NeWater

ADAPTIVE FLOOD MANAGEMENT: THE ROLE OF INSURANCE AND COMPENSATION IN EUROPE

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Policy Summary

Large-scale floods have the potential to generate substantial economic losses. Within Europe, governments have dealt with these losses in different ways, which may or may not have enhanced adaptability of their societies. In this research we develop a classification of insurance and compensation systems to deal with losses from floods. We suggest that, from the perspective of adaptive capacity to uncertain future risks, commercial flood insurance is to be preferred on the basis of the assumption that commercial insurance premiums are better capable of transferring price signals of actual flood risks. Such systems can therefore give stronger incentives for risk reduction. Next, we describe the actual insurance and compensation systems for dealing with flood losses that have been set up in 19 European countries. Our findings are that the availability of commercial flood insurance is widespread in Europe. However, actual market penetration can be called high (50% or more) in only 7 countries. To get an indication of the dynamic behind this, we statistically assess whether or not the choice of flood risk management system and factors such as market penetration are related to flood risks and socio-economic aspects, such as population size and GDP. This analysis indicates that country surface area and population size seem to be the dominant factors for determining the type of flood insurance system, and therefore possibilities may exist in some European countries to increase the share of commercial flood insurance. In some countries flood hazards and flood risks may be too high for the private sector to provide full cover. This implies also that there is a continued role for governments in helping to increase the market penetration of private flood insurance, as well as for loss prevention programmes. Further harmonisation of insurance regulation in Europe could increase the possibilities for private insurance companies to take on risks.

1. Introduction

Large-scale floods can generate substantial impacts. Global direct economic losses from so-called great floods have increased from approximately 32 billion during the period 1950-1959, to 245 billion US dollars during the period 1995-2004 (Kron, 2005). Catastrophic natural disasters have the potential to reduce the number of insurance firms that underwrite coverage and reduce the amount of premiums collected, as shown for instance for the USA (Born and Viscusi, 2006). For the most part, the increases in losses from weather related disasters have been caused by increased exposure, as growing numbers of people and amounts of capital are located in areas that are at risk from natural hazards (e.g. Changnon, 2003). Some have argued that global warming and subsequent increases in the frequency and/or severity of extreme weather events may have played a role as well (e.g. Mills, 2005; Höppe and Pielke, 2006).

Some weather related risks, such as storm and hail risks are usually well covered in most developed countries through voluntary insurance. The market penetration of storm insurance is above 75% in 14 out of 18 European countries (CEA, 2005). However, a number of factors make that commercial insurance of flood risk based on individual and voluntary policies remains difficult (Munich Re, 1997; Swiss Re 1998a):

- Since floods in coastal and river floods can lead to an enormous accumulation of losses, if they affect a low-lying area with substantial amounts of assets, leading to correlated risks of the different insurance policies;
- Flood risks are not uniformly distributed over space in regions or countries, as they tend to occur in particular confined locations. Therefore only a certain part of the population is at (greatest) risk and may want to buy insurance, which is called adverse selection. Adverse selection is a problem for insurance companies if they have difficulty in screening customers (information asymmetry) and/or if they are not allowed to charge risk-based premiums. Adverse selection would make the system economically unsustainable, as a substantive population is required to carry the burden of the premiums needed to cover the losses. For policymakers, adverse selection leads to a potential collective action problem, as only part of the population would support efforts to reduce or transfer risks;
- In order to set a premium that adequately reflects the cost of risk, insurers need to be able to determine to a particular degree the expected losses and their return period. Flood risks are relatively difficult to assess, as for many countries there are no long records of historic losses available, also because large flood, such as storm surges, are relatively rare. The numerical modelling of floods is to some extent a solution, as it may provide insight in the possible size of loss events. Also loss events with low return periods can be simulated in this way. However, the accurate assessment of return periods and potential losses from floods can be much more difficult for situations that are hydrologically more complex, such as in The Netherlands, (see Floris, 2005; Van der Most and Wehrung, 2005).

Within Europe, governments have developed different ways in which to deal with losses from flood risks (e.g. Van Schoubroeck, 1997). In most countries, the government has a role in securing coverage of flood losses. This is often achieved through insurance regu-

lation, for instance through the prescription of compulsory natural hazards cover, that is sold together with commercial fire contracts. Alternatively, the government may set up a system similar to traditional insurance in the sense that funds are collected ex ante (before the event), either through premiums, or taxes on insurance premiums. Finally, governments may provide loss compensation from tax money, either ad hoc or through budget reservations, borrowing or running budget deficits.

In the future, there may be an increase in loss potentials due to ongoing economic development and increasing vulnerabilities. Additionally, probabilities of extreme weather events could increase due to future climate change, which may reduce the availability and affordability of insurance (Mills, 2005). In this light, current practices with regard to compensation and insurance of losses due to flooding may need to be reconsidered. Within the literature on adaptation to climate change, insurance is often mentioned as an important tool to transfer risks and create incentives for risk reduction (e.g. Dlugolecki, 2000; Vellinga *et al.,* 2001; ABI, 2005; Bouwer and Vellinga, 2005; Bouwer and Aerts, 2006; UNEP-FI, 2006). The climate policy arena has also identified insurance as a means to accommodate increasing risks due to climate change, as can be read in a recent report on technologies for adaptation to climate change by the United Nations Framework Convention on Climate Change (UNFCCC, 2006). However, only few have addressed how exactly insurance would contribute to adaptation.

Within water resources management, thinking on so-called adaptive management also puts emphasis on the development of non-structural measures that may reduce risks, such as tools related to finances and risk. Typical characteristics of adaptive regimes would in this respect include "financial resources diversified using a broad set of private and public financial instruments" (Pahl-Wostl, 2007: table 1).

Within this latter context the question can be asked what particular aspects of flood risks management contribute to an adaptive approach towards increasing natural hazard risks. Increasing natural hazard risks in turn lead to the question what adjustments in flood insurance systems are exactly needed and which adjustments can be made in order to be able to sustain current insurance systems. Adjustments could consist of risk reduction, improved loss sharing between public and private sector to increase insurability (e.g. Swiss Re, 2002), or reform of insurance sector regulation (e.g. Huber, 2004). Flood insurance systems may thus contribute to adaptive management of flood risks. However, the different insurance systems in operation now may need to be adjusted as well in view of changing risks. These are the two main issues we want to address, through an overview of flood insurance systems in Europe and their properties.

The goal of our research is to assess government compensation systems and commercial insurance arrangements for dealing with flood losses in a number of European countries on the basis of existing literature. Flood losses in this research cover property losses to buildings and their content, rather than loss of life or business interruption. Our aim is not to provide an in depth and detailed review of each national system, as this is already done by a number of original sources from which we report. Instead we provide a cross-country overview of broad characteristics and differences that may serve as an illustration of the applicability of different insurance systems. Our research involves an explorative exercise, which tries to generate some general conclusions on the functioning of flood insurance systems and their contribution to adaptive management. Our aim is to

divide different systems in Europe into categories, and describe some general characteristics for each of these categories.

