NATURAL DISASTERS AND NATIONAL NATURAL DISASTER INSURANCE: AN AUSTRALIAN PERSPECTIVE

PROFESSOR ANDREW C. WORTHINGTON

PURPOSE

This is a research report in a series of studies commissioned by the Australian Centre for Financial Studies (ACFS) on key issues in the areas of banking, insurance, and funds management/superannuation.

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Andrew C. Worthington

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Griffith University
170 Kessels Road
Nathan QLD 4111
Tel: 07 3735 4273
Email: a.worthington@griffith.edu.au

Australian Centre for Financial Studies
Level 46 Rialto South Tower
525 Collins Street
Melbourne VIC 3000
Tel: 03 9666 1050
Email: info@australiancentre.com.au

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ABBREVIATIONS AND ACRONYMS

ABS Australian Bureau of Statistics

ACFS Australian Centre for Financial Studies

ACT Australian Capital Territory

BOM Bureau of Meteorology

BTE Bureau of Transport Economics

CCR Caisse Centrale de Réassusrance

CCS Consorcio de Compensacion de Seguros

CFA Country Fire Authority

CIP Catastrophe Insurance Pool

COAG Council of Australian Governments

CRED Centre for Research on the Epidemiology of Disasters

CSIRO Commonwealth Scientific and Industrial Research Organisation

DSE Department of Sustainability and Environment

DTRS Department of Transport and Regional Services

EMA Emergency Management Australia

EQC Earthquake Commission

ERC Earthquake Reinsurance Company

FEMA Federal Emergency Management Agency

FNQ Far North Queensland

FONDEN National Fund for Natural Disasters

GDP Gross domestic product

GEJE Great East Japan Earthquake

HE House Equivalent

IAA Institute of Actuaries of Australia

ICA Insurance Council of Australia

IPART Independent Pricing and Regulatory Tribunal

NDIR Natural Disaster Insurance Review

NDRRA Natural Disaster Relief and Recovery Arrangements

NFIP National Flood Insurance Program

NSW New South Wales

NT Northern Territory

NWA Northwestern Australia

NZ New Zealand

OECD Organisation for Economic Co-operation and Development

PC Productivity Commission

QLD Queensland

QFCI Queensland Floods Commission of Inquiry

SA South Australia

SEQ Southeast Queensland

TAS Tasmania

UK United Kingdom

UN United Nations

US United States

VBRC Victorian Bushfires Royal Commission

VIC Victoria

WA Western Australia

WYO Write-Your-Own

EXECUTIVE SUMMARY

Recent natural disasters in Australia have prompted some calls for the establishment of national natural disaster insurance program to address apparent problems of availability and affordability in the existing private insurance market. We first examine the incidence and impact of natural disasters during a recent period and find that although there is strong evidence of an upward trend in the costs of overall loss, particularly among the few very severe outlier events, there is much less suggestion from the trends in the insurance data on the number of events. However, the expectation is that two of the natural disaster types most relevant to Australia, namely, flood and bushfires, will increase in frequency with climate change, intensified by socioeconomic development and population growth, especially in exposed coastal and riverine settlements and regions and in large densely populated urban areas.

Based on four recent extreme natural disaster events as illustrative cases, areas of particular concern with property insurance are that insured losses are only a relatively small percentage of total costs, and that while property insurance is quite widespread in Australia, the levels of noninsurance and underinsurance, as well as cover for particular sources of damage may be inappropriate. Apart from availability, other concerns are evident with affordability, failures in risk disclosure by government, the unclear disclosure of coverage, and noninsurance resulting from perceptions of government as a provider of cover of last resort. However, the recommendations from recent natural disaster reports and inquiries mostly concern mitigation, prediction, emergency services response, land use and planning controls and building regulations, and disaster relief and recovery, with relatively few concerning any deficiencies in existing private insurance markets.

Following a review of six existing international national disaster insurance programs with a particular emphasis on nonmarket problems arising from moral hazard and adverse selection, it would appear that there is insufficient evidence of insurance market failure to justify the development of a national natural disaster insurance program. This is particularly so because of initiatives by insurers and regulators to rectify some of the problems arising after recent disasters, especially because of the last several reports and inquires. However, there are elements of a specifically targeted eligibility-limited joint government-industry subsidy scheme for very high-risk households in relation to floods that may be deserving of further attention.

