions, by internalizing expected damage or risk. Furthermore, insurance encourages the risk-averse insured to make investments that they would not make otherwise[5].
Traditionally insurance is considered a means to spread the risk of loss across society and to provide businesses and households with the resources needed to recover and rebuild after a disaster strikes. Insurance is one of several ways, along with post disaster assistance and tax deductions for disaster losses, that risky area residents shift a portion of disaster costs to their fellow citizens.
As concerns climate change consequences, the insurance industry is directly involved in providing coverage of the climate risks accepted from clients and climate experts predict changes in the intensity and distribution of extreme weather events because of the resulting risk of catastrophic property and business interruption claims[6].
About this role, insurance companies are well placed to calculate actuarial risks, set adequate premiums and insurance conditions such as cover and deductibles. Insurance

[4] Mills (2009, pp. 18-19).
[5] Shavell (1982; 2000).
[6] Agrawala, Fankhauser (2008).

companies are also inclined to take a long time horizon in mind that would allow the valuation of and planning for low probability-high loss events[7].

In a perfect market, risk-based insurance products send signals to the market and to households and enterprises regarding the proper economic cost of managing risks.

In reality, insurance markets are rather imperfect, and regulatory interventions are needed to lead to a much wider coverage, especially because, as insurance is based on the law of large numbers, a larger pool due to the risk diversification effect should lead to lower premiums for all and thus better help allocate risk[8].

Moreover, the disaster insurance market is characterized by other kinds of imperfections.

First of all, for typical insured losses, the chance that any two policyholders suffer a loss in a given year is independent. When risks are independent, an insurance company can pool risks by issuing a large number of policies. But in the case of natural disasters there might be a chance that all policyholders have claims in the same event. Consequently, insurers face a greater risk of insolvency for catastrophes. Insurers then must either accumulate substantially larger reserves or purchase reinsurance.

Secondly, ambiguity prevents natural disaster insurance from using pricing processes similar to life or car insurance, for which actuaries have millions of prior events to estimate probabilities of loss with precision. In comparison, natural disaster risks are uncertain. There are few prior disasters on the recent historical record, and changing climatic conditions limit the inferences for future losses that can be drawn from past events.

Thirdly, availability, exchange and communication of data such as risk maps very often are not shared between research institutes, private companies (e.g. insurers), state agencies, local governments and endusers. Communication of location-specific information, location-specific factors such as the type and severity of a hazard or extreme event at a given place, are important to determine the vulnerability and exposure of different elements at risk.

Another important issue in the case of climate change consequences is the assignment of respective roles of private and public sector to provide compensation and incentives to reduce the risk of catastrophic losses and financial management of large scale disaster risks[9].

The choice is essential given that in the case in which the government does not provide any policy instruments to prevent the events and to compensate the victims, the costs of natural catastrophes fall on the individuals[10]. In many cases, these costs could be a substantial portion of an individual's wealth, leading to devastating personal and business liabilities.

Alternatively the government can carry the risk directly or as "insurer of last resort"; in this case, the costs of weather events are borne by the taxpayer, contributing according to the tax regime of the country. Or private sector can, at least partially, cover weather risks and the costs of climate change will be shared among a portion of society. With risk-based pricing, those at greatest risk pay most for this risk sharing, while those who avoid or minimise risk pay least. This last "private" solution can be achieved by the insurance industry involvement.

[7] Charpentier (2008).
[8] Porrini (2012).
[9] Grossi, Kunreuther (2005).
[10] Kaplow (1991).