The following section provides an introduction into the relationships between insurance, flood risk management and the role of government and private sector, as well as aspects that may contribute to adaptive management. Next, we present the methods and datasets that are used for the comparative research. In the two final sections, the results are presented and discussed, and some conclusions are drawn.

2. Flood insurance and compensation systems and adaptive management

Flood insurance and compensation systems are important parts of strategies for dealing with flood risks. In order to assess possibilities for further adjustments in insurance and compensation systems it may be useful to gather information on the properties of the various flood insurance systems and especially on the roles of governments and private enterprises in flood insurance systems. This focus on the roles of governments and private sector is not new (e.g. Epple and Lave, 1988; Nutter 2002; Green and Penning-Rowsell, 2004), but it appears that most comparative studies on properties of insurance systems for natural hazards have provided a rather general overview of insurance system functions and coverage (e.g. OECD, 2003; Paklina, 2003; CEA 2005), have focused on the legal aspects of flood insurance systems (e.g. Van Schoubroeck, 1997), or they have compared insurance systems in terms of coverage and market penetration (e.g. Swiss Re, 1998b). There is increasing evidence, however, that a combination of natural and institutional aspects explains the vulnerability to natural disasters and their impacts (Kahn, 2005; Ahrens and Rudolph, 2006). The ways in which residual losses are covered through insurance and compensation probably also reflect the broader institutional setting.

2.1 Government role

Flood risk management consists of the two main aspects of protection against floods and response to the consequences of floods, including compensation of any losses that may occur (Huber, 2004). Governments have a central role in flood protection, mainly by designing and executing flood protection programmes aimed at maintaining public safety and suitable environments for economic development (Dahlström *et al.,* 2003). As mentioned before, three distinct roles emerge for the government with regard to dealing with residual losses: A government may either regulate the private insurance sector market, it may set up own systems for primary insurance or reinsurance, or it may provide ex ante relief, as an insurer of last resort. Some national governments have regarded their liability for flood losses as too large, and are making attempts to shift a larger share of the risk to the private market, for instance in Belgium (Van Schoubroeck, 2003) and The Netherlands (ACW, 2006).

Several developments are already ongoing in the area of policies for flood risk assessment and protection, as well as loss compensation, that may address these issues both at the national and European level. For instance, a proposed Flood Water Directive[1] aims at regulating downstream flood risks, with requirements for EU member states to assess and eventually reduce flood risks. The EU Solidarity Fund[2] was installed after the catastrophic flooding in Central Europe in 2002. The fund currently has an annual budget of 1 billion Euros, and is intended to supply emergency financial aid to member state governments. The fund potentially limits the demand for commercial insurance if such reim-

[1] http://ec.europa.eu/environment/water/flood_risk/pdf/com_2006_15_en.pdf
[2] http://europa.eu/scadplus/leg/en/lvb/g24217.htm

bursements would, directly or indirectly, allow victims to obtain aid without paying a premium.

2.2 Commercial insurance

Insurance systems set up by the private sector have the power to transfer risks from the local level to national and global insurance markets through primary insurance and reinsurance. Additionally, ongoing mergers and consolidation within the financial services market would increasingly allow insurance companies to shift risks towards the capital market and would reduce the vulnerability of the sector (Vellinga *et al.,* 2001). However, it has to be noted that primary insurance in Europe is still very much a national or even sub-national level activity. This national focus is likely to be largely due to the fact that insurance regulation varies considerably between countries.

The application of commercial insurance may also lead to more flexible and adaptive management of risks, as the sector is better equipped to estimate potential losses using models and historic data and set adequate premiums. Price signals are transferred through the setting of premiums to individual citizens about their actual risks, which may influence their behaviour and decisions, for instance regarding house construction (Kunreuther, 1974).

In government compensation systems, governments may be more inclined to grant compensation just before elections, for example shown for the US (Downton and Pielke, 2001). The same holds true for European governments, based on either ex ante premium or ex post compensation, for instance in Belgium and The Netherlands. Within the commercial system the decision to provide compensation is not politicised, but bound by insurance contracts.

Some specific efforts of the commercial sector are targeted towards risk reduction. These activities may also be beneficial for reducing the impacts from climate change, although most efforts in the insurance sector related to climate change appear to be aimed at reductions of greenhouse gas emissions (Mills and Lecomte, 2006). However, indirect incentives may be given if loss reduction is stimulated through insurance premiums that are based on actual risks.

2.3 Adaptive management

Adaptive management is an approach to the management of ecosystems that anticipates change and addresses uncertainty. To a degree the agenda of adaptive management is about adaptation to foreseeable climatic change. At a more fundamental level however, adaptive management is about “adaptability”, which refers to concepts such as learning, openness, and flexibility of approach. Adaptive management is increasingly embraced as a leading paradigm for water management (Pahl-Wostl, 2007; Huitema *et al.,* submitted). This justifies the question how insurance and compensation systems relate to adaptation and adaptability.

Ongoing development in at-risk areas and possible changes in extreme weather events, may lead to growing risks and therefore an increasing demand for loss compensation of some sort, either through commercial insurance or government compensation. As mentioned earlier, flood risk management consists of the important factors of flood protec-

tion and flood loss compensation. Measures for flood protection and exposure reduction are closely linked to decisions on land use allocation. Price signals trough differentiated commercial insurance that reflect actuarial risks may contribute to incentives to reduce exposure. For instance, conditions for cover and premium reduction may be applied if individual policyholders manage to reduce risks. Additionally, insurance companies may decide that the risk in certain areas is no longer insurable. This could lead to pressure on the government to invest in flood risk reduction. This situation has been observed in the UK, where insures have announced to be no longer prepared to take on risks, if land use planning and flood defences would not be improved (Crichton, 2005: 84).

If premiums do not reflect the actual risks, cross subsidies of risks may occur between groups at high risk and groups at little or no risk. This is the case for instance in the United Kingdom, where market penetration rates are estimated to be as high as 95%, whilst the share of people at risk from flooding is only 10% (Huber 2004). Such cross subsidisation may be present in any country where fixed rates for flood insurance are applied, and where bundling of flood cover with fire insurance is either compulsory or commonplace. Cross subsidisation could be acceptable and desirable from a social point of view. But potentially increasing risks may lead to higher costs that render the system unsustainable. Risk reduction is therefore key to keep insurance systems viable. In the UK for instance, it is becoming clear that a lack of investment in flood protection on the part of the government has lead to a belief by the insurance sector that in certain areas risks may become no longer insurable, and premiums are now becoming differentiated in some areas (Huber, 2004). A similar observation can be made in The Netherlands, where there are indications that flood risks have increased deteriorated over the past 50 years (Ten Brinke and Bannink, 2004), which may reduce the willingness of insurance companies to start covering flood risks. At the same time, the government has denied compensation in a number of instances.

