TSUNAMI PROJECT

The Uninsured Elements of Natural Catastrophic Losses

Seven Case Studies of Earthquake and Flood Disasters
Summary Report

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Of course, only the authors are responsible for the information and analyses contained in this report.

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1. INTRODUCTION

Insurers are paying increasing attention to the insured and uninsured losses from catastrophic natural disasters. Recent floods and windstorms in Europe and recent disasters in the United States, where the insurance industry has calculated scenarios for natural catastrophes ranging from USD 21 to 101 billion of *insured* losses, have alerted insurers to the potentially huge losses to the industry from natural disasters. The escalating losses create risks to the insurance industry, but also offer the potential for significant market opportunities. Munich Re (2000) estimates that worldwide losses from major natural disasters in the 1990s - almost nine times as high as in the 1960s - amounted to over USD 600 billion. O*ver 80% of these losses were uninsured*. Even in the developed countries, the vast majority of catastrophic exposures faced by corporations, businesses and households are self-retained (Froot and O'Connell, 1997).

International disaster relief plays an even smaller role than insurance in spreading the global burdens of natural catastrophes (Linnerooth-Bayer and Amendola, 1998). With limited private/public insurance and international aid, *ex post* public intervention in the case of a catastrophic event is a reality in most of the world, including countries with mature insurance markets. In the US, the average expenditure by the federal government for disaster assistance is significantly greater than the average annual loss borne by reinsurers on US catastrophe coverage (Froot, 1997). Still, government disaster assistance seldom covers more than a modest share of the actual losses. Therefore, despite a large insurance and reinsurance industry, extensive government programs and international aid, the victims in *both rich and poor countries* bear the major share of the increasing losses from natural disasters (Linnerooth-Bayer and Amendola, 1998).

The full losses from natural disasters, however, are seldom reported, and include short- and long-term disruptions to business and other activities both in the immediate vicinity of the disaster and throughout the national and sometimes even global economy. Moreover, the reported figures on the uninsured losses absorbed by the victims and their governments do not fully reveal the ultimate bearers of these losses. Post-disaster government relief imposes burdens on diverse groups depending on how it is financed. Tax increases, as one financing mechanism, entail a cross subsidy from the non-victim community to the victim community; guaranty funds, as another mechanism, may penalise groups holding other types of insurance policies; budget diversions victimise the beneficiaries of other government programs; public borrowing may pass the burden on to future generations. To avoid budget diversions, borrowing and taxes, governments of poor countries may default on international obligations. During the past decade, for example, up to 35 per cent of the World Bank's lending for infrastructure projects in Mexico has been diverted to finance disaster relief (Freeman, 1999). Finally, even international and domestic charitable aid has associated opportunity costs. Responding to the victims of a natural disaster inevitably diverts funds from other victims, frequently the victims of military conflict.

While it is clear that transferring disaster risks and losses imposes burdens elsewhere, the welfare gains of *ex ante* risk transfers or *ex post* loss transfers from the more vulnerable persons in society to those who are are better able to absorb the losses are indisputable - particularly if these transfers can be linked with measures for mitigating the losses. Given the potential societal gains from risk and loss transfers, the important question arises why a significant proportion of losses from recent natural catastrophic events in the US, Europe and Asia has been absorbed by the immediate victims?

In addressing this question, this study provides comparative insights on the uninsured losses from catastrophic events by: (1) comparing how losses from natural disasters are absorbed by individuals, businesses, voluntary organisations and government taxpayers; (2) examining why a

large proportion of these losses has been uninsured; and, (3) showing how natural disaster losses and the bearers of these losses are influenced by public policy and private insurer behaviour.

This summary document is based on separate, detailed case studies of the following flood and earthquake disasters:

- U.S. Midwest floods, 1993;
- German Rhine river floods, 1993 and 1995;
- Polish flood, 1997;
- UK Easter flood, 1998;
- California Northridge earthquake, 1994;
- Japanese Kobe Earthquake, 1995; and,
- Italian Umbria-Marche earthquake, 1997.

Flood and earthquake disasters were selected for study because, as shown in Table 1.1, these hazards have accounted for almost half of the catastrophes and 65 percent of the economic losses during the past five decades. While the number of catastrophes and losses are fairly evenly distributed, fatalities have been considerably higher with regard to floods, and the insured losses higher with regard to earthquakes.

Table 1.1 Earthquake and Flood Disasters (1950-99)

Catastrophes (1950-99)	**Earthquake**	**Flood**
Number of catastrophes (total 234)	29%	27%
Fatalities (total 1.4 million)	47%	7%
Economic losses (total USD 960 billion)	35%	30%
Insured losses (total USD 141 billion)	18%	6%

Source: Munich Re (2000)

The estimated direct losses from the seven selected disasters in this report approximate USD 176 billion, which is almost one-third of the total global losses from *all* major disasters in the last decade as estimated by Munich Re (2000). These cases were also chosen because they provide a useful comparison of national public-private systems for mitigating and sharing disaster losses. For example, we compare the US with its public flood insurance program to countries, such as the UK, with its greater reliance on the private market, and Poland, where the government plays a greater role (and apparently more legitimate one to the public) in spreading disaster losses across the population.

The objective of this study is to provide comparative information and insights on the uninsured losses of natural catastrophes, including how public policies and institutional arrangements influence their scope and distribution. The case studies describe the main events of the

disaster,[1] the economies of the regions affected and the institutional arrangements for natural disaster risk management. Data permitting, the studies report on estimates of the direct and indirect losses to residential property, commercial property, industry and government infrastructure. They trace the reimbursement of these losses to insurance (and reinsurance companies), governments, and international aid providers, and they document the institutional arrangements with regard to private insurance and public/voluntary forms of compensation. Finally, the case studies discuss the insurability of flood and earthquake risks in the respective regions and countries.The motivating questions concern the *extent* of the uninsured losses, *why* these losses are uninsured, and *whether* they are, in fact, insurable.

This report provides insights to insurers as well as to public policymakers. First and foremost, potential markets for catastrophic natural disaster insurance are identified. This study can also be of value to the insurance industry in identifying its role in public policy reform. A number of countries in the developing and developed world are in the process of legislating national systems for natural disaster insurance, such as those that exist in France, the U.S. and Japan. The insurance industry could play a role in the design of these systems.

The research has been carried out jointly by the Risk Research Group, Centre for Environmental Strategy at the University of Surrey, and the International Institute of Applied Systems Analysis (IIASA), Laxenburg, Austria.

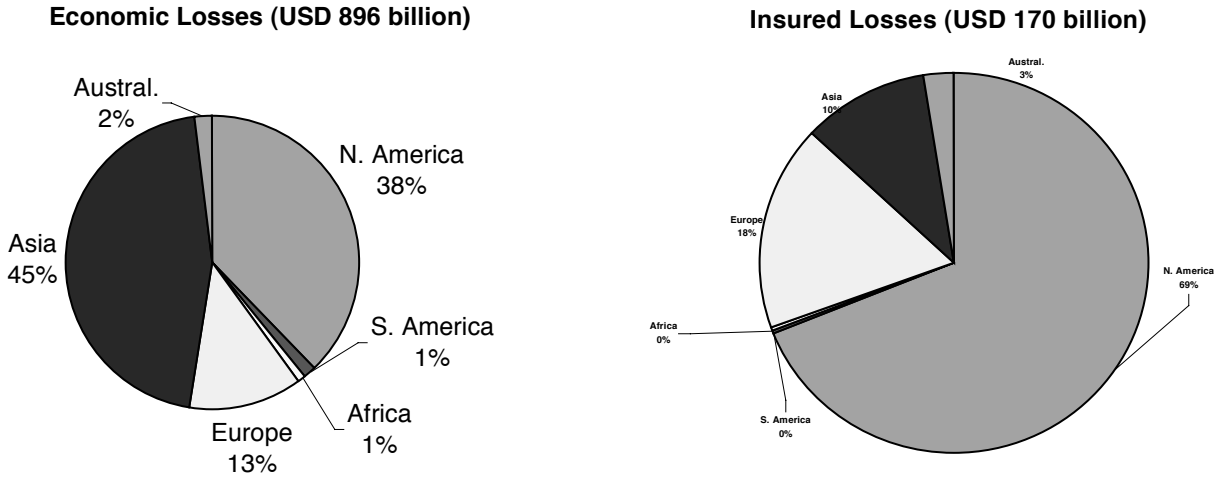
1.1. Background: The global picture

The increasing losses from natural disasters, and especially those that are weather-related, have been attributed mainly to growing populations and economies. For this reason, most analysts minimize the role of climate change on weather-related disaster losses. Yet, many scientists suggest that worsening weather extremes are a likely consequence of climate warming, although it is not possible to predict their magnitude and timing (MacDonald, 1998; Changnon, et. al., 1997). Another global-change phenomenon appears, however, to be more directly and seriously implicated in increasing disaster losses. Changing patterns of land use, especially urbanisation and deforestation, and the increasing concentration of people and capital in vulnerable areas are primary contributors to increasing disaster losses. Indeed, the nine-fold increase in losses from major natural disasters since the 1960's would be far less if normalized to account for population and wealth increases (Mileti, 1999).

The global pattern of these financial losses is far from even. As shown in Figure 1.1, the largest proportion of disaster losses has occurred in Asia, followed by North America, Europe, Australia, South America and Africa.

[1] This report does not give attention to institutional arrangements for flood response and crisis management. A comparative European study can be found in Rosenthal and Hart (1998).

Figure 1.1 The Global Distribution of Natural Catastrophes (1985-1999)



Source: Munich Re (2000)

As mentioned above, there is comparatively little international disaster aid and thus little international loss sharing at the global level. Throughout the world, governments incur huge expenses in compensating uninsured citizens for their losses from natural disasters and in repairing public infrastructure damage (although as we show in this report, the role of government assistance varies considerably across countries). Insurance and reinsurance play a smaller role than national governments in absorbing losses, but these institutions are becoming increasingly important in transferring risks over the globe, especially as insurance markets become more international. But private insurance cover is also far from evenly distributed. Referring to Figure 1.1, Asia (including Japan) has the highest percent of the losses, but only around 10 % of worldwide insured losses. In contrast, North America and Europe together have about the same percentage of economic losses as Asia, but over 85% of the worldwide insured losses. In this report, we show that even in OECD countries, the insured losses are only in the range of 1 to 40% of the direct overall losses (including private and public-sector losses). Since few governments have insurance on public-sector property, the insured proportion of commercial, residential and crop losses are generally higher.

In examining the incidence of natural disaster losses, the question arises who ultimately pays the *insured* losses? In principle, and in the absence of government involvement, the premium payers bear the losses from insured risks over the long run. However, a unique feature of catastrophic risk insurance is that risks cannot be spread just by having a pool of premium payers. The problem is the timing, since a rare catastrophic event can occur before enough premium income has accumulated to cover the claims. Therefore, insurance companies rely on both reinsurance and capital reserves to meet very large, dependent claims. Indeed, the reinsurance of extremely disastrous events is of utmost importance to the insurability of natural disaster losses. To overcome the finite nature of insurance capital, recent attention has been given to novel risk-transfer or hedging instruments, including catastrophe bonds that transfer the risks to the global capital markets (Smith, et al, 1997; Froot, 1999).

To protect policyholders in the event of insurer insolvency and encourage private insurance, many national insurance schemes provide a role for the government. As we show in this report, these national insurance schemes are varied with regard to how they spread the losses from very costly natural disasters.

1.2. Disaster loss estimates and their reimbursement

The victims of direct losses can be households (private residential property), small businesses and industries (commercial property), farmers (agriculture) and governments (public infrastructure). *Direct losses* refer to the initial and delayed damages to properties and their contents (stock losses). Most of the damage or loss figures reported in this study are measures of direct expenditures for repairing damages, or, alternatively, the market valuations of the loss of goods and structures (usually valued in terms of the replacement cost and thus excluding depreciation). This excludes losses in human lives, as well as non-marketable losses, such as lost memorabilia, cultural assets, environmental degradation and disaster trauma.

Losses resulting from the consequences of physical destruction are referred to as *indirect losses* from the disaster. These include losses to businesses that cannot supply goods or services during and after the event, or losses to factories relying on just-in-time inventory systems if a critical parts supplier cannot meet its obligations (flow losses). Indirect losses can be borne by persons and businesses very long distances from the disaster area, and there is even concern over the global economic ramifications of large-scale disasters. Indirect losses have not been measured, studied and modeled to the same extent as direct losses. Evidence to date suggests that indirect losses can be significant, that they may constitute a larger fraction of total losses in large disasters than in smaller ones (Gordon and Richardson, 1995; Toyoda, 1997),[2] and that there may be indirect gains in terms of sizable regional economic expansion after an event (for example, the Northridge earthquake) (Mileti, 1999).

It must be kept in mind that *all* loss figures in this report are recorded estimates, which only approximate the real losses from the selected natural disasters (for a discussion, see National Research Council, 1999; Howe and Cochrane, 1993). Insurance companies keep good records of disaster-related property damage, but data on life insurance claims, business disruption, and unemployment are frequently not identified as disaster claims. Outside of insurance claims, data on losses is far less comprehensive and reliable. Some European countries, notably Poland, have a tradition of systematic data collection by the central government. Otherwise, estimates of direct and indirect, uninsured losses have been approximated by government agencies and some private organizations.

In many cases, there is a wide range of reported loss estimates. While we report on this full range, for comparative purposes we have attempted to arrive at a single estimate of direct losses. Based on published estimates we calculate the *average of reported estimates of direct losses* (AREDL). In calculating the AREDL, we consider

- only estimates of direct losses (or we adjust total loss estimates to reflect direct losses);
- only estimates that have been made at least four months following the disaster; and
- only primary estimates or those based on original data.

In each case study, we attempt to estimate the *reimbursed direct losses* as a percentage of the AREDL. We examine only the following sources of reimbursed losses: insurance, local and national government compensation, and voluntary local and international aid. Other sources might include help from family members, defaults on bank loans (unintended), higher prices (borne by consumers), and so forth. By reimbursed losses, we mean any monetary or other type of payment made to a victim of a natural disaster to help the victim recover, and reimbursed direct losses are

[2] Note that total losses may be exaggerated by summing direct and indirect losses. Some indirect losses (e.g., business losses due to damaged capital) are already accounted for in the capital loss since the value of capital represents its discounted flow of income (see Howe and Cochrane, 1993).

these payments targeted at repairing or replacing physical damage. The victims of natural disasters include individuals, households, businesses, corporations, farms, and local and national governments. The following are examples of reimbursed direct losses:

- a household or firm receives payments for damaged property from its insurance company;
- a farm receives a grant from its local government to cover its losses from crop damage;
- a local government receives a grant from the national government to help repair streets and schools that are the property of the local government (note that national government expenditures to repair national government roads and other property do not count as a reimbursed losses); and,
- a national government receives a subsidized loan from an international lending organization to help finance its disaster relief expenses (note that only the reduced interest and any defaults count here as a reimbursed loss).

For purposes of this study, we define *uninsured direct losses* as the difference between the average reported estimate of direct losses (AREDL) and insurers' payments of claims for direct losses. This residual also includes losses not reimbursed because of a deductible or a cap in the insurance contract. In other words, we define losses that fall below the deductible or above the cap in the insurance contract as uninsured losses. This definition of uninsured losses is not entirely correct since some insured losses cover indirect losses (however, this cover is usually minimal and, where possible, we control for this).

1.3. Institutional arrangements to improve the insurability of catastrophic risks

According to Kunreuther (1998a), insurers can offer protection against any risk that they can identify and for which they can obtain information to estimate the frequency and magnitude of potential losses, as long as they have the freedom to set premiums at any level.[3] However, due to problems of ambiguity in estimating very low-probability events, adverse selection, moral hazard, and highly correlated losses, insurers may desire to charge premiums that considerably exceed the expected loss. These premiums may be so high as to make insurance ill affordable. If demand is very low, it is not profitable for insurers to incur the costs of operating in the market.

In this report, we consider losses to be *uninsurable* if they cannot be estimated, or if insurers are reluctant to offer cover because of such factors as lack of demand due to very high premiums, the potential of very large losses, adverse selection and moral hazard.[4] The insurability of losses is thus dependent on both the willingness of insurers to *supply* cover for potentially catastrophic risks and the willingness of households, businesses and the public authorities to purchase or *demand* cover for catastrophic risks.

Many of the conditions resulting in high premiums (and low demand) have been or can be corrected with private institutional arrangements. For instance, insurers can reduce moral hazard problems with deductibles or co-insurance. If insurers operate in a regulatory environment where they are free to set "risk-based" premiums consistent with the customer's risks, the adverse selection problem can be reduced with improved information on the risks. The problem of capital insufficiency and insolvency risk can be improved with strategies of diversification, reinsurance, and the use of newly developing capital market instruments, such as catastrophe bonds, for transferring risks to the capital markets (Kunreuther and Linnerooth-Bayer, 1999).

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[3] See, also, Roth (1997).

[4] For a discussion of the insurability of flood risks, see Swiss Re (1999).

Taking account of these measures, however, insurers are still reluctant to enter many catastrophic risk markets with premiums low enough to attract customers. One important factor contributing to low demand for insurance is the widespread belief that governments will compensate losses occurring to uninsured victims. This assistance can be given to private households and enterprises, but it can also be given to local government authorities (on the part of the national government). Public assistance to the uninsured victims of natural catastrophes is substantial but varied. As we show in this report, governments of countries like Italy and Poland have traditionally granted large amounts of disaster aid and assistance to private victims. In contrast, the UK and Germany promote private responsibility by granting only very limited aid after disasters. The US federal government provides a great deal of assistance to state and local governments in the case of a nationally declared disaster.