The involvement of the insurance industry is based on the implementation of insurance systems that are financed from premiums that are paid before the event, in addition these systems may have support from the government, for instance through state-guaranteed reinsurance. In these systems the government could have a considerable role.
Analysing the reality, we notice there are different categories of insurance systems, depending on the roles of the insurance industry and the state.
For example, in the Netherlands and Denmark insurers play a minimal or optional role in the provision of cover for natural hazards. The state provides cover funded from its annual budget or through a tax levied on fire damage policies which are managed by a specific fund.
In Switzerland the state does not intervene in the provision of insurance but instead makes the insurance of certain risks compulsory, mostly through fire contracts. Specifically, we have a dual system of private and public insurance with monopoly character. In all cantons, fire insurance and insurance against atmospheric damage is mandatory for all buildings and household content (at replacement value) with an excess of 10% per incident of damage or at least 200 CHF with a maximum value of 1000 CHF (680 Euros). Reinsurance is provided via two pools of direct insurers with compulsory membership. The pool system for cantonal property insurance offers unlimited cover whereas the private insurance pool for atmospheric damage only provides coverage for up to 25 billion CHF (17 billion Euros). The private and the public insurers link the risk transfer with the maintenance of the emergency services (fire service) and have the right to participate in Federal State Planning and Land Use Planning.
In France there is a mix of compulsory insurance and state intervention. In fact, we have a mandatory inclusion of all ‘uninsurable’ natural hazards (not including storm, frost, hail and snow load) in all contents insurance contracts by way of a uniform surcharge of 12% on the insurance premium with a low excess (e.g. 380 Euros per incident of damage to buildings and cars). Reinsurance is offered at a fixed cost through the state Caisse Centrale de Réassurance (CCR) with an unlimited state guarantee.
In most of these countries, the natural catastrophe cover has to be included in certain insurance policies (e.g. home insurance), but purchase of those policies is voluntary. A similar approach is currently being considered in Italy, where till now we have an insurance against natural disasters characterised by fully private contracts without government regulation and reliefs are assigned after specific events. Over the years, the authorities have prepared various projects for covering natural risk (particularly providing the inclusion in a fire coverage for buildings).
In Spain, we have a legal obligation to insure against damages caused by natural hazards and other ‘unusual events’ (terrorist attack, political unrest). Premiums are collected by private insurers as an add-on premium in building, contents, accident, life and occupational incapacity insurance and are passed on to the so-called Consorcio de Compensación de Seguros (Consorcio) which is a state monopoly insurer. The Consorcio is subsidised by an unlimited government guarantee. The insurance density is high, depending on the density in the individual sectors, up to 80%. Insurers' excess is usually around 10%.
Where there are state insurance schemes, they differ from country to country depending on the pricing freedom accorded to insurers. For example, insurance pricing is not regulated in the Great Britain. In Germany we have pure private insurance with

individual premium calculation in the case of flood damage (ZÜRS). Insurance against storm and hail is prevalent (95%). However, insurance density against other natural hazards is under 10%. German banks regularly require fire insurance for mortgages but no insurance against natural hazards. If an extreme event occured ad-hoc relief is often provided for emergency and reconstruction. Victims of damage do not, however, have a legal right to this government relief and it is subsidiary to the provisions of private insurance.

Also in Austria we have insurance against storm, hail and snow load is fully private contracts without government regulation. Additional coverage against other natural hazards (flooding, avalanche, landslides, etc.) is possible but rarely used. Since 1986 Austria has had a government disaster fund financed by tax-payers. Victims of damage do not have a legal right to access this fund. It covers approximately 50% of damages (on average) if the claimant is not privately insured.

In analysing the different insurance models in field of natural hazard insurance in Europe we have the classic tensions between private and social risk responsibility, free market and state regulation – as in other fields of economic policy. The various existing European insurance systems can be aligned to staggered combinations of regulatory interventions in private insurance markets to enforce private risk responsibility vis-à-vis unregulated commercial natural hazard insurance which comes with a degree of 'socialisation of risks', mainly driven by government aid after disasters.

Another important source of differences between insurance systems is the risk exposure, and consequently the supply of specific coverage.

Europe's diverse climate makes it vulnerable to a wide range of weather-related risks: areas of western, central and eastern Europe with large rivers are vulnerable to flooding; southern Europe is susceptible to drought and forest fires, western Europe to storms, and mountainous areas such as the Alps and the Pyrenees to landslides and avalanches.

Consequently, while almost all European countries are affected by the adverse consequences of climate change, they are not necessarily exposed to the same types of risk. Some northern and most southern and eastern European countries are also exposed to catastrophes of geophysical origin (such as earthquakes, tsunamis and volcanic eruptions). In these countries, most insurers combine coverage for these events with coverage for extreme weather catastrophes and extend the insurance coverage for property to both weather-related and geophysical hazards, as we can see in Table 2.

