

PUBLIZIERBARER ENDBERICHT

A) Projektdaten

Kurztitel:	InsAdapt
Langtitel:	Insurance for Adaptation
Programm inkl. Jahr:	ACRP 4 2011
Dauer:	01.02.2013 bis 30.04.2016
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Projekt- und KooperationspartnerIn (inkl. Bundesland):	Wharton Risk Management and Decision Processes Center of the University of Pennsylvania; US Munich Climate Insurance Initiative (MCII); Germany
Schlagwörter:	Climate change, insurance, risk transfer, risk sharing, risk reduction, resilience, adaptation, extreme events, EUSF, stakeholder processes
Projektgesamtkosten:	343.744 €□
Fördersumme:	343.744 €□
Klimafonds-Nr:	KR11AC0K00277
Erstellt am:	30.04.2016

B) Project overview

1 Kurzfassung

Mit zunehmenden ökonomischen Risiken durch Extremereignisse (IPCC 2012) diskutieren politische Entscheidungsträger verstärkt die mögliche Rolle von Risikotransfermechanismen wie z.B. Versicherungen als Sicherheitsnetz für die betroffene Bevölkerung und als Möglichkeit, das Katastrophenrisiko zu verringern. Diese Fragen wurden um erstmals als Teil der Loss and Damage Diskussion im Zuge des Rahmenübereinkommens der Vereinten Nationen über Klimaänderungen (UNFCCC) vor mehr als 20 Jahren behandelt. Dennoch besteht kein Konsens darüber, ob eine umfassende Anwendung von Versicherungsmechanismen auch disaster risk reduction (DRR) verstärkt bzw. zu einer ausgeprägteren Klimawandelanpassung (CCA) führt. Manche sagen, dass die Monetarisierung von Risiko, wie sie von Versicherungen durchgeführt werden zu einer effizienten Risikoreduktion führt, andere vertreten die Meinung, dass Versicherungen ein Hemmnis für Anpassung darstellen, da Versicherungsnehmer durch die finanzielle Absicherung im Ernstfall weniger geneigt sind, Vorkehrungen zu treffen. Die Rolle von Versicherungen zur Reduktion von Schäden durch Wetterextremen gewinnt an Bedeutung für den Klimawandeldiskurs, insbesondere im internationalen Loss and Damage Mechanismus (Warner et al. 2015), in dem Wege zur Verringerung von Klimawandelauswirkungen gesucht werden und Möglichkeiten zur Verteilung der Belastungen gefunden werden sollen. Unter Anbetracht steigender finanzieller Risiken betrachten betroffene Länder wie z.B. China Versicherungslösungen als Möglichkeit, ihre Bevölkerung und Wirtschaft vor den Auswirkungen von Klimaextremen abzusichern (Bin 2014). Karibische und Afrikanische Staaten, unterstützt durch die internationale Gemeinschaft, starteten bereits Versicherungslösungen. Eine neue G7 Initiative zur Versicherung von Klimarisiken (InsurResilience) hat zum Ziel, bis 2020 weitere 400 Millionen Personen in Entwicklungsländern mit einer Klimaversicherung zu versorgen (GIZ 2015).

Das Projekt InsAdapt (Insurance for Adaptation) untersucht die mögliche Bedeutung von Versicherungsinstrumenten für DRR und CCA und verfolgt drei übergeordnete Ziele: (1) Zu eruieren, auf welche Art Versicherungsmechanismen für Haushalte und Unternehmen für unterschiedliche Katastrophen zu Anpassungsstrategien für Extremereignisse in Europa und Nordamerika beitragen; (2) Zu untersuchen, welche Rolle die Europäische Kommission und im Besonderen der Solidaritätsfonds der Europäischen Union (EUSF) gegenwärtig für die Entwicklung von Versicherungsinstrumenten zur Verstärkung der Klimawandelanpassung spielt, bzw. zukünftig spielen kann; und (3) Optionen für eine Reformierung der österreichischen Versicherungsregelungen für Katastrophen zu entwickeln, basierend auf der Analyse anderer nationaler Systeme, europäischen Regulationen und Stakeholdermeinungen.

Das Projekt ist sowohl in theoretischer, als auch in methodischer Hinsicht interdisziplinär. Aufbauend auf ökonomischen Theorien und Versicherungstheorie, kommt auch eine kulturtheoretische Betrachtungsweise zur Anwendung, die unterschiedliche Sichtweisen der Personen auf Katastrophen und Versicherungen hervorhebt. Zur Operationalisierung dieses Zugangs werden qualitative und quantitative sozialwissenschaftliche Methoden verwendet (Experten- und Stakeholderinterviews, standardisierte Umfrage, Analyse von grauer und peer-reviewed Literatur).

Diese Methoden werden ergänzt durch Stresstests und andere statistische Modellierungen unter Verwendung des vom IIASA entwickelten Catastrophic Simulation Model (CATSIM). Der Fokus liegt auf Hochwasserversicherungen in wohlhabenden Ländern mit ausgereiften Versicherungsmärkten, in denen Überschwemmungen zu den zerstörerischsten Gefahren zählen. Private Versicherungspläne, nationale Versicherungssysteme (mit einem Schwerpunkt auf Österreich) und der Solidaritätsfonds der Europäischen Union (EUSF) werden in vier miteinander verbundenen Arbeitspaketen behandelt.

- Arbeitspaket 1 untersucht die Verbindung von Versicherungen und der Reduktion von Verlusten auf Ebene der Versicherungsunternehmen und identifiziert sechs Möglichkeiten, wie Versicherer Anreize zur Risikominderung schaffen können und Versicherungsnehmern Risikoreduktion vorschreiben oder sogar finanzieren können. Versicherungen machen sich derzeit größtenteils nicht ihr gesamtes Potential zur Risikoreduktion zu Nutze.
- In Arbeitspaket 2 werden öffentliche und private Versicherungsansätze in zwölf Ländern untersucht und anhand ausgewählten Kriterien analysiert, z.B. deren Effektivität zur Risikoreduktion, ihre Solidarität und Gerechtigkeit und ihr Potential ein zuverlässiges Sicherheitsnetz darzustellen. Diese Analyse zeigt einen möglichen trade-off zwischen Leistbarkeit/Solidarität und risikobasierten Prämien, welche einen großen Einfluss auf das Potential für DRR haben und wie die unterschiedlichen Länder mit diesem Konflikt umgehen. Es konnte gezeigt werden, dass es keine Lösung gibt, die auf ähnliche Weise flächendeckend in allen Ländern angewendet werden könnte.
- Mittels einer Umfrage in Österreich, Rumänien und England wird in Arbeitspaket 4 risikoreduzierendes Verhalten auf Haushaltsebene erforscht. Öffentliche Unterstützung und die Bereitstellung von Informationen können effektive Maßnahmen sein, um Risikoreduktion zu fördern. Überraschenderweise konnten die gängigen Meinungen, dass Personen in Erwartung von staatlicher Unterstützung weniger in Risikoreduktion bzw. Versicherung investieren, noch, dass Personen nicht in DRR investieren, wenn sie über eine Versicherung verfügen, nicht bestätigt werden. Das Ergebnis der Umfrage zeigt den Bedarf nach besser gestalteten öffentlichen und privaten Maßnahmen, die Anreize für die Risikoreduktion auf Haushaltsebene darstellen.
- Im Arbeitspaket 3 wird der EUSF auf seine Robustheit und Leistung hinsichtlich Solidarität und Forcierung von Risikoreduktion untersucht. Das Ergebnis der Untersuchung zeigt, dass der EUSF kaum Ausgleich zwischen wohlhabenden westlichen Ländern und osteuropäischen Ländern schafft: westeuropäische Länder haben prozentual gesehen höhere Entschädigungen nach Katastrophen erhalten als osteuropäische Länder. Weiters ist die Gefahr einer Erschöpfung der finanziellen Mittel im Fonds gegeben. Durch diese Forschungsarbeit können Reformvorschläge für eine Verstärkung der Solidarität und Robustheit des Fonds und zur einer Steigerung von DRR in den Mitgliedsstaaten entwickelt werden.