Certain aspects would affect the adaptability of insurance and compensation systems. Although we do not attempt to prove which aspects would make such systems more adaptable, we propose a tentative definition. Future research could test which insurance systems are more adaptable, using this definition and using empirical indicators. Our suggested understanding of adaptable flood insurance and compensation systems consists of the following elements:

- If the reduction of the aggregate costs of flood protection and loss compensation (residual losses) is an important aim of adaptive management, then premiums or taxes would need to reflect actuarial risks. This could be best achieved through differentiated ex ante premiums, in combination with insurance conditions. Ex post compensation, if funded from regular taxes, could never transfer risk prices, and would therefore be a less preferable option. Accepting that differentiated premiums are necessary implies accepting that this could make risky areas unattractive for habitation, and may put parts of society in an undesirable situation;
- Insurance companies are likely to be better placed to calculate actuarial risks, and set adequate premiums and insurance conditions such as cover and deductibles, and would therefore be well positioned to develop insurance products. Insurance companies may also be more inclined to take a long time horizon in mind that would allow the valuation of and planning for low probability-high loss events;

- The diversity within Europe of various national approaches for insurance systems, which will be discussed in more depth below, reflects the particular local flood risks and the political decisions that have been taken in those countries, also with regard to cross subsidies and solidarity. This diversity could be seen as beneficial to developing and testing different approaches. However, as we will show later, scale is an important issue, as flood risks may be too high in some of the smaller European countries. This scale dependence may be prohibitive for developing viable insurance systems that transfer risks outside the region. A concerted and Europe-wide approach to flood risks would therefore seem more suitable.

3. Methods and data

Insurance systems within European countries can be divided in three classes. We compare the insurance systems properties, consisting of the role of the government and insurance market penetration, with statistical country properties, such as the physical flood hazard and flood risk, national population size and gross domestic product (GDP).

3.1 Properties of insurance and compensation systems

Information on properties of insurance system was collected from various sources, but mainly from published scientific literature and information collected by the insurance sector. These sources included the following:

- Van Schoubroeck (1997), who provides an overview of the legal aspects of natural disaster cover in 14 European countries;
- Swiss Re (1998b), which provides an extensive overview of areas at risk, historical loss figures, loss potentials and flood insurance systems in 24 countries, including 11 European countries;
- OECD (2003), which provides a table with characteristics of disaster compensation systems for 15 countries, including 8 European countries;
- CEA (2005), which provides an overview of insurance cover and insurance market penetration levels for natural hazards, including flood insurance in 18 European countries.

The information from these reports was analysed and used to describe the general characterisation of flood insurance systems, and determine the extent of cover from these systems.

Information on the market penetration index of the different insurance systems consists of quantitative and qualitative information. Therefore both the quantitative and qualitative were translated into an index. Table 3.1 shows how the index was based on market penetration percentages and penetration qualifications.

Table 3.1 Market penetration index.

Penetration %	Qualification	Index
Negligible		0
<10%		1
10-25%		2
25-50%		3
50-75%	High	4
75-100%	Very high	5

3.2 Statistical country properties

A series of data for 19 European countries was taken from the European Spatial Observation Network (ESPON) dataset, which is available from http://www.espon.eu.

The advantages of using this data are that the dataset covers all 27 European Union countries, as well as Switzerland and Norway, it has a comprehensive set of data on

population, employment, economic output, the data is comparable across countries as it has (mostly) the same source and baseline date, and the dataset has information on flood hazards, based on actual observations.

All data was collected at the Nomenclature of Territorial Units for Statistics (NUTS) 3 level, which is a local administrative unit, the geographical size of which varies per country[3]. The variables taken from the ESPON dataset for the present study are listed in Table 3.2.

Table 3.2 ESPON NUTS3 level data.

Symbol	ESPON code	Description	Unit	Period
H_0	FlooN302	Regional flood hazard potential	5 classes	1987-2002
A	Area	Surface area	km^2	2003
GDP	GDPph02N3	Gross domestic product	Euro	2002
P	AvgPopN303	Average population	Inhabitants	2003

Information on flood risks is usually available for most European countries at the national and basin level. There are at present however no comprehensive flood hazard or risk assessments available for the whole of Europe that would allow a cross-country comparison. Munich Re (1997) for instance relates the global flood hazard to the global distribution of the maximum 24-hour precipitation amount, which is only a rough approximation of flood risks. A number of European research projects is now working to create flood risk maps, that take into account both the hazard and exposure to flooding, such as the Floodsite project (http://www.floodsite.net/) and the Armonia project (http://www.armoniaproject.net).

The flood hazard index in the ESPON dataset contains actual floods observed during the period 1987-2002, based on information from the Global Active Archive of Large Flood Events of the Dartmouth Flood Observatory (USA) and additional data (Schmidt-Thomé, 2006). The ESPON dataset may currently be the most comprehensive one, although it is only based on observed floods for a relatively short period, that may include flood events that can have a both relatively high and low frequency of occurrence. The dataset therefore does not provide information on probabilities attached to the observed events. However, the observed flooding over the period 1987-2002 is likely to have influenced the present flood management policy in European countries, as well as the policy and legislation related to flood insurance and compensation. Therefore this dataset is clearly important for our study.

3.3 Calculations

In order to make cross-comparisons of flood hazard characteristics between countries, it was necessary to aggregate the information from the NUTS3 level to the national level, and to make some adjustments in order to get an area weighted value.

The area-adjusted flood hazard index H for each country is defined as:

[3] For details see http://en.wikipedia.org/wiki/Nomenclature_of_Territorial_Units_for_Statistics

$$H = \frac{\sum(H_0 \times A)}{\sum(A)} \quad (1)$$

where H_0 is the original flood hazard index (see above) and A is the surface area of each individual NUTS3 level area from ESPON (see Table 3.2).

Usually, flood risk is defined as the total capital that is actually at risk multiplied by the probability of flooding. However, we have no accurate information for both for each country. In order to get a rough estimate of the capital at risk from flooding in each country, we multiplied the total amount of GDP produced in all NUTS3 level areas with the flood hazard index H. Total risk R is therefore defined for a total of NUTS3 levels per country as:

$$R = \frac{\sum(H_0 \times A \times GDP \times P)}{\sum(A)} \quad (2)$$

where GDP is the gross domestic product per inhabitant, and P is the population size in each individual NUTS3 level area.

Population density is simply calculated as the total population size per country divided by the total country area.

4. Results

The results of our research are presented as follows: first we present measures of actual flood risks in Europe. Second, we provide an overview of the different insurance systems, and a brief summary of its characteristics. Thirdly, a number of physical and socio-economic properties such as geographical country size, population size, flood hazard and flood risk, and GDP are presented and their relationships with insurance systems are discussed.

4.1 Flood risks in Europe

Table 4.1 provides a list of estimates of absolute flood loss potentials (the product of hazard and exposure) in 11 European countries for which estimates are available from Swiss Re (1998a; 1998b). Note that these are not precise numbers, but rather indications of the order of magnitude of the largest direct economic losses that can be expected. Flash floods are estimated to lead to losses in the order of hundreds millions of Euros in most countries, with perhaps higher losses in Switzerland. River floods have the potential to cause billions of Euros in losses in most countries. Particularly vulnerable to river floods are Germany, The Netherlands and the United Kingdom. Storm surges have the potential to inflict the largest damages, again in particular in Germany, The Netherlands and the UK. However, it is important to relate the absolute potential losses from floods to the local economy. These relative losses may be best measured by the potential losses as percent of national GDP, are listed in the fifth column of Table 4.1. According to this list, the Czech Republic, Poland and The Netherlands are particularly vulnerable, as they may experience losses of over 2% of their GDP.