Table 2
Natural catastrophe insurance coverage across Europe

	Austria	Belgium	Czech Republic	Denmark	Finland	France	Germany	Greece	Italy	Netherlands	Norway	Poland	Portugal	Spain	Sweden	Switzerland	Turkey	United Kingdom
Storm	O	C[1]	O	O	O	C	O	S	N	O	P	O	O	P	O	C	O	O
Cyclone/hurricane	O	C[1]	N	O	O	C	O	S	N	O	P	N	O	P	O	C	O	O
Floods	O	C[1]	O	N	O	C	S	S	O	N	P	O	O	P	O	C	O	O
Hail	O	O	O	O	O	O	O	S	O	O	S	O	C[2]	O	O	C	S	O
Landslides	O	C[1]	O	O	O	C	S	S	O	S	P	O	O	S	O	C	O	O
Snow	O	O	O	O	O	O	S	S	O	O	N	O	N	O	O	C	O	O
Frost	O	O	O	O	N	O	O	S	O	O	O	O	N	O	O	O	N	O
Avalanche	O	N	O	N	O	C	S	N	O	N	P	O	N	O	O	C	N	N
Drought	O	N	S	N	N	C	N	N	N	N	N	N	N	S	O	N	N	N
Subsidence	O	C[0]	O	N	N	C	S	S	N	N	N	O	O	S	O	N	O	O
Earthquakes	N	C[1]	O			C	O	O	N	N	P	O	O	P	O	O	C	O
Forest fires	S	N	N	O	O	S	O	S	N	O	O	O	O	S	O	N	S	N
Volcanic eruption	N	N	O			C	O	O	N	N	P	O	O	P	O			N
Lightning	O	O	O		O	O	O	O	O	O	O			O	O		O	O

1 for simple retail risks only
2 only if hail results from a storm

Type of insurance cover

C = Compulsory cover by law
P = Obligatory pool
O = Optional cover
S = Cover offered but not widely taken
N = Non-existent

Rate of penetration of cover

= > 75%
= 25-75%
= 10-25%
= < 10%
= not known

Source: CEA (2009), p. 18

The differences in coverage may reflect the differences in risk exposure and the difficulty in meeting the conditions of insurability. But there are other possible reasons such as underestimation or a lack of awareness of the magnitude of the risk exposure, or the anticipated receipt of compensation from public authorities, as we will see in the models defined in the next paragraph.

2. Defining the different insurance models

Following Schwarze and Wagner (2009, p. 4), the extent to which the systems imply the involvement of private insurance or/and of the government can be represented in five stylized models, as in the following Table.

Table 3

MODEL	DESCRIPTION
M1	(Regional) public monopoly insurer of natural hazards
M2	Compulsory insurance of all natural hazards
M3	Compulsory inclusion of (all) natural hazards into general house owner insurance (coupling of contracts)
M4	Free-market natural hazard insurance with ad hoc-governmental relief programs
M5	Tax-financed governmental relief funds

In **Model 1**, public monopoly insurance regulates the mandatory legal affiliation of individuals and legal entities to a specific public insurance provider, a so called monopoly insurer, in most cases, regional monopolies. The monopoly insurer is guided by statutory provisions and public consultation processes in the way it draws up its contracts, but in practice it frequently also has rights of participation in public proceedings governed by public law, such as disaster mitigation planning, land use planning and building regulations.

As a result of the Third EU Directive on Non- Life Insurance, such regional or national monopoly insurers are no longer permitted under European law[11]. On account of their special status as institutions of public service provision and the fact that these companies also fullfil the integrated task of damage prevention and mitigation, they may however be permissible under European law by virtue of the special status of "service publique", despite the prohibition on monopolies mentioned above.

Model 2 corresponds to a compulsory insurance of all natural hazards, a mandatory insurance regulated through law. For all those potentially affected by natural hazards, mandatory insurance by its very nature represents a compulsory obligation to purchase a corresponding policy. It is almost always combined with an obligation to contract on the part of insurance providers, i.e. the insurers are obliged to offer interested buyers the legally defined level of insurance at predetermined conditions. Within this regulatory framework different types of insurance can be offered by a large number of companies, i.e. competition is possible to a limited extent in the context of mandatory insurance.

Model 3 is characterised by a bundling of insurance coverage with the obligatory inclusion of natural hazards in buildings and contents insurance contracts, e.g. fire insurance. It is ultimately also a form of mandatory insurance, in that the parties to the contract are not able to negotiate freely which hazards are to be insured. Consumer sovereignty is maintained, however, to the extent that the parties may decide whether an insurance contract should be concluded at all.