1. INTRODUCTION

Especially in response to recent catastrophic floods in Queensland and bushfires in Victoria, some commentators have called for a national natural disaster insurance scheme, being a public sector insurance provider concerned with redressing apparent deficiencies in a purely private insurance market, notably the availability and affordability of property insurance. Apart from citizens and insurance policyholders, such a change would have profound implications for the Australian economy in general and the insurance industry in particular. This is because appropriately designed and priced insurance products provide important positive externalities that go beyond purely financial concerns. With respect to natural disasters, insurance is not only a tool for addressing immediate risk assessment and subsequent mitigation, it is a powerful mechanism for discovering and motivating appropriate risk-taking behaviour. This partly motivates the interest in a national disaster insurance scheme.

Natural disasters represent a serious threat to the insurance market in that they potentially violate the conditions needed for privately insurable risks, namely that losses cannot be catastrophic and that premiums must be reasonable and affordable. One possible solution is a national disaster insurance scheme. However, this entails a number of obvious concerns. First, whether the insurance industry is currently incapable of providing an appropriate level of cover and insurance products to cope with natural disasters, many of which are expected to increase in severity and frequency with climate change. Second, aspects of nonmarket failure expected to be associated with insurance schemes that are largely or in part developed and motivated by nonmarket concerns. Finally, the impact of moral hazard and adverse selection in household decision-making and behaviour, and the effects these may have on the performance and viability of any such scheme and the burden placed on funding. These important issues are yet unaddressed in the Australian context, thereby motivating a comprehensive review of the primary challenges and risks facing the industry in response to natural disasters. The relatively small size of the Australian insurance industry also puts it at risk of large exposures expected to increase in both magnitude and frequency in the future.

Through a process of research and engagement with representatives from the Australian insurance industry, our primary research objective is to conduct a comprehensive review of current activities in response to natural disasters and identify the gaps in response options facing the insurance industry. The study comprises three subtopics to cover the most important strategic issues facing the Australian insurance industry with reference to natural disasters as follows. First, place the project in context, outline the costs and distributions of natural disasters (primarily floods and bushfires) to the insurance industry and governments in Australia over the past 20-30 years, and assess trends in the pricing of insurance to individuals in regions affected because of these disasters. Second, review innovations in insurance techniques and insurability, including disaster modelling and insurer response to natural disasters, and consider how climate change could undermine insurability in the future, and what insurers can do to reduce this possibility in conjunction with other stakeholders.

Finally, provide a critique of international natural disaster insurance programs as they presently exist. Particular emphasis is on the advantages and disadvantages of existing approaches, including innovations and initiatives under development, and the proposed alternative approaches, especially the potential for moral hazard among policyholders of a national disaster insurance scheme.

2. NATURAL DISASTERS IN AUSTRALIA: INCIDENCE, IMPACT AND INSURANCE

2.1 INTRODUCTION

The purpose of this section is to review briefly the incidence and impact of natural disasters in Australia and any insurance issues that have arisen as a result. Section 2.2 discusses the definition of natural disasters. Section 2.3 examines the incidence and impact of these disasters. Section 2.4 reviews four recent extreme natural disaster events as illustrative cases. Section 2.5 summarizes the role of insurance in relation to these events. Section 2.6 provides a brief summary.

2.2 DEFINITION

COAG (2002) defines a natural disaster as a serious disruption to a community or region caused by the impact of a naturally occurring rapid onset event that threatens or causes death, injury, or damage to property or the environment and which requires a significant and coordinated multi-agency and community response. Any one, or a combination, of the following natural hazards, could account for such serious disruption in Australia, including bushfires, earthquakes, floods, storms, cyclones, storm surges, landslides, tsunamis, meteorite strikes, and tornados.