2 Executive Summary

As economic and livelihood risks from weather extremes increase (IPCC 2012), policymakers continue to discuss the role of risk-transfer mechanisms, including insurance, in providing adequate safety nets and, at the same time, promoting disaster risk reduction. These issues were first raised more than two decades ago as part of the loss and damage discourse under the United Nations Framework Convention on Climate Change (UNFCCC); however full consensus is still lacking especially on whether the wider availability of insurance mechanisms will enhance disaster risk reduction (DRR) and by so doing enhance climate change adaptation (CCA). Many claim that putting a price tag on risk taking will lead to its efficient reduction. Others consider insurance as an impediment to adaptation given the propensity of insured agents to take less precaution, what is often referred to as "moral hazard". The role of insurance for reducing the impact of weather extremes, and thus the resolution of this debate, is increasingly important in the climate change discourse, especially in light of the International Loss and Damage Mechanism (Warner et al. 2015) which is seeking ways of sharing and reducing climate change impacts. Recognising the increasing financial risk from climate extremes, many vulnerable countries, including especially China, are considering insurance solutions to protect their economy and society (Bin 2014). The Caribbean and African countries, with the active help of the international community, already have insurance instruments in place. The recent G7 initiative on climate risk insurance (InsurResilience) aims to bring climate insurance to an additional 400 million exposed individuals in poor countries by 2020 (GIZ 2015).

The 'Insurance for Adaptation' project (InsAdapt) investigates the potential role of insurance instruments in enhancing DRR and CCA, with three overarching objectives: (1) To build an evidence base on ways in which catastrophe insurance instruments for households and businesses contribute to adaptation to extreme weather events in Europe and North America; (2) To examine the current and potential role of the European Commission, and especially the European Union Solidarity Fund (EUSF), in advancing insurance instruments that promote climate adaptation; and (3) To identify options (based on a review of national systems, analyses of European pool(s) and stakeholder deliberation) for reforming Austrian catastrophe insurance arrangements.

The project is interdisciplinary both in theory and methodology. It builds on economic and insurance theory, but moving beyond economics it applies a cultural theory lens that postulates different perspectives that influence the way people view and respond to disasters and insurance. In order to operationalize this approach we apply qualitative and quantitative social research methods, including expert and stakeholder interviews, a standardized questionnaire and a detailed survey of grey and peer-reviewed literature.

These methods are complemented by stress testing and other statistical modelling exercises using IIASA's Catastrophe Simulation Model (CATSIM). We focus on flood insurance arrangements in wealthy countries with mature insurance markets, where flood is among the most devastating climate-related hazards. Private insurer practices, national insurance systems (with dedicated focus on Austria) and the European Union Solidarity Fund (EUSF) as an EU-wide risk pool are addressed in four interlinked work packages.

- Work Package One (WP1) examines the connection between insurance and loss reduction at the scale of insurance companies and presents six ways in which insurers can incentivize, instruct, persuade, prescribe, and even fund risk-reducing activities and investments. It concludes that insurance as widely practiced is not leveraging its full risk reduction potential.

- Work Package Two (WP2) reviews public and private national insurance arrangements in twenty countries based on selected criteria including their effectiveness to incentivize risk reduction, their solidarity and equity, and their ability to provide a reliable safety net. The analysis highlights the potential trade-off between affordability/solidarity and risk-based premiums, which greatly influences the connection between the system design and its DRR potential, and shows how countries differentially make this difficult tradeoff. It confirms that there is no one single or best national arrangement that can be applied in a similar manner in all countries, and
- By conducting a survey in Austria, Romania and England, Work Package Four (WP4) investigates risk reduction behavior at the household level and finds that public support and provision of information can be particularly effective to enhance risk reduction. Surprisingly when viewed in light of the conventional wisdom, the findings support neither the existence of a charity hazard (persons invest less in DRR and insurance if they expect public support) nor moral hazard (persons invest less in DRR if they have insurance). The survey results show a need for better designed public and private policies that provide sufficient incentives for household level risk reduction.
- At the European level, Work Package 3 (WP3) assesses the EUSF including its robustness and performance in terms of solidarity and enhancement of risk reduction. It concludes that (surprisingly) the EUSF has not shown significant solidarity between wealthy and less wealthy European countries; in fact, as a percentage of losses, Western European countries have received higher post-disaster payments than their Eastern counterparts. The Fund is also at a relatively high risk of depletion. The research suggests reforms that increase the solidarity and robustness of the Fund, as well as its propensity to strengthen DRR in Member Countries.

3 Background and objectives

Increasing losses from floods, storms, landslides and other extreme weather have made disaster risk reduction and the combat against climate change priority items on the global agenda. Many highly exposed countries, both developed and developing, are urgently examining ways to improve their resilience to disaster risks. Countries with mature insurance markets are debating how to reform their existing disaster insurance schemes to make them more robust in meeting current and upcoming challenges. A well-known example is the recent and far-reaching reform of the U.K. flood insurance arrangement, which transformed from a mainly private system backed by government investments in flood risk reduction to a government-backed system with the establishment of a new entity, Flood Re. In parallel, developing countries, where insurance penetration has historically been much lower, are increasingly considering insurance instruments to protect their economies. How insurance can help the most vulnerable countries is one of the major discussions in the context of the Warsaw Loss and Damage Mechanism (Warner et al. 2015) under the United Nations Framework Convention on Climate Change (UNFCCC).

It is frequently claimed that insurance instruments, in addition to pooling risk, creating safety nets and providing timely liquidity for the post-disaster period, encourage disaster risk reduction (DRR). By so doing, the argument goes, they are important tools for climate change adaptation (CCA). Reference is often made to fire insurance in the 18th and 19th centuries, when insurance, essentially by putting a price tag on risk (e.g., high premiums on wood-constructed buildings in major cities), led to its cost-effective reduction. Others claim an opposite case - that insurance leads to increased risk if the insured, by not bearing the full losses, may take sub-optimal precautionary measures (e.g., not put their sofa upstairs once they hear a flood warning) (UNFCCC 2008). Insurance has been the cornerstone of the Loss and Damage discourse under the UNFCCC for over two decades, yet full consensus is still lacking on if and how the wider availability of insurance contributes (or can contribute) to DRR and CCA. The InsAdapt project contributes to this information gap by fulfilling its first objective of **building an evidence base on ways in which catastrophe insurance instruments for households, businesses and farms, as offered by private insurers and national insurance systems, contribute to adaptation to extreme weather events (or maladaptation because of moral hazard).**

With the help of the international community, some poor and highly vulnerable country governments, including especially small island states, have access to disaster insurance via regional risk pools, such as the Caribbean Catastrophe Risk Insurance Facility that was established in 2007. One of the main benefits of these arrangements is that they allow more efficient risk diversification, which enhances robustness. The European Union also has its dedicated fully-public disaster risk pool, the European Union Solidarity Fund (EUSF). The EUSF provides ex-post financial support for those EU countries that are least able to cope with the post-disaster demands on their budgets (OJ 2002). This research **assesses the performance of the EUSF, and examines its potential role in advancing insurance instruments to enhance disaster resilience and promote climate adaptation.** This part of the research directly informs the ongoing discussions among European policymakers who have been trying to identify ways to enhance Europe's disaster resilience (European Commission 2013).

