



## Analysis

# Incentivising flood risk adaptation through risk based insurance premiums: Trade-offs between affordability and risk reduction



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## ABSTRACT

The financial incentives offered by the risk-based pricing of insurance can stimulate policyholder adaptation to flood risk while potentially conflicting with affordability. We examine the trade-off between risk reduction and affordability in a model of public–private flood insurance in France and Germany estimating household flood adaptation decisions in response to financial insurance incentives. An integrated model of household level mitigation behaviour and insurance premiums is developed. The model investigates how aggregated household adaptation behaviour differs under financial incentives as compared to when households act on their own subjective risk beliefs. The results indicate that insurance based incentives are able to promote adaptation. The incentives could reduce residential flood risk by 12% in Germany and 24% in France by 2040. The higher level of flood risk in France results in a strong present incentive to reduce risk. Rapid growth of flood risks in Germany results in more effective incentives in later periods. Insurance is unaffordable for approximately 20% of households at risk. Providing vouchers, to correct for unaffordability, after 2040 has a lower cost than the total incentivised damage reduction. A policy recommendation is that strengthening the link between flood insurance and financial incentives can guide household level adaptation.

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## 1. Introduction

Flooding is a natural disaster that can have a great effect on humanity (UNISDR, 2011). A combination of socio-economic development and climate change means that flood risk could increase in the future (Jongman et al., 2014). This results in a growing interest in strategies that can be effective in adapting to future flood events; these strategies include both disaster risk reduction measures, such as flood-proofing buildings (Aerts et al., 2013), and financial risk transfer instruments, such as flood insurance (Botzen and van den Bergh, 2008). Insurance allows individuals to cope with risk by sharing financial risks across policyholders. However, insurance may become less attractive for households when insurance companies raise premiums to reflect increases in the underlying risk (Botzen et al., 2009a). The challenge is to design an insurance scheme that is affordable while offering financial protection and incentives for policyholders to reduce risk (Kunreuther, 1996; Botzen et al., 2009b; Kunreuther and Michel-Kerjan, 2009; Mechler et al., 2014; Penning-Rowsell and Pardoe, 2012; Surminski and Oramas-Dorta, 2014).

Risk-based insurance pricing is a key condition for incentivising both risk reduction and the willingness of insurers to offer coverage

(Blanchard-Boehm et al., 2001; Kunreuther and Michel-Kerjan, 2009). The reason for this is that it allows insurers to match premium income with the expected indemnity payments (Kousky and Kunreuther, 2013). Moreover, such a policy acts as a price signal of risk by charging premiums according to the risk encountered. This signal can provide an incentive for household level adaptation if an insurer provides a premium discount to policyholders who reduce their risk; for example, risk can be reduced by having flood-proofing buildings.

The relevance of providing financial incentives to promote individual flood risk adaptation can be found in the observation that few floodplain inhabitants voluntarily invest in cost-effective flood risk mitigation measures (e.g. Kreibich et al., 2005). Such behaviour can be explained by several individual decision-making processes (Kousky and Cooke, 2012). For example, many individuals underestimate flood risk and the benefits of reducing it (e.g. Bubeck et al., 2013; Poussin et al., 2014). Offering premium discounts means that the decision to invest in disaster risk reduction by policyholders is simplified to comparing the costs of the measure using premium discounts instead of the perceived risk reduction benefits, which are often underestimated. However, the effectiveness of such financial incentives has hardly been studied empirically (Surminski, 2014). An exception is Botzen et al. (2009b) who used survey methods to show that many Dutch homeowners express the intention to take such measures for financial rewards.

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Risk-based pricing and affordability are potentially contradictory aspects of the insurance scheme since risk-based premiums can make insurance contracts unaffordable for some households (e.g. Kunreuther and Michel-Kerjan, 2009). This may be inferred from Zahran et al. (2009) who show that flood insurance uptake is positively related to community-wide implementation of flood risk mitigation measures in the USA; the implementation is rewarded through premium discounts from the Community Rating System. However, flood insurance premiums in the USA are not fully risk based, and that study did not examine the affordability of risk-based flood premiums for low-income individuals (Zahran et al., 2009; Michel-Kerjan et al., 2015).

To make flood insurance affordable, it is sometimes provided through public–private partnerships in which the government covers part of the risks instead of a private reinsurer (e.g. Paudel et al., 2012) or premiums are subsidised (Burby, 2001). Subsidisation of premiums improves affordability, but this results in policyholders not fully made aware of their risk and thus generates incorrect incentives for risk management. This situation can be overcome by providing the subsidy in the form of a temporary voucher for low-income households, and the cost can be covered using overall taxation, as proposed by Kousky and Kunreuther (2013).