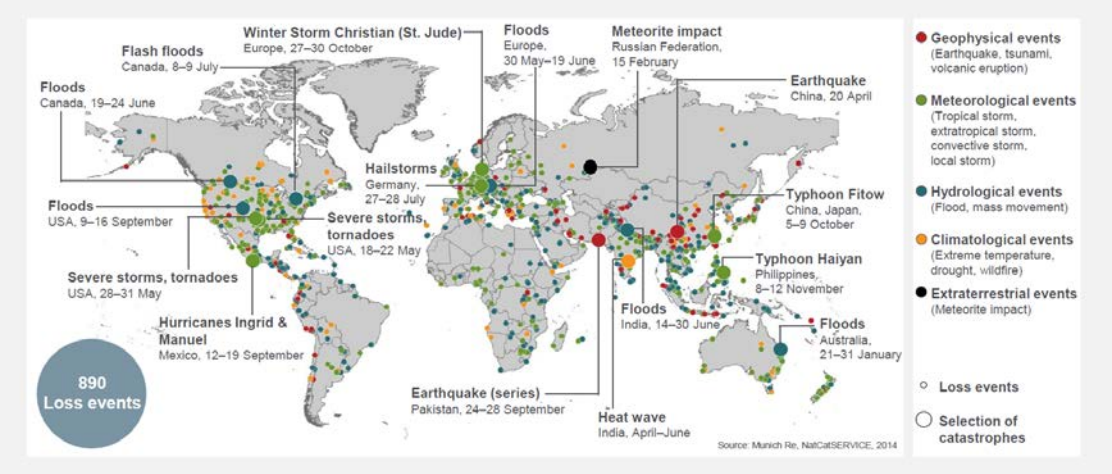
Elsewhere, in 2009 the Centre for Research on the Epidemiology of Disasters (CRED) and the Munich Reinsurance Company (Munich RE) jointly developed an operational disaster category classification and terminology that defines natural disasters as:

> [A] situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance and an unforeseen and often sudden event that causes great damage, destruction and human suffering.

This is an important definition as it determines the criteria for a disaster to be entered into CRED's and Munich RE's respective disaster databases, such that at least one of the following criteria must be fulfilled: 10 or more people reported killed, 100 or more people reported affected, declaration of a state of emergency, and a call for international assistance. On this basis, in 2013, Munich RE (2013) identified 890 loss events worldwide, accounting for some 20,500 fatalities, US$135 billion in total damages, and US$35 billion in insured losses. Of these events, 44% were categorised as meteorological (tropical, subtropical, convective and local storms), 37% percent as hydrological (floods and other mass water movements), 10% as geophysical (earthquakes, tsunamis, volcanic eruptions) and 9% climatological (droughts, forest fires).

In 2013, these respectively accounted for 38%, 49%, 5% and 8% of fatalities, 49%, 37%, 7% and 7% percent of overall losses, and 71%, 27%, <1% and 2% of insured losses. As shown in Figure 1, these criteria resulted in a relatively small number of loss events recorded for Australia in 2013, exclusively comprising metrological, hydrological, and climatological events.

Figure 1: Loss events worldwide, 2013



Source: Munich RE (2014)

The globally low incidence and cost of natural disasters in Australia is likewise borne out by a CRED study conducted by Guha-Sapir et al. (2012). While figures are only available at the regional level (Oceania), as shown in Table 1, Australia and its immediate surrounds does not figure predominately in terms of its global share of the number of natural disaster events, the number of victims or the costs of damage. For example, in 2012, Oceania (including Australia) only accounted for only 3% of natural disaster events in the CRED database, 0.2% of victims, and 0.5% of the costs of damage globally.

However, these figures well illustrate the volatility of these measures over the medium term. In evidence, the annual number of natural disaster events in Oceania in 2012 was 25% less than the average over the period 2001-11, but the number of victims was 52% higher and the damages were 82% lower.