European countries have diverse disaster insurance arrangements in place; some countries, like the UK, rely extensively on the private sector in loss compensation, while in others this burden falls more on their governments. In Austria, the government is strongly involved in compensating the victims of extreme events. Solidarity is a treasured social value. A critique of post-disaster aid is its potential to disincentive households and businesses to locate out of high-risk areas and take other preventive measures. Moreover, in Austria post-disaster support (for floods) has typically been restricted to uninsured victims. In contemplating reforms to the Austrian system, information on systems operating in other European countries as well as the potential for regional (and pan-

European) pools is essential. The third objective of the InsAdapt project is to **identify options (based on a review of national systems, analyses of European pools and stakeholder deliberation) for reforming Austrian catastrophe insurance arrangements such that they better promote risk reduction and climate adaptation, and are politically, economically and socially acceptable.**

4 Project content and result(s)

Work package 1

Background and research questions

It is argued that insurance, beyond enabling post-disaster relief, reconstruction and recovery, is a powerful pre-disaster tool for promoting risk reduction. "Insurance instruments, made affordable with donor assistance, can help highly exposed developing countries cope with weather-related disasters by providing needed economic security, reducing economic volatility and providing *loss prevention incentives*" (Linnerooth-Bayer et al. 2009; emphasis added). The most powerful incentive for loss prevention can be pricing risk: "risk-based insurance premiums could act as a price signal for settlement in an area and thus stimulate development in less risky areas and restrain development in hazard-prone areas, since premiums would be higher in the latter" (Botzen 2013, p 30). This argument dates back to the 18th and 19th centuries, when fire insurance companies "charged double [premium] for timber [properties]" (Wermiel 2012), which, it is claimed, eventually led to a strong decline in the number of conflagrations in many Western societies (Frost and Jones 1989). Yet, besides this historical role, little is known to what extent insurance encourages or, in the light of moral hazard, discourages loss prevention in the context of floods, storms, landslides and other extreme weather events. WP1 aims to answer the following questions:

- In what ways does catastrophe insurance for households contribute to reducing the risks and losses from extreme weather events?
- How can insurance contracts and pricing be better tailored to incentivize and advance risk reduction and adaptation?

Main results

As a first step of our investigation we identified *the types* of activities that can be cost effective in reducing flood losses, and *to whom* the incentives, information or requirements provided by insurance should be targeted to promote these activities. We distinguished preventative activities according to three components of risk: hazard, exposure and vulnerability. Hazard-reduction measures aim to minimize the probability and severity of the flood, typically by employing structural flood defenses or enhancing natural water storage potential to reduce runoff, or less typically by seeding clouds to divert rainfall. Public authorities usually have the primary responsibility for these measures. Exposure-reduction measures aim to reduce property, assets and lives exposed to floods, mainly by limiting settlement and development in flood-prone areas. Again, planners and other public authorities typically take responsibility for determining and regulating land use, although private households and businesses, if they are aware of the risk and most importantly if it is priced, can decide not to locate in high-risk areas. Finally, vulnerability-reduction measures aim to reduce loss and damage if a flood occurs, for instance, by building or retrofitting properties to withstand inundation. Vulnerability-reducing measures are generally the responsibility of property owners. These distinctions are important, particularly when examining the incentive effect of insurance. As an example, premiums set to reflect the hazard, such as pricing insurance according to the postal zones in the U.K, will not incentivize households to take preventive measures. Only premium discounts that reflect household flood proofing measures can serve this purpose.

In addition to risk-based pricing, we identified five additional ways in which insurers can support risk reduction in the context of flood risk, including: warranties, deductibles, risk engineering, information sharing and awareness raising and direct investment in flood prevention. The six potential links of insurance to DRR are shown in Figure 1.

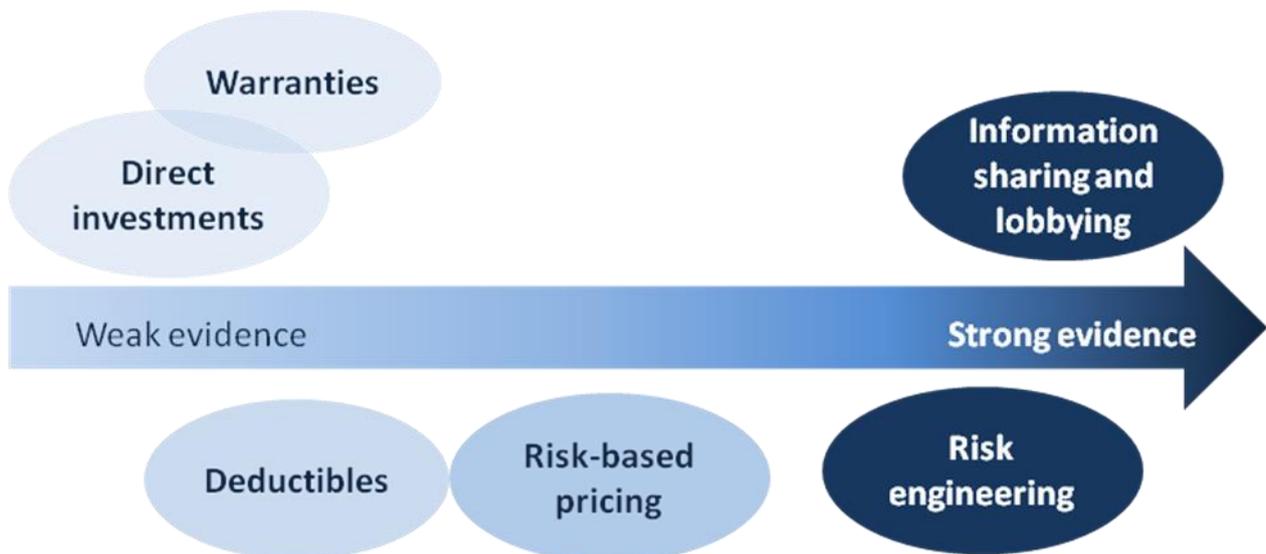


Fig. 1: Six ways insurance can support flood risk reduction and their prevalence based on available evidence

The research investigated the prevalence and effectiveness of each of the six links with the following results:

- Risk-based pricing is the most powerful theoretical link of insurance to risk reduction by providing a price signal to clients to reduce their risks; yet, in practice it significantly falls short of its potential. In our review of 20 countries, we found that insurers most often base their premiums either exclusively on property value (one element of exposure) or, with the increasing availability of flood maps, also consider hazard and location. We found few cases of differential pricing practices that take full account of hazard, exposure and vulnerability. An important exception is the Community Rating System (CRS) of the National Flood Insurance Program (NFIP) in the US, which provides premium discounts to households and communities that take specified measures for reducing flood risk. As another exception, Allianz Insurance has recently introduced the practice of inspecting high-risk properties individually in order to assess their insurability and provide them tailor-made insurance coverage and premiums that take account not only of hazard, but also of exposure and vulnerability.
- According to our review of insurance practices, deductibles are generally low (e.g. in Central-Eastern EU countries where they can be as low as EUR 100 (Pollner 2012)) or they are absent (e.g. in Romania). The French system offers an interesting exception in its differentiated use of deductibles to provide risk-reduction incentives.
- Warranties, if they exist at all in flood insurance contracts, typically take the form of general requirements to maintain the property in reasonable condition. This was a conclusion of a review of 19 household insurance "Terms and Conditions". According to follow up interviews with insurers, it was reported that violations of these general conditions are for the most part not taken into account in awarding claims due to reputational risk after a disaster, especially in times of a 'soft' insurance market when insurers are eager to maintain or increase their client base and premium income.
- Risk engineering is an under-recognized service offered by insurers to their large commercial clients. Risk engineers conduct risk assessments that range from the off-site reviews of property characteristics such as construction, occupancy, protection and exposure (usually assessing fire risk) to detailed on-site flood and other hazard

assessments. The engineers provide recommendations for risk improvements, which can result in significant risk reduction. However, as interviews with risk engineers revealed, the information collected by risk engineers is not systematically taken into account by underwriters as in the case of fire hazard, and thus the link to insurance is less developed.