Model 4 provides a free-market natural hazard insurance. The model is considered even if free-market natural hazard insurance practically does not exist in reality. A careful survey of practices in Europe[12] demonstrates that "free-market natural hazard insurance" does always co-exist with ad hoc-governmental relief programs. The latter fills the gaps of coverage that are unavoidable in a system of cream-skimming and uninsurability limits on the side of purely commercially-oriented insurers[13].

[11] Directive 92/49/EEC of 18 June 1992 on the coordination of laws, regulations and administrative provisions relating to direct insurance other than life insurance.

[12] CEA (2005).

[13] In this regard, free market "natural hazardism", following Anderson and Leal (2001)'s concept of

Model 5 is characterised by a tax-financed governmental relief funds. Disaster funds are tax-based government funds used to compensate for damage caused by natural disasters up to a maximum fixed amount. Payments are made in cases where the claimant is not privately insured. Supplementary comprehensive natural hazards coverage is possible through market-based voluntary private insurances, which in practice are usually offered as an add-on to buildings insurance. In contrast to the previous models, the disaster fund is an indirect obligation to take out insurance, enforced through the obligation to pay taxes into the fund. However, it should be noted that this "enforced solidarity"[14] in the case of damage entails no legal right to a transfer of risk. Although every taxpayer makes an obligatory payment, the payment received in the case of damage is not to be regarded as a service in return but as a relief measure provided upon the "request" of the claimant. Thus it is important to distinguish clearly between an insurance payment based on a legal claim and disaster assistance applied through a disaster fund, even if the claimant makes a prior payment in each case.
The main example is the EU Solidarity Fund (EUSF) created after the floods in central Europe in summer 2002 and entered into force already on November 15th of that year. Member states, and countries applying for accession, can request aid in the event of a major natural or technological disaster and the fund provides financial aid for emergency measures.
The Table 4 shows the models adopted in some European countries

"Free market environmentalism", is a nirvana approach.
[14] For a detailed analysis of the concept of "solidarity" in the case of natural disaster insurance: see Van den Bergh, Faure (2006).

Table 4

COUNTRY	MODEL ADOPTED
Netehrlands	M1/M2
Denmark	M1/M2
Switzerland	M1/M2
France	M2/M3
Spain	M2/M3
Great Britain	M3/M4
Germany	M4
Austria	M4/M5
Italy	M4/M5

Different models are implemented in Europe and this diversity could be seen as beneficial to developing and testing different approaches.

3. Testing the informational and market efficiency of the different insurance models

We will now consider the five different models in relation to their efficiency facing the problems from the presence of informational imperfections.
Generally the insurance market is characterized by asymmetric information. In the previous paragraph, we have already mentioned the difficulty of the insurance companies to collect information about environmental risks. Moreover insurers suffer from lack of information regarding the level of risk characterising insured individuals: this aspect of the asymmetry leads to two phenomena, adverse selection and moral hazard[15].

[15] Porrini (2005).

Adverse selection arises if a person knows better than the insurer that he is likely to have a loss; the risk is known to him but hidden from the insurer. An insurer can respond to a known high risk by charging a higher premium, but the potential for a hidden high risk can disrupt private insurance markets. Adverse selection occurs in drawing up contracts due to asymmetrical information between the insurance company and the policy holders. "Good quality" risks are not prepared to insure themselves at a premium oriented towards the average costs of all policy holders. "Poor quality" risks, by contrast, do not reveal their character to the insurer. The problem of adverse selection means that poor quality risks squeeze good quality risks out of the pool[16].

Moral hazard occurs when knowledge that loss or damage will be compensated reduces the incentive for people to prevent the damage or loss[17]. In addition, third-party payment after losses is another problem, as it lowers the out-of-pocket cost to the policyholder and leads to overspending (moral hazard ex post[18]), particularly if the contract cannot precisely specify what must be paid.

While informational imperfections imply adverse selection and moral hazard, market functioning imperfections imply charity hazard and transaction costs.