Table 1: Natural disaster occurrence and impact by global region, 2012

No. of natural disasters	Africa	Americas	Asia	Europe	Oceania	*Global*
Climatological 2012	16	12	12	45	0	***85***
Avg. 2002-11	14	14	12	17	1	***59***
Geophysical 2012	0	6	23	3	0	***32***
Avg. 2002-11	3	7	22	2	2	***36***
Hydrological 2012	30	26	71	16	7	***150***
Avg. 2002-11	46	41	82	23	5	***197***
Meteorological 2012	11	35	39	1	4	***90***
Avg. 2002-11	9	34	39	14	7	***102***
Total 2012	**57**	**79**	**145**	**65**	**11**	**357**
Avg. 2002-11	***72***	***95***	***156***	***56***	***16***	***394***

No. of victims (millions)	Africa	Americas	Asia	Europe	Oceania	Global
Climatological 2012	28.01	1.82	6.37	0.45	0.00	***35.21***
Avg. 2002-11	23.86	1.36	76.80	0.27	0.00	***102.57***
Geophysical 2012	0.00	1.41	1.48	0.03	0.00	***2.91***
Avg. 2002-11	0.08	0.83	7.13	0.01	0.07	***8.12***
Hydrological 2012	9.34	1.54	53.52	0.10	0.24	***64.74***
Avg. 2002-11	2.08	4.26	111.05	0.28	0.06	***117.71***
Meteorological 2012	0.47	0.80	18.93	0.00	0.02	***20.22***
Avg. 2002-11	0.37	2.19	37.05	0.11	0.04	***39.75***
Total 2012	**37.82**	**5.57**	**80.29**	**0.58**	**0.26**	***124.52***
Avg. 2002-11	***26.38***	***8.64***	***232.03***	***0.66***	***0.17***	***267.88***

Damages (2011 US$ bn)	Africa	Americas	Asia	Europe	Oceania	Global
Climatological 2012	0.00	22.46	0.02	4.15	0.00	**26.63**
Avg. 2002-11	0.04	2.79	3.50	2.76	0.39	**102.57**
Geophysical 2012	0.00	0.68	2.14	15.80	0.00	**18.62**
Avg. 2002-11	0.57	4.08	36.73	0.53	2.47	**44.36**
Hydrological 2012	0.83	0.58	19.25	4.24	0.70	**25.61**
Avg. 2002-11	0.31	3.95	13.51	4.73	1.16	**23.66**
Meteorological 2012	0.10	79.67	6.56	0.01	0.15	**86.48**
Avg. 2002-11	0.07	39.14	8.19	3.64	0.77	**51.81**
Total 2011	**0.93**	**103.38**	**27.97**	**24.20**	**0.85**	157.34
Avg. 2002-11	***0.99***	***49.96***	***61.93***	***11.66***	***4.78***	***129.33***

Source: Guha-Sapir (2012)

In terms of other working definitions affecting sources of data used throughout this report, the Insurance Council of Australia (ICA), the peak representative body of the Australian general insurance industry, collates data on natural disasters derived from the submissions of general insurance companies following large events incurring cost to the community and insurers. The criterion for inclusion as a natural disaster in this particular database is the potential for the insured loss to exceed $10 million.

2.3 INCIDENCE AND IMPACT

Table 2 details the 123 natural disasters recorded by the ICA (2014) in its database during the 20-year period from January 1994 to June 2014 (roughly 4.1 natural disasters per year) ranked by 2011 normalised cost (in $ millions). Also included in the table is the event type (hail, flood, storm, cyclone, bushfire, and earthquake), the event date (or start date for multiday disasters), and the location and state. As shown, the five most-costly disasters during this period are all relatively recent, comprising the 1999 Sydney hailstorm, the 2010 southeast Queensland floods, the 2007 Hunter Valley and Newcastle storms, Cyclone Yasi in Queensland in 2011, and the 2009 'Black Saturday' bushfires in Victoria. We discuss four of these events in detail in Section 2.4.

Overall, and as discussed elsewhere, the incidence of natural disasters has not changed markedly over this relatively short period, however, the average annualized cost has steadily increased. In the four approximately five-year periods 1994-98, 1999-2003, 2004-08 and 2009-14, there were 34, 33, 32 and just 24 recorded events, respectively, but the average normalized cost was A$85.06, A$188.82, A$156.97, and $439.28 million, respectively.