- Information sharing and awareness raising appear to be routinely practiced by many insurers and insurance associations, which provide their clients with guidance on flood preparedness and flood risk reduction, typically through publicly available information on their websites; yet, there is little information on the effectiveness of this information in reducing risks. Lobbying by insurers to convince public authorities to provide flood protection appears to be effective in the few documented cases, although there is little evidence on how widespread this practice is.
- Direct investments in flood prevention measures by insurers are understandably rare for private insurers, but appear to be an option practiced by at least one public monopoly insurer in Switzerland that financially supports fire and civil defence services and also private loss prevention via dedicated funds.

In conclusion, available evidence suggests that current insurance practices fall significantly short of claims made by proponents of insurance as an instrument for disaster risk reduction and climate change adaptation, and at the same time there is potential for reformed risk transfer systems that provide this link. This finding has important implications, not only for reforming insurance systems in established markets, but also for designing and implementing risk-transfer instruments in highly vulnerable developing countries.

Work package 2

Background and research question

The link between insurance and adaptation depends on practices of private insurers (WP1), and also on the institutional arrangements of national public-private insurance systems. Switzerland serves as a good example. The public monopoly insurers operating in many but not all cantons have an exemplary record in reducing risks compared to their private market counterparts. This is due partly to their participation in processes that set building codes, plan land use and finance the fire and cantonal civil defence services (Ungern-Sternberg 2006).

It is important to recognize that reducing risks, for example by penalizing risk-taking behaviour with higher premiums, can compete with other social objectives, like providing affordable insurance to households in high-risk areas (typically poor households). Thus an efficient system in terms of loss reduction may not be an equitable system in terms of providing affordable insurance to the most vulnerable. The equity-efficiency tradeoff, along with other competing objectives, is generally not addressed in existing literature on disaster insurance systems (see, for example, Paudel et al. 2012; Schwarze et al. 2012; Michel-Kerjan, 2010; Faure and Hartlief, 2006; Botzen and van den Bergh, 2008; Schwarze and Wagner, 2009; Paklina, 2003). To fill this gap, this WP focused on competing objectives or criteria in the design of national insurance systems. Specifically, we addressed the question of how Austrian insurance arrangements compare with other national insurance systems across Europe and the U.S, not only with respect to their contribution to risk reduction and climate adaptation (efficiency), but also with regard to their affordability (equity).

Main results

Currently, national systems perform very differently across the features outlined in Table 1. However, some trends are emerging:

- **Public versus private**

European insurance arrangements are increasingly moving towards regulated market-based systems, yet with significant public support in the form of reinsurance and state guarantees;

- **Voluntary versus mandatory**

Mandatory insurance purchase is difficult to implement under European competition laws. This has been illustrated in The Netherlands, where a mandatory system was rejected for this reason. Yet,

several countries have mandatory insurance in place, for example Spain, Switzerland, Romania, and France. Other countries such as Norway, require insurer’s to offer insurance, but do not oblige households to purchase it. An alternative with similar effects is the bundling of insurance.

• **Bundling insurance**

Most European systems are bundled in one or two different ways: combining natural catastrophe (NatCat) risks into one NatCat package or combining NatCat insurance with standard homeowners or fire insurance policies. Bundling insurance spreads and diversifies risks by creating a larger risk pool and thus a more robust insurance arrangement.

• **Risk-based premiums**

In pricing insurance policies, none of the reviewed insurance systems accounts for all risk factors, including hazard, exposure and vulnerability. The system closest to full risk-based pricing is the US National Flood Insurance System (NFIP) with its community ranking system (premiums are set according to measures taken by the community as well as by the individual households). Insurers in Germany, the UK and the Czech Republic base premiums on hazard and exposure maps, but do not account for the vulnerability of households. Insurers are reluctant to take household DRR measures into account in setting premiums because of the transaction costs involved in tailoring millions of household policies to individual household risk profiles.

• **Incentives to invest in risk reduction**

Apart from risk-based premiums other mechanisms to motivate risk reduction are available, such as warranties determining preconditions for purchasing a policy, deductibles and indemnity limits and awareness-raising. While indemnity limits and deductibles are sometimes applied, although not necessarily with the objective to incentivize risk reduction, warranties and awareness-raising efforts are rarely in place.

Table 1: Selected criteria for the analysis of insurance and relief arrangements

Effectiveness to incentivize risk reduction (efficiency)	<ul style="list-style-type: none"> • Mechanisms motivating property-level risk reduction • Indicators are risk-based pricing; indemnity limits and deductibles; and warranties
Affordability	<ul style="list-style-type: none"> • Mechanisms ensuring affordability with respect to particularly vulnerable policy holders. Affordability can be made possible with taxpayer solidarity (see below) and also can take the form of cross-subsidies within the insurance system
Taxpayer solidarity	<ul style="list-style-type: none"> • Taxpayer solidarity can take many forms, including an ex-post public catastrophe fund that provides post-disaster assistance, the public capitalization of national systems and direct premium subsidies to households .
Ability to provide a reliable safety-net (robustness)	<ul style="list-style-type: none"> • Mechanisms ensuring private and public liquidity in case of exceptionally large extreme events.

We summarize our comparison of the 20 systems along the these criteria (Table 1) as follows:

• **Effectiveness to incentivize risk reduction (efficiency)**

Countries rank generally low on incentives for risk reduction. It is important to note that although Germany, the Czech Republic and the US rank high, no country achieves comprehensive risk-based premiums. Achieving this is difficult as it would entail considering risks of individual households and the effectiveness of a wide range of individual risk reduction measures. Furthermore, transaction costs for these considerations would be exorbitant.

• **Equity as affordability**

Explicit mechanisms to enhance the affordability of insurance, or equity, are in place in Hungary, the US, and Belgium. In the case of Hungary, this is a stand-alone public insurance targeting particularly low-income households in high-risk areas. In the US these are for example subsidized premiums, whereas in Belgium the government supports cases with exceptionally high flood risk (only for buildings before the implementation of the policy). Cross subsidies from low-risk to high-risk households characterize systems in Switzerland and France, which require all households to insure at a premium that accounts only for the property value.

- **Taxpayer solidarity**

Countries with strong taxpayer solidarity in providing post-disaster assistance include the Netherlands Austria, Belgium, Germany, Hungary, Romania, Poland and Slovakia. These countries have low penetration of private insurance. Taxpayers, for example in France, Iceland and Spain also contribute to making private insurance affordable by providing government reinsurance or guarantees.

- **Ability to provide a reliable safety net (robustness)**

The salient design features for a robust insurance system include: (1) high market penetration, which characterizes mandatory systems and systems where NatCat coverage is a standard part of homeowner or similar policies; (2) private or public reinsurance, mandated reserves and state guarantees; (3) a diversified insurance portfolio and (4) public disaster funds to provide a safety net in the absence of insurance penetration. All the reviewed systems met at least three of these indicators.

The main trade-off among these criteria is between efficiency and equity (including affordability and solidarity); recent insurance reforms have generally emphasized efficiency at the expense of overall equity. An exception is the recent reform of the U.K. flood insurance system that has strong subsidies for low-income households located in high-risk areas.

Work package 3

Background and research questions

Insurance penetration in Europe is relatively high compared to developing countries, yet EU governments typically finance a large portion of disaster losses (Hochrainer and Mechler 2009). Recognising that the burden of these post-disaster liabilities can exceed the coping capacity of governments, the EU created the European Union Solidarity Fund (EUSF) in 2002 to “show practical solidarity with Member States” and provide financial aid to disaster-stricken EU countries. The EUSF has recently been reformed to provide more timely aid to governments and to improve its stipulations for reducing risks. In parallel, the European Commission (EC) has initiated a formal consultation on the adequacy and availability of appropriate disaster insurance with the aim of assessing whether or not action at EU level is warranted to improve the market for disaster insurance in the Union (European Commission 2013). WP3 directly informs these policy discussions by answering the following questions:

- To what extent does the pre-and post-reformed EUSF fulfil the objectives of European policymakers, such as the promotion of solidarity, contribution to pro-active disaster risk reduction and robustness to increasing disaster risks?
- What role does and could the European Commission, and especially the EUSF, play in supporting insurance systems and pooling arrangements that promote resilience in the EU to weather-related risks? What is the potential for public-private insurance pools in Europe?