On one hand, the so called "charity hazard" which, according to Browne and Hoyt (2000), arises out of a reduced incentive to insure oneself against disaster damage in anticipation of governmental and/or private assistance. On the other hand, the literature on insurance economics highlights problems deriving from the presence of transaction costs in insurance competition, that include both the costs of competition and the costs of settling claims[19].

We are now going to analyse how the different insurance models perform in avoiding these informational and market imperfections.

In **Model 1**, public monopoly insurers are one solution to the problem of adverse selection in insurance pools. Adverse selection, as we have seen above, occurs in drawing up contracts due to asymmetrical information between the insurance company and the policy holders with the consequences that poor quality risks squeeze good quality risks out of the pool. This problem does not arise in the context of monopoly insurance, as all individuals and legal entities necessarily exert demand, so that "good risks" are not able to shift to self-insurance strategies instead and "bad risks" can be reduced to a level manageable for the pool of those compulsorily insured by means of the power of disposition held by the monopoly insurer in damage prevention.

This obligation to take out insurance also makes possible to avoid "charity hazard", meaning the incentive reduction to insure oneself against disaster damage in anticipation of governmental and/or private assistance.

The problem of moral hazard, which consists in prevention incentives being reduced on the part of the policy holder through the existence of an insurance, is minimised through the regulation and observation of prevention. A monopoly insurer involved in governmental precautionary action on risk prevention has an existential interest in prevention measures and will monitor their enforcement in order to reduce the extent of potential damages ex ante.

For what concerns the problems associated with transaction costs, including both the costs of competition and the costs of settling claims, whereas competition costs are

[16] Akerlof (1970); for an overview: see Milgrom, Roberts (1992).
[17] Shavell (1979).
[18] For an overview of different forms of moral hazard: see Baker (1996).
[19] Von Ungern-Sternberg (2000).

barely significant on a monopoly market, if at all (there is practically no need for advertising here), considerable settlement costs certainly can arise in the monopoly insurance model, as demonstrated by numerous examples from social welfare insurance (most famously the explosion of costs in the health care system). However, damage management is combined systematically with precautionary action to prevent damage, as in some exisiting public monopolies (e.g. in Switzerland, the expense associated with settling claims is, of course, much smaller accordingly).

In **Model 2**, with a compulsory insurance model, adverse selection is also avoided in the mandatory insurance model by the "obligation to buy". A similar positive result emerges with regard to the "charity hazard" problem, in that the obligation to insure counteracts the squeezing of insurance demand through (anticipated) ex post assistance. However, the problem of moral hazard comes fully into play in the mandatory insurance model, in that the insurance companies have no right to participate in prevention planning at the individual or collective level. Transaction costs in Model 2 also exceed those in monopoly insurance, because insurance is supplied by a large number of competing companies so that, in addition to the costs of settling claims, competition costs arise, as described by Von Ungern-Sternberg (2000).

Model 3 shows, in principle, a possibility that adverse selection and the problem of charity hazard may arise – or at least they cannot be ruled out completely. In addition, the problem of moral hazard may arise, as in Model 2. With mandatory coverage competition costs as well as relevant claims settlement costs also arise.

For what concerns **Model 4**, there are good reasons to believe that ad hoc relief is inferior with regard to the objectives stated above (prevention of moral hazard, transaction costs, etc.) than any systematic ex ante (M1-M3) and even systematic ex post system of risk transfer (M5).

In **Model 5** since no taxpayer can evade this obligation, the problem of adverse selection is avoided. The problem of moral hazard, however, does arise, in that the incentive to obtain private preventive insurance is reduced on account of the general safety net of the disaster fund. What is particularly evident in this model is the problem of "charity hazard", i.e. impaired willingness to obtain private insurance. The reason for this is, first, that government assistance is anticipated due to its institutionalisation through the disaster fund and, second, that only those claimants who have no private insurance benefit from this assistance. Both elements contribute to a situation in which this system, in principle, completely undermines the incentive to acquire insurance. In terms of transaction costs as well there are considerable differences compared with the previous models. On the one hand, no competition costs arise in a disaster fund system. On the other hand, the costs of settling claims may be much higher compared with claims processed by insurance companies. There is likely to be a longer waiting period as well as lower coverage[20]. As a result, macroeconomic disruptions are eliminated less promptly and to a lesser extent.