Opponents of government assistance to uninsured victims point out the inefficiencies of this policy (Kunreuther, 1998a). If uninsured disaster victims are guaranteed grants and low-interest loans that enable them to continue to locate their property in hazard-prone areas, and more people build in those areas, taxpayers will be subject to increasingly larger expenditures for bailing out victims of future disasters. On the other hand, many may feel that this inefficiency is offset by the promotion of social solidarity in the community or country. Governments also intervene in ways besides compensating private and public victims. To assure the availability of insurance and to protect policyholders against insurer insolvency, the public authorities in some countries are involved in insuring or reinsuring natural disaster risks.

In many vulnerable countries, there is increasing recognition that national programs must be developed that will effectively and fairly link private and public responsibility, insurance and loss mitigation (Kunreuther and Roth, 1998). From the insurers' perspective, the government can most usefully pursue this goal by improving conditions for the private insurance market to operate effectively. These measures might include:

- Data collection and public information;
- Mandatory insurance and private mitigation measures;
- Reinsurer of last resort;
- Making government relief to private victims conditional on insurance;
- Encouraging public infrastructure insurance; and
- Tax relief measures for insurers and insureds.

These and other measures will be discussed in more detail in the case studies and in the concluding section.

In what follows, we summarize each of the seven case studies emphasizing the loss estimates and the ways these losses have been reimbursed by governments, insurance companies and voluntary aid. We also discuss the institutional arrangements influencing the balance between these loss-sharing arrangements and the insurability of the uninsured losses. We conclude with a comparison of the losses, loss-sharing arrangements and insurability issues across the seven cases.

2. THE MIDWEST FLOODS OF 1993, USA

2.1 Description

The Midwest floods of 1993 affected nine US states comprising an area of almost 1 million km^2, and inundated over 27,000 km^2 (see Figure 2.1).[5] Nearly 150 major rivers and tributaries were involved. A wet season and heavy snowfall in 1992 prepared the way for the floods, which were caused by numerous events of heavy rainfall in June and July 1993. The flooding led to the loss of fifty lives, and tens of thousands of people were evacuated, many of whom were left homeless. Flooding destroyed thousands of residential properties and caused major infrastructure loss, particularly in transportation systems and the municipal provision of water and power. Nearly 50% of the approximately 100,000 damaged homes suffered losses due to groundwater or sewer backup as opposed to riverine flooding. The largest financial losses, however, were recorded in the agricultural sector.

Figure 2.1 The nine states affected in the 1993 Midwest floods

Adapted using source: http://www.nationalatlas.gov/scripts/start.html

2.2 The loss estimates

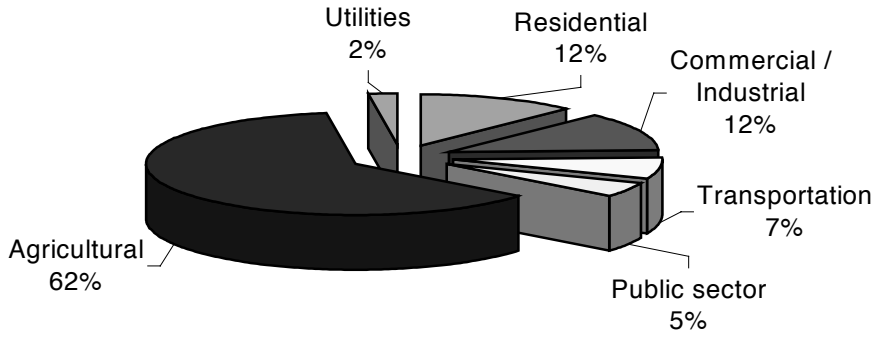
An early study carried out by an interagency committee estimated direct losses from the floods to be USD 12 billion,[6] and a more thorough study by the National Weather Service (NWS) (reported in Interagency Floodplain Management Review Committee, 1994) updated this estimate to USD 15.7 billion.[7] A later extensive survey carried out by the United States Army Corps of Engineers (USACE) estimated direct losses to be far lower, or USD 6.2 billion (USD 7.5 billion

[5] For detailed descriptions see Changon (1996) and Larson (1998).
[6] Interagency Floodplain Management Review Committee (IFMRC) (1994), p.15. Sum of individual state damage estimates.
[7] National Weather Service, in IFMRC (1994), p.15

including indirect losses), which is a conservative estimate according to USACE.[8] Other non-governmental estimates that include indirect losses are in the order of USD 18 billion.[9]

Based on the NWS and USACE estimates, we calculate the average of reported estimates of direct losses (AREDL) to be approximately USD 11 billion. Note, however, the large uncertainty in this estimate, where the higher estimate is nearly 150% greater than the lower. Only the USACE study reports direct losses according to sector. As shown in Figure 2.2, an estimated 62% of total direct damages were accounted for by the agricultural sector, 12% each by the commercial and residential sectors and 7% by the public sector (including utilities but excluding road and bridge damages). This figure does not include indirect losses, which were reportedly very high due to the long duration of the flood event.

Figure 2.2: Estimated Direct Losses by Sector
(Based on USACE estimate of direct losses = USD 6.2 billion)



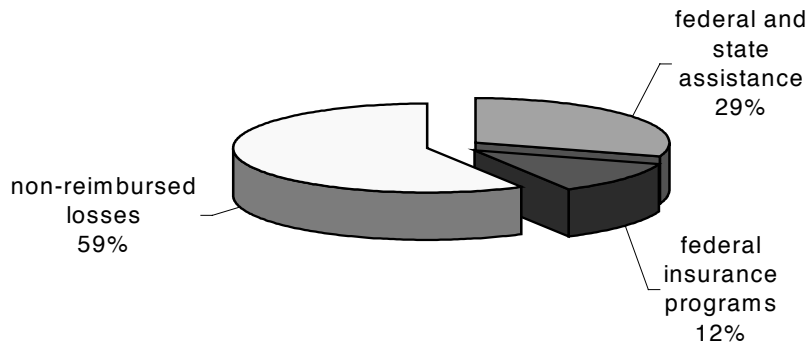
Source: US Army Corps of Engineers (1996). Note: 'Transportation' includes only roads and bridges.

2.3 Reimbursing the losses

As shown in Figure 2.3, around 42% of the direct losses (based on the AREDL estimate) were reimbursed. Federal insurance programs paid out over USD 1.3 billion in claims, which amounted to about 12% of AREDL[10] (note that this figure of insured losses would be close to 20% using the lower USACE estimate of direct losses). Insured losses increase to 14% when only private direct losses are taken into account. Federal and state assistance payments to private, commercial and public authorities in repairing direct losses amounted to approximately 29% of AREDL. Much of the federal payments were allocated to the commercial, transportation and public sectors.

[8] United States Army Corps of Engineers (1996). This database has been updated since its inception.
[9] Changnon (1996) and Swiss Re (1999)
[10] Interagency Floodplain Management Review Committee (1994), p.27. The National Flood Insurance Program (NFIP) paid USD 300 million in claims, and the Federal Crop Insurance Program paid USD 1 billion. This study deals mainly with the NFIP.

Figure 2.3 Estimated Reimbursed Direct Losses by Sector (AREDL = USD 11 billion)



2.4 Institutional arrangements

The National Flood Insurance Program (NFIP)[11] is the only public insurance arrangement in the seven case studies (see Appendix 1). The NFIP is administered by the Federal Emergency Management Agency (FEMA) and provides insurance on buildings and their contents (both residential and non-residential). The NFIP was designed to increase the role of the insurance industry in providing flood cover and ultimately to have the industry take over a risk-bearing role. The private insurance industry acts as writer of NFIP flood insurance policies within the framework of the WYO (Write Your Own) program, but private insurers do not bear any risk. NFIP currently offers coverage in 19,000 communities, and individuals can insure themselves once their community participates in the program. A notable and unique feature of the NFIP is that communities must take prescribed mitigation measures if their residents are to be eligible for cover. In addition, there are considerable incentives in the form of discounts on premiums provided to communities that undertake mitigation measures. Although flood insurance is not mandatory in the US, federally related loans/mortgages can only be provided to inhabitants of high-risk flood areas if they possess flood insurance. A major loophole, however, is that property owners tend to cancel this insurance once they have their mortgage. People having received federal disaster assistance for floods will only be eligible for such assistance in the future if they have purchased flood insurance.

Despite major efforts to extend coverage, only about 30% of US floodplain occupants are insured against floods. Premium rates are increasingly risk-based, but about 30% of policies cover properties built before flood-risk maps were available, and on average these properties are charged about 38% of the full risk premium. Crop insurance is made available through the Federal Crop Insurance Program. In 1993, crop insurance cover (which varies by crop and year) ranged between 11% in Wisconsin and 93% in South Dakota. With the aim to move the burden of disaster payments away from the state, new rules for promoting the marketing of NFIP policies have been recently introduced.

In years of higher losses, FEMA can borrow funds from the US treasury to cover NFIP losses. Since interest is paid on these funds, taxpayers do not bear the burden. However, if a number of major loss events were to occur within a single year, a direct intervention by the federal government to help cover insurance claims from general taxes is possible.

[11] For a good description of this program, see Pasterick (1998).

Another notable feature of the US system is the extent of federal government aid provided in the event of a declared disaster (this declaration is made by the president), in which case FEMA can make funds available to the affected states to help in repairing damage to public infrastructure (and also some assistance to private citizens). This assistance is usually conditional on state matching funds of 25% of the total. In the case of the 1993 Midwest floods, it was decided to lower the state match funds to 10 percent.

2.5 Uninsured losses and their insurability

Based on the AREDL of USD 11 billion, an estimated 88% of the direct losses from the Midwest floods were uninsured. In spite of the general success of NFIP since its inception in 1968, the majority of floodplain occupants still remain without coverage. Excluding the public sector, we see from Table 2.1 that 14% of private losses were insured (residential 15%, agricultural 15%, and industrial/commercial 7%). Although data is limited, there is evidence of some public sector insurance, for example, a public water treatment facility in Des Moines, Iowa, had extensive flood damage cover from a private insurer.

Table 2.1: Available Information on Insured Losses

	Total Direct Losses (Percentage of AREDL)	Direct Losses Insured (approximate)*	Information on Insured Indirect Losses
Private Losses	**86**	14 % of private	n.a.
Household	12	15 % of household	n.a.
Commercial/Industrial	12	7% of comm/ind	Few firms hold business interruption cover
Agriculture	62	15%of agriculture	n.a.
Public Losses	**14**	0.1% of public	n.a.
TOTAL	**100**	12%	

Sources: USACE (1996), IFMRC (1994)

*These losses are based on the assumption that the percentages of sector losses reported in the USACE report (with direct losses of USD 6.2 billion) apply to the AREDL (with direct losses at USD 11 billion)

There are a number of possible reasons for the low insurance cover. Myopia or a sense that "it can't happen to me" has been shown to be an important factor in insurance demand (Kunreuther, 1998a). Other reasons include a lack of willingness to purchase insurance due to the belief that federal financial assistance will be provided in cases of disasters (this is understandably the case with the local public authorities where assistance is statutorily available), a lack of awareness of available insurance, and the fact that many living in high-risk areas have low incomes. While flood insurance is a condition of a mortgage, many persons eventually cancel their policies (Pasterick, 1998).

There is considerable room for further insurance cover in all sectors (by writing NFIP policies, or offering private policies), especially in light of the extensive NFIP flood rate mapping. The move toward risk-based premiums on the part of the NFIP will open possibilities for the private sector to compete. Furthermore, insurance for business interruption and other indirect losses is not offered by NFIP, again posing opportunities for the private sector. Higher interest rates in the US may make reinsurance more viable since the NFIP borrows funds from the treasury in times of high loss payments. Finally and importantly, legislation has been introduced to reduce the extensive federal disaster aid to local and state governments. This could lead to increased demand for public-sector and private flood insurance.

3. THE RHINE RIVER FLOODS OF 1993 AND 1995, GERMANY

3.1 Description

The floods of December 1993 and January 1995 on the Rhine river and its tributaries inundated 12 of the 16 German federal states (see Figure 3.1). The worst damage was in Baden-Württemberg (state capital, Stuttgart), Bavaria (Munich), North Rhine-Westphalia (Düsseldorf), Rhineland-Palatinate (Mainz), and Saarland (Saarbrücken). The cities most affected by the floods were Cologne and Koblenz. The 1993 floods, which were mainly the result of a ten-day period of heavy and persistent rainfall, caused more damage in the Rhineland-Palatinate and Baden-Württemberg states than the 1995 floods. North Rhine-Westphalia is further downstream and was affected more severely in the 1995 floods. The 1995 floods were caused by a combination of heavy precipitation in the form of rain in the lowlands and snow in the highlands and continued freezing temperatures in some areas and thawing in others. These factors resulted in the saturation and thus high runoff propensities of soils. Five persons lost their lives in both the 1993 and 1995 floods.[12]

Figure 3.1 Map of Germany showing the Rhine river

Adapted using source: http://www.lonelyplanet.com

3.2 The loss estimates

The floods of the Rhine river and its tributaries caused estimated direct losses of over USD 575 million (DEM 1,000 million) in 1993 and USD 360 million (DEM 550 million) in 1995.[13] Early estimates of losses were much higher than later estimates. Indeed, the over estimation of flood losses in 1993 brought about considerable caution in the estimates made in 1995.

[12] For a description, see Dombrovsky and Ohlendieck (1998).

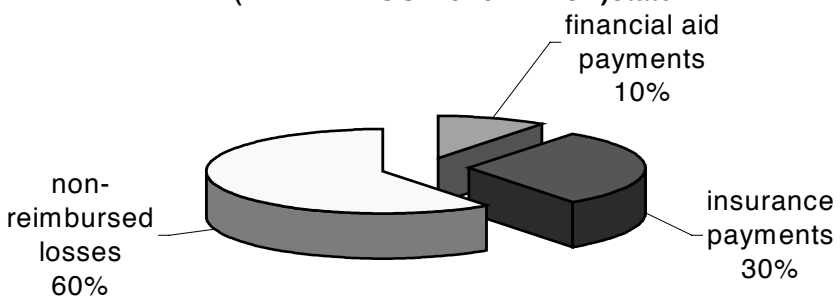
[13] Bayerische Rück (1994, 1995), Munich Re (1999), Bundesanstalt für Gewässerkunde (1996)

The average of reported estimates of direct losses (AREDL) for 1993 is calculated here as USD 575 million; this figure is based on the direct loss estimates provided by Bayerische Rück (1994), Munich Re (1999) and Bundesanstalt für Gewässerkunde (1996). It should be kept in mind that these estimates are incomplete and inexact since there is no comprehensive loss reporting system in Germany. Little information exists on the share of losses by sector, but agricultural losses were relatively low due to the season of the floods. Most of the losses appear to have been experienced in the household and commercial/industrial sectors. However, there is no information on the extent of public infrastructure losses (it is assumed in this report that reported estimates of direct losses include public-sector losses). In the 1993 floods, in Rhineland-Palatinate 38% of private losses were attributed to the household sector and 54% to the commercial sector. The figures were 25% and 75%, respectively, for the Saarland (Bayerische Rück (1994)). There is no division of direct and indirect loss figures, but besides clean-up expenses (USD 6 million) and loss of income from non-navigability of waterways (USD 26 million), most costs appear to have been direct since there was not a long period of business interruption (Dombrowsky and Ohlendieck, 1998; Bundesanstalt für Gewässerkunde, 1996).

3.3 Reimbursing the losses

Figure 3.2 shows the estimated reimbursements made through state financial aid and insurance payments for the 1993 floods (similar data on state aid are not available for 1995). Estimates of total insured losses amounted to DEM 300 million (USD 172 million) for the 1993 floods and DEM 220 million (USD 144 million) for the 1995 floods. Information on the amount of insured losses in each state is not readily available (except for Baden-Württemberg).

Figure 3.2: Estimated Reimbursed Direct Losses for the 1993 Flood (AREDL = USD 575 million)



Sources: Bayerische Rück (1994), Munich Re (1999), Bundesanstalt für Gewässerkunde (1996)

3.4 Institutional arrangements

In Germany insurance against floods is voluntary, and there is no governmental arrangements for reinsurance (see Appendix 1). Standard fire-peril insurance includes fire, lightning, aircraft and explosion, where flood and earthquake cover can be purchased for an additional premium. Until 1994, private flood insurance was mandatory for buildings of all types in the state of Baden-Württemberg. This insurance is no longer mandatory since the monopolistic nature of the market (due to barriers to entry) was ruled contrary to European Union regulations. There are, however, proposals for mandatory private insurance if the market should become more

competitive. One problem limiting entry of private firms into the market is that the decentralized structure of the German federalist government complicates data gathering.

An important factor in favor of private insurance in Germany is the limited government aid provided by state authorities to uninsured victims. Public assistance is generally based on a minimum amount of damage incurred (between DEM 1,000 and 3,000) and is only provided to property owners who are not able to cope with the costs of repairing the damage within the foreseeable future.

3.5 Uninsured losses and their insurability

Based on the AREDL of USD 575 million for direct losses from the 1993 floods, approximately 70% were uninsured; for the 1995 floods, approximately 60% of direct losses were uninsured (Bayerische Rück, 1994; Munich Re, 1999). This increase in insured losses is explained partly by more persons purchasing insurance after the 1993 floods. It may also result from the loss-reducing measures put into place after 1993, especially on the part of persons not carrying flood insurance. These measures may have reduced the amount of uninsured more than insured losses. It is important, however, to recognize the significant uncertainty in the loss accounting. As shown in Table 4.1, there is very little information available on insured and uninsured losses.