Also listed in the last column in Table 4.1 is the flood risk index *R*, as calculated by using Equation 2. This index reflects the historic flood risk, rather than the potential flood risk as it contains the observed flood hazard over the period 1987-2002. In particular Switzerland, Italy, France, Spain and the UK have experienced considerable impacts in the recent past, which is reflected in the index *R*.

Table 4.1 Flood loss potential estimates for 11 European countries, in absolute terms, in percent of gross domestic product (based on Swiss Re, 1998a; 1998b), and risk index R.

Country	Flood loss potential (10^6 Euros)			Share of GDP	Flood risk *R* (this research)[1]
	Flash flood	River flood	Storm surge		
Belgium	100s	100s	>1,000	<1%	$14.0\ 10^9$
Czech Republic	-	1,000s	None	>2%	$23.6\ 10^9$
France	100s	1,000s	-	<1%	$29.4\ 10^9$
Germany	100s	10,000s	10,000s	1-2%	$10.6\ 10^9$
Italy	100s	10s	-	1-2%	$31.9\ 10^9$
Poland	-	1,000s	-	>2%	$15.1\ 10^9$
Portugal	100s	1,000s	-	1-2%	$8.3\ 10^9$
Spain	-	1,000s	100s	<1%	$28.3\ 10^9$
Switzerland	1,000s	1,000s	None	1-2%	$35.2\ 10^9$
The Netherlands	100s	30,000-60,000	100,000	>2%	$24.7\ 10^9$
United Kingdom	-	>1,000	10,000-60,000 [2]	1-2%	$26.2\ 10^9$

Notes: - No information

[1] See Equation 2 for explanation

[2] Estimate for insured losses for storm surge on the east coast, storm surge barrier on the Thames remains intact

4.2 Overview of insurance and compensation systems in Europe

Table 4.2 lists the different insurance and compensation systems in Europe. They are divided into the three categories of traditional insurance systems, insurance systems in which the government participates, and ex-post compensation by the government. These three types are listed in the third, fourth and fifth column of Table 4.2. One or more systems may be present in a country at the same time; closed circles indicate the main insurance system, open circles represent additional systems. The specific situation is specified for a number of countries in the footnotes.

We used the following distinction to classify insurance and compensation systems:

1. Traditional (private) insurance systems. Their main characteristics are that these systems are set up and managed by private companies, and that the cover is financed from premiums that are paid before the event (ex ante). Some of these systems may have support from the government, for instance through state-guaranteed reinsurance;
2. Insurance or pooling systems in which the government has a considerable role, through setting up and managing the pool. Cover is provided through ex ante premiums or ex ante taxes on insurance policies;
3. Systems administered by the government, consisting of ex post compensation of flood losses. These systems are not considered to be insurance, as the basic property of ex ante premium or tax collection is not present. Rather, loss compensation is paid from tax money, either ad hoc or through budget reservations.

Figure 4.1 gives an overview of the countries considered in this study and the type of insurance system. The commercial insurance system is subdivided in systems that have a market penetration of 50% or more, and countries that have an insurance penetration of less than 50%. In most European countries private flood insurance systems prevail (15 out of 19 countries). However, in these countries market penetration of insurance varies considerably as can be seen form the last column in Table 4.2. The number of countries where at least half the population has taken out flood insurance amounts to only seven. Also, in some countries the government has recently stepped in to compensate losses, regardless of the fact that commercial flood insurance was available, such as in Hungary and Germany (Vari *et al.,* 2003; Schwarze and Wagner, 2004; Thieken *et al.,* 2006). In another three countries (Belgium, Denmark and Switzerland), the government is playing an active role in setting and managing up ex ante mechanisms. In Belgium, a compulsory insurance system has been put in place since late 2005. In this analysis however, we treat Belgium according to the prior classification, as the market penetration and overall effects of this new system have yet to be determined. One country, The Netherlands has an ex post system for compensation of flood losses operated by the government, in which compensation is paid from tax money. This system was institutionalised in 1998 by law, after an earthquake in 1992 and flooding in 1993 (Faure and Hartlief, 2001).

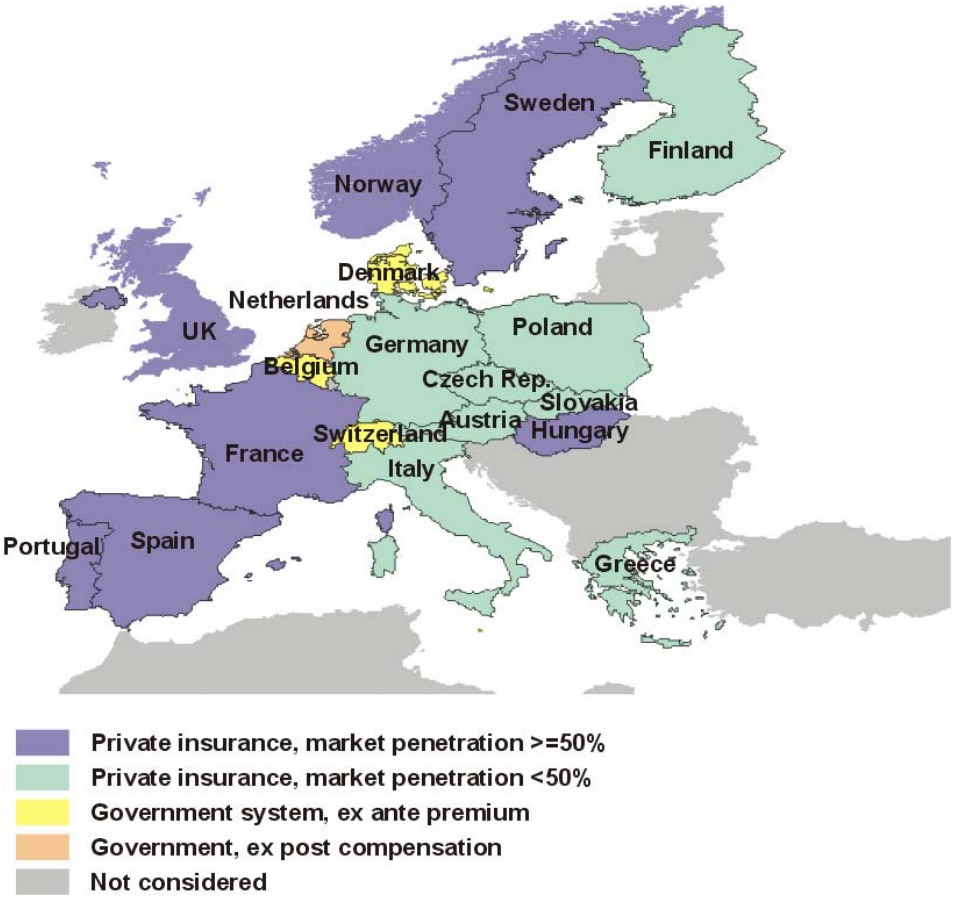

Figure 4.1 Overview of national flood insurance and compensation systems in Europe considered in this study.