Table 5 summarizes the relative efficiency of the different insurance models that we have described in the previous paragraph. The assessment dimensions selected here are adverse selection, charity and moral hazard, and the level of transaction costs, and they listed in the table rows. The alternative stylised models depicted in the table columns are public insurance monopoly (M1), compulsory insurance (M2), the obligatory

[20] Evidence of this sort is to be found in Raschky et al. (2010).

inclusion of natural hazards insurance in other insurance contracts (M3), a free insurance market (M4), and a governmental disaster fund (M5).

Table 5

MODEL	Adverse Selection	Moral Hazard	Charity Hazard	Transaction Costs
M1 Public Monopoly Insurance	No	Avoidable	No	Yes/No
M2 Compulsory Insurance	No	Yes	No	Yes
M3 Compulsory included Insurance	Possible	Yes	Possible	Yes
M4 Free Market Insurance	Yes	Yes	Yes	Yes
M5 Governmental Disaster Fund	No	Yes	High	Yes/No

In the next paragraph, another "efficiency" test will be conducted for the five insurance models but with reference to mitigation, adaptation and management of climate risks.

4. Mitigation, adaptation and the financial management of climate extremes

Differently from the previous paragraph, we are going now to analyse the insurance models considering their role in incentivating adaptation, mitigation, and financial risk management for climate-related risks. As we have seen above, the insurance sector can make a significant contribution to risk and loss reduction measures to decrease the social and economic impact of natural catastrophes as far as possible. Insurers have expertise in the identification and analysis of risk, developing sustainable financial solutions and encouraging risk-reducing behaviour by both individuals and businesses. Such measures are of great value to private insurers because they can reduce claim costs and provide that insurance coverage can be sustainable.

In addition, prevention and mitigation measures will not only reduce the direct losses when a disaster occurs, but will also act to decrease other risks such as health risks and business interruption risks[21].

The challenge which insurance as political economic instrument faces is not only to place the burden of recovery on those who suffer losses from natural disasters, but also to promote investments in cost effective loss reduction mechanisms. Insurance generally encourages safe building and manufacturing practices since insurers must pay claims when accidents occur. In practice, insurers can charge premiums which encourage loss

[21] Aakre et al. (2010).

prevention measures and people would voluntarily adopt these measures based on the annual premium reduction[22].

In this sense the insurance industry's role is far beyond simply compensating climate change's victims for their losses ex post. So the activity of the insurance companies can contribute to develop political economic instruments within an ex ante strategy with the target to financially manage large-scale catastrophes, as a complement of ex post instruments for the compensation of disaster losses[23].

The importance of considering also this role comes from different factors. First of all, compensation in case of extreme events is not an adaptation or a mitigation measure per se, since no climate change damage is prevented or reduced; in fact insurance does not reduce the losses, yet reduces the follow-on economic impacts and thus stabilizes the income and consumption stream of the affected, and thus clearly reduces vulnerability and impacts; but compensation is relevant for adaptation and mitigation in the sense that it may influence the incentives to produce adaptation measures.

Adaptation and mitigation are strictly connected with the financial management of climate change risks that provides for the necessary economic resources. Particularly for weather risks, risk management options are used to augment traditional insurance. Examples include alternative risk transfer mechanisms such as financial derivatives, options and futures to hedge against losses and catastrophe bonds. To avoid the high transaction costs of indemnity-based insurance systems, index-based or parametric schemes make payouts contingent on a physical trigger, circumventing expensive claims settling. In the case of weather derivatives, insureds collect an insurance payment if the index reaches a certain measure or "trigger" regardless of actual losses.

In the European Commission's strategy for adaptation, climate change demands "innovative solutions on the financial services and insurance markets", as well as the "further integration of these solutions into the framework of EU financial services policy" and also a "review of the risk structure of existing public and private disaster funds including the EU's solidarity funds" (Commission of the European Community, Green Paper, 2007, p. 23). The reform of natural hazard insurance is, seemingly, becoming a cornerstone of the EU's strategy for adapting to climate change.

The insurance industry is developing innovative ways to respond efficiently to increasing exposure to climate-related risks and there are already new financial products, such as catastrophe bonds and weather derivatives[24].