Table 2: Historical natural disasters, 1994-2014

Event type	Start date	Location	State	Normalised Cost (A$m)
Hail	14/04/1999	Sydney	NSW	4296.00
Flood	21/12/2010	SEQ	QLD	2387.62
Storm	8/06/2007	Newcastle/Hunter	NSW	1742.00
Cyclone	2/02/2011	Various	QLD	1412.24
Bushfire	7/02/2009	Various	VIC	1266.00
Storm	6/03/2010	Melbourne	VIC	1160.00
Storm	22/03/2010	Perth	WA	1019.00
Flood and Storm	21/01/2013	Various	QLD	977.00
Storm	25/12/2011	Melbourne	VIC	728.64
Bushfire	18/01/2003	Canberra	ACT	660.00
Cyclone	20/03/2006	FNQ	QLD	609.00
Flood and Storm	14/02/2008	Mackay	QLD	507.00

Event type	Start date	Location	State	Normalised Cost (A$m)
Storm	4/02/2011	Melbourne	VIC	487.62
Hail	9/12/2007	Sydney	NSW	486.00
Storm	16/11/2008	Brisbane	QLD	355.00
Hail and Storm	20/02/2005	Various	NSW/TAS/VIC	304.00
Hail	29/09/1996	Armidale &	NSW	288.00
Hail	16/12/1998	Brisbane	QLD	254.00
Flood and Storm	10/01/1998	Townsville	QLD	245.00
Bushfire	16/01/1994	Various	NSW	215.00
Flood	26/01/1998	Katherine	NT	201.00
Storm	23/05/1994	Perth	WA	187.00
Bushfire	17/10/2013	Various	NSW	183.40
Hail	6/11/1995	SEQ	QLD	166.00
Hail	31/12/2003	Melbourne	VIC	156.00
Hail	11/12/1996	Singleton	NSW	149.00
Flood	3/05/1996	SEQ	QLD	134.00
Flood	24/02/2012	Various	NSW/VIC	131.89
Flood	24/01/2012	SEQ	QLD	131.43
Bushfire	25/12/2001	Sydney	NSW	131.00
Flood	13/01/2011	Various	VIC	126.50
Flood and Storm	27/01/2013	Various	NSW	121.30
Earthquake	6/08/1994	Cessnock	NSW	115.00
Storm	19/12/1997	Sydney	NSW	113.00
Hail	9/10/2007	Lismore	NSW/QLD	109.00
Storm	16/05/2005	Bunbury	WA	108.00
Cyclone	22/03/1999	Exmouth	WA	108.00
Storm	20/11/1994	Sydney	NSW	100.00
Flood and Storm	9/03/2001	Brisbane	QLD	99.00
Flood and Storm	17/08/1998	Wollongong	NSW	97.00
Flood and Storm	30/06/2005	SEQ	QLD	93.00
Bushfire	4/01/2013	Various	TAS	89.00
Hail	12/10/2005	Gold Coast	QLD	89.00
Storm	24/10/1999	Sydney	NSW	89.00
Flood and Storm	17/01/2008	Emerald	QLD	85.00
Storm	13/10/1998	SEQ	QLD	80.00
Storm	20/04/2008	Various	SA/TAS/VIC	79.00
Storm	23/11/1996	Coffs Harbour	NSW	67.00
Storm	17/01/2001	Casino	NSW	65.00
Hail	31/10/2006	Newcastle/Hunter	NSW	60.00
Storm	30/12/2001	Sydney	NSW	57.00
Storm	18/11/2001	Sydney/Port	NSW	57.00
Flood and Storm	21/05/2009	Various	QLD/NSW	55.00
Hail	24/01/2004	Brisbane	QLD	54.00
Bushfire	22/11/2011	Margaret River	WA	53.45
Flood	5/03/2010	Various	QLD	49.00
Cyclone	25/02/1995	Kalgoorlie	WA	48.00
Hail and Storm	13/12/2004	Sydney/Lismore	NSW	46.00
Flood and Storm	6/03/2001	Grafton/Kempsey	NSW	45.00
Bushfire	8/10/2002	Engadine	NSW	43.00
Storm	31/01/1996	Sydney	NSW	43.00
Bushfire	11/01/2005	Eyre Peninsula	SA	41.00
Cyclone	2/04/2000	FNQ	QLD	41.00
Hail	31/03/1997	SEQ	QLD	41.00
Flood	10/04/2009	Various	NSW	40.00
Storm	24/08/2003	Various	NSW/VIC/TAS	39.00
Storm	23/06/1998	Hunter Valley	NSW	39.00
Flood and Storm	30/06/2005	Northern NSW	NSW	37.00
Storm	15/12/2005	Hunter Valley	NSW	36.00
Storm	16/01/2002	Various	NSW/QLD	36.00
Bushfire	5/02/2011	Perth	WA	35.13