Table 4.2 Overview of flood insurance and compensation systems in 19 European countries. (Mainly based on Van Schoubroeck, 1997; Swiss Re, 1998b; OECD, 2003; and CEA, 2005). Closed circles indicate the main insurance system, open circles represent additional systems. Type of contract can be O=optional, or B=bundled; an asterisk (*) denotes compulsory inclusion.

Country	Code	Insurance/compensation system			Contracts		Market penetration	
		Private	Government		Household	Business/industry	Household	Business/industry
		Ex ante premium	Ex ante premium	Ex post (compensation)				
Austria	AT	●			O	O	10-25%	
Belgium	BE	○[1]	●[2]			O	<10%	
Czech Republic	CZ	●			O	O	15%	10-30%
Denmark	DK		●[3]		B*	B*	High	
Finland	FI	●[4]			O	O	10-25%	
France	FR	●[5]			B*	B*	100%	100%
Germany	DE	●		○[6]	O	O	<10% [7]	<10%
Greece	GR	●			B	B	<10%	
Hungary	HU	●		○[8]	B	B	60% [9]	
Italy	IT	●			O	O	<5%	40-50%
Norway	NO	●[10]			B*	B*	≥75%	
Poland	PL	●			O	O	25%	25-50%
Portugal	PT	●			B	B	High	High
Slovakia	SK	●			O	O	<10%	
Spain	ES	●[11]		○	B*	B*	Very high	Very high
Sweden	SE	●			B	B	≥75%	
Switzerland	CH	○[12]	●[13]		B*	B*	100%	100%
The Netherlands	NL	○[14]		●[15]	O [14]	O	Negligible [16]	Low
United Kingdom	UK	●			B	B/O	95%	100%

Notes:

[1] A compulsory insurance system is in place since late 2005, the market penetration of which is yet to be determined. Listed penetration is from Swiss Re (1998).

[2] Through the Calamity Fund established in 1990

[3] Flood insurance pool through levy on fire contracts, with state guarantee

[4] With state participation (CEA, 2005)

[5] Through the Cat Nat scheme (private), with state guaranteed reinsurance through the Caisse Central de Réassurance (OECD, 2003)

[6] After the 2002 Elbe floods, the German federal government provided substantial ad hoc relief for flood victims (Thieken *et al.,* 2006)

[7] Regionally, penetration can be much higher, such as in Baden-Württemberg (80%) and Saxony/Saxony-Anhalt (50%) (Thieken *et al.,* 2006)

[8] The central government provided relief after the 2001 Tisza flood, despite many insurance payments (see Vari *et al.,* 2003)

[9] In high-risk areas this percentage may be less, around 40% (see Vari *et al.,* 2003)

[10] Through the Norsk Naturskadepool, managed by the Norwegian Financial Services Association

[11] Through the private/public corporation Consorcio de Compensación de Seguros

[12] Contents and business interruption, and buildings in some cantons

[13] In 19 of 26 cantons, state monopoly insurers cover buildings, with mutual intercantonal reinsurance association

[14] Damage from heavy precipitation is covered by private insurance. Additionally, some foreign insurance companies provide cover for losses from river flooding and storm surges

[15] Compensation of catastrophic losses by the Calamities Compensation Act (WTS) since 1998

[16] It is estimated that most households have insurance against damage from heavy precipitation (RIZA, 2003)

The sixth and seventh column in Table 4.2 show whether the flood insurance cover is sold as a bundled package (usually with fire insurance), or as optional cover in insurance contracts. The last two columns show the level of market penetration of the ex ante insurance systems (both private and government), that is the amount of policies that are sold relative to the number of potential sales. As bundled options are often compulsory on account of the regulator, bundled flood insurance typically has a higher market penetration level than optional insurance. All countries that have bundled insurance have a market penetration of 50% or more, except for Greece. As penetration may be regarded as the end result of the way insurance products are offered (either bundled or optional), it seems more relevant to classify the different insurance systems by market penetration level, rather than contract type.

Next, we relate a number of country specific properties to the different insurance systems and their penetration levels, which may explain why certain systems have been set up in different countries.

4.3 Systems and flood hazard

Figure 4.2 illustrates the relationship between the flood hazard index, as calculated from observed flood events over the period 1987-2002 (Equation 1), and insurance type. There appears to be no clear relationship between flood occurrence and the type of flood insurance system, although some countries that have a private insurance system have a substantially lower flood hazard (e.g. Norway, Sweden, Finland, and Greece).

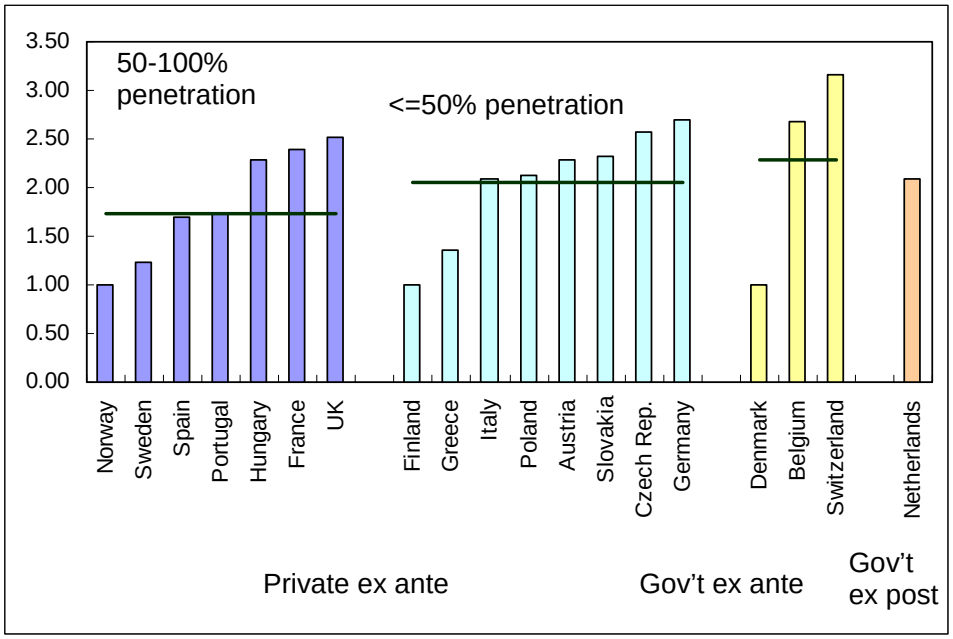

Figure 4.2 Average national flood hazard index H and insurance systems in 19 European countries. The line delineates the average per category.

4.4 Systems and flood risk

Figure 4.3 illustrates the flood risk per country as calculated by Equation 2. Note that flood risk *R* is not a measure for the actual potential losses in flood plains in Europe. Rather, it is a measure of risk, reflecting the total amount of GDP production in each NUTS3 area, multiplied by the local flood hazard index *H*, summed per country. This measure is relevant, as it shows that despite the flood hazard index *H*, countries may have more or less capital exposed in flood prone areas.