The first kind of insurance products, called catastrophe (cat) bonds, consist in securitising some of the risk in bonds, which could be sold to high-yield investors[25]. Cat bonds are able to transfer risk to investors that receive coupons that are normally a reference rate plus an appropriate risk premium. By these products, insurers limit risk exposure transferring natural catastrophe risk into the capital markets. Due to their size, financial markets offer enormous potential for insurers to diversify risks. But transaction costs can be considerable, and the unfamiliarity of investors with insurance risks means that they currently demand a relatively large risk premium.

[22] The importance is also clear from the numerous EC documents that look at the need of a consolidated EU climate adaptation strategy: Commission of European Community, Green Paper on adaptation, 2007; and White Paper, 2009

[23] Boyer, Porrini (2002).

[24] Association of British Insurers (2005).

[25] Lewis (2007)

Weather derivatives are another kind of financial instrument used by companies to hedge against the risk of weather-related losses. Weather derivatives pay out on a specified trigger, e.g. temperature over a specified period rather than proof of loss. The investor providing a weather derivative charges the buyer a premium for access to capital. If nothing happens, then the investor makes a profit[26].

With this kind of financial products the insurance industry tries to reach two goals. First of all, there is the need for extra capital and to spread risks beyond the insurance sector. Particularly cat bonds are used to spread insurance risk in the financial sector. The second goal is to improve the accuracy and the resolution of hazard data and the likely impacts on climate change with the involvement of financial market forecast ability.

We can now consider the different insurance models defined in the previous paragraphs in relation to their capacity to develop mitigation and adaptation measures and to induce financial management of risks.

Regarding **Model 1**, the public insurance monopoly performs well given that the measures to reduce natural catastrophes related damage should not only be undertaken at the private level, but that there also has to be a collective effort, requiring political support from the authorities. For example, it is mostly public institutions that decide on land-use planning (e.g. allowing or avoiding building in areas with a high risk exposure), adopting construction codes (e.g. to reduce damage caused by extreme weather) and are responsible for the investment in general prevention measures. Managing financial risks dependes on the financial efforts and capacity of the public insurance company.

For what concerns **Model 2**, we can say that despite many of the risk financing modalities are conventional, some (most notably index insurance and catastrophe bonds) are rather novel and have been made possible by new developments in modeling risks and financial transactions by private insurance companies. While conventional insurance is written against actual losses, index-based insurance is written against physical or economic triggers. Index-based insurance is against disaster events that cause loss, not against the loss itself. The fact that the insurance is compulsory make possible to overcome the problem that index-based insurance implies the substantial decrease in transaction costs that, particularly for developing countries, have limited the development of these kind of insurance products.

In **Model 3**, we have the problem that the insurance is included in another contract making difficult to financially managing the risks by an autonomous insurance market mechanism.

In the case of **Model 4** characterised by free market, we can expect not so many adaptation and mitigation investments, but probably a diffusion of catastrophe bonds. By this instrument disaster risks are packaged (securitized) in the financial markets and the investor receives an above-market return when a specific catastrophe does not occur in a specified time but sacrifices interest or part of the principal following the event. Disaster risk is thus transferred to international financial markets that have many times the capacity of the reinsurance market. Another advantage accrues to investors: by adding catastrophic risk to their investment portfolios, needed diversification is increased since natural catastrophes are not correlated with stocks and other investments tied to economic performance.

[26] Dischel (2002).

Finally the governmental disaster funds that characterises **Model 5** is a typical ex post mechanism that is not connected with any mitigation and adaptation investment and not even with the development of financial management of the risks derived by climate change.
In Table 6 the performance of the five models considering adaptation, mitigation and financial risk management is summarised.

Table 6

MODEL	Adaptation	Mitigation	Managing Financial Risks
M1 Public Monopoly Insurance	Easy	Easy	Difficult
M2 Compulsory Insurance	Low	Low	Yes
M3 Compulsory included Insurance	Low	Low	Difficult
M4 Free Market Insurance	Very low	Very low	Yes
M5 Governmental Disaster Fund	No	No	No

After perfoming the two test on the five models, we are now going to address some conclusive remarks about the design of a future European insurance model.