Table 3.1: Available Information on Insured Losses (1993 flood)

	Total Direct Losses (Percentage of AREDL)	Direct Losses Insured (approximate)*	Information on Insured Indirect Losses
Private Losses	n.a.	n.a.	n.a.
Household	n.a.	n.a.	n.a.
Commercial/Industrial	n.a.	n.a.	n.a.
Agriculture	n.a.	n.a.	n.a.
Public Losses	n.a.	n.a.	n.a.
TOTAL	**100**	30%	

Sources: Bayerische Rück (1994), Munich Re (1999)

Notwithstanding data limitations, insurers report a widespread lack of private flood insurance, which can be partly attributed to the considerable amount of population movement into risk areas (new residents often being unaware of their risk of flooding) and to lower income households in certain flood-exposed areas. Contrary to many other countries in Europe, this lack of insurance demand cannot be attributed to a belief that the government will compensate uninsured losses, nor does it appear to be explained by myopia or a lack of flood awareness, at least not after 1993. What may be salient in Germany is the relatively high incomes of the persons living in the high-risk areas since many residents appear to prefer self-insurance and taking extra precautions rather than purchasing a flood insurance policy. They may also count on help from family, friends and neighbours in a general show of solidarity.

Adverse selection poses an obstacle for insurers offering flood cover since floodplain risk identification is almost non-existent. The loss potential may also be quite high. Munich Re (1999) postulates that the losses incurred during the numerous flood catastrophes of recent years may be far exceeded by an extreme event in the catchment area of the Rhine with potential economic losses of USD 10 billion. Swiss Re (1999) calculates a loss potential from river floods of up to USD 30 billion in Germany (extreme flooding of the Rhine). Informing the public about possible hazard mitigation and offering incentives for mitigation expenditures should be a priority.

4. THE POLISH FLOOD OF 1997

4.1 Description

In the summer of 1997, torrential rains caused several major rivers to break through flood dikes resulting in disastrous flooding in southwestern Poland, the Czech Republic and the eastern part of Germany. Poland was the most affected with over 100 persons losing their lives and thousands left destitute. The rains, which began on July 5 and lasted for two weeks, inundated 1.5 million acres in Poland. The worst surge was along the Oder, devastating the city of Wroclaw. Damage was substantial: 45,000 flooded buildings, more than 3,000 kilometres of damaged roads, almost 2,000 kilometres of damaged rail lines, and hundreds of damaged or destroyed bridges (International Federation of Red Cross and Red Crescent Societies, 1998). The floods hit heaviest in the provinces of Wroclaw, Walbrzych and Opole (see Figure 4.1). Precipitation of this magnitude had not occurred in the country in over 1,000 years.

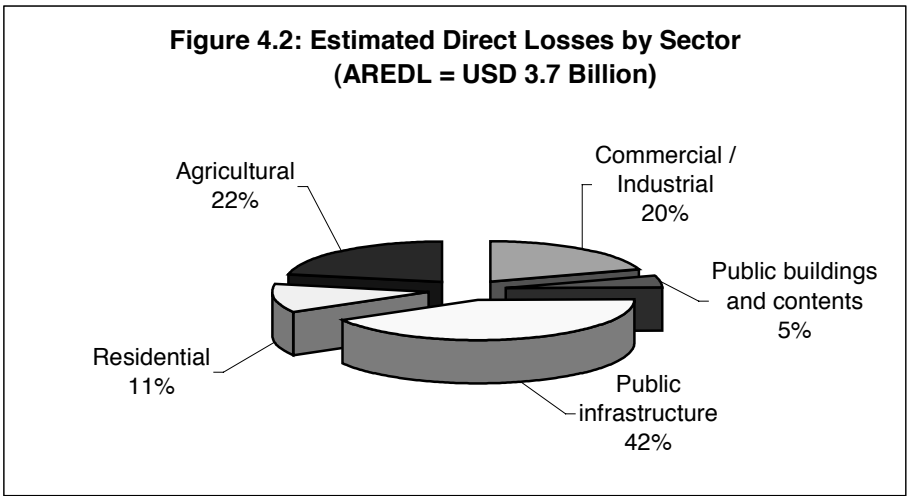
Figure 4.1 The Oder and Vistula rivers in Poland

Adapted using source: http://www.lonelyplanet.com

4.2 The loss estimates

The government estimate of USD 3.7 billion for direct losses from the 1997 flood was the only estimate, and therefore this figure serves as our estimate for the average of reported direct losses (AREDL) (Polish Statistical Bureau (1998). This estimate appears to be more certain than others in this report since Poland has a rather comprehensive government system for reporting losses. Indirect losses were estimated to be around USD 500 million, although the uncertainty is probably greater with respect to this estimate. As shown in Figure 4.2, a large part of the direct losses occurred in the public sector (nearly 50%) with main damage to roads and railways (USD 438

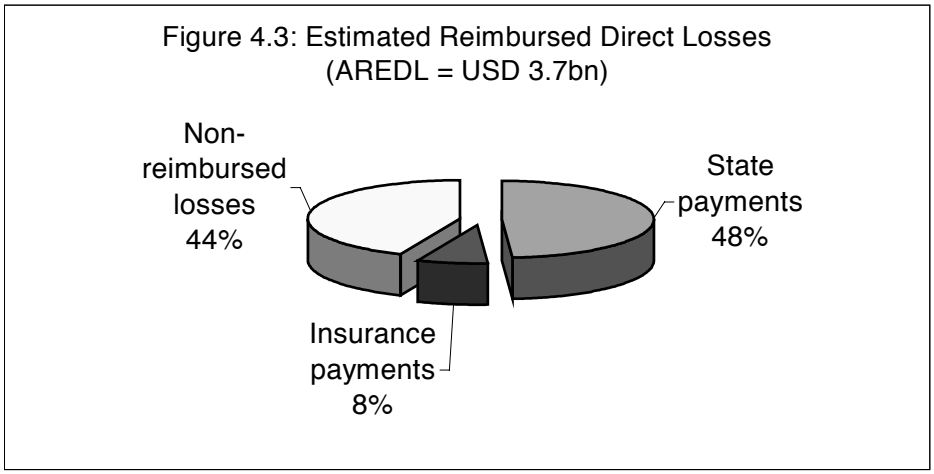
million), water/sewage facilities (USD 663 million), communication infrastructure (USD 439 million) and buildings (USD 180 million). The agricultural, commercial and residential sectors also suffered extensive damage.



Source: Adapted from data from Polish Statistical Bureau (1998)

4.3 Reimbursing the losses

Figure 4.3 shows that a relatively high proportion of the direct losses from the 1997 floods was reimbursed (56%) mainly due to government assistance to private victims. State aid payments amounted to approximately USD 1.7 billion. In addition, many property owners in the flooded area carried limited private insurance. Insurance companies reportedly paid out USD 280 million in claims, which represented about 8% of total and 17% of private direct losses. Approximately half of these insurance losses were absorbed by international reinsurers. [14]



Source: Polish statistical Bureau (1998)

Assistance also came in the form of low-interest loans from international institutions, which amounted to about 23% of the estimated direct losses. While the loans must be repaid by Polish taxpayers, the interest savings can be considered a reimbursement from taxpayers of countries that

[14] Both figures are reported in Swiss Re (1997).

contribute to these financial institutions. The European Investment Bank and the World Bank each approved USD 300 million to repair public infrastructure. In addition, the European Bank for Reconstruction and Development offered approximately USD 110 million in loans to damaged Polish and Czech cities.

4.4 Institutional arrangements

Prior to 1989, a compulsory state insurance scheme for natural hazards was in existence. Today, insurance against natural disasters is voluntary and private, although agricultural buildings are still compulsorily insured (see Appendix 1). About 25% of commercial/residential property and 50% of industry have insurance coverage for natural perils, which is available for an extra premium to the standard fire perils policy. Premiums vary, but there is too little information on flood risks for rigorous risk-based pricing. Most insurance is offered by domestic insurance companies, which in some cases have limited reserves and too little reinsurance to cope with large or consecutive disasters. Recent proposals for the introduction of a nation-wide insurance system for natural catastrophes, possibly with government reinsurance arrangements, have been put forward with the encouragement of the World Bank.

Traditionally, Polish citizens have relied on their government to reimburse losses incurred from natural disasters, in effect spreading the losses across all Polish taxpayers. However, in view of the efforts of the government to reduce budget deficits (to comply with the Maastricht Treaty criteria for European Union membership), the public authorities are striving to reduce their role in reimbursing disaster victims by encouraging more private insurance and mitigation. However, the public appears reluctant to accept this switch away from the traditional forms of national solidarity. Indeed, as the Polish flood waters rose, the Prime Minister made a public statement that uninsured victims had only themselves to blame for their financial losses and should not expect government help. This remark raised such a public outcry that the Prime Minister was forced to apologize (Stripple, 1998).

Another way the government can reduce its liabilities for post-disaster recovery is with public-infrastructure insurance or, alternatively, with novel hedging instruments such as catastrophe bonds (Kunreuther and Linnerooth-Bayer, 1999). Especially developing and transition countries may have difficulties in financing post-disaster relief through more conventional financing instruments. If the disaster results in a reduced credit rating for the country, it may be difficult to borrow (this was not, however, the case after the 1997 flood). Moreover, poor countries may not have capacity after a major disaster to raise relief and reconstruction funds from taxpayers. In Poland, a flood tax was considered but rejected mainly because the government deficit was alleviated with loans from international lending institutions.

4.5 Uninsured losses and their insurability

Based on the official government estimate of USD 3.7 billion of direct losses from the 1997 Polish floods, an estimated 8% of total losses and 17% of the private losses were insured. Table 4.1 presents a breakdown of available information on the insurance of private and public losses by sector. Most notable is the complete lack of insurance for public-sector losses. Since the repair of damaged property owned by the public sector is particularly large in the transition countries relative to the private sector, there is increasing interest in these countries in public-sector insurance.

Table 4.1: Available Information on Insured Losses

	Total Direct Losses (Percentage of AREDL)	Direct Losses Insured (approximate)	Information on Insured Indirect Losses
Private Losses	**59**	17%	n.a.
Household	12	Approx, 37% of households were insured	n.a.
Business	25	n.a.	Few firms hold business interruption cover
Agriculture	22	n.a.	n.a.
Public Losses	**41**	0	No public-sector cover
TOTAL	**100**	8%	

Sources: Polish Statistical Bureau (1998); Kunreuther and Linnerooth-Bayer (1999)

There are many explanations for the general lack of private insurance in Poland. Foremost is the low level of household and business income. In addition, prior to 1997, many people may not have perceived themselves to be at risk from flooding even though a 1994 study by the Supreme Board of Inspection found that 2,000 of the country's 9,000 kilometres of dikes required extensive upgrading. Moreover, many Poles still consider their government to be primarily responsible for compensating disaster victims.

The insurance industry is also reluctant to offer flood insurance without additional premium for their perceived risks. The problem of adverse selection exists especially since flood-risk assessment is only in preliminary stages, although efforts are now being made to prepare flood-risk maps. Once the dikes are upgraded and flood-risk maps are available, insuring flood risks will become a more amenable task. However, domestic insurers may still be vulnerable to low-probability, high-loss floods (for example the flooding of Warsaw) or to a series of less severe floods. Moreover, foreign-based insurers appear reluctant to enter areas in Poland at high risk. Because of the difficulties in expanding insurance cover, research funding has been made available by the World Bank to investigate the formation of a national insurance system in which the government might play a role.

The relatively high public-sector losses in Poland, which characterize many disasters in transition and developing countries, may offer a special opportunity for insurers. As discussed above, Poland and other Eastern and Central European countries are considering possibilities for hedging their losses to public infrastructure through insurance or capital market instruments.

5. THE EASTER FLOODS OF 1998, UNITED KINGDOM

5.1 Description

The UK Easter floods affected an area of more than 5,000 square kilometres in the Midlands, Anglian, Wales and Thames regions over the bank holiday weekend of 9-13 April, 1998 (see Figure 5.1). At that time, the riverine flooding was the most severe ever recorded in many parts of central England (the floods in late 2000 were even more severe). Five people were killed, over 100 people were airlifted to safety (mainly from caravan and camping sites on the Avon River) and thousands were evacuated from their homes. More than 4,700 homes, 500 commercial properties and 1,900 caravans were inundated, and many bridges and roads were submerged (Bye and Horner, 1998).

The flooding was caused by 50-75 millimetres of rain (more than the average monthly rainfall for April) that fell in less than 36 hours in parts of central and eastern England. The rain fell on saturated catchments, causing rivers to rise at record rates, in places reaching the level of a 1-in-200 year flood event. Unlike the spring flood of 1947, which is a benchmark flood for most rivers in England and Wales, the floodwaters receded quickly resulting in lower losses than initially predicted.

Figure 5.1 The Area affected by 1998 Easter Floods

Source: Adapted from Bye & Horner (1998)

The disaster generated a great deal of media and public interest in floods, motivated largely by the speed of the flood onset and the record rise in water levels together with the exaggerated initial loss estimates. The level of the floods set a new benchmark against which return periods are now measured. A great deal of attention was focussed on the performance of the Environment Agency, which was criticised for its poor co-ordination of the emergency response and the lack of adequate warnings. The Agency subsequently identified the need for more stringent land-use controls to avoid further imprudent development of the floodplains. The Agency also commenced a campaign to increase public awareness of the risks of flooding and the consequences of living in

flood prone areas. The Easter floods have thus been instrumental in changing the attitudes and priorities of the authorities in addition to increasing public and media awareness of floods.

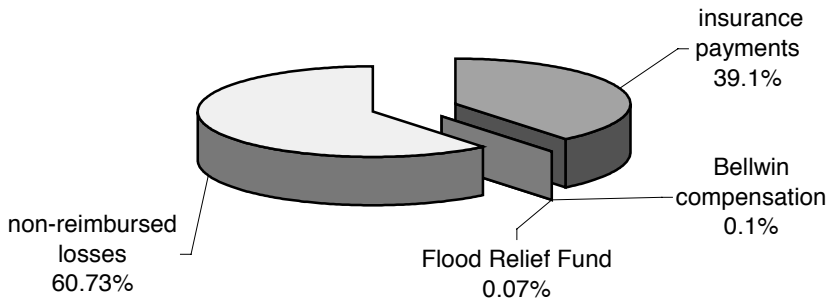
5.2 The loss estimates

The official estimate of direct losses from the Easter flooding prepared by Bye and Horner (1998) is USD 585 million (GBP 350 million). Since this is the only official estimate, in this study it represents our estimate of the average of reported estimates of direct losses (AREDL). Like in other countries, this estimate is based mainly on insurance claims. However, even with more extended insurance cover in the UK, this estimate remains highly uncertain given the lack of a coordinated data collection system among UK insurers. The losses have not been estimated by sector.

5.3 Reimbursing the losses

As shown in Figure 5.2, about 39 percent of the total direct losses from the Easter floods were reimbursed - almost solely by private insurance. The Association of British Insurers (ABI) (1999) has estimated insured losses to be £137 million (USD 230 million). At the time of the flooding, the Deputy Prime Minister promised government aid for the victims of the floods in Northampton (BBC News, 1998), but this aid program was not carried out (Hill, 1999). The UK central government has a general policy of not reimbursing losses from insurable risks. An exception is the Community Care Grant, which is a small, discretionary fund for payments to victims with very limited incomes, administered by the Department of Social Security.[15] Details of these payments, however, are not available. The Bellwin Scheme provides discretionary central government compensation for emergency relief to local authorities,[16] but this amounted only to USD 580,000 (£345,000) (DETR, 1999).

Figure 5.2: Estimated Reimbursed Losses (AREDL = USD 585 million)



Sources: ABI (1999a), DETR (1999), Hill (1999)
Note: Details of flood relief funds have been estimated based on information from several borough councils.

[15] See http://dss.gov.uk/ba/GBI/5a59bb4.htm
[16] Section 155of the Local Government and Housing Act of 1989, DETR (1998)

The church, local voluntary services and local flood relief funds provided in-kind disaster aid to uninsured victims, but the financial assistance was minimal. For tax purposes, local flood relief funds require charitable status, which forces them to 'alleviate poverty' and thus discriminate between the victims by means-testing (Welsh Consumer Council, 1992).

5.4 Institutional arrangements

A notable feature of the UK is that reimbursements for natural disaster risks are almost fully arranged through private insurance (see Appendix 1). According to Swiss Re (1999), the UK has insurance penetration levels of 95-100%; however, according to the ABI (2000) only about 75% of households have contents insurance and 62% have building insurance, and these figures may be lower for high-risk areas. Still, this is a comparatively high rate of insurance cover, which is probably attributable to two main factors: First, the public does not expect government aid for insurable risks. Second, building insurance policies are required as a condition of mortgages, and they automatically include or "bundle" cover for most natural hazards. Insurers estimate flood risks by the risks of postal zones (reducing adverse selection), and there is increasing availability of flood data. Because of the low flood risk in the UK (only 7% of the land is at risk) and the high penetration rates, private insurers do not generally have reinsurance.