This paper conducts an analysis of the effectiveness of flood insurance premiums as a means to provide financial incentives that can encourage policyholders to invest in flood-proofing measures, which can promote adaptation to changing future flood risk. The potential trade-off between risk reduction and the affordability of risk-based premiums is also investigated. In addition, this study develops a model of public–private flood insurance, which is combined with both a model of household flood preparedness decisions and a flood risk model that provides input for estimating insurance premiums at an aggregated level. The behavioural model is based on a cost–benefit framework that accounts for the role of individual risk perceptions and the perceived risk reduction of flood-proofing in individual decision making as well as insurance incentives. Although our application focussed on France and Germany, there is a wider interest in linking natural disaster insurance and risk reduction incentives in the EU as is reflected by the publication of a Green Paper on this topic (European Parliament, 2014).

The paper continues with a description of the methodology and data in Section 2. Section 3 presents the results of the model; the results are then discussed in Section 4, followed by the conclusion of this study in Section 5.

## 2. Methods: Integrated Insurance, Household Flood Preparedness and Flood Risk Model

### 2.1. Insurance Model

#### 2.1.1. Modelled Insurance Scheme

It has been argued that the French and German insurance markets can provide better incentives for risk reduction. France has a compulsory natural hazard insurance scheme known as *CatNat* with flat-rate premiums unrelated to the natural hazard risk faced. This scheme offers reinsurance by the Central Fund for Reinsurance (CCR), which is owned by the French state. *CatNat* aims to promote risk reduction through risk prevention plans, which are community level plans to manage risk by using zoning regulations or by requiring households to employ risk mitigation measures. The lack of risk-based pricing weakens the incentives for policyholders to go beyond these minimum requirements. Several studies have suggested differentiating *CatNat* premiums according to the risk faced by policyholders to provide stronger incentives for risk reduction (e.g. Van den Bergh and Faure, 2006; World Bank, 2012; Poussin et al., 2013). Germany currently has a voluntary insurance scheme with a low take up rate of 19% for content insurance and 33% for residential building insurance (GDV, 2013). Flood insurance premiums are based on the flood probability, but insurers do not

actively promote household investments in risk reduction (Thieken et al., 2006). Moreover, the German government is able to provide ad-hoc disaster relief payments after natural hazard events occur. This kind of assistance can hamper the functioning of the private flood insurance market by introducing charity hazard. This charity hazard implies a reduction in demand for flood coverage since uninsured individuals expect compensation for flood damage from the government (Osberghaus et al., 2010; Raschky and Weck-Hannemann, 2007). Nevertheless, in voluntary insurance markets, ad-hoc disaster relief is important from a social perspective because uninsured households can receive assistance for recovery in the aftermath of a flood. Schwarze and Wagner (2007) have called for a scheme that promotes affordability by making flood insurance compulsory and by having the state cover part of the flood risk. In addition, investments in risk reduction should be encouraged by financial insurance incentives.

This study examines the introduction of a hybrid insurance scheme of the current French and German insurance market structures. The features of the proposed scheme are presented in Table 1 and are based on the work by Paudel et al. (2012). This insurance covers flood damage that is done to residential properties. Lamond and Penning-Rowsell (2014) state that a robust insurance scheme spreads insurable risk across a population that is aware of the risk faced and can afford the premiums charged. Moreover, they suggest that there should be mechanisms in place to provide capital to insurers in case of abnormally large losses; for example, one possible mechanism is reinsurance. They also argue that an insurance scheme should integrate incentives for risk reduction as a mechanism to reduce potential pressure placed on the scheme in the future. Combining the above components of risk transfer, risk pooling and proactive risk reduction into a coordinated scheme helps produce the optimal portfolio of economic risk management (Porrini and Schwarze, 2014). In addition, such a coordinated scheme across a country can have the effect of providing accurate information for policyholders to act upon the risk they face (Filatova, 2014).

The insurance scheme presented and investigated in this current paper is concerned only with fluvial (river) flood risk, which is common for flood insurance applications as Blanksby and Ashley (2013) argue (see also Jongman et al., 2014; Aerts and Botzen, 2011). However, it must be noted that while this study will focus on riverine floods, flash floods are a major cause of flood damage as well. The investigated scheme is a layered public–private partnership where policyholders, private insurers, and a government reinsurer cover different parts of the flood losses incurred. The distributions of risks among these stakeholders are based on the optimal allocations as found in the work by Paudel et al. (2015). The objective of the study by Paudel et al. (2015) is to gain an insight into efficient and practically feasible allocations of risk in a public–private flood insurance system. In particular, Paudel et al. (2015) develop a model to estimate economically optimal

**Table 1**  
Features of a public–private flood insurance scheme.

Feature	Description
Public sector responsibility	Maintain flood protection standards; provide reinsurance; provide vouchers to overcome insurance unaffordability
Private sector responsibility	Provide (re)insurance policies at the predetermined rates
Risk zoning and risk maps	Yes at the level of NUTS 2 regions
Damage covered	Residential property and content damage
Policy deductibles	15% of damage suffered
Premium setting rule	Risk-based between NUTS 2 regions; flat within regions; alters due to risk reduction actions at an individual level
Reinsurance	Risk neutral government reinsurer for rare flood events; private reinsurers cover more common events
Purchase requirement	Flood coverage is compulsory for households at risk of flooding.
Risk reduction incentive	Premium discounts

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