These questions are also highly relevant for developing countries, specifically for the discussions under the Warsaw International Mechanism for Loss and Damage on the possible development of a climate risk pooling facility to address impacts associated with severe weather events in vulnerable countries.

Main results

The assessment of the pre- and post-reformed EUSF shows that reforms will improve certain aspects of the Fund, including its responsiveness due to the clarified eligibility rules and simplified administrative procedures. However, the EUSF still falls short of fulfilling its objectives in terms of solidarity, robustness and the promotion of risk reduction activities.

Solidarity

Our estimates show that new EU member states tend to receive significantly less aid as a proportion of their eligible costs than more wealthy (Western European) countries (Fig. 2). Thus if solidarity is defined as a needs-based concept, the EUSF falls short of its fulfilment. Solidarity with new EU member countries could be enhanced by changing the loss threshold that qualifies a government for EUSF support, as well as changing the pay out schedule.

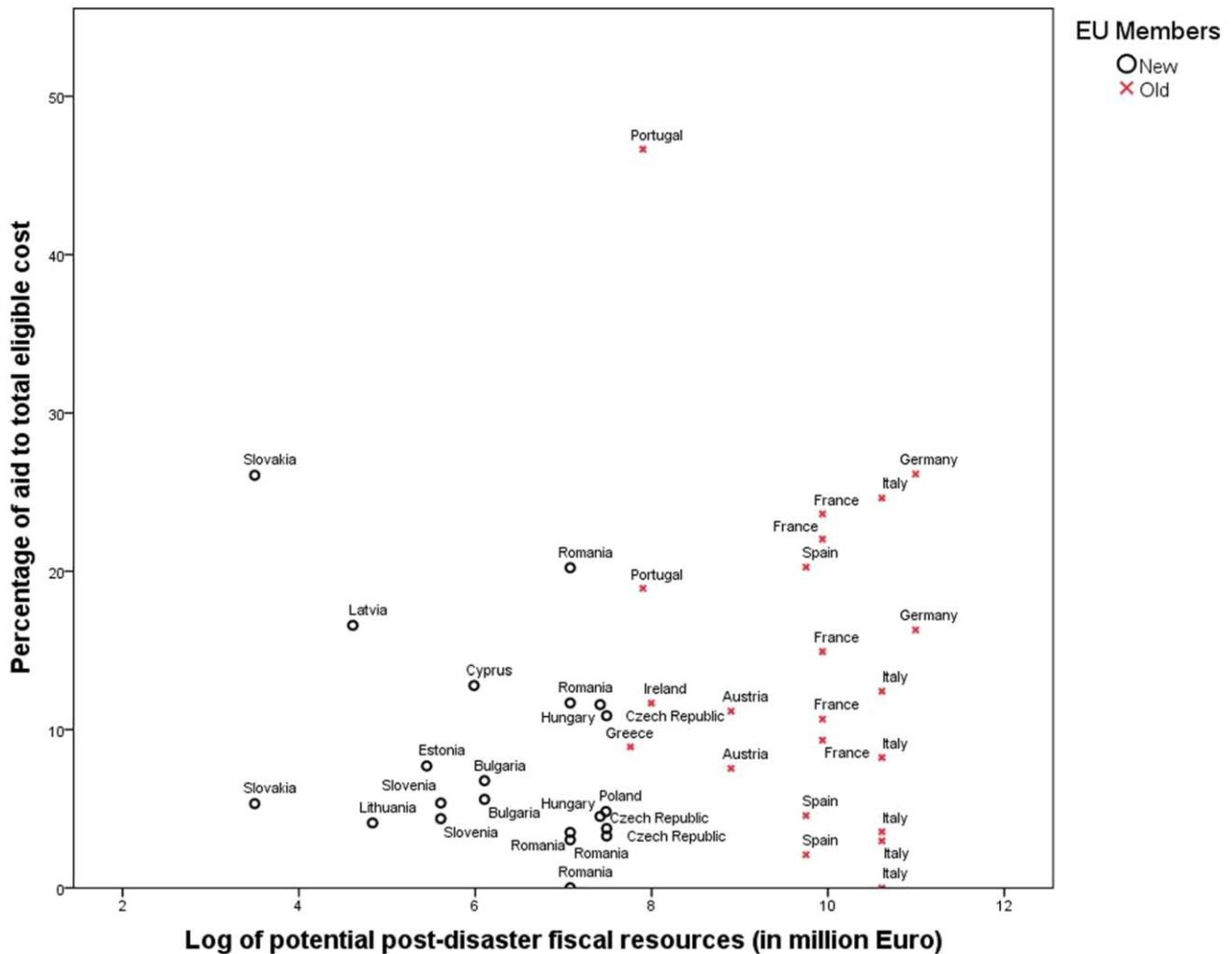


Fig 2: Past EUSF aid/eligible costs according to anticipated maximum fiscal resources of “old” and “new” EU member countries

Risk reduction

The recent EUSF reform strengthens the link between the Fund and DRR/CCA by introducing additional reporting requirements and making the EUSF aid conditional on the implementation of relevant EU law, such as the Floods Directive which requires flood risk mapping and thus sets the stage for flood risk reduction. The InsAdapt research demonstrated that this link can be significantly improved by changing the contingent nature of EUSF financing. Currently, contributions to the Fund are outside the regular EU budgeting procedure as the financing is raised only after a disaster occurs. The drawback of this contingent budgeting is that it bypasses the need to estimate potential liabilities before events occur. Direct budgeting, on the other hand, would require member states to estimate the hazard probability, exposure and vulnerability of public and private capital at risk, which would raise awareness of the risk and risk-reduction options.

Robustness

Considering flood risk only (without accounting for potential river basin interdependencies), the annual probability of depleting the Fund is 3.03 per cent, or, in other words, depletion can be

expected about once in every 33 years. Transferring this depletion risk through financial instruments, such as reinsurance or catastrophe bonds, can increase the Fund's robustness, although this can prove to be a costly strategy.

In sum, InsAdapt research formed the basis for recommendations to improve the performance of the EUSF. These recommendations include: (1) enhancing EUSF solidarity by changing the criteria for pay outs so that the Fund favours low-income countries, (2) increasing the EUSF's risk-reducing potential by changing the contingent nature of its financing, and (3) improving EUSF robustness with reinsurance, catastrophe bonds or other risk-transfer instruments.

Work package 4

Background and research questions

The Austrian government offers generous post-disaster compensation to victims of all natural disasters financed by its structured national disaster reserve with the result that households, businesses and farms, with the exception of windstorm, carry little private insurance for property and crop damage. For what is insured, Austrian insurers operate on a market basis; yet, premiums reflect only to some small extent the hazard, and they do not reflect preventative measures taken by the insured. A unique feature of the Austrian system is that in many provinces insured losses do not qualify for post-disaster public financial assistance. It has been suggested that this provision creates a strong disincentive to purchase insurance in addition to the "charity hazard" (disincentive that post-disaster compensation poses for the reduction of losses).

Although charity hazard is a strong argument for moving to a private insurance system, there is actually little empirical evidence for the existence of a charity hazard. WP4 added to the empirical evidence with a three-country survey. To isolate government post-disaster compensation as one (negative) driver of DRR, the research investigated the range of public and private incentives for risk reduction as perceived at the household level. Combined with the opinion of public and private experts this allowed us to achieve the overall objective of this WP, which is to elicit options specifically for Austria for reforming insurance practices and catastrophe insurance arrangements such that they better promote risk reduction and climate adaptation, and are politically, economically and socially acceptable?

Main results

The survey yielded important insights for designing and reforming national insurance and public compensation schemes with the aim to increase their potential to enhance private risk reduction. The following results are most salient for the Austrian case.