Event type	Start date	Location	State	Normalised Cost (A$m)
Bushfire	13/01/2013	Coonabarabran	NSW	35.00
Storm	4/02/1998	Sydney	NSW	34.00
Cyclone	27/02/2000	FNQ	QLD	31.00
Flood and Storm	7/02/2000	Longreach	QLD	30.00
Storm	31/08/1996	Sydney	NSW	30.00
Bushfire	21/02/1997	Ferny Creek	VIC	29.00
Bushfire	20/01/2006	Various	VIC	28.00
Hail	19/05/2005	Brisbane	QLD	28.00
Storm	29/01/2004	Melbourne	VIC	28.00
Storm	6/01/2001	Dubbo	NSW	28.00
Cyclone	20/04/2000	NWA	WA	28.00
Flood and Storm	9/04/1998	Sydney	NSW	28.00
Hail	14/11/1996	Tamworth	NSW	28.00
Storm	5/01/1998	Nyngan	NSW	27.00
Cyclone	22/03/1997	Cairns	QLD	27.00
Flood and Storm	26/12/1998	Melbourne	VIC	25.00
Storm	6/08/1998	Sydney	NSW	25.00
Bushfire	8/01/2003	Various	NSW/VIC	24.00
Storm	15/01/2001	Sydney	NSW	24.00
Flood and Storm	26/12/1999	Various	VIC	23.00
Storm	14/11/1998	Brisbane	QLD	23.00
Flood	13/01/2009	FNQ	QLD	22.00
Storm	16/02/2002	Sydney	NSW	19.00
Storm	16/06/2007	Gippsland VIC	VIC	18.00
Flood and Storm	4/01/2008	Various	NSW/QLD	17.00
Bushfire	1/02/2006	Various	VIC	16.00
Bushfire	11/01/2014	Perth	WA	15.00
Flood and Storm	14/01/2000	Perth	WA	15.00
Cyclone	1/03/2000	NWA	WA	14.00
Cyclone	12/02/1999	FNQ	QLD	14.00
Flood	17/11/2000	Mackay	QLD	13.00
Storm	16/11/1997	Grafton	NSW	13.00
Cyclone	8/03/2007	Pilbara	WA	12.00
Flood	20/03/1999	Moora	WA	12.00
Flood and Storm	24/10/1999	Wollongong	NSW	11.00
Storm	7/08/2006	Various	WA	9.00
Cyclone	11/04/2014	Various	QLD	8.40
Bushfire	31/12/2009	Toodyay	WA	8.00
Storm	10/12/2002	SEQ	QLD	8.00
Bushfire	21/12/1997	Menai	NSW	8.00
Flood and Storm	7/02/1999	SEQ	QLD	7.00
Storm	13/12/2004	Brisbane/Gold	QLD	6.00
Cyclone	5/04/1996	Pannawonica	WA	6.00
Storm	26/10/2007	Lismore Region	NSW	5.00
Storm	16/01/2007	Wagga Wagga	NSW	5.00
Flood and Storm	6/11/2005	Broken Hill	NSW	5.00
Flood and Storm	7/11/2005	Central West	NSW	4.00
Storm	24/12/2002	SEQ	QLD	4.00
Storm	30/09/2000	Various	VIC	4.00
Storm	4/12/1996	Brisbane	QLD	4.00
Flood	24/06/1998	East Gippsland	VIC	3.00
Storm	15/01/2007	Nyngan	NSW	2.00

Source: ICA (2014)