It could be expected that in countries with a high flood risk, commercial insurance would be a less interesting option. But it seems that there is no decisive influence from flood risk on insurance type. This finding is similar as for the flood hazard (see Figure 4.2). Countries that have a high flood risk, and a commercial insurance system, such as France, Spain and the UK, may be able to spread the flood risk due to their large geographical size (see below).

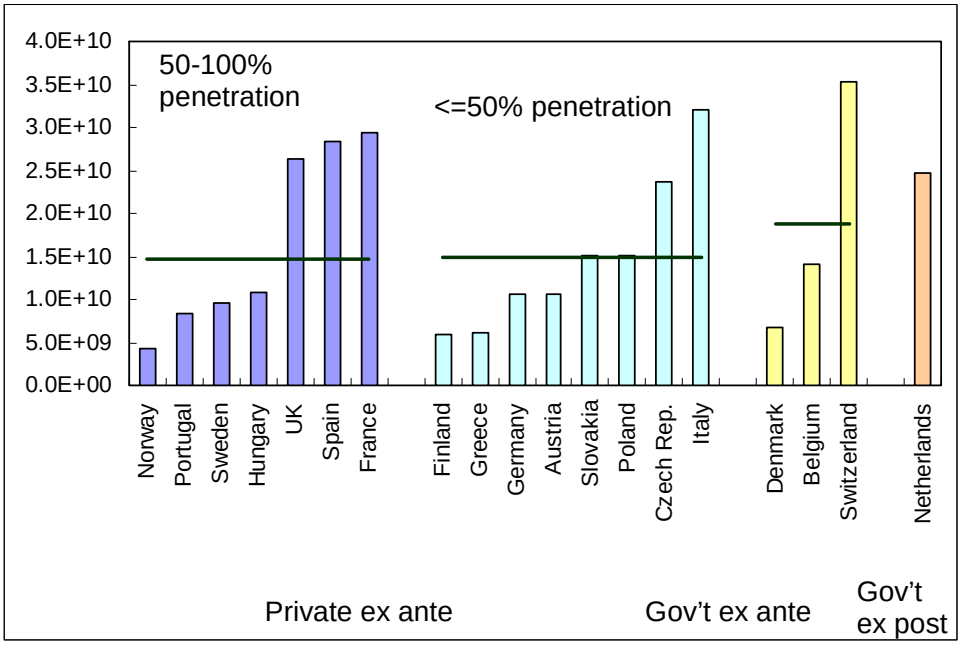

Figure 4.3 Flood risk R and insurance systems in 19 European countries.

4.5 Systems and country size

Figure 4.4 illustrates the geographical size of the countries per country and per insurance type. The solid black lines show the average per country group. The private system is separated into two parts: the systems with a market penetration level up to 50%, and systems with a higher market penetration level. It is clear that the countries with the largest surface area tend to have private insurance systems, with reasonable market penetration. This can be seen for instance in Sweden, Spain and France. Countries with a large geographical size have a lower probability of a high loss event affecting a large part of the country at the same time, which is the correlated risk of flood losses. At the same time, countries with a small country size, such as Denmark, Switzerland, Belgium, The Netherlands and Hungary, have no extensive commercial flood insurance cover.

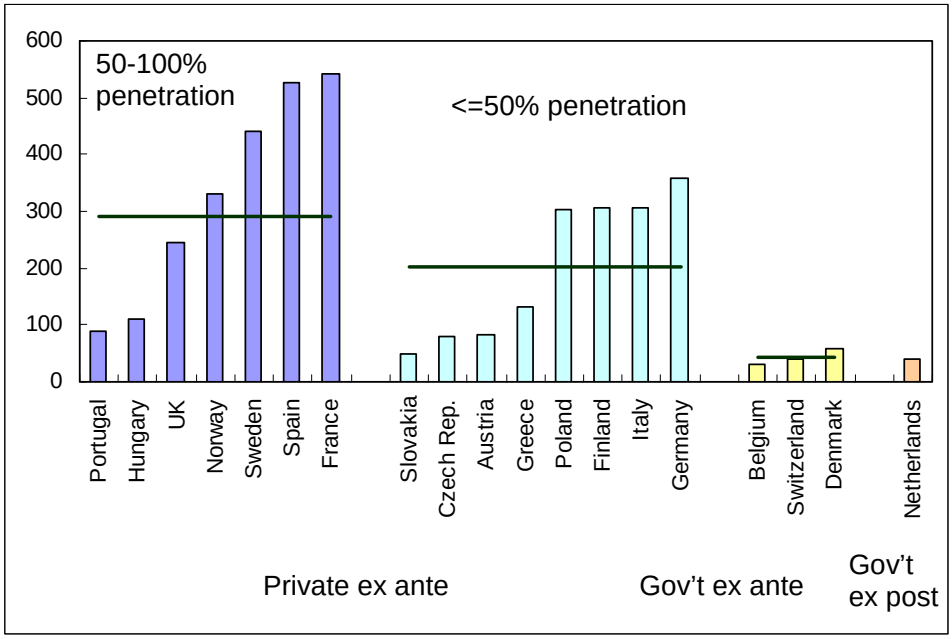

Figure 4.4 Country surface area (1,000s km2) and insurance systems in 19 European countries.

There seems to be a relationship (although not significant at 95% confidence) between the geographical size of the countries and the market penetration level of the different systems (r^2=0.21, p=0.051) (Figure 4.5). There are some countries that do not follow this trend; in particular Switzerland that has a high market penetration level despite a relatively small country size; and Germany that has a considerable country surface area, but a low market penetration level.

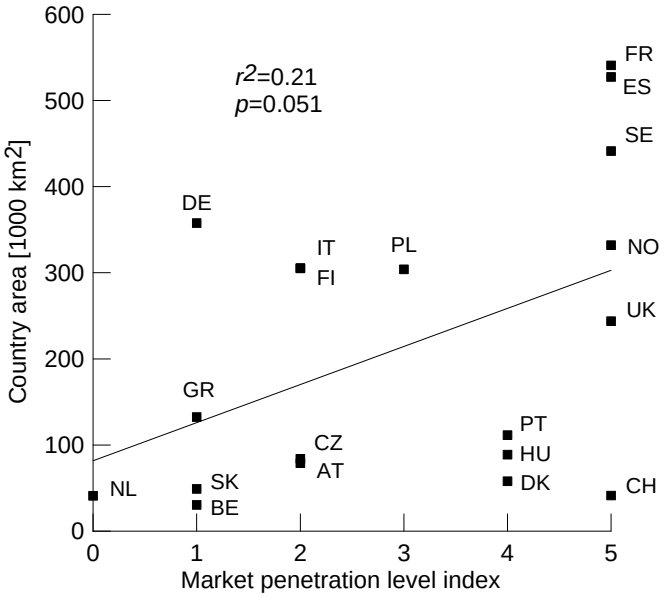

Figure 4.5 Correlation between market penetration level and country surface area. For country codes see Table 4.2.