The insurance industry is not heavily regulated, but an informal agreement between the industry and the government has ensured that flood insurance is widely available. It is made affordable as a standard peril by cross subsidies from those at lower risk from floods and other perils to those at high risk (Threadgold, 1995). Increasingly, however, premium rates and deductibles are set on a risk basis, although loss and risk data are still incomplete for assessing very extreme events. (The main foreseeable risk in this category is the failure of the Thames Barrier). Risk-based pricing will eventually reduce the substantial cross subsidies and may lead to considerably less flood insurance since those with low incomes living in high-risk areas will not be able to afford it. At the present, arrangements are in place to make insurance more affordable to low-income households, although there has been a recent government decision to remove allowances for insurance from social security benefits.

The Environment Agency is responsible for flood defence systems and the dissemination of flood warnings in England and Wales. After criticism of its response to the Easter floods, the Agency commissioned an independent review, the Bye Report (Bye and Horner, 1998), to assess its performance. This review found that the speed and intensity of the floods were without precedent in many areas, but it also highlighted serious shortcomings in the performance of the Agency. The main points raised were unsatisfactory planning of flood defences, inadequate warnings to the public, incomplete defences and poor co-ordination with the emergency services. After publication of the report, the Environment Agency (1999) announced an Action Plan that set out a range of improvements to flood forecasting, warning and response, which were estimated to cost GBP 45.4 million over 10 years. Attempts were made to impose a legal obligation on property owners to determine their risk of flooding and disclose this information to prospective purchasers and tenants, but this legislation was not passed (Keeble, 2000). Due to perceived shortcomings in the government's performance, there were also unsuccessful calls for government compensation to victims.

5.5 Uninsured losses and their insurability

Based on the AREDL of USD 585 million, approximately 61% of the estimated direct losses were uninsured. As shown in Table 5.1, there is no information available on insured private versus public losses, nor on insured losses by sector. Finally, there is no information available on insurance for the indirect losses.

Table 5.1: Available Information on Insured Direct and Indirect Losses

	Estimated Direct Losses (percentage of AREDL)	Direct Losses Insured	Information on Insured Indirect Losses
Private Losses	Breakdown of sectors not available	Breakdown of sectors not available	n.a.
Residential			No details available
Commercial			n.a.
Agriculture			n.a.
Public Losses			n.a.
TOTAL	**100% (*£350 million*)**	**39%**	

Sources: ABI (1999), DETR (1999), Hill (1999)

It is striking that the estimate of insured losses (39%) is substantially less than the average building and content insurance cover in the UK (estimated at 62% and 75%, respectively). The explanation may lie in the fact that traditionally the floodplains have provided inexpensive land that has attracted developments for low-income groups, for example, old age homes and council estates. Depots, leisure centres and industrial parks are also sited in these areas, while caravan and camping sites are commonly situated along the river banks. The residents and users of these building types seldom have mortgages and thus have no mandatory requirement for building insurance. Moreover, they are unlikely to carry contents insurance.

The extent of uninsured losses indicates that flood insurance opportunities are still available in the UK. However, these opportunities exist mainly for low-income persons, who may find the premiums unaffordable. This problem that will be exasperated by the trend towards risk-based premiums. It has been suggested that insurers offer contents insurance packages for council and private tenants, administered through their landlords, and that these packages be subsidised for low-income households. Another opportunity may be expanded business interruption cover for commercial and industrial policyholders. Finally, public authorities carry block insurance, but there may be scope for increased cover.

Since the risk of very extreme flood losses in the UK is relatively low, insurers of flood risks can offer broad cover by diversifying across hazards and regions. For this reason, there are no demands on the government to operate as the insurer of last resort. This system might be jeopardised, however, by a very high loss event.

6. THE GREAT HANSHIN EARTHQUAKE, 1995, KOBE, JAPAN

6.1 Description

The Great Hanshin or Kobe earthquake struck a dense urban area in the Hyogo, Kyoto and Osaka prefectures of Japan on 17 January 1995, exactly a year after the Northridge earthquake. The earthquake was of moderate size, measuring 6.9 moment magnitude (Shinozuka, 1995). It was the first large earthquake to hit a major industrial city in modern Japan. The depth of the earthquake was shallow, causing immense devastation, especially in the Hyogo prefecture around Kobe, which is Japan's sixth largest city and the location of the country's largest trans-shipment port. A total of 6,427 people died, 43,000 required medical attention, and over 300,000 persons (20% of the population of the prefecture) were made homeless (Munich Re, 1995). More than 210,000 buildings were destroyed or severely damaged. Response was severely hampered by the failure of the water supply and the disruption caused to the transportation system. Even without wind, fires razed an area of one square kilometre and destroyed 7,500 buildings (Tiedemann, 1996).

The area had experienced no seismic activity over the previous 30 years, and the risk was assumed to be low. Earthquake building codes were somewhat less stringent than for the higher-risk Tokyo area and did not make allowance for the stronger ground motions that occur on reclaimed land, of which there is much in Kobe particularly around the port area.

Figure 5.1 Map showing Kobe

Source: United States Geographic Survey

Japan has a long seismic history, yet Kobe was ill prepared for an earthquake. For the six thousand buried under the rubble of their dwellings, the help that arrived was too little and too late. The emergency response was hampered by lack of information regarding the scale of the disaster. Local authorities only requested help from the Japanese military four hours after the event, and this assistance arrived from Tokyo 32 hours later (Katayama, 1996). Offers of foreign rescue aid were only accepted after the second day (Swiss Re, 1995). Access to the affected areas was limited, delaying the emergency operations, and bureaucratic restrictions slowed the catastrophe aid.

The earthquake punctuated the well-known lesson that the seismic performance of a structure is dependent on the type of construction, and most destroyed buildings were traditional, post-war timber Japanese homes. Other building types also suffered badly, particularly non-ductile steel and reinforced concrete buildings built prior to the 1981 regulations. Most of the serious damage to larger commercial and industrial buildings and infrastructure occurred on reclaimed land. This soil type is prevalent in Japan due to the high land costs (EQE International, 1995). Ground deformation and liquefaction destroyed almost all of the Kobe port, leading to large business interruption losses and affecting both revenue and local employment.

Kobe has a narrow transportation corridor linking the commercial Osaka-Kyoto area with southern Japan. The earthquake severed the rail links and destroyed both the Hanshin and new Wangan expressways. This meant that the only land access for rescue operation was via the city streets. These narrow streets, some only three meters wide, caused considerable bottlenecks in the supply of emergency relief and failed to act as fire breaks. The utilities were also badly damaged including water-supply facilities, which made it difficult for fire fighters to respond to the many fires following the earthquake.

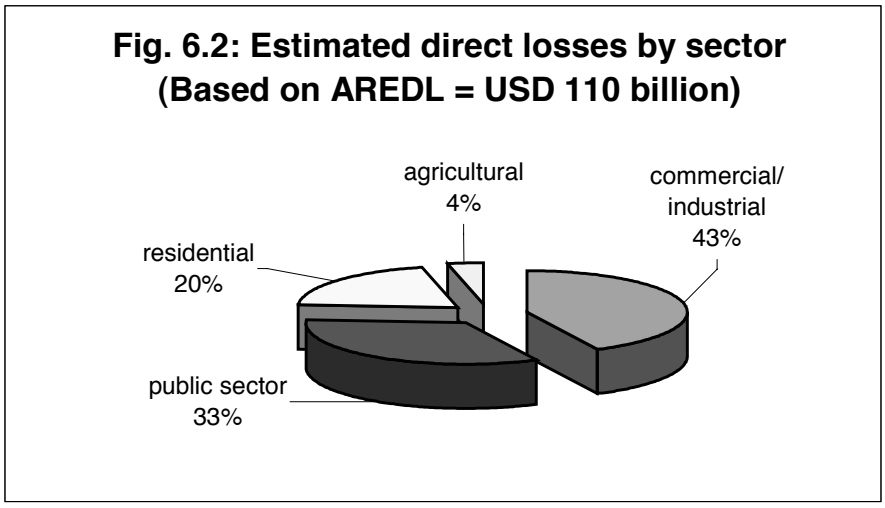
6.2 The loss estimates

The average of reported estimates of direct losses (AREDL) is calculated as USD 110 billion. This figure is based on the following estimates for direct losses: USD 100 billion by the Alexander Howden Group (1995), USD 99 billion by Hyogo Prefecture (in Katayama, 1996), USD 120 billion by Kagawa (1995) and USD 95-147 billion by EQE International (1995). The 50% difference between the low and high estimates reflects the large uncertainty in the loss accounting.

Ninety percent of the berths and cranes at Kobe port were damaged, which affected business revenue and local employment (Werner, et al., 1997). Much of Japanese industry relies on the 'just-in-time' (*kanban*) production method, which is vulnerable to the widespread lifeline and transportation disruptions that occurred after the earthquake. In addition, damage to public (and partly private) infrastructure was extreme, particularly to elevated transportation systems and utilities. This damage contributed to the high but unmeasured indirect losses, which probably increase the total loss figure considerably. After the earthquake, demand for human and material resources greatly exceeded available capacity. Resources had to come from long distances, which increased delays and costs significantly (Eguchi, 1997).

Most of the damage took place in a narrow band along the central axis of the city, which also serves as the transportation corridor. The area is characterised by high-density, low-rise wooden buildings with mixed residential and commercial occupancies. As shown in Figure 6.2, damage in the residential area was about 20% of estimated direct losses; in the commercial/ industrial sector about 43%; and public-infrastructure damage accounted for around 33% of direct losses. The division between the commercial/industrial and the public sectors, however, is not entirely clear since some publicly used infrastructure in Japan is privately owned.

Most recent structures conforming to the revised 1981 building code were earthquake resistant, but earlier engineered buildings proved to be very vulnerable (EQE International, 1995). Most of the serious damage to larger commercial buildings and infrastructure occurred in areas of soft soil and reclaimed land. Liquefaction occurred over wide areas of artificial landfill, particularly at the port area. The extent of losses was less where suitable construction techniques, such as deep-pile foundations, had been used (Muir-Wood, 1995).



Sources: Authors' calculations based on multiple sources.

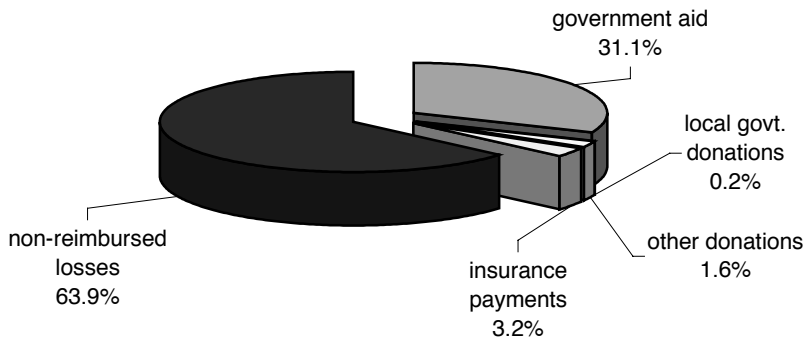
6.3 Reimbursing the losses

Figure 6.3 shows the share of estimated direct losses that were reimbursed by the national government, insurers and voluntary donations. National government expenditures amounted to over USD 34 billion over two years, or 31.5% of the AREDL (Property and Casualty Insurance Rating Organisation of Japan, 1997). The central government subsidised 90% of the cost of repairing local government public facilities (Tiong, 1995, EQE International, 1995). The local prefectural government provided USD 183 million in grants to victims. Donations from private corporations and the public were channelled into a fund, which apportioned USD 1.8 billion in aid to the victims (Property and Casualty Insurance Rating Organisation of Japan, 1997).

The average of reported estimates for insured losses is calculated to be USD 3.5 billion, which is only about 3 percent of estimated direct losses.[17] Residential insurance amounted to USD 0.8 billion (Kagawa, 1995), and approximately USD 1.2 billion was paid by the National Mutual Federation of Farming Co-operatives (*Zenkyoren*). Marine and commercial/industrial insured losses were estimated to be USD 0.5 billion. Foreign non-life insured losses have been estimated to be USD 150 million. (Munich Re (1995), Muir-Wood, 1995)

[17] EQE International (1995), Swiss Re (1995), Kagawa (1995), Munich Re (1995)

Figure 6.3 **Estimated reimbursed direct losses (AREDL = USD 110 billion)**



Sources referenced in Section 6.3

6.4 Institutional arrangements

Since the Kobe earthquake, Japan has increased its focus on earthquake disaster mitigation by enacting the Disaster Countermeasures Basic Act as well as an amendment to the Basic Plan for Disaster Prevention. Coordination of the different agencies now dealing with mitigation could prove to be a problem.

Earthquake insurance is available as an endorsement to the comprehensive fire insurance policies, and there is a legal requirement for the insurer to offer earthquake cover to the homeowner. Residential earthquake cover is backed by a government-private scheme with strict limits and set claim levels (see Appendix 2). The top layer of the national insurance system is covered by the taxpayer (95%) and the Japanese Earthquake Reinsurance Company (JER). The total value of private and government reinsurance cover in 2000 amounted to approximately USD 39 billion (Japan Earthquake Reinsurance Co., 1999). Should this reinsurance be exceeded, a pro-rata payback proportion will apply. At the time of the Kobe earthquake, commercial and industrial property indemnity provided coverage depending on the regional risk zone and the structure of the building.

6.5 Uninsured losses and their insurability

Based on the AREDL of USD 110 billion, around 3.2% of the estimated direct losses and 4.8% of the private losses were insured. The low level of insurance claims reflect the level of earthquake insurance penetration in Japan of only about 10 percent. As shown in Table 5.1, the largest proportion of insured losses in the Kobe case were attributed to agriculture. Many Japanese individuals and companies are classified as having agricultural holdings even in urban areas, since this is a way to overcome the stringent risk classification system building cover. The local governments do not appear to insure public infrastructure, perhaps due to the high level of central government reimbursements after a disaster.

The lack of demand for earthquake insurance in Japan appears to be mainly due to high premiums for low levels of cover. Premiums are necessarily high in many areas due to the high levels of risk, and in the past cover was limited to 30-50% of the sum insured in the main fire insurance policy. Since deregulation in 1996, cover is no longer restricted, and there is now greater

product differentiation between the various insurers (Insurance Market Report, 1999). These developments have caused cover to increase two or threefold.

Table 5.1: Available Information on Insured Losses

	Total Direct Losses (percentage of AREDL)	Direct Losses Insured (approximate)	Information on Insured Indirect Losses
Private Losses	**67%**	4.8%	
Residential	20%	5%	n.a.
Commercial	43%	7%	A few firms hold business interruption cover, available only from foreign insurers
Agriculture	4%	18%	n.a.
Public infrastructure	**33%***	No mention	No public sector cover
TOTAL	**100%**	**3.2%**	

* Japanese divisions between commercial private and public infrastructure losses are not clear and have been estimated.
Sources: Tokai Research and Consulting Inc, in Katayama (1996), Tiong (1995), EQE International (1995), Munich Re (1995), Alexander Howden (1995)

Opportunities for additional insurance products could focus on the commercial and industrial sector, as well as utilities, railways, motorways and the port, some of which are in the private and 'semi-public' sectors. A large proportion of commercial activity is concentrated in Tokyo, which is a particularly high-risk area. There may also be a market for insurance covering public-infrastructure damage. Business interruption insurance can provide opportunities, but insurers should be aware that the *kanban* (just-in-time) system carries enormous loss potential. Much of Japanese industry relies on this system, which is vulnerable to the widespread lifeline and transportation disruptions that occurred after the Kobe earthquake. This discontinuity resulted in substantial business interruption losses, yet no details of the insured indirect losses are available. The only insurers offering business interruption cover for earthquakes at the time of the Great Hanshin earthquake were foreign insurers, but this has changed since deregulation.

Japan is one of the most active seismic areas in the world, but the lessons learned from Kobe - and the increased public awareness of the risks - may contribute to opportunities for increased levels of earthquake insurance.

7. THE NORTHRIDGE EARTHQUAKE OF 1994, USA

7.1 Description

The Northridge earthquake that struck at 4.31 A.M. on 17 January 1994 affected an area of 5,700 km^2 in the San Fernando Valley, a densely populated residential area of northern Los Angeles, California. The moderately sized earthquake occurred on an unknown hidden fault and measured 6.7 moment magnitude. Although building structures were in most cases relatively new and building codes were stringent, the financial losses were significant. This moderate earthquake occurred in one of the best prepared regions of the world, yet its financial impact made it one of the worst disasters in US history. There were 57 fatalities, and 11,500 people received hospital treatment for injuries (EQE International, 1994).

Figure 7.1 The Northridge Earthquake Area

Source: U.S. Geological Survey

The Northridge earthquake demonstrated the value of seismic strengthening and mitigation measures in reducing deaths and injuries, still the scale of the economic losses was unprecedented. The earthquake demonstrated the extensive costs associated with the repair and reinstatement of damaged buildings as well as the vulnerability of some building types. The economic costs of improved seismic protection are high, and the public is not always willing to invest in costly mitigation measures that are essentially long-term, particularly when the likelihood of residential occupation is short-term.

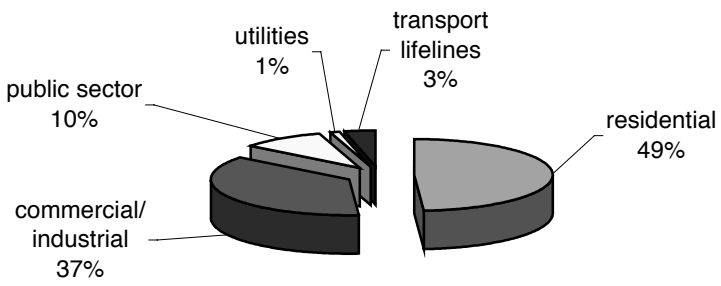
The Northridge earthquake also raised awareness of the value of good data collection and the use of geographical information systems (GIS). The proactive measures taken by the California Office of Emergency Services (OES) in the commission of a GIS system appear to have served the emergency response and planning needs of the Office well (Goltz, 1996). The earthquake also highlighted the uncertainty of present seismic risk predictions. Earthquakes pose a significant risk in at least 38 other states, none of which are as well prepared as California (Jacob, 1995). Federal and state governments are keen to reduce their responsibility for disaster relief, which is unlikely to be equally generous next time. Insurers have also grown wary - as the increased premium rates and

reduced coverage offered by the California Earthquake Authority indicate - and earthquake insurance policies are no longer as widely carried by the public as before.