- The findings do not support the existence of a charity or moral hazard. Austrians, who have post disaster relief at their disposal, are equally or more protective of their homes than Romanians and the English (controlling for income). Based on this analysis, partial but institutionalized ex-post compensation does not appear to discourage private risk reduction. Whether there is charity hazard in terms of crowding out insurance is difficult to substantiate due to the recent trend to include limited natural disaster coverage in homeowner's insurance.
- Information provided locally (but not nationally) was positively associated with private risk reduction behaviour, particularly for avoidance and preparedness measures (APMs). This is strongest in England. Financial and in-kind assistance (e.g. by providing protection equipment) from public authorities is positively associated with the implementation of structural measures (SMs) both in Austria and England. Overall this shows that public incentives are more fruitful than insurer's measures.
- Public flood protection creates a sense of safety (levee effect), which is negatively associated both with risk perception and risk reduction behaviour. This applies to the overall model, Austria, and England individually in the case of APMs. It is rational to make location and other decisions based on reduced risk from public protection measures; however, if the added safety is perceived higher than it actually is, this may lead to maladaptation due to authorities,

businesses, and households underestimating residual risk. The potential for a levee effect highlights the relevance of targeted local awareness raising.

- The research shows that there is untapped potential for more targeted incentives for private risk reduction behaviour. At the same time the Austrian case shows that there is considerable room for insurance to complement public compensation efforts. A risk layering approach may be facilitated if public aid is consistently restricted to cases of exceptionally high flood damages and resulting hardship.
- Finally, in light of the difficulties associated with comprehensive risk-based pricing (see WP 1) alternative options for incentivizing or regulating risk reduction at the household level, such as local information campaigns and stricter spatial planning and building regulations, should be considered.

Given Austria's generous provisions for post-disaster assistance (up to 50% of damages) it was surprising to hear the opinion from participants at the expert workshop that only a small fraction of flood damage is compensated by public payments and private insurance companies. While the national government provides the funding, it is distributed by the provincial governments. The provincial government of Vorarlberg, for instance, does not compensate insurable damages unless they exceed 7200 EUR, which is a standard coverage of natural disaster damage that many insurance policies offer these days. In Salzburg damages on property in the high-risk (red) zone are only eligible for compensation in exceptional cases. In Lower Austria valid building permits are a precondition for public compensation for damages on properties.

Both in the public and in the private sector, isolated solutions for reforming the current systems have been put forward. In a public-private partnership between Austrian ministries and private insurers a risk-based insurance scheme for multiple perils has been proposed to cover 100% of damages. This proposal foresees mandatory insurance (Prettenthaler et al. 2009). The scheme is controversial as it is intended to be quasi-mandatory and may thus be interpreted as a new tax.

From the discussions at the expert workshop it was evident that there is no agreement on whether Austria should reform its dominantly post-disaster public assistance approach towards more private responsibility and insurance. Experts did agree that housing construction should be more emphatically restricted in high-risk areas and that Austrian households should take more preventative measures. The following options for linking disaster financing with disaster loss reduction emerged:

- Making post-disaster payments from the national disaster fund conditional on risk reduction measures that are pre-specified in a catalogue of preventive measures;
- A multi-level approach that requires insurance up to a maximum level, and only losses exceeding this limit are eligible for public compensation;
- Converging and harmonizing country-specific approaches to damage compensation;
- Cross-sectoral communication: institutionalization of a regular discussion forum for all relevant stakeholders, for example in the context of developing the flood risk management plan;
- Tax incentives for property level protection measures;
- Risk awareness campaigns to reduce risk dementia through participatory information design.

Concluding, we would like to emphasize that currently public compensation mainly aims at providing financial help in emergency situations whereas the insurance industry strives for universal coverage of damages in return for premiums. Therefore both approaches may be applied so they complement each other, thus achieving more comprehensive coverage of private damages.

5 Conclusions and recommendations

The InsAdapt project has advanced knowledge in the field of climate change adaptation by investigating the link between insurance instruments and disaster risk reduction/climate change adaptation, which continues to be a core issue in the climate adaptation discussions. At the start of

the project little was known about how insurance contributes or can contribute to DRR/CCA. InsAdapt addressed this gap by assessing insurance as well as public disaster relief arrangements at the enterprise, national and European scales. While several interesting and important insights can be drawn from this interdisciplinary project, we would like to highlight four key messages:

1. Available evidence suggests that current insurance practices at the enterprise, national and European scale fall significantly short of claims made by proponents of insurance as an instrument for disaster risk reduction and climate change adaptation, and at the same time there is potential for reformed risk transfer systems that provide this link.

Although it is claimed by insurers and academics that insurance directly contributes to disaster risk reduction and thus climate change adaptation, the InsAdapt project found little evidence to support this claim. At the level of individual insurance companies, the project team identified six practices that in theory can support risk reduction in the context of flood risk. However, available evidence – for the flood hazard - suggests that the implementation of DRR practices is still lacking. For instance, full risk-based pricing is rarely applied; most often insurers set their premiums on the basis of hazard and/or exposure, and vulnerability is hardly taken into account. Individual property inspections, an essential condition for full risk-based pricing, target large corporate clients (via the risk engineering service); yet the results of such flood risk assessments do not have a direct impact on insurance underwriting. Warranties are generally non-existent, and deductibles are often too low to provide a potent incentive. Most insurers post information on DRR on their websites, but survey evidence suggests that there is little impact.

A stronger link between insurance and disaster risk reduction will require a transformation of current insurance practices to incorporate or enhance all or most of the identified six insurance/DRR links. Interviews with insurance executives suggest that the transformation has already started; however, it will likely take many years for insurers to develop the appropriate set of tools to better promote disaster risk reduction and thus climate change adaptation.

2. The efficiency-equity trade-off is not a major constraining factor in pursuing DRR and CCA.

Solidarity through taxpayer support, or assuring that insurance premiums are affordable through direct or indirect subsidies, have been considered major constraints for reducing disaster losses. The reasoning is that households and governments, in the expectation that they receive public support, will invest less in preventative measures or insurance (charity hazard). Moreover, if premiums are subsidized, the price signal, for example for locating in a high-risk area, is distorted. Insurance can also provide a disincentive for reducing losses, which is dealt with by deductibles.

Solidarity with disaster victims has a long history in Austria, and it underlies the Austrian flood risk compensation system, where the government provides ex-post assistance to the victims of disasters. Critics of public disaster assistance argue that it creates strong disincentives for property owners to mitigate disaster risk and take out insurance policies. Our research shows that the charity hazard, at least in the sense of households taking precautionary measures, plays very little role. Austrians, who have post disaster relief at their disposal, are equally or more protective of their homes than Romanians and the English (controlling for income).

3. In Austria, improved coordination is needed between the public and private roles for financing disaster losses

Despite generous rules for post-disaster assistance from the Austrian catastrophe reserve fund, the workshop participants claim that a large percentage of flood losses are absorbed by households. The participants recommended a more comprehensive approach for financing disaster losses that would build upon private insurance coordinated with the public reserve fund. In designing a public-

private arrangement, it was agreed, emphasis should be put on conditions for DRR. This might be awareness raising campaigns, tax incentives, and making public compensation conditional on the implementation of risk mitigation measures. A risk-layer approach was suggested, for which households would be required to hold insurance for a specified loss, and only losses exceeding this limit would be eligible for public compensation. This approach is under exploration in the province of Vorarlberg and, if successful, could serve as a model for other Austrian provinces. In a developing country context, public capacities might, however, be insufficient for providing a high-layer of support, unless supported by international assistance.

4. The European Union Solidarity Fund (EUSF) could be reformed such that it promotes increased solidarity in Europe, is more robust to shocks and has more impact on DRR and CCA.

Regional risk pools are becoming more common, especially in the developing world as they enhance disaster resilience of highly vulnerable countries. The EUSF has been suggested as an example for the design of regional catastrophe pools; however, our findings show that the EUSF falls short of meeting its goals of solidarity, robustness and a vehicle for DRR and CCA.