Table 3 provides summary statistics for the natural disasters in Table 2 according to the disaster type. Note that 'composite' disasters, such as flood and storm and hail and storm are included with flood and hail, respectively. As shown, storms are the

most common natural disaster in Australia, accounting for 34% of all events, followed by floods representing 27% of events and bushfires with 15% of events. However, storms and floods only account for 2% and 10% of the total normalized cost of A$24.6 billion associated with natural disasters during this period, with bushfires representing 77% of the total normalized costs, followed by cyclones with 9%. Accordingly, storms and floods are relatively frequent types of natural disasters in Australia, but generally less costly in total terms, while bushfires cyclones and hail are rather less frequent, of which bushfires are significantly more costly in total cost terms than either cyclones or hail. The dollar cost per natural disaster event in the final column provides a different perspective, showing that the dollar cost per is highest for bushfires, followed by cyclones, earthquakes, floods, hail, and storms. In terms of distribution, the costs of these natural disasters exhibit significant positive skewness for all disasters and by disaster type, suggesting a long tail of a few very costly events dragging the mean cost higher.

In terms of overall costs, BTE (2001) in an analysis of natural disasters in Australia (with a total cost per event over $10 million) concluded a cost to the Australian community pf A$37.8 billion (including deaths and injuries) in 1999 prices over the period 1967 to 1999. The average annual cost of these disasters between 1967 and 1999 was A$1.14 billion. However, as here, BTE (2001) concluded that a relatively small number of outlier events strongly affected the high average level of costs. For example, by excluding just three outlier events—Cyclone Tracy in 1974, the 1989 Newcastle earthquake and the 1999 Sydney hailstorm, the average annual cost declined to A$860 million, a fall of some 25%. Further, BTE (2001) was unable to conclude whether the annual cost was increasing over time, that there was no evidence that the total cost of smaller and more frequent events (less than $10 million total cost) exceeded the total cost of large rarer events. However, BTE (2001) did find evidence that the number of disasters per year was increasing due partly to better reporting and possibly increasing population in vulnerable areas. As for the impact of climate change, Munich Re announced that as Australia's population density increases as well as the severity and frequency of storms, floods, cyclones and bushfires, the annual total costs of natural disasters were projected to soar from A$6.3 billion currently to about A$23 billion in 2050. Coleman (2002) likewise concluded that the incidence of natural disasters, especially floods and bushfires would increase with climate change.

Table 3: Historical natural disaster statistics, 1994–2014

Disaster type	No	% of total	Total cost A$m	% of total	A$m per event
Bushfire	18	15	18939.12	77	1052.17
Cyclone	13	11	2157.22	9	165.94
Earthquake	1	1	121.30	<1	121.30
Flood (incl. flood and storm)	33	27	2358.45	10	71.47
Hail (incl. hail and storm)	16	13	523.13	2	32.70
Storm	42	34	589.40	2	14.03
Total	123	100	24688.61	100	200.72

Risk Frontiers (2012) provide an alternative perspective on the general incidence and impact of natural disasters in Australia in terms of House Equivalent (HE) losses. This measure recognises that damage to buildings is a major impact of natural disasters that dramatically affects the availability of shelter, causes displacement,

and results in direct and indirect health, economic and social impacts. One lost HE is equivalent to the loss of a single median-sized residential home. Losses to all buildings are included in this measure, including residential, commercial, and industrial buildings, as well as public buildings (e.g. hospitals, schools, police stations). However, HE losses do not include damage to building contents, cars, machinery, aircraft, crops, etc.

Table 4 details the HE losses for all states in Australia over the period 1900-2011 over ten different types of natural disaster. As shown, over this very long sample period, hail is responsible for the most HE losses (26,075), closely followed by floods (25,908), cyclones (16,315) and bushfires (14,551). However, the impact of natural disasters varies dramatically by state, with the three most-populous states of NSW, Queensland, and Victoria respectively accounting for 35%, 30% and 15% of total national HE losses, or 80% of HE losses together

Similarly, the HE losses also differ according to the type of natural disaster. Tropical cyclone winds have caused most damage in Queensland and the Northern Territory (the most damaging being Cyclone Tracy in Darwin in 1974), while the major historical bushfire HE losses have been in Victoria. Most HE flood losses have also been recorded in Queensland (including the 1974 Brisbane and 2011 Queensland floods), and to a lesser extent in NSW. Storm damage has been historically highest in NSW, as has the damage associated with the few instances of earthquakes in Australia (notably the 1989 Newcastle earthquake). The biggest HE losses from hailstorms are mainly in NSW (especially Sydney), while there has also been significant hail damage in HE terms in Queensland (Brisbane/Gold Coast) and Victoria (Melbourne).