7.2 The loss estimates

A loss estimate of USD 13-22 billion was prepared for the California Office of Emergency Services (OES) eight days after the event (Goltz, 1996), and later estimates of total direct losses totaled USD 25 billion (Risk Management Services, 1999). These estimates were revised upwards to between USD 39.6 billion (Scawthorne, et al., 1997) and USD 44 billion (OES in Eguchi, et al., 1998). Using the latter two figures, this report calculates the average of reported estimates of direct losses (AREDL) to be USD 41.8 billion. Due, however, to the lack of a systematic loss-reporting system in the US, these estimates are highly uncertain. Indeed, a recent report by the National Research Council (1999) has recommended that a natural disaster, loss-accounting system be put into place in the US. The increase in the loss estimates over time was due to the initial damage estimates being prepared by building inspectors, who were checking for safety rather than losses, while loss adjusters prepared later increased estimates. Damage to contents, hidden structural damage, and retroactive building code requirements (in reconstruction) increased the direct economic loss estimates even further (Eguchi, et al., 1998).

Figure 7.2 **Estimated Direct Losses by Sector (Based on AREDL = USD 41.8 billion)**



Sources: Scawthorne, et al. (1997) and Eguchi, et al. (1998).

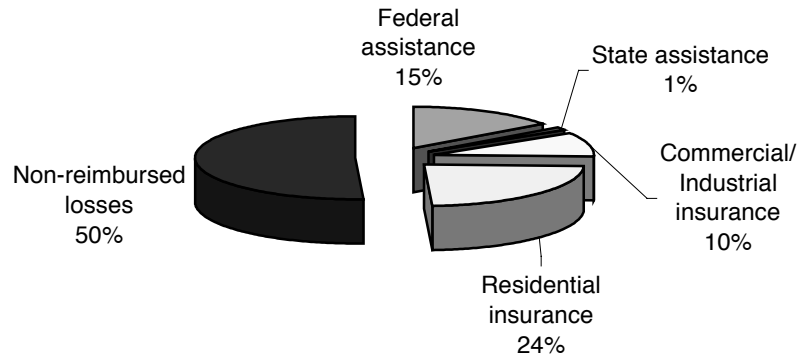
As shown in Figure 7.2, the residential and commercial sectors suffered the most damage. Not surprisingly, agricultural losses were minimal. Public-sector losses were relatively small, but Los Angeles is highly dependent on motor vehicles for urban transportation, and damage to transportation and other infrastructure led to high indirect losses. Other indirect losses resulted from over twenty thousand people left homeless (EQE International, 1994) and from the destruction of the major shopping centre in the area that took over 16 months to reopen causing long-term changes in retail patterns.These indirect losses have been estimated to be over USD 7.5 billion, of which more than 80% were from business interruptions.[18] Most of these losses were uninsured and have led to social and economic changes in the area. Tax-revenue losses were estimated to be USD 0.86 billion, and almost 1% of the USD 4.1 billion Small Business Administration loans defaulted (Small Business Administration, 1999). The San Fernando valley had been subjected to a recession for three years prior to the earthquake, and this exacerbated the economic effects of the earthquake (Alesch and Holly, 1996).

[18] Gordon, et al. (1996); Federal Emergency Management Agency (2000)

7.3 Reimbursing the losses

Since the Northridge earthquake was declared as a national disaster by the US president, the Federal Emergency Management Agency (FEMA) and other federal agencies were legally obliged to make funds available to California. Total federal expenditure was USD 13 billion, making Northridge the largest and most costly US disaster in terms of federal funding.[19] The earthquake occurred in a congressional election year, which may have contributed to the generosity of the federal assistance. Reimbursements from FEMA for direct losses have been estimated at over USD 5 billion and those from other agencies at over USD 1 billion. The state of California was liable for 10% of the costs of the federal assistance programme, and contributed USD 0.6 billion in assisting private victims for their losses (see Figure 7.3) (Egushi, et al., 1998). Insured losses were initially estimated at USD 2.5 billion by the Property Claim Services (PCS), but were subsequently revised to USD 12.5 billion eighteen months later.[20] The Institute of Building and Home Safety (1999) used

Figure 7.3 **Estimated reimbursed direct losses (AREDL = USD 41.8 billion)**



Sources: FEMA (2000) HUD (2000), Eguchi et al (1998) Scawthorne (1997), IBHS (1999)

actual claims data to calculate losses to a final estimate of USD 15.3 billion. Based on the latter two figures, the average for insured losses has been calculated here to be USD 13.9 billion. These insured losses amounted to more than three times the total earthquake premiums collected by California insurers in the 25-year period prior to the disaster (Kunreuther, 1998a).

7.4 Institutional arrangements

In California, it is mandatory for insurers selling homeowners policies to offer earthquake cover to their policyholders. The high level of losses from Northridge and seismologists' predictions of further earthquakes caused most insurers to stop writing earthquake policies and, therefore, to stop offering homeowner's insurance, causing an insurance availability crisis. To overcome this market availability problem, the California Earthquake Authority (CEA) was created in 1996 as a

[19] See http://www.fema.gov/library/df_4htm
[20] Scawthorne (1997), Eguchi et al (1998)

state-organised insurance/reinsurance program (see Appendix 2). [21] Companies joining the CEA continue to offer earthquake insurance as an endorsement of homeowners' insurance policies. Due to the unwieldy nature of the CEA, a number of insurers have moved outside the scheme.

The standard policy offered by the CEA has increased deductibles from 5-10% to a standard 15%, restricted cover to the main dwelling structure only and limited the value of contents and additional living costs. The CEA commissioned earthquake risk analyses for the entire state and subsequently doubled the rates of earthquake insurance to actuarially based premiums, although due to political pressure rates in northern California were reduced. This is partly due to a recent US Geological Survey (USGS) prediction of an increase in seismic tremors and earthquakes over the next 30 years. Rates are dependent on earthquake probability as well as on the age and construction of the home, soil type and proximity to faults.

The increased premiums, high deductible and reduced cover offered by the CEA have caused the level of residential earthquake coverage in California to drop by half to 17 percent. Moreover, over the last decade the number of insurers writing homeowners' policies in California has fallen by 23 percent. This has resulted in a higher concentration of policies, an increased market share and, therefore, a disproportionately larger exposure for the three largest homeowner insurers. Commercial earthquake insurance exposure has approximately 80% of the earthquake insurance market, although commercial insured losses from the Northridge earthquake were less than those of the residential sector.

7.5 Uninsured losses and their insurability

Based on the AREDL of USD 4.1 billion, approximately 66% of the direct losses were uninsured. As shown in Table 7.1, nearly 84% of commercial and industrial losses were uninsured, primarily because small businesses generally do not purchase earthquake insurance. This has been attributed to the high costs of insurance, the short time horizon of many small businesses, the small amount of assets at risk and the availability of disaster loans and grants. Around 76% of residential losses were uninsured, which has been attributed mainly to high premiums and low perceptions of risk. Higher value properties tend to insure, but higher-risk properties, such as mobile homes and older structures, tend to belong to the lower-income groups, who find it difficult to afford insurance. No information on public infrastructure insurance carried by the State of California has been found, but this is probably low due to the high levels of federal disaster aid.

Table 7.1: Available Information on Insured Direct Losses

	Estimated Direct Losses (percentage of AREDL)	Direct Losses Insured (approximate estimates)	Information on Insured Indirect Losses
Private Losses	85.9	39.6	n.a.
Residential	49.3	24	n.a.
Comm/Ind	36.4	16	n.a.
Private utilities	0.2*	n.a.	n.a.
Agriculture	n.a.	0.1	n.a.
Public Losses	14.1*	n.a.	n.a.
TOTAL	**100%**	**34%**	

*Specified losses incurred by private utilities amount to USD 90 million.[22]

Sources: FEMA (2000), HUD (2000), Eguchi et al (1998), Scawthorne (1997), IBHS (1999)

[21] For a good discussion of the CEA, see Roth (1998).

[22] The following companies are private: SoCal Edison, Pac Bell, GTE, SoCal Gas. LADWP and LA Sewer are owned by LA City, while MWD and CalTrans are publicly owned.

Some insurers are still reluctant to offer homeowner policies in California due to the enormous loss exposure and the strict regulation of entrance and exit to the market. Opportunities are presented by the low level of insurance cover, but careful attention needs to be paid to the engineering, seismological and geological characteristics of any particular area. There are several potential areas of uninsured losses where private insurance companies could provide insurance:

- Residential cover in competition with the CEA, particularly with lower deductibles and increased additional living-expenses cover, perhaps tied to further mitigation measures;
- Commercial and business-interruption cover;
- Small businesses insurance packages, perhaps with federal or state input;
- Property damage and bodily injury liability cover, particularly for the building profession, municipalities, and utility companies;
- Government-infrastructure losses, particularly if legislation is passed reducing federal assistance;
- State and municipal losses, particularly if the percentage not reimbursed by the federal government rises above 25% liability for the state.

The Northridge earthquake resulted in a new emphasis on preparation and mitigation measures by both federal and state agencies. After Northridge the federal government set up a National Earthquake Hazards Reduction Programme (NEHRP) to focus on earthquake mitigation. The stated mitigation goal of the Federal Emergency Management Agency (FEMA) is to reduce natural disaster losses by half by the year 2010. Many agencies are exploring measures by which to make this goal attainable. [23] Several state-run mitigation measures and retrofitting programmes for lower-income groups have been initiated, but implementation measures are expensive and the effectiveness of mitigation strategies is perceived by the public to be low. To date insurers have also been reluctant to provide incentives for mitigation measures.

[23] See California Universities for Research in Earthquake Engineering - http://www.curee.org

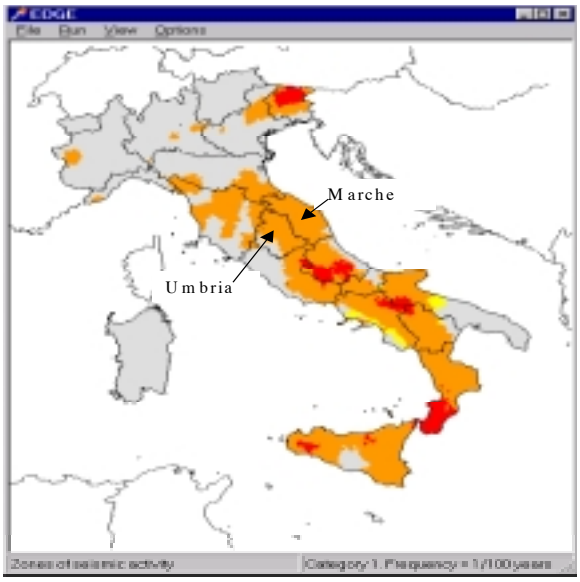
8. THE 1997 UMBRIA-MARCHE EARTHQUAKE, ITALY

8.1 Description

The Umbria-Marche Earthquake began on 26 September, 1997, with shakes of intensities VIII-IX (Mercali scale, MKS). The epicenter was at Colfiorito in Foligno, Umbria (see Figure 8.1). In the subsequent four months approximately 3,300 shakes followed, and ten shakes had intensities larger than VI (MKS). Fourteen people were killed as a result of the earthquake, and over 10,000 rescue operators were involved. The number of people receiving assistance ranged from 13,500 on the first day to 38,000 after the violent shakes in mid-October. In total, 25,700 people were left homeless due to the event.

Six months later, in March-April, 1998, new shakes of intensities VII-VIII occurred with an epicenter in the municipality of Gualdo Tadino, Umbria. The number of victims was lower, but very serious damage was inflicted especially on buildings of cultural heritage (including the San Francesco Basilica in Assisi) and public infrastructure. The urban structure of the towns affected is typical of many cities located in the seismically hazardous regions of central and southern Italy.

Figure 8.1 Map of Seismic Activity in the Umbria-Marche region



8.2 The loss estimates

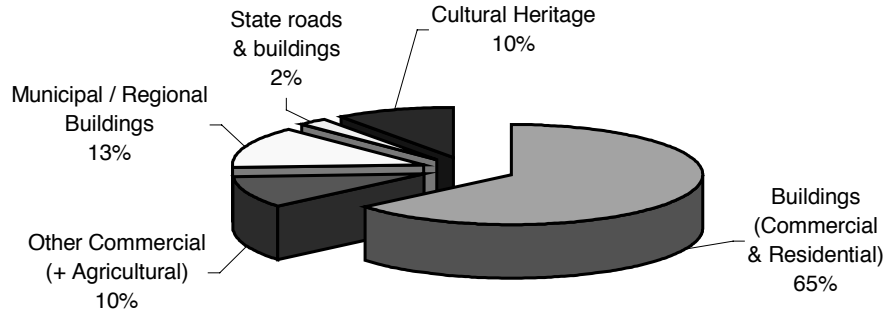
The first estimates of direct losses from the 1997 earthquake in the Umbria-Marche region ranged between USD 4.5 and USD 6 billion (Lira 8,000 and 10,655 billion) (Department of Civil Protection, 1998). More recent figures for the Umbria region show that reconstruction would cost Lira 15,000 billion instead of the originally estimated Lira 6,600 billion for that region.[24] Assuming the same percentage increase in Marche, the total figure for reconstruction in both regions would stand at USD 13.6 billion (based on 1997 exchange rate), including damages from the subsequent shakes in 1998. Due to the lack of data for the Marche region, the latest figure of USD 8.5 billion

[24] Regione dell'Umbria (1999). Including the damage caused by subsequent shakes in 1998.

for direct losses in the Umbria region is taken here to represent the reported estimate of direct losses (AREDL). As the figures for reconstruction in the area indicate, this figure is highly uncertain and incomplete. There is no formal loss-reporting system for natural disasters in Italy. For the direct losses by sector (as shown in Figure 8.2), the data is only available for the original USD 6 billion direct loss estimate.

The indirect losses from production and business disruption were reportedly significant, but they cannot be quantified due to the lack of data. The two regions rely greatly on tourism activities for income (both regions for their cultural heritage and Marche for its coastline), and the number of visits to the area decreased considerably after the event.

Figure 8.2 Estimated Direct Losses by Sector (Based on original DPC estimate of direct losses=USD 6 billion)

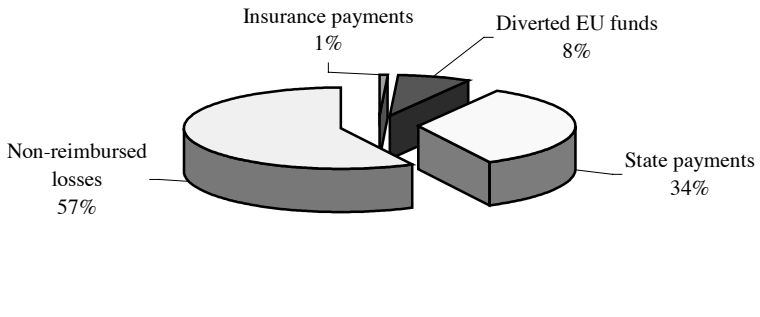


Source: Department of Civil Protection (1998) for damage from 1997 shakes.

8.3 Reimbursing the losses

According to informal sources, the level of earthquake insurance in Italy is very low, but there are generally no published figures documenting the insured losses from recent earthquakes. An estimate of USD 90 million has, however, been quoted for the 1997 earthquake, which means that approximately 1% of the total direct losses and 4.5% of the private direct losses were insured

Figure 8.3 Estimated Reimbursed Direct Losses for the Umbria Region (AREDL for Umbria = USD 8.5 bn)



Source: Regione dell'Umbria (1999)

(Marzano, 1999). As shown in Figure 8.3, including diverted EU funds, the state provided financial aid to Umbria covering 42% of the AREDL. This figure will likely increase since reconstruction in the Umbria region is still proceeding.

8.4 Institutional arrangements

In Italy, standard fire insurance cover includes fire, lightning, aircraft and explosion. Earthquake insurance can be purchased for an additional premium charge, but there is almost no demand for this additional cover. A main reason may be that traditionally the state has provided compensation for a large amount of the losses incurred from earthquakes. In the 20 years before 1997, nearly USD 52 billion (Lira 120,000 billion, or approximately 6% of Italy's GDP in 1997) was spent on repairing damage caused by earthquakes[25]. A noteworthy feature in Italy is the recent (1998) statutory requirement for central government compensation to victims of earthquake damages. Depending on the extent of the damage and the income of the households, the government can be obligated to compensate from 90 to 100% of damages to residential properties. For industrial, agricultural and commercial losses, the government can be obligated to compensate up to 30% of the losses up to a specified maximum. Clearly, this system of social solidarity to the victims has discouraged the purchase of private insurance.