The Fund allocates significantly more aid as a percentage of eligible costs to 'old' EU member states (EU15) that are more able to face up to their disasters than Central-Eastern European countries ('new' member states). It also falls short on incentivizing DRR. While recent reforms made EUSF aid conditional on the implementation of relevant EU law, which will help promoting risk mitigation activities, the role of the Fund could be defined more broadly to enhance its DRR impact. Most importantly, the contingent nature of funding the EUSF could be changed such that Member States explicitly take account of disaster risk in their budgeting process. Finally, the EUSF was shown to be moderately at risk to depletion, which could be reduced by backing the Fund with reinsurance or catastrophe bonds.

Our assessment also shows the advantages and disadvantages of different design options of current risk pools, including (besides the EUSF) the Caribbean Catastrophe Risk Insurance Facility, the South East Europe and Caucasus Catastrophe Risk Insurance Facility and the African Risk Capacity pool.

We expect that in addition to the research community, policymakers as well as the insurance industry will draw relevant and useful insight from these project results. As mentioned earlier, Stefan Hochrainer-Stigler, member of the InsAdapt team, was invited by the European Parliament to provide expert testimony during the reform process of the EUSF. Our work also attracted the attention of one of the major insurance companies, Zurich Insurance, and currently we are working together with their representative on a policy brief to disseminate our findings more widely within the insurance industry.

C) Project details

6 Methods

Work package 1

WP1 examines the important questions – if and how insurance is linked to disaster risk reduction and climate change adaptation – both in theory and practice by investigating flood insurance practices in wealthy, developed countries. We confine our analysis to flood risk since it is the most devastating climate-related hazard in terms of human and economic losses, and flood insurance is well established in many wealthy countries. We assess the available evidence based on a review of the grey and peer-reviewed academic literature as well as extensive interviews with insurance representatives. This entailed a detailed survey of company websites, including documentation of

corporate social responsibility, carbon disclosure projects and other technical reports. In addition, 20 face-to-face and telephone interviews were conducted with high-level insurance representatives, specifically executives and heads of risk engineering departments in Europe, North America and Australia, as well as risk engineers, underwriters and other insurance experts.

Work package 2

We reviewed residential flood insurance solutions in 20 selected countries: Austria, Australia, Belgium, Canada, Czech Republic, Germany, Finland, France, Hungary, Iceland, Japan, Netherlands, Norway, Poland, Romania, Slovakia, Spain, Switzerland, the United Kingdom, and the United States of America. We chose these countries because they represent institutional arrangements that span the main characteristics of insurance systems across the EU, while the insurance programs outside of Europe provided useful comparative examples. The selected systems differentially include common hazards, such as storms, hail, floods, earthquake, and also landslides or subsidence. These risks are covered separately or bundled, for example, with a fire policy or an “all hazards” policy. They differ with respect to the extent of cover offered, as well as indemnity limits, and whether the policies are compulsory, bundled or voluntary. They differ institutionally with regard to the involvement of the public authorities and private insurers, and, importantly, on how they link their contracts to risk reduction.

Based on published and grey literature, and supplemented by expert interviews, we describe these systems according to distribution of public and private roles, as well as a set of design features (Table 2).

Table 2: Roles and design features of disaster insurance and relief arrangements

Public vs. private roles	<ul style="list-style-type: none"> • Is flood insurance provided by the private sector, the public sector, or through public-private collaboration? • In cases of public-private collaboration, what are the respective roles? • Are insurers bearing the risk, sharing it, or are they financial intermediaries via their marketing networks and claims adjustment expertise? • Are public post-disaster relief mechanisms in place?
Voluntary vs. Mandatory	<ul style="list-style-type: none"> • Is flood insurance purchased voluntarily by homeowners, is it mandatory, or mandatory depending on a home mortgage? • Are insurers required to offer flood insurance to residents (e.g., those living in high-risk zones and those with a mortgage)?
Bundled insurance	<ul style="list-style-type: none"> • Is flood insurance provided as component of an existing homeowner’s property insurance policy, as part of the coverage under a homeowner’s policy or as stand-alone coverage?
Risk-based premiums	<ul style="list-style-type: none"> • How are insurance premiums determined? Do premiums reflect risk fully, i.e. are they based on hazard, exposure and vulnerability, only partially, for example based on hazard and exposure, or not at all as in cases when premiums are uniform across all homeowners? • Are premium subsidies offered to those who may need or merit special treatment (e.g., low-income households)?
Incentives to invest in risk reduction	<ul style="list-style-type: none"> • Are there other incentives for homeowners or communities that take on or invest in risk reduction measures?

Work package 3

WP3 relies strongly on statistical modelling, including stress testing, the estimation of post-disaster fiscal resources of EU governments and the application of copulas to assess the spatial correlation of flood risks across European river basins, which has important implications in the context of risk pooling.

Specifically, we simulated 1 million disaster events per member states and estimated the Fund's annual liability by calculating and summing up the required EUSF aid generated by those events that met the Fund's intervention threshold (Fig 3). The simulations made use of estimated flood loss distributions on the country scale for all EU member states, derived from Luger et al. (2010). A Monte-Carlo sampling procedure based on the inverse transformation method generated loss event (one million loss events for each country, as mentioned above).

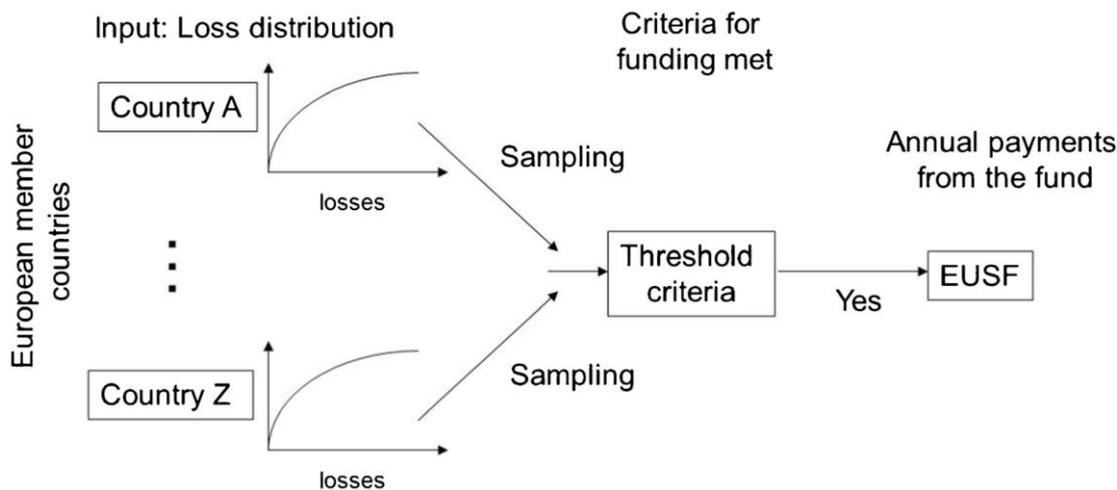


Fig 3: modeling procedure to analyse the European Union Solidarity Fund

The in-house IIASA catastrophe simulation model, CATSIM, was used to estimate the coping capacities of EU member countries, which was necessary for the assessment of the EUSF solidarity performance (by comparing the coping capacities to the EUSF aids received after disasters). Fiscal capacities include the government's potential to divert funds from its budget or to borrow on the domestic and international markets, as well as its likely access to outside assistance. Fiscal capacity estimations take account of sovereign debt ratings, current lending interest rates, the ratio of government expenditure to government revenue (with a threshold that indicates the upper percentage of diversion) and the world average disaster aid (about 10% of losses).