4.6 Systems and population size

The pattern that was observed for insurance systems and geographical size can also be observed for population size (Figure 4.6). Large populations may be able to share flood risks more easily, and make private systems attractive for large countries, as it increases the possibility for diversification. This pattern however is less pronounced than country size (see above), as some countries with smaller population sizes do have a quite extensive commercial flood insurance cover, such as Norway, Sweden and Portugal. However, these countries, except for Hungary, also have a considerable smaller flood hazard (see Figure 4.2), which may explain why penetration is high in these relatively small countries. Another reason may be that offering flood insurance is more cost efficient in larger countries if the average costs of flood insurance decrease when insurance companies serve more clients. That is, if economies of scale of scale are present in flood insurance markets (Molyneux *et al.,* 1996). This would decrease the cost per policy and could increase market penetration.

There is a significant relationship between average population density per country and market penetration level (r^2=0.26, p=0.027) (Figure 4.7). Countries that have high population densities, such as The Netherlands and Belgium (404 km^{-2} and 304 km^{-2}, respectively), tend to have a high government involvement in insurance or compensation arrangements.

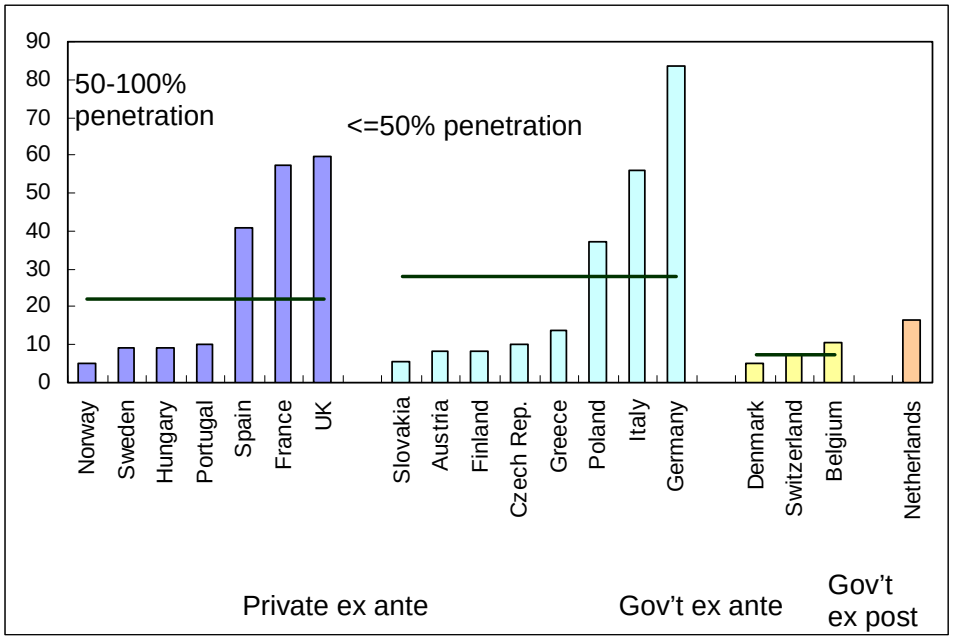

Figure 4.6 Total population size (millions) and insurance systems in 19 European countries.

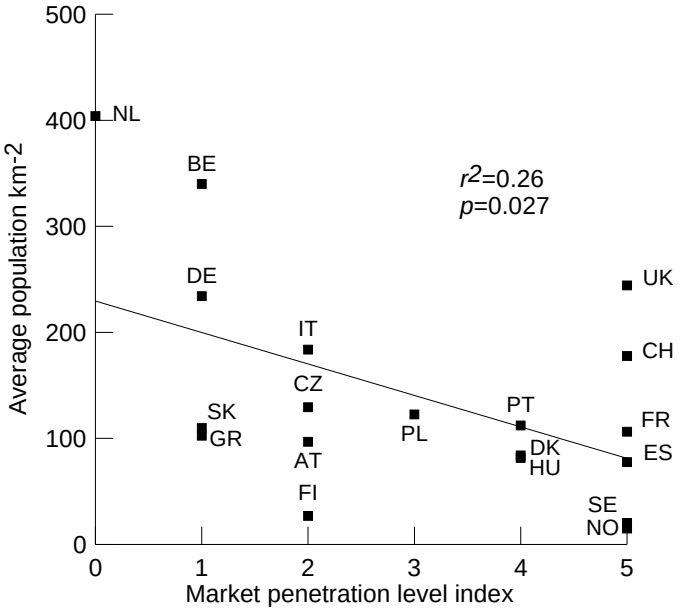

Figure 4.7 Correlation between market penetration level and average population density. For country codes see Table 4.2.

4.7 Systems and gross domestic product

It seems that the different insurance systems are applied irrespective of gross domestic product per capita (GDP) (Figure 4.8). However, countries that have a relatively low per capita GDP, such as Poland, Slovakia, Czech Republic, Hungary, Portugal and Greece tend to have commercial flood insurance systems. Countries that have opted for a system where the government has a central role, in particular Belgium, Denmark, Switzerland and The Netherlands, have a GDP above the average GDP of countries with a commercial flood insurance system.

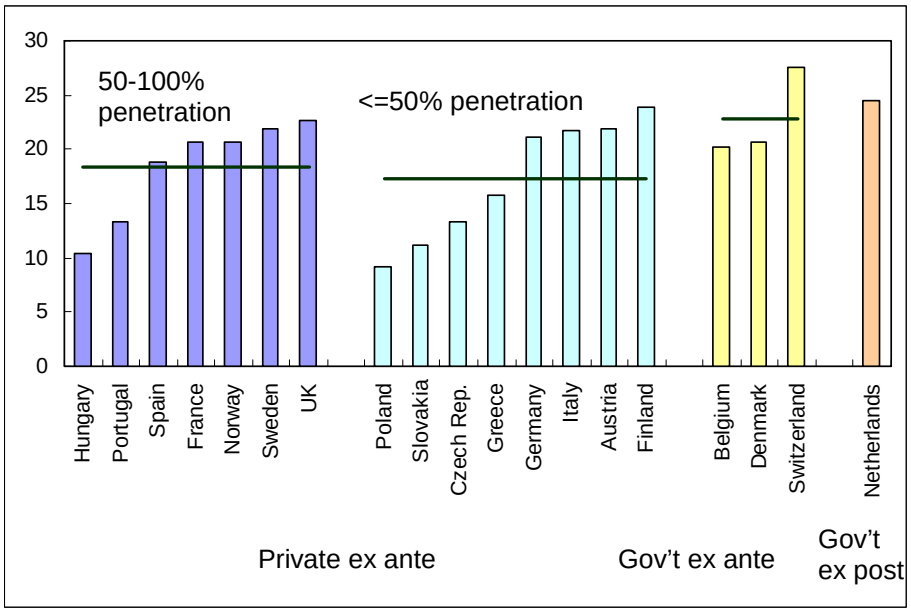

Figure 4.8 National gross domestic product per capita (1,000s Euros) and insurance systems in 19 European countries.