Recognizing that the future costs of this generous national program can be extensive, there have been a number of political initiatives to transfer more responsibility to citizens through private insurance. A new national insurance program for earthquakes, which may be modeled after the French system, has been proposed in recent draft legislation (see Appendix 2). The system in France (see Appendix 1) is characterized by compulsory fire insurance that includes natural disaster cover for all property owners. Since the additional premium for natural disaster cover is standard, there are large cross-subsidies across perils and across regions. The Italian proposal has a clause to compensate only insured victims over a certain loss threshold. A new micro-zoning program is currently being completed, which will enable improved risk identification in the future.

8.5 Uninsured losses and their insurability

Close to 99% of the estimated direct losses in Umbria were uninsured. As shown in Table 8.1, the information on the breakdown of losses and insured losses is not available. A number of reasons appear to explain the very low supply and demand for earthquake insurance in Italy. Until 1980, there was no general classification framework for regional earthquake exposure, which made risk-based premium calculations very difficult. Although the Italian territory is now classified according to exposure, 64% of buildings were constructed before completion of this classification system, which also determines the seismic building codes to be applied. This means that premiums would have to be high in many cases, and probably not affordable. Another reason for the low level of insurance is the fact that the authorities historically intervene to cover a large part of the cost of damage inflicted by earthquakes.

Although a great deal of funds have been spent on the reconstruction of damaged property in the past decades, very little has been allocated to retrofitting or other forms of mitigation. New legislation however requires buildings to be reconstructed according to high seismic resistance standards.

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[25] For information on government compensation to earthquake victims, see http://www.regione.umbria.it/ and http://www.regione.marche.it/

Table 8.1: Available Information on Insured Losses (Umbria)

	Total Direct Losses (Percentage of AREDL)	Direct Losses Insured (approximate)*	Information on Insured Indirect Losses
Private Losses	n.a.	n.a.	n.a.
Household	n.a.	n.a.	n.a.
Commercial	n.a.	n.a.	n.a.
Agriculture	n.a.	n.a.	n.a.
Public Losses	n.a.	n.a	n.a.
TOTAL	**100**	1%	

Taking into account the state budget burdens from financing earthquake losses, and the Maastricht criteria on public debt, a national system for insuring earthquake risks is likely to be introduced. This system would greatly reduce government compensation to earthquake victims, probably linking this compensation to insured losses, and thus encourage the participation of the private insurance industry.

9. A COMPARATIVE ANALYSIS

9.1 Introduction

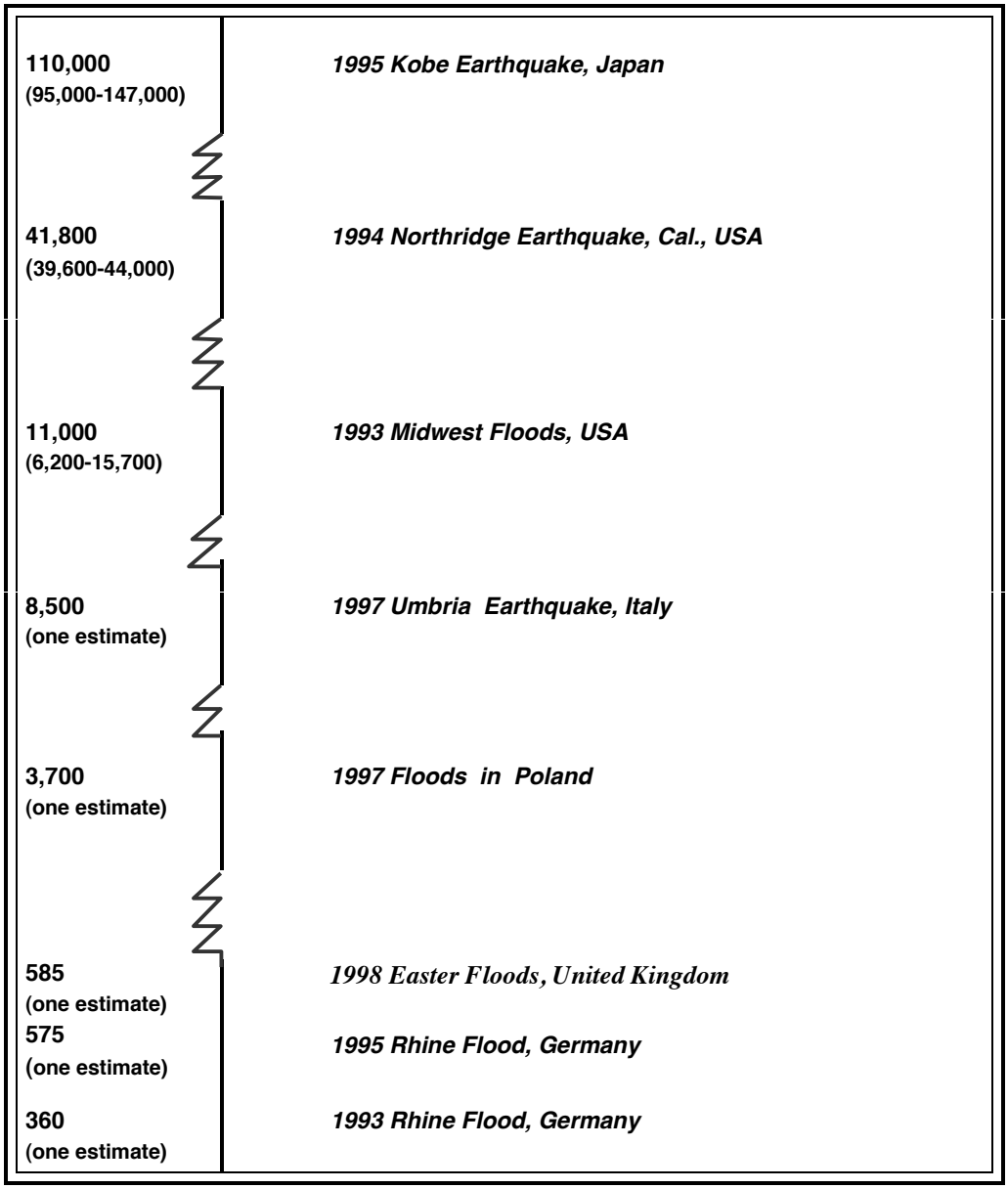
This final section provides comparative information and insights on the seven disasters with respect to the uninsured losses, as well as public policies and institutional arrangements affecting the extent and distribution of the losses. The motivating questions of the seven flood and earthquake disaster cases have been the *extent* of the uninsured losses, *why* these losses are uninsured, and *whether* they are, in fact, insurable. In what follows, we compare the flood and earthquake disasters in terms of the estimated direct economic losses, the portion of these losses that were uninsured, the ways in which these losses are reimbursed, the national systems for insuring losses, and the potential markets or insurability of the losses.

9.2 A comparison of estimated direct losses

The most challenging aspect of estimating the uninsured losses from the flood and earthquake disasters has been finding data on the full extent of the economic losses. This report has mainly examined estimates of the direct or stock losses. Keeping in mind that these estimates are, without exception, incomplete and uncertain, they do give a general picture of the very wide range of losses from the studied disasters.

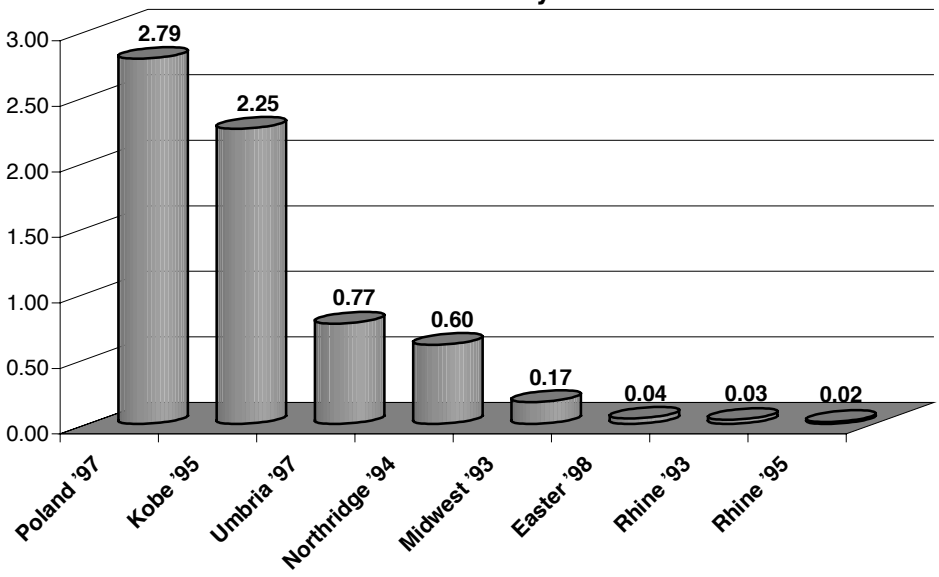
Figure 9.1 shows the average of reported estimates of direct losses (AREDL) from the disasters analysed. In total, there were an estimated USD 174 billion of direct losses, which is approximately 30% of the losses from major disasters in the last decade as estimated by Munich Re (2000). These losses were far from evenly distributed. Estimated direct losses from the Kobe earthquake were 2½ times as great as those from the Northridge earthquake, and an order of magnitude greater than from the Midwest floods. The relatively lower-loss cases (under USD 10 billion) include the Italian Umbria-Marche earthquake of 1997, the Polish floods of 1997, the UK floods in April of 1998 and the German floods of 1993 and 1995. It cannot be overly emphasised, however, that these loss estimates are highly uncertain. Only in one case, Poland, was there a systematic collection of loss data by the national government, and the reporting may be biased as a result of its link with compensation. In the large-loss cases (the Midwest floods, the Kobe earthquake and the Northridge earthquake), there were a wide range of losses, for example, in the case of the Midwest floods the higher estimate was 150% greater than the lower estimate. For the most part, losses have been estimated from reported damage to insurance companies and to government officials for purposes of compensation.

Figure 9.1 The Average of Reported Estimates of Direct Losses (AREDL) (USD millions)



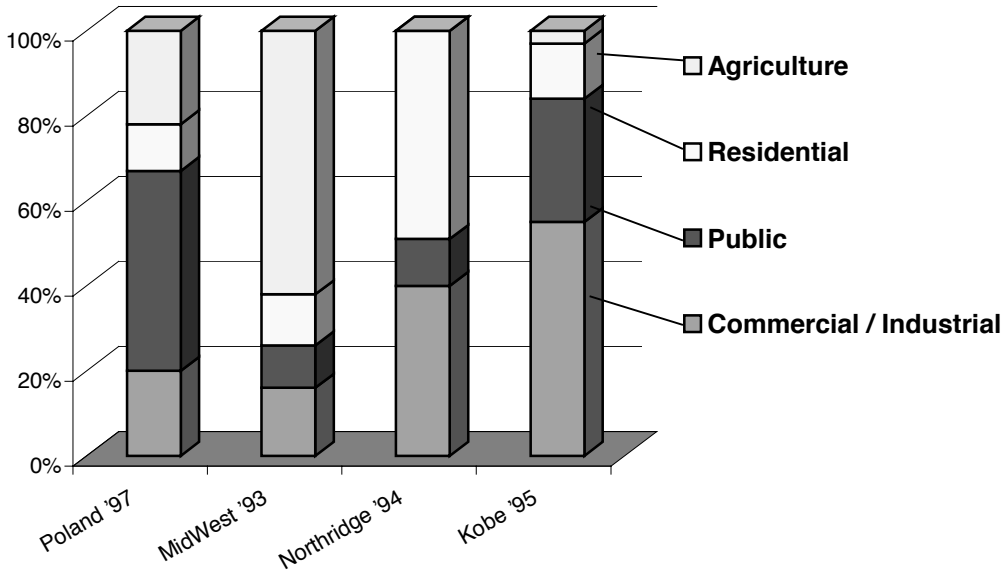
Whether a disaster is truly catastrophic from an economic point of view depends on the ability of the victims and society to absorb and repair the losses. If one considers direct losses in relation to national GDP as shown in Figure 9.2, it may come as a surprise that the Polish flood with an estimated loss of USD 3.7 billion was more economically catastrophic, that is the disaster represented a greater percentage of its GDP (2.79%) than the Kobe earthquake with an estimated loss of USD 105 billion representing 2.25% of its GDP.

Figure 9.2: Direct Losses (AREDL) as a Percentage of Country Year GDP



For selected countries, depending on data availability, Figure 9.3 shows the breakdown of direct economic losses according to the sectors affected, including residential property, commercial property, agriculture, and public infrastructure. Again, the cases differ considerably. Public sector losses dominate in the case of the Polish floods; agricultural losses dominate in the case of the Midwest floods; and commercial losses dominate in the case of the Kobe earthquake. Since public-sector losses are generally uninsured - and because of current discussions with respect to reducing government liabilities - the large public sector losses in the case of the Polish floods and, to a lesser extent, the Kobe earthquake are of particular interest.

Figure 9.3: Direct Losses by Sector in Percent



9.3 A comparison of uninsured losses

Figure 9.4 shows the uninsured losses as a percentage of the estimated direct losses or AREDL. In total, there were over USD 160 billion of estimated uninsured losses, representing around 90% of the total estimated direct losses from the eight disasters (including the two Rhine river floods). Munich Re (2000) estimates that from 1985-1999 the world-wide insured losses from natural disasters have been around 20% of the estimated total losses from these disasters. This study finds a lower figure of about 10% of *direct* losses; however, in the absence of the Kobe case with only 3% insured losses, the proportion is about 23% insured losses.

Average uninsured losses, however, give a misleading picture of insurance cover. As shown in Figure 9.4, the uninsured losses cover a wide range: from almost 99% of estimated direct losses in Italy to around 60% of estimated direct losses in the UK and Germany (Rhine '95). Indeed, in three countries - Italy, Japan, and Poland - insured losses were less than 10% of estimated direct losses. This figure was considerably higher, but still low in absolute terms, in California (33%), Germany (30%, 40%) and the UK (39%). The analysis shows that there is large, but varied, potential for providing flood and earthquake insurance in these countries.

Figure 9.4: Uninsured Losses as a Percentage of Direct Losses (AREDL)

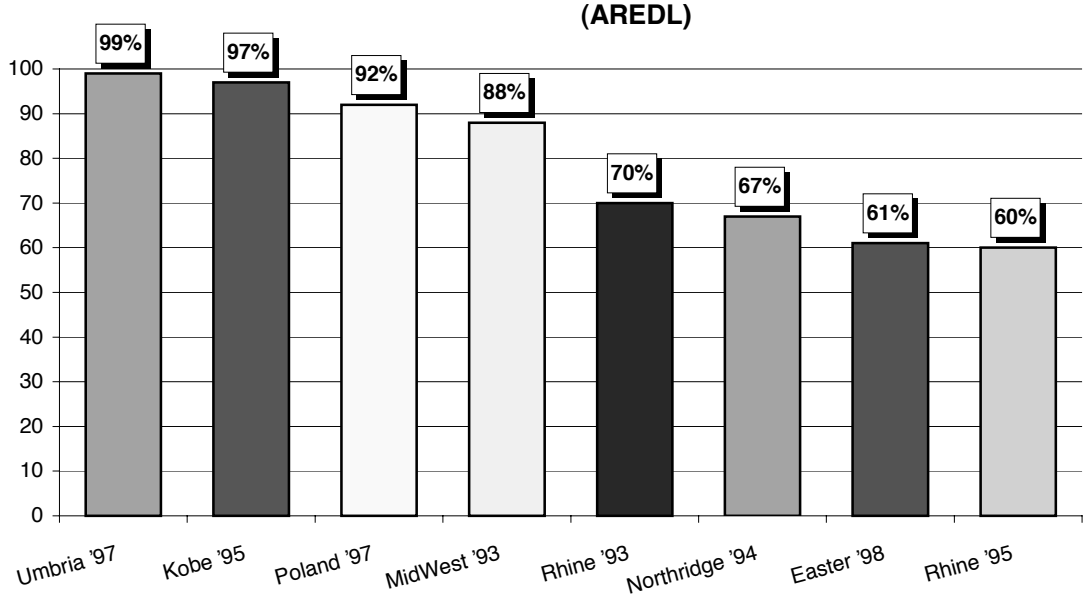
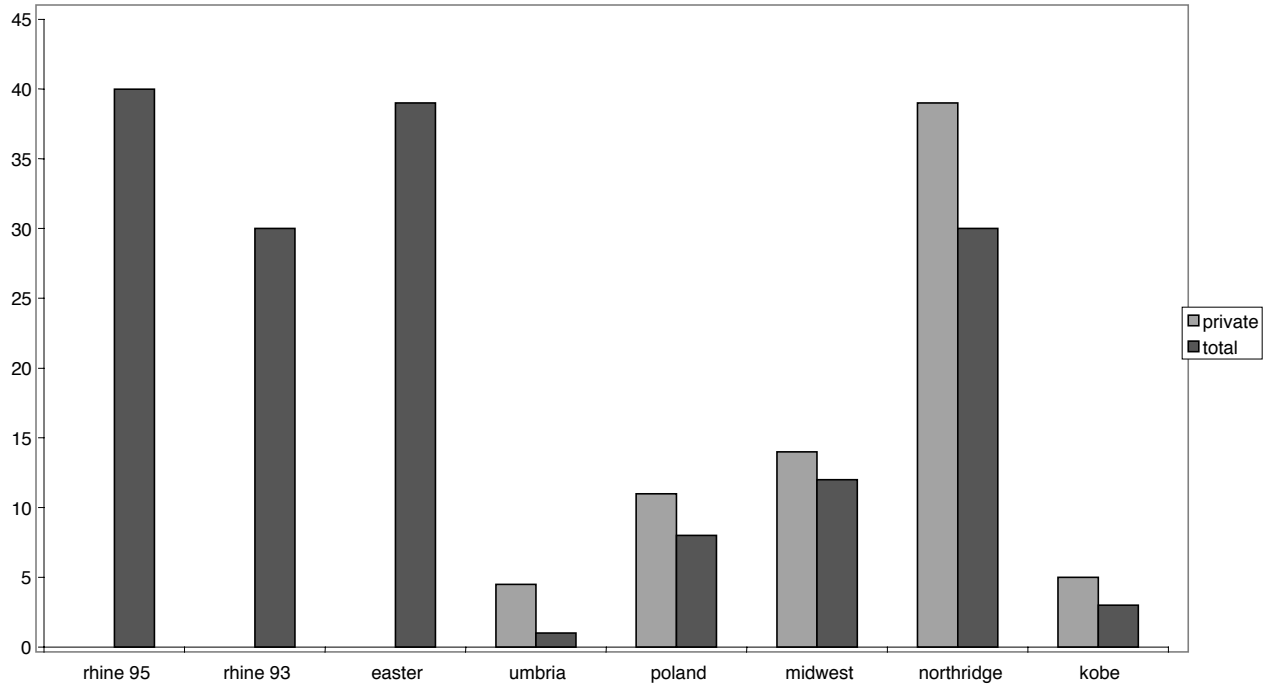


Figure 9.4, however, gives a slightly misleading picture of insurance since it includes public-sector losses. With the exception of the UK and the US, where local governments appear to have some insurance for their infrastructure losses, the governments of the countries studied do not appear to carry public infrastructure insurance, such as on roads and schools. (Since these risks are generally spread among taxpayers, it can be questioned whether public-infrastructure insurance is advisable.) Since private insurance has traditionally covered mainly private losses, it is instructive to examine the extent of the private losses insured. These estimates are shown in Figure 9.5, which presents the percentage of insured losses in terms of *total* estimated losses (AREDL) and in terms of the estimated *private* losses (AREDL minus public infrastructure losses) for those countries with available data.