Work package 4

The research team designed a household telephone survey that was carried out by the Austria-based company, IMAS, using computer assisted telephone interviews (CATI) targeting homeowners (and renters if applicable) of voting age in flood risk areas in Austria, England and Romania (n=600/country). The sample was selected from postal zones with a large share of properties in high flood risk zones. Despite EU regulations, e.g., the Floods Directive that requires flood risk mapping, there are no coherent standards for the categorization of flood risk, the design of flood risk maps, and the resolution and format in which data is available. Therefore different baseline data had to be used to determine the sample frame for the survey. We selected respondents based on their own perceived risk by means of a pre-selection question, rating their own risk at a scale of 1 = *high flood risk* to 5 = *no flood risk*. Respondents reporting no flood risk or reporting that they live above ground level were excluded from the survey. In a second pre-selection question we determined whether the respondent solely or collaboratively made decisions concerning flood risk in the household. Non-decision makers were also excluded from the survey.

We consulted experts and existing studies in order to ensure the relevance and validity of the survey questions. In Austria we extended this to a more comprehensive interview effort, conducting 15 semi-structured interviews with people in flood prone areas, as well as public and private experts representing involved interest groups.

We presented the results from WP2 as well as the Austrian section of the survey in an expert workshop in Vienna. This workshop involved not only national level representatives from various

ministries and the Austrian Insurance Association, but also regional insurers and policy-makers from the provinces, who are responsible for distributing disaster relief. Furthermore, persons active in a citizen initiative and academic experts joined the discussion on reform options for the current Austrian flood insurance and compensation practices.

7 Work and time schedule

InsAdapt: Project Workflow and timeline	2012				2013				2014				2015				2016																	
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Work package 1	planned												actual																					
Work package 2	planned												actual																					
Work package 3	planned												actual																					
Work package 4	planned												actual																					
Dissemination	planned												actual																					

8 Publications and dissemination

The project team has been using various channels to dissemination of the main results of the InsAdapt project. In addition to the numerous scientific publications (see list below, publications are also annexed to this report) the project team was particularly keen on producing highly policy relevant outcome and share it outside of the scientific community. One of the major achievements in that respect is that the InsAdapt team was invited by the EU Parliament to provide expert witness at recent hearings addressing the robustness of the EU Solidarity Fund (on the basis of our work under WP3). The main findings of InsAdapt were also presented at the second European Climate Change Adaptation Conference, a major gathering of European policy-makers, industry representatives and researchers in the field of climate change adaptation. We also organised a workshop targeting Austrian policymakers, to elicit their views on Austrian reform packages and collect their feedback. Based on these meetings and other research activities, we have published several working papers and reports. A complete list can be found below.

Journal articles

- Hochrainer-Stigler S, Linnerooth-Bayer J, Lorant A (2015) The European Union Solidarity Fund: an assessment of its recent reforms. *Mitigation and Adaptation for Global Change*. DOI: <http://dx.doi.org/10.1007/s11027-015-9687-3>
- Jongman B, Hochrainer-Stigler S, Feyen L, Aerts JCJH, Mechler R, Botzen WJW, Bouwer LM, Pflug GC, Rojas R, Ward PJ (2014) Increasing stress on disaster-risk finance due to large floods. *Nature Climate Change*, 4(4):264-268. DOI: <http://dx.doi.org/10.1038/nclimate2124>
- Linnerooth-Bayer J, Hochrainer-Stigler S (2015) Financial instruments for disaster risk management and climate change adaptation. *Climatic Change*, 133(1):85-100 DOI: 10.1007/s10584-013-1035-6
- Hanger S, Linnerooth-Bayer J, Surminski S, Lorant A, Nenciu Posner C, Armaş I and Ionescu R, in review. Insurance, public assistance and household flood risk reduction: A comparative study of Austria, England and Romania. *Risk Analysis*.
- Lorant A, Linnerooth-Bayer J and Hanger S, in review. Insurance and climate adaptation: does the practice validate the theory?. *Mitigation and Adaptation Strategies for Global Change*.
- Hochrainer-Stigler S and Lorant A, n.d. Evaluating Partnerships to Enhance Disaster Risk Management using Multi-Criteria Analysis: An Application at the Pan-European Level. (in progress)
- Hanger S, Bayer J and Lorant A, n.d. Designing National Catastrophe Insurance Systems: Equity and Efficiency. (in progress).

Book chapter

- Kunreuther H and Michel-Kerjan E (2013) Managing Catastrophic Risks Through Redesigned Insurance: Challenges and Opportunities. In: Dionne G (ed) *Handbook of Insurance*. Springer, New York, pp 517-546

Reports and working papers

- Hanger S and Riegler M (2016) Anreize zur Reduktion von Schäden durch Naturkatastrophen mit besonderem Augenmerk auf Möglichkeiten im Kontext von Kompensation und Versicherung von Hochwasserschäden (IIASA Working Paper No. 16-3). IIASA, Laxenburg.
- Atreya A, and Kunreuther H (2016) Measuring Community Resilience: The Role of the Community Rating System (CRS). Wharton working paper. Available at: http://opim.wharton.upenn.edu/risk/library/WP201607_Measuring-Community-Resilience-CRS.pdf Cited: 24 August 2016
- Michel-Kerjan E, Atreya A and Czajkowski J (2016) Linking the five capitals of flood resilience to FEMA's Community Rating System. Toward a holistic view of community flood mitigation activities. Wharton working paper
- Atreya A, Hanger S, Kunreuther H, Bayer J and Michel-Kerjan E (2015) Insuring flood risk: a comparison of 25 countries. Wharton working paper. Available at:

http://opim.wharton.upenn.edu/risk/library/WP2015_FloodInsurancePrograms-25Countries_2015-06-28.pdf Cited: 24 August 2016

- Hanger, S., Bayer, J., Lorant, A., Atreya, A., Michel-Kerjan, E., Kunreuther, H., forthcoming. Designing National Catastrophe Insurance Systems. (IIASA Working Paper). Laxenburg, Austria.
- Hanger, S., Linnerooth-Bayer, J., Surminski, S., Armaş, I., Nenciu, C., Lorant, A., Ionescu, R., forthcoming. A household survey on flood risk mitigation and design features of public and private insurance and compensation systems: Austria, Romania and England (IIASA Working Paper). IIASA, Laxenburg.

Other publications

- Hanger S, (2015) Die Deckung von Katastrophenschäden – zwischen staatlicher Kompensation und privater Versicherung. Newsletter Klimawandelanpassung 15. Available via: http://www.klimawandelanpassung.at/ms/klimawandelanpassung/de/newsletterregistrierung/kwa_archiv/
- Lorant A, Linnerooth-Bayer J and Szoenyi M, n.d Policy brief: Insurance and climate adaptation: six potential links (in progress)

Conference participation

- Hanger, S (2015) Designing national flood insurance systems: the equity-efficiency trade-off. European Climate Change Adaptation Conference (ECCA), Bella Center, Copenhagen, Denmark, 12-14 May, 2015
- Lorant, A (2015) Do insurers help Europe to adapt to climate extremes? European Climate Change Adaptation Conference (ECCA), Bella Center, Copenhagen, Denmark, 12-14 May, 2015
- Hanger et al. (2014) Risk Financing and Risk Reduction - a Comparison National Arrangements Across Developed Countries and Specific Lessons From Austria 2002-2013. 6th International Conference on Flood Management, São Paulo, Brazil, 16-18 September, 2014
- Hanger, S., Riegler, M., 2016. Der Einfluss von Versicherungs- und Kompensationslösungen auf privates Hochwasserschutzverhalten Österreich im Vergleich mit Rumänien und England.

Special contribution to policy discussions

- Hochrainer-Stigler S (2014): Expert testimony at a public hearing of the European Parliament on 22 January 2014

Project workshop

- Anreize zur Reduktion von Schäden durch Naturkatastrophen mit besonderem Augenmerk auf Möglichkeiten im Kontext von Kompensation und Versicherung von Hochwasserschäden: Experten- und Stakeholder Workshopp 9:30-15:00, 20. November 2015, Hotel Altstadt, 1070 Wien

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