5. Discussion and conclusions

Our analysis has shown that flood insurance systems in Europe can be classified according to a number of characteristics, in particular:

- The role of the private sector and the government;
- The ex ante or ex post provision of premiums;
- The level of market penetration of the insurance system.

These characteristics were chosen, since the roles of the two sectors and the mode of provision of premiums indicate to what extent the private market or governments are exposed to flood losses, and to what extent they play a role in transferring price signals of flood risks. The level of market penetration reflects the extent to which the system has been adopted. Other characteristics may also be relevant for measuring the systems functioning, such as the differentiation of premiums, the height of the premiums, the height of the deductibles, and the height of the limits of indemnity. These latter characteristics are important in order to determine the exact cover of households and business, and the exact exposure to losses of the private market and government sectors. But information on these characteristics is less accessible or comparable.

From our analysis it is clear that, contrary to what many believe, the availability of flood insurance is widespread in Europe (see Figure 4.1, and Table 4.2), although systems may be quite different from country to country. Market penetration for instance is high (50% or more) in only 7 out of 19 countries included in our study. And in these countries, some form of solidarity exists in the sense that flat rate premiums are mandatory for all, regardless of actual flood risks (e.g. in France and Spain). It seems that country surface area and population size are the dominant factors for determining the type of system (see Figure 4.4 and Figure 4.6). Market penetration depends on whether flood cover is sold as bundled (often mandatory) or separate cover, and also to some extent on the country surface area (Figure 4.5) and the average population density (Figure 4.7). The flood hazard over recent times (Figure 4.2), a crude estimate of flood risks (Figure 4.3), or GDP per capita (Figure 4.8) have little to no relation with the flood insurance systems.

Governments in Europe have claimed a central role in flood insurance, in particular by setting up and regulating insurance systems. In a number of instances they also actively participate in flood insurance pools based on ex ante premiums, such as in Belgium, Denmark and Switzerland. An ex post system compensation system has been installed in The Netherlands. In this country flood risk management has focussed on the prevention of floods, which would lead to a reduction of losses and a reduction in the demand for insurance. But this policy may now slowly be changing (see Ten Brinke and Bannink, 2004).

Ex post compensation of flood losses still exists, either institutionalised, such as in The Netherlands, or ad hoc as shown in a number of countries in a number of instances (see Table 3.1 for details). Although ad hoc relief is mostly targeted to public infrastructure, it is clear that in some countries where commercial insurance exists, governments may be inclined to compensate individual victims also. Ad hoc relief may reduce public interest for commercial insurance cover, and it would be interesting to investigate the effect of

public compensation on private insurance demand, for example in Germany and Hungary where widespread aid was given, despite the availability of private insurance. It has also been suggested that relief may remove an incentive to reduce risks (Schwarze and Wagner, 2004).

From our analysis we draw a number of conclusions.

1. Possibilities may exist in some European countries that have commercial flood insurance but low market penetration to increase the share of commercial flood insurance. In these countries the flood hazard flood is relatively modest and the countries have a reasonable geographical and a relatively large population, which all would enable risk spreading. This is supported by our observation that country surface area and population size seem to be the dominant factors for determining the type of flood insurance system. This seems logic, as large countries have a better chance of diversifying natural hazard risks across the country and within a larger population, which is for instance the case in Germany, Italy and Poland;
2. It may be desirable to transfer risks towards the European or global insurance, reinsurance and capital markets, if countries face high flood risks that national governments are unwilling to take on. Increasing the share of commercial flood insurance can be preferable over systems in which the government has a major role, if commercial insurance premiums are better capable of transferring price signals of actual flood risks. Countries where the government has taken a central role in flood loss compensation, and that have a relatively low flood hazard and flood risk may be able to shift this risk to the private sector. This is the case for Denmark, for instance;
3. Insurance markets are only willing to take up flood risks if loss prevention is increased and the risk of high loss accumulation is reduced. Therefore, an important role for the government remains for the assessment and communication of actual flood risks, and programmes for loss prevention;
4. In some countries, the flood hazard and flood risks may be too high, relative to their geographical size and population size for the private sector to provide full cover (see Table 4.1, and Figure 4.1 and Figure 4.3). This holds true for Belgium, Switzerland and The Netherlands. In these countries, governments will probably keep a central role in covering or managing cover for flood losses. However, constructions may be found in which an initial part of the risks is taken up by the private sector, and excess losses are covered by government budgets. In these instances, a compulsory system would be needed, in order to overcome adverse selection, such as in France, and recently in Belgium, and a proposal for Germany (Schwarze and Wagner, 2004). Such improved loss sharing between public and private sectors would thus increase the commercial insurability of part of the risks;
5. Currently, primary insurance is largely confined to companies operating in a single country, which is due to the fact that there are considerable differences between European countries in the regulation of insurance of natural catastrophes (CEA, 2005). The establishment of a single market could increase the possibilities for private insurance companies to take up risks simultaneously in different countries, would provide the opportunity to spread risks more widely and thereby contribute to adaptability.

We conclude that increasing application of flood insurance in Europe, perhaps with some adjustments, may contribute to a higher adaptability to changes in exposure and flooding

probabilities. We have presented a line of reasoning in this article, according to which countries with a high market penetration of insurance with ex ante premium provision would be better able to handle uncertain future risks associated with floods. This is because under such a scheme, both the costumers of insurance products and government are sensitised to reduce risks. We have provided a number of assumptions of how this would work (see Section 2). The main assumptions were that for risk reduction incentives, premiums or taxes would need to reflect actuarial risks, which could be best achieved through differentiated ex ante premiums. Private insurance companies are likely to be better positioned to develop insurance products. As flood risks may be too high in some of the smaller European countries, private insurance systems may be needed that are capable of transferring risks outside the region.

If this theoretically inspired assumption are true, we can interpret the remarkably large differences between the various European countries as signs of varying degrees of adaptability to flood risks. Countries with a private insurance system with a high market penetration may have an advantage, such as the countries of France, Hungary, Norway, Spain, Sweden and UK. Whilst countries with an ex ante polling system operated by the government, or ex post compensation system would have a disadvantage, such as the countries of Belgium, Denmark, Switzerland and The Netherlands.

Increasing the scale at which private flood insurance systems in Europe operate would require three activities, in which national European governments would have the leading role: First, increasing the market penetration of private flood insurance will probably require mandatory inclusion of flood risks in insurance policies. Secondly, a harmonisation of European financial services regulation, so that primary insurers could take up risks in different countries, thereby diversifying and spreading flood risks. Further harmonisation of financial services regulation within the EU as proposed in a recent White Paper on Financial Services Policy 2005-2010[4] may contribute to the establishment of a single market for insurance. Thirdly, European flood risk management may need to take a next step. After the development of a Flood Water Directive for the European Union with requirements for flood risk assessment and risk reduction, suggestions could be made to develop a European-wide insurance system to deal with residual flood losses.

[4] http://ec.europa.eu/internal_market/finances/docs/white_paper/white_paper_en.pdf

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