Figure 9.5: Insured Losses as Percentage of Total and Private Losses

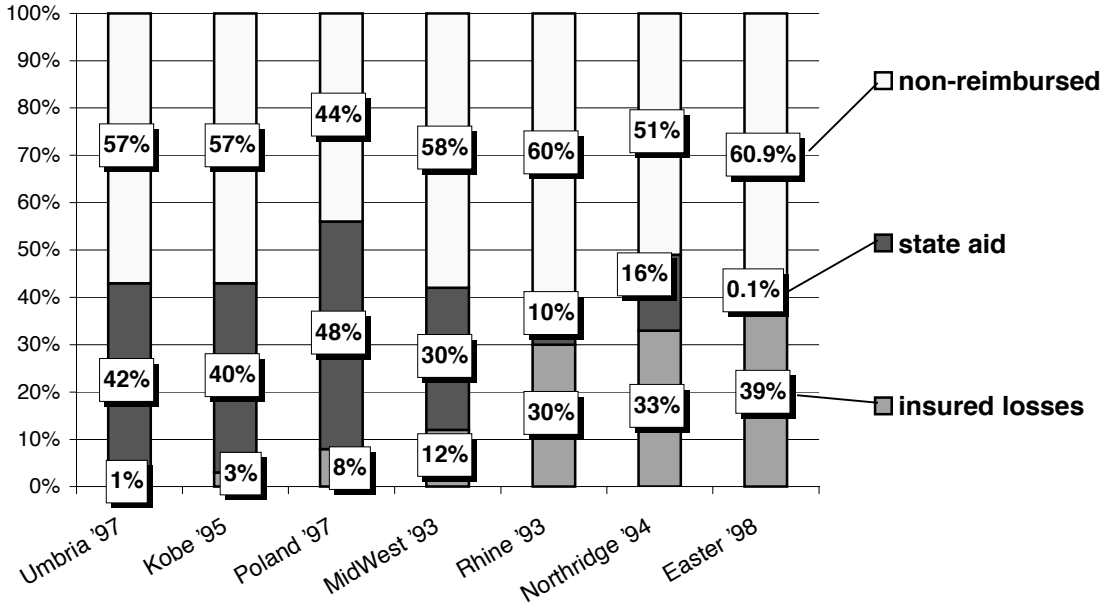


9.4 A comparison of reimbursed losses

In three of the seven cases - the Northridge earthquake, the Rhine floods '93 and the Easter floods - insurance was the primary institutional arrangement for reimbursing the victims from the losses. In the other four cases (and in many countries) the government plays a larger role than private insurance in assisting victims in their recovery, and in some countries international and domestic aid is also important. These non-market forms of reimbursement are critically important in determining incentives for private insurance and thus for determining the extent of the insured losses.

As shown in Figure 9.6, the role of public assistance and aid varies considerably. In Poland, the government reimbursed around 48% of the estimated direct losses from the 1997 floods and this was mainly central government compensation to private victims. In stark contrast, in the UK local and national governments gave practically no assistance to the victims of the Easter flood (nor did the central government give significant aid to repair local government infrastructure). The lack of government assistance resulted in only about 39% of the estimated losses being reimbursed, and almost fully by private insurers who claim close to 75% flood insurance penetration. Poland was the only country receiving international aid, mainly in the form of subsidised loans.

Figure 9.6: Losses Reimbursed from Government Aid and Insurance as a Percentage of AREDL



Like in the UK, the German government also plays a small role in reimbursing private flood losses. In the case of the 1993 Rhine floods, only an estimated 10% of private losses (incurred mainly by needy households) were compensated by the German state governments. In contrast, the US federal government plays a large role in assisting state and local authorities for repairing infrastructure damage as well as in aiding private victims. Around 16% of the private and public sector losses of the Northridge earthquake were reimbursed by government assistance, and close to 30% percent in the case of the Midwest floods. The Japanese central government was an even larger contributor (40%) to private citizens and public authorities after the Kobe earthquake, where only 3 percent of the estimated direct losses were insured. It is not surprising from a historical perspective that the Polish government played by far the largest role in assisting public and private victims after the disastrous 1997 floods in that country, when the central government paid out close to half of the losses in disaster aid (a substantial amount of this aid was borrowed by the government in the form of subsidized loans from international financial institutions). Finally, the Italian government may eventually play the largest role in assisting private earthquake victims since rebuilding plans after the devastating Umbria earthquake are continuing.

Two points are particularly noteworthy from the results shown in Figure 9.5. First, there is a similarity among the seven cases on the *total* of reimbursed losses (state aid plus insurance), which averages at around 45% (55% of *non-reimbursed* losses), with surprisingly little variance given the diversity of the countries examined. However, the way in which these losses are reimbursed - whether by private insurance or public assistance - varies considerably. Second, the results lend support to the notion that insurance demand is inversely related to post-disaster government assistance.

Finally, it should be kept in mind that reimbursement by private insurance does not mean that there are no transfers within society or even any government assistance. Many national insurance schemes involve cross subsidies from persons at risk from the same or different perils (e.g., in the UK and France) as well as direct involvement by the taxpayers for very large losses (e.g., in Japan).

9.5 National insurance arrangements and institutions

Many governments are becoming increasingly concerned about their large budget outlays for public assistance programs following major natural disasters. Because of inevitable political pressure to aid uninsured households and businesses devastated from natural events, some governments are encouraging their citizens to invest in private insurance. However, insurers are hesitant to operate in markets that present a high risk of large losses. Particularly for countries with the prospects of extremely costly disasters, reinsurance arrangements are critical for the insurability of the risks. National authorities in high-risk countries are thus recognizing the importance of developing a program that will effectively and fairly link private and public responsibility, insurance and loss mitigation.

Some important features of national and state arrangements for flood and earthquake insurance are shown in Appendixes 1 and 2. Because of the importance of the French system in Europe, it is also included. The national arrangements vary significantly with respect to how the losses from floods and earthquakes are borne. In the UK and Germany, there are no governmental arrangements for reimbursing policyholders (and protecting insurers from insolvency) if losses exhaust insurers' reserves and private reinsurance (very unlikely in these countries). Alternatively, the French system (also proposed for Italy) bundles all-perils policies with property insurance, and in this way risks are spread across all policyholders (as in the UK). Moreover, the French government will be liable for very large losses. In Japan, extreme losses will be shared through a layered system of prorated losses to policyholders, reinsurance, capital market instruments and taxpayers. California has a similar system, except it purposely excludes any liability for large losses falling on the taxpayer (however, in the case of a very large earthquake there may be considerable political pressure for taxpayer involvement). Finally, the US flood insurance program is the only system where the government is the underwriter. This system is designed to reduce the burden to the taxpayers from government interventions.

Another way the government can reduce its liabilities for post-disaster recovery is with public-infrastructure insurance or, alternatively, with novel hedging instruments such as catastrophe bonds. Insurance or other instruments may be attractive for countries like Poland and Japan, where natural disaster losses can be a very high percentage of the country's GDP. Especially developing and transition countries may have difficulties in financing post-disaster relief through more conventional financing instruments. If the disaster results in a reduced credit rating for the country, it may be difficult to borrow. Moreover, poor countries may not have capacity after a major disaster to raise relief and reconstruction funds from taxpayers.

From the insurers´ perspective, the government can usefully improve conditions for the private insurance market to operate effectively. These measures might include:

- Data collection (in the US the government provides flood risk maps);
- Mandatory natural peril insurance: Natural peril insurance is not mandatory in any of countries studied, but mandatory earthquake insurance is being considered in Japan. It appears that a policy of bundling natural disaster insurance with property or household insurance, as in the UK and France, is successful at increasing insurance cover.
- Providing or ensuring the provision of reinsurance, at least in high-risk countries: In France and Japan, the governments operate as "insurers of last resort".
- Making government relief to private victims conditional on insurance. This is the cornerstone of the insurance system proposed for Italy;
- Improving public awareness of the risks of natural disasters;

- Reducing central government aid for local infrastructure repair and otherwise encouraging public infrastructure insurance. This is being considered in the US and Poland, where the central/federal governments are committed to large expenditures for local public infrastructure repair.
- Linking mitigation measures with insurance, for example, by requiring insured properties to carry a seal of approval that the property has taken specified mitigation measures (Kunreuther, 1998b).

9.6. The insurability of the losses

In what follows, we briefly summarize the highlights of each disaster with regard to the uninsured losses and their insurability:

Japan: Kobe earthquake

Earthquake risk insurance is low in Kobe and throughout Japan (10% penetration). Since insurance premiums are set according to earthquake risk zones, they are prohibitively expensive to many living in Japan's high-risk areas. A portion of the risks are transferred to the taxpayer in the case of large losses, a part to the Japanese Earthquake Reinsurance Company, and a part pro-rated to the policy holders. Despite favourable reinsurance conditions and a pro-active stance on the part of the government in promoting community mitigation measures, insurers are reluctant to become over-exposed in high-risk areas. To transfer the risks more widely, some insurance companies have issued catastrophe bonds.

California: Northridge earthquake

After the Northridge earthquake, demand for insurance rose significantly, but recent hefty premiums combined with high deductibles have reduced demand. Moreover, the generous federal government aid for local and state infrastructure repair discourages public-sector insurance, although there are legislative proposals to reduce this assistance. It is compulsory for insurers offering household insurance to offer earthquake coverage, which (before the introduction of the California Earthquake Authority) resulted in the withdrawal of property insurers from high-risk areas. This cover has been linked to risk and to private mitigation measures, which has given incentives for property owners to take risk-reducing measures. Even with the state-organized insurance/reinsurance program by the CEA, insurers are still cautious in entering this market. The positive note is that earthquake losses are becoming better understood as a result of new developments in computer modelling.

Italy: Umbria-Marche earthquake

The very generous government compensation for uninsured victims after a major disaster and the lack of risk identification have resulted in close to no private insurance for earthquake risks. There are, however, proposals before the Italian legislature to compensate only insured victims over a certain loss threshold and to introduce a new nation-wide system for insuring natural disasters with the participation of the private insurance industry. A new micro zoning program is currently being completed, which will enable improved risk identification in the future.

U.S.: Midwest floods

In addition to crop insurance, the federal government offers primary flood insurance for properties (household and commercial) provided communities have taken required mitigation measures. This National Flood Insurance Program is unique in our case studies in that the government is the primary insurer, and mitigation measures are explicitly and importantly tied to

insurance supply. The study also illustrates the disincentives for private mitigation imposed by flood protection measures, since there had been a great deal of development in the protected flood plains resulting in higher losses from the 1993 floods. Flood-risk maps are made available by the Federal Emergency Management Agency, which greatly increases the insurability of flood risks. The demand for insurance is low, but more efforts are being made to enforce requirements for flood insurance as a condition of mortgage. The demand for insurance by the private and the public sector is also low as a result of generous federal government aid for national disasters, but legislation is pending to reduce this aid (at present, victims who have received federal disaster aid once will have to take on flood insurance to be eligible for further aid for future losses). The pending legislation will put considerably more pressure on public authorities to pre-finance their natural disaster risks, possibly with private insurance. There are opportunities of private insurers to administer NFIP policies and also to provide private insurance as a supplement to NFIP policies, particularly for industrial risks and for business disruption (which is not covered by NFIP).

Poland: Flood of 1997

Demand for flood insurance can be expected to be low as a result of low Polish incomes and because households and businesses anticipate generous compensation from the central government after a major flood. There were large public-sector losses as a result of the 1997 floods, and there is interest on the part of local governments in insuring their public-infrastructure risks. Supply of insurance is limited, mainly because of poor information on the risks and because the government has no statutory obligation to reinsure. A major problem is that the capital reserves and reinsurance on the part of domestic insurers are insufficient to cover very large losses, such as a costly flood in Warsaw. Another major problem on the part of the Polish government is its large potential liabilities in the case of another disastrous flood, which may jeopardize Poland's fiscal austerity program. Mainly for this reason the government is considering a national insurance system with more participation from the private sector. The government has traditionally devoted substantial resources to structural mitigation measures, and it may become more involved in non-structural measures, including zoning and building regulations. Early warning systems need improving.

UK: Easter floods

A notable feature of the UK is its limited public assistance to uninsured disaster victims and the high penetration of flood insurance. Insurers estimate flood risks by postal zones, and there is increasing availability of flood-loss data. Still, loss and risk data are incomplete, and there are difficulties in assessing very extreme events (the main foreseeable risk in this category is the failure of the Thames Barrier). The high penetration of flood risk cover is the result of the automatic inclusion of an all-perils insurance into household insurance policies with substantial cross-subsidies across regions and perils. However, insurers are moving towards risk-based premiums, which may result in reduced cover for low-income households - and may ultimately lead to demands for more government compensation in the result of a major disaster. The government plays no role in reinsurance, which is generally not considered necessary given the relatively low flood risk (6% of land area) relative to the capacity of the insurance industry. Insurers also tie premiums to mitigation measures.

Germany: Rhine floods

The low demand for insurance in Germany is surprising considering that there is very little government post-disaster compensation to the needy. Many people appear to prefer self insurance and taking necessary precautionary measures rather than purchasing private flood insurance, although this may change if risks are perceived as increasing. The effectiveness of private mitigation

motivated by a keener awareness of "what to do" was illustrated by the lower losses from the 95 floods than experienced two years earlier, partly as a result of persons moving their valuables to higher levels. The German government does not act as reinsurer. Early warning systems are effective, and the state governments are responsible for community and private mitigation measures.

9.7 Conclusions

This report has examined seven case studies of flood and earthquake disasters representing close to one-third of the estimated financial losses from major disasters in the last decade. A country's vulnerability to financial losses from disasters depends on its economic strength, its mitigation efforts and its loss-transfer/loss-recovery institutions. As regards the mitigation of losses, all countries could improve on the public measures in place as well as private incentives for reducing losses, and some notable examples have been noted in this study. Mitigation measures, as well as the economic strength of the countries studied, differ remarkably. The USD 3.7 million Polish flood represented a higher percentage of the country's GDP (2.8%) than did the USD 100 billion Kobe earthquake (2.2%). This is important because most loss-sharing institutions stop at national borders; there is very little international disaster aid relative to the costs of disasters, although insurance is having an increasingly global spread.

How nations share the costs of recovery, and how these costs can be transferred outside of national borders, is therefore of utmost importance to disaster recovery. Besides communal loss sharing among families, churches and communities, the main forms of loss sharing are state assistance and private insurance. The mix of these state and market institutions will depend on *public values* towards individual responsibility and social solidarity. Loss-transfer institutions are also important because they can influence the *reduction* of the losses, for example, private insurance premiums and state compensation can be tied to risk-mitigation measures.

In our case studies we find, at one extreme, Italy with practically no insurance for earthquake disasters and substantial statutory state aid and, at the other extreme, the UK with practically no state aid and substantial insurance cover for flood risks. Between these extremes, the case studies demonstrate a mix of public assistance and private insurance. Interestingly, across all our disaster studies, the *sum* of this private-public mix amounted to between 40 and 60 percent of the direct losses (to private households, industry and public infrastructure). However, these figures must be viewed with extreme caution given the lack of systematic loss-accounting in all the countries (with the exception of Poland). Improved loss-reporting systems should be a priority for all who are interested in reducing and sharing the losses from natural disasters.

As governments become more concerned with fiscal austerity, there is increasing pressure to shift the public-private mix to more responsibility to the private market. Many point to the advantages of individual responsibility in promoting incentives for loss reduction, for example, in making it more costly to locate capital in high-risk areas. These incentives could be enhanced by directly linking insurance premiums to private mitigation measures.