5. Conclusive remarks

In this paper, looking at the present situation in some European countries, we have seen that pure systems of risk transfer are not utilized. Rather mixed systems exist, where different models of risk transfer co-exist in different regions (e.g., Switzerland) and in different hazards (e.g., Austria). Empirically it has been proven that where after disasters state reliefs (model M4 and M5) are implemented the penetration of natural hazards insurance is very low, such as in Germany and in Italy, while in country like Great Britain in absence of state relief the penetration is high[27]. Moreover, "charity hazard" induces individuals to not buy insurance because they believe that they will be substained by the society[28].
As the White paper on adaptation states "Optimising the use of insurance and other financial services products could also be explored. It should be evaluated whether certain private actors/sectors (such as those providing public services, critical

[27] Faure (2006).
[28] Browne, Hoyt (2000).

infrastructure) need to be covered by compulsory standard weather-related insurance. In cases where insurance is not available, for example for buildings located in flood plains, publicly supported insurance schemes may be required. Due to the cross-border effects of climate change, there may be benefits in promoting EU-wide insurance as opposed to national or regional schemes" (2009, p. 13).

The issue of a mandatory comprehensive disaster insurance comes from the fact that people today do not voluntarily protect themselves against some natural disasters such as flood and earthquakes[29]. Because of the mandate, insurers need not be concerned that buyers in any part of its portfolio will drop coverage should it charge high premiums based on risk. Using the law of large numbers, this higher premium base and the diversification of risk across many hazards reduces the likelihood that such an insurer will suffer a loss that exceeds its surplus in any given year.

Another feature is having an insurance policy that covers all perils, including all natural hazards regardless of type, so that there will be no ambiguity by the homeowner as to whether or not she has coverage[30].

If one believes that those residing in hazard-prone areas should be responsible for bearing their own financial burden for losses from a natural disaster, then insurance rates should reflect the risk. The use of catastrophe models and exceedance probability curves can be extremely useful in this regard for determining and legitimizing the types of rates that should be charged[31].

Risk-based rating can be efficiency-improving in several dimensions. It provides a signal to individuals as to the risk they actually face so they can make a different decision as to whether or not they want to invest and reside there. High premiums in high risk areas might help considering loss probabilities and therefore support more rational investments in mitigation. Such insurance is efficient by having those at risk bear the expected costs of residing in hazard-prone area, and therefore potentially deciding to live in areas with lower expected housing costs. A system of risk based premiums also provides economic incentives to invest in cost-effective loss prevention measures.

The implementation of a mandatory system requiring everyone to purchase coverage will give regulators less of a reason to bow to political pressure to cross-subsidize rates from intense minorities, such as high-income residents with large homes in high-risk areas, who can afford this coverage. There are also distribution issues that have to be dealt with under such a system.

But such a comprehensive disaster insurance program to reduce losses from future disasters needs to be linked with other private-public sector initiatives. The importance of well-enforced building codes and land-use regulations to control development in hazard-prone areas becomes an important part of such a program. If European countries are providing protection against catastrophic losses, they can also require these risk-reducing measures as part of such a private-public partnership. Also tax incentives to encourage individuals can be offered to adopt mitigation measures.

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[29] Swiss Re (2007).

[30] The attractiveness of insurance that guarantees that the policyholder will have coverage against all losses from disasters independent of cause has also been demonstrated experimentally by Kahneman and Tversky (1979). They showed that 80 percent of their subjects preferred such coverage to what they termed probabilistic insurance where there was some chance that a loss was not covered. What matters to an individual is the knowledge that she will be covered if her property is damaged or destroyed, not the cause of the loss.

[31] Harrington (2006).

Furthermore the system could be better implemented if insurance companies could obtain better data to reduce the uncertainties surrounding the risk assessment process, if they could be provided by better information on the risk and alternative ways of reducing the risk faced by different interested parties ranging from the potential victims to government agencies.
For the implementation, the public decision making process is also important[32]. Politicians discount future hazards, possibly even more than their electorate because current economic issues are, for politicians, more important than long-term fundamental changes in the existing risk transfer system.
In conclusion, natural hazard insurance has developed in each country over the years, in fact over decades, but at the same time, natural hazard insurance also has a long, difficult path ahead of it before it is reconstructed for the conditions of climate change. In order to reach an European common insurance model, the very first thing that must change is risk awareness amongst citizens and politicians. This is a protracted process which can only be sustained through credible risk studies on a sound scientific basis.

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[32] Schwarze, Wagner (2007).

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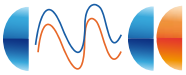

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