The reported disasters show significant opportunities for insurers in providing cover for catastrophic events. Insured losses were generally low, ranging from only one percent in the Italian Umbria earthquake to 39% in the UK Easter floods. The reasons for the large portion of uninsured losses can be linked to both insurance demand and supply. Demand for insurance is low in many countries because of the high risks and correspondingly high premiums, for example, in Japan and California. Demand is also constrained by low incomes, for example, in Poland, and ironically by high incomes and a propensity to self insure, for example, in Germany. The most important limiting factor on insurance demand may be the perception that the government will compensate uninsured

losses, for example, in Italy, Japan, Poland and the US, and the case studies show an inverse relationship between insured losses and government compensation to victims. None of the countries studied has mandatory catastrophic insurance, but it appears that a successful measure to increase demand is to bundle catastrophic insurance with property insurance as in the UK. The supply of natural disaster insurance is also constrained by the willingness of insurers to enter high-risk markets where information on the risks is incomplete, but risk mapping and computer technologies for estimating risks is improving insurability in many countries, for example, in Poland, Germany, the US and Italy. Another important factor in encouraging insurance supply in high-risk countries is government reinsurance, as is the case in Japan and the US. The emergence of new risk-transfer instruments, such as catastrophe bonds, may also improve reinsurance opportunities for insurers operating in these high-risk markets.

Despite these limitations in demand and supply, catastrophic insurance opportunities exist in all countries and in all sectors: residential, commercial, agricultural and public infrastructure. Especially in transition countries like Poland, public-sector insurance presents a novel insurance opportunity, but only if the country faces disasters that will potentially swamp the government's ability to borrow or raise post-disaster recovery funds through taxes. In addition, business interruption risks were only scantly insured in the countries studied, and these risks are increasingly recognised as a potential market.

In all countries, and especially those with the risk of very large losses from natural disasters, market opportunities appear to be enhanced by government involvement in a national insurance system. Insurers, brokerage firms and other financial institutions could play a more active role in designing these public-private systems. No one system will fit all countries and cultures, and each raises a set of questions and issues that will largely determine the share of private insurance for natural disaster risks. In concluding this report and suggesting further study in this important area, a few of these questions are listed below:

- What role should private insurance versus the government or taxpayer play in reducing natural disaster losses, sharing these losses and aiding the recovery process?
- What measures can the government take in improving the insurability of natural disaster risks, e.g., in reinsuring these risks or improving loss reporting?
- To what extent should private insurance premiums be strictly risk-based to encourage private mitigation measures (as is developing in the US), and to what extent should these policies promote national solidarity through implicit cross subsidies (as in the UK and French systems)? How can the public and stakeholders be involved in deciding this tradeoff?
- Should governments legislate mandatory catastrophic insurance, mandatory insurance as a condition of a mortgage, or should catastrophic cover be bundled with property/fire insurance?
- Under what conditions is insurance for public-sector risks a preferred alternative to traditional financing instruments for transition and other countries?
- How can private insurance or government compensation be linked to incentives or regulations encouraging or requiring loss-mitigation measures?
- How can the insured risks from very high-consequence, natural disasters be transferred outside national borders? Can emerging new risk-transfer instruments, such as catastrophe bonds, play a role in this regard?

In considering these and many other open questions, the fundamental issue is how societies can put public-private systems into place for efficiently and fairly reducing and sharing the risks

from natural disasters. Insurance companies and other financial institutions, along with the many other stakeholders, have a key role to play in the design and implementation of these emerging systems. With the unprecedented increase in the losses from natural disasters over the globe, innovative measures and institutions for reducing these losses and for sharing them among those who are able to absorb them are urgently needed.

REFERENCES

Alesch, D.J. and J.N. Holly (1996). "How to Survive the Next Natural Disaster: Lessons for Small Business from Northridge Victims and Survivors." Paper presented at the Pan Pacific Hazards Conference, Vancouver, British Colombia, July 29- August 2.

Alexander Howden Group, Ltd. (1995). "The Great Hanshin Earthquake, Japan," Alexander Howden Non-Marine Division, London and Sydney.

Association of British Insurers (1999). *Insurance Statistics Yearbook*, 1988-1998.

Association of British Insurers (2000). "Family Expenditure Survey 1998/1999". February, ISSN 1357 6690.

Bayerische Rück (1994). *The Christmas Floods in Germany 1993/94*. Authors: U. Ebel and H. Engel, Bayerische Rück, Munich.

Bayerische Rück (1995). *…13 Months Later. The January 1995 Floods*. Authors: U. Ebel and H. Engel, Bayerische Rück, Munich.

Bolin, R. and Stanford, L. (1998). *The Northridge Earthquake*. London: Routledge.

BBC News (1998). Flood inquiry attacks Environment Agency. June 2. In: http://news1.thls.bbc.co.uk/hi/english/oldbusiness/newsid

Bundesanstalt für Gewässerkunde (BfG) (1996). *Das Januar Hochwasser 1995 im Rheingebiet (The January 1995 floods in the Rhine Area),* BfG, Koblenz.

Bye, P. and M. Horner (1998). "Easter 1998 Floods," Report by the Independent Review Team to the Board of the Environment Agency, 30 September.

Changnon, S.A. (1996). *The Great Flood of 1993*. Boulder: Westview Press.

Changnon, Stanley A., David Changnon, E. Ray Fosse, Donald C. Hoganson, Richard J. Roth, Sr., and James M. Totsch (1997). "Effects of Recent Weather Extremes on the Insurance Industry: Major Implications for the Atmospheric Sciences," *Bulletin of the American Meteorological Society*, 78:425-435.

Department for Civil Protection (1998). *DPC Informa*, Periodical of the Dipartamento della Protezione Civile, No. 8, January/February. In: http://www.protezionecivile.it/dpcinforma/008/testo.html

Department of the Environment, Transport and the Regions (1999). Personal Communication with B. Stafford, Local Government Revenue Expenditure Division, Sept. 8.

Department of the Environment, Transport and the Regions (1998). "Bellwin Scheme of Emergency Financial Assistance to Local Authorities: 1998/99 Guidance Notes and Thresholds." In: http://www.local.doe.gov.uk/finance/bellwin/bell989l.htm

Dombrovsky, W.R. and L. Ohlendieck (1998). "Flood Management in Germany," *Flood Response and Crisis Management in Western Europe: A Comparative Analysis,* (Rosenthal, U. and P. Hart. Eds), Berlin: Springer Verlag, 153-186.

Eguchi, R.T. (1997). "Economic Implications of Damage to Infrastructure and Mitigation Opportunities," In *Economic Consequences of Earthquakes: Preparing for the Unexpected* (Jones, B.G., ed.), NCEER-SP-0001, Buffalo, 111-123.

Eguchi, R.T, J. Goltz, C.Taylor, S. Chang, P. Flores, L. Johnson, H. Seligson, and N. Blais (1998). "Direct Economic Losses in the Northridge Earthquake: A Three Year Post-Event Perspective." *Earthquake Spectra*, 14: 245-264.

Environment Agency (1998). Flooding information on the Easter floods. In: http://www.environment-agency.gov.uk/ourservices/flood_a/fld_a_fld_wn_inf_easter.ht

Environment Agency (1999). "Action Plan for Flood Forecasting, Warning and Response." Progress Report, June.

EQE International (1994). "The January 17, 1994 Northridge, CA Earthquake." EQE Summary Report, March. In: http://www.eqe.com/publications/northridge/executiv.htm

EQE International (1995). "The January 17, 1995 Kobe Earthquake." EQE Summary Report. In: http://www.eqe.com/publications/kobe/kobe.htm

Federal Emergency Management Agency (2000). Personal communication with Carl Suchocki, Mar. 10.

Freeman, Paul (1999). Natural Catastrophe Risk Transfer and Developing Countries, Draft Paper, International Institute of Applied Systems Analysis, Laxenburg, Austria.

Froot, Kenneth (1999). "The Financing of Catastrophe Risk," *National Bureau of Economic Research Project Report*, University of Chicago Press: University of Chicago.

Froot, Kenneth A. (1997). The Limited Financing of Catastrophe Risk: An Overview, Harvard University Working Paper, Harvard Business School and National Bureau of Economic Research.

Froot, K. A. and P. O'Connell (1997). The Pricing of U.S. Catastrophe Reinsurance, Paper presented at the NBER conference on the Financing of Property/Casualty Risks, Palm Beach Fl., Nov. 21-23.

Goltz, J.D (1996). "Use of Loss Estimates by Government Agencies in the Northridge Earthquake for Response and Recovery". *Earthquake Spectra*, 12:441-455.

Gordon, P. and H.W. Richardson (1995). "The Business Interruption Effects of the Northridge Earthquake," Research Report No. LCRI-95-OIR, Lusk Center Research Institute, School of Urban and Regional Planning, University of So. California.

Hill, B. (1999). (Representative from Northampton Borough Council),Telephone Conversation, December.

Howe, C. W. and H.C. Cochrane (1993). "Guidelines for the Uniform Definition, Identification and Measurement of Economic Damages from Natural Hazard Events." Special publication No.28, Natural Hazards Information Center, University of Colorado, Boulder.

Institute for Business and Home Safety (1999). "Insured Losses from the Northridge Earthquake." January 1999. In: http://www.ibhs.org/html/ibhs_projects/projects_northridge.htm

Interagency Floodplain Management Review Committee (IFMRC, 1994). **"**Sharing the Challenge: Floodplain Management into the 21st Century," Report of the IFMRC to the Administration Floodplain Management Task Force, Washington, D.C.

International Federation of Red Cross and Red Crescent Societies (1998). "European Floods Bring Pressures for Change," *World Disasters Report 1998* (N. Cater and P. Walker, eds.), Oxford: Oxford University Press, 122-131.

Japan Earthquake Reinsurance Co., Ltd (JER) (1999). "Earthquake Insurance on Dwelling Risks in Japan," April 1.

Kagawa, T. (1995). "Great Hanshin Earthquake - A Japanese Insurer's View." *The Geneva Papers on Risk and Insurance*, 20:481-487.

Katayama, T. (1996). “Lessons from the 1995 Great Hanshin Earthquake of Japan with emphasis on Urban Infrastructure Systems.” *Proceedings of Structural Engineering in Consideration of Economy, Environment and Energy*. 15th Congress, June, Copenhagen, 187-200. In: http://incede.iis.u-tokyo.ac.jp/kobenet/report/publ/publ-1.html

Keeble, S. (1999) "MP criticises Flood Report: "It’s a Miracle More Lives Weren't Lost," http://freespace.virgin.net/sally.keeble/1press-releases/EACRITIC.txt., Sept. 14.

Kunreuther, Howard and Richard Roth, Sr. (1998). *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States***,** Washington, D.C: Joseph Henry Press.

Kunreuther, Howard (1998a). “Introduction”, *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*, (H. Kunreuther and R. Roth, eds.), Washington, D.C: Joseph Henry Press, 209-228.

Kunreuther, Howard (1998b). “A Program for Reducing Disaster Losses through Insurance,” in *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*, Washington, D.C: Joseph Henry Press, 209-228.

Kunreuther, Howard and Joanne Linnerooth-Bayer (1999). “The Financial Management of Catastrophic Flood Risks in Emerging Economy Countries,” Paper Presented at Conference on Global Change and Catastrophic Risk Management, IIASA, Laxenburg, Austria, June 6-9.

Larson, L.W. (1997). “The Great USA Flood of 1993”, In: *Destructive Water: Water-Caused Natural Disasters, their Abatement and Control,* IAHS Publication No. 239, Institute of Hydrology, Wallingford, Oxfordshire, UK, 13-20.

Linnerooth-Bayer, J. and A. Amendola (2000). "Global Change, Natural Disasters and Loss Sharing: Issues of Efficiency and Equity," *The Geneva Papers on Risk and Insurance: Issues and Practice* 25:203-219.

Marzano, A. (1999). Italian National Insurance Company Association, Personal communication, September 16.

MacDonald, G. (1998). “Climate and Catastrophic Weather Events”, Paper presented at the Engineering Academy of Japan, 17 Apr. International Institute of Applied Systems Analysis, Laxenburg, Austria.

Mileti, Dennis (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States (1999)*, Joseph Henry Press, National Academy Press, Washington, D.C.

Muir-Wood, R. (1995). "Do We Know Enough? Assessing the Risk: Kobe-Counting the Cost." Third International Reinsurance Conference, London Underwriting Centre, 7/8.6: 71-75.

Munich Re (1995). "Catastrophe Portrait of the Year: The Great Hanshin Earthquake of 17th January 1995 in Kobe, Japan". *Annual Review of Catastrophes 1995*, Munich Re, Munich.

Munich Re (1999). "Natural Catastrophes in Germany- Loss Experience and Loss Potentials," Munich Reinsurance Co., Munich.

Munich Re (2000). "Topics 2000: Natural Catastrophes-The Current Position," Munich Reinsurance Co., Munich.

National Research Council (1999). T*he Impacts of Natural Disasters: A Framework for Loss Estimation,* National Academy Press: Washington, D.C.

Pasterick, Edward (1998). "The National Flood Insurance Program," In *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States* (H. Kunreuther and R. Roth, eds,)**,** Washington, D.C: Joseph Henry Press, 125-155.

Polish Statistical Bureau (1998). *Approximate Effects of the Flood of 1997*, Warsaw: Government Review.

Property and Casualty Insurance Rating Organization of Japan (1997). "Hanshin-Awaji Great Earthquake Data," Earthquake Insurance Survey Report 26, March (Japanese text only).

Regione dell'Umbria (1999). "Giunta Regionale, Lo Stato della Ricostruzione (The State of Reconstruction Works*)*," Umbria, Italy.

Risk Management Solutions (1999). "What if the 1906 Earthquake Strikes Again?"
In: http://www.riskinc.com/rms/publications/publications3.html

Rosenthal, U. and P. Hart (1998). *Flood Response and Crisis Management in Western Europe: A Comparative Analysis,* Berlin: Springer Verlag.

Roth, R.J. (1997). "What are the Principles of Insuring Natural Disasters?" In http://www.eeri.org/EQ_Basics/INS/INS3.html

Roth, R.J. (1998). “Earthquake Insurance Protection in California,” In *Paying the Price: The Status and Role of Insurance against Natural Disasters in the United States (*Kunreuther, H. and Roth, R., eds.), Washington, D.C: Joseph Henry Press.

Scawthorne, C, B. Lakshari and A. Naseer (1997). “What happened in Kobe and What if it Happened Here?” In *Economic Consequences of Earthquakes: Preparing for the Unexpected*, NCEER-SP-0001, National Center for Earthquake Engineering Research, Buffalo, New York, 15-49.

Shinozuka, M. (1995). “Summary of the Earthquake,” In *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995*. MCEER publications, New York.

Smith, Richard E., Emily A. Canelo and Anthony M. Di Dio (1997). “Reinventing Reinsurance Using the Capital Markets,” *The Geneva Papers on Risk and Insurance*, 22:26-37.

Small Business Administration (1999)."Audit of Northridge Disaster Early Defaults Finds Improvements needed in Loan Origination and Liquidation," p. 3, and "Efforts to Improve SBA Program Management," p. 21; Semiannual Report March 1999. See http://www.sba.gov/IG/sar3-99.pdf

Smolka, A. (1995). “Comparing Faults,” *Reinsurance*, October, 29-34.

Stripple, J. (1998). "Securitizing the Risks of Climate Change: Institutional Innovations in the Insurance of Catastrophic Risk," IIASA Interim Report IR-98-098, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Swiss Re (1995). *The Great Hanshin Earthquake, Kobe: Trial, Error, Success*. Zurich: Swiss Reinsurance Company.

Swiss Re (1997). *Learning from Disaster: The Floods in the Czech Republic, Poland and Germany in the Summer of 1997*, Zurich: Swiss Reinsurance Company.

Swiss Re (1999). *Floods – An Insurable Risk? A Market Survey*. Zurich: Swiss Reinsurance Company.

Swiss Re. (1999). "Natural Catastrophes and Man-Made Disasters 1998." Table 3, *Sigma* 1:15.

Threadgold, S. (1995). "A Call for Change," *Post Magazine*, 14 Dec., 23-25.

Tiedemann, H. (1996). “Kobe: Was this a Foretaste for the World's Greatest Earthquake Disaster?” *Catastrophe Reinsurance Newsletter*, August, 42:155-160.

Tiong, R. (1995). “The Great Hanshin Earthquake: A Quick Look at Loss Estimates and Insurance Aspects.” *Asia Insurance Review*, May-June 1995, 59-60.

Toyoda, T. (1997). “Economic Impacts and Recovery Process in the Case of the Great Hanshin Earthquake,” Presentation to the Fifth U.S.-Japan Workshop on Urban Earthquake Hazard Reduction, Pasadena, Calif. Jan. 15-17.

United States Army Corps of Engineers (1996).”Impacts of the Great Flood of 1993,” USACE Lower Mississippi Valley Division and *1993 Flood Data Homepage,* In: http://www.mvd.usace.army.mil/fl93/fl93home.htm

Welsh Consumer Council (1992). “In Deep Water: a Study of the Consumer Problems in Towyn and Kinmel Bay following the Floods of 1990.” Welsh Consumer Council, Cardiff.

Werner, S.D, S.E. Dickenson and C. Taylor (1997). “Seismic Performance of Ports: Lessons from Kobe,” In *Economic Consequences of Earthquakes: Preparing for the Unexpected* (B.G. Jones, ed.), NCEER-SP-0001, Buffalo, NY, 125-153.