Table 4: Australian HE losses 1900-2011

	ACT	New South Wales	Queensland	Victoria	South Australia	Western Australia	Northern Territory	Tasmania	**Australia**
Bushfire	1,142.39	2,705.37	33.40	7,394.26	1,103.21	519.18	0.00	1,652.95	14,551
Earthquake	0.00	4,403.83	8.70	7.44	313.95	201.65	16.00	1.50	4,953
Flood	172.81	5,807.26	15,335.68	1,493.33	106.87	1,204.67	1,415.11	372.00	25,908
Gust	89.85	1,714.23	1,888.02	573.69	160.98	175.05	15.17	27.00	4,644
Landslide	0.00	54.95	27.31	1.00	0.00	0.00	0.00	51.31	135
Storm - lightning, thunderstorm and	0.40	5,236.11	717.91	393.60	112.49	631.36	0.00	0.26	7,092
Hail	210.73	13,554.12	5,437.32	5,189.61	278.63	1,404.77	0.00	0.00	26,075
Tornado	6.00	1,389.11	179.89	166.14	59.46	187.71	0.00	1.50	1,990
Tropical Cyclone	0.00	885.47	6,564.26	0.00	0.00	1,819.29	7,045.73	0.00	16,315
Tsunami	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total	1,622	35,750	30,192	15,219	2,136	6,144	8,492	2,107	101,662

Source: Risk Frontiers (2012)

Clearly, the four most important natural disasters for Australia in terms of damage (share of total HE losses in brackets) are hail (26%), floods (25%), cyclones (16%), and bushfires (14%). Together, these account for 81% of all HE losses associated with natural disasters in the country.

2.4 EXTREME CASE EVENTS

In this section, we discuss in detail a number of selected illustrative national disasters in Australia during the past 20 years. These are all among the most significant in terms of losses, both property and human, in their particular category of natural disaster. Accordingly, they provide an extreme reflection of the types of natural

disasters in Australia and the amount of damage caused. Where able, we discuss the response of the insurance industry to these events and the findings of industry and governments in reports as to the causes and possible efforts to mitigate any future events and their associated losses.

2.4.1 HAILSTORM, SYDNEY, APRIL 1999

On the late afternoon and early evening of 14 April 1999, a thunderstorm developed south of Sydney, NSW. As the storm moved through the densely populated eastern part of the city, it brought with it lightning, high winds, heavy rain, and large hailstones. The large hail in particular damaged 24,000 homes and 70,000 motor vehicles along the storm's path, along with 2,800 commercial and industrial buildings damaged by the storm, and 23 aircraft at Sydney Airport. The storm affected some 130,000 people, with 500 left homeless, and 50 people injured with one fatality, attributed to lightning. The storm also resulted in in severe transport delays, with approximately 15,000 homes left without power, and significant business disruption (Latham et al. 2010).

The hailstorm resulted in an estimated A$2.2 billion in damage, making it Australia's most costly storm event, with insured losses accounting to A$1.7 billion, making it the largest insured loss in Australian history. Approximately 60% of the A$1.7 billion insured loss was paid out for damage to residential, commercial, and industrial properties, with an additional 29% for damage to motor vehicles. The 23 aircraft that were damaged at the Sydney Airport accounted to close to A$100 million dollars of damage, or another 6% of the total insured payout. The remaining insurance payments were losses arising from business interruption (Schuster et al, 2005a).

As Australia's most significant disaster in terms of normalised cost (but not fatalities) during the period 1994-2014 (but superseded by a normalized loss of $3.65 billion for Cyclone Tracy in 1974 and $4.3 billion for the 1989 Newcastle earthquake over the longer term), there has been some attempt at gauging the likelihood of a similar event in the future. Using the ICA's historical disaster statistics from 1967 through to 2006 adjusted to current values, Crompton and McAneney (2008) concluded that a severe convective storm loss in the Sydney metropolitan area equivalent to the 1999 event had a return period of several decades but not more than 100 years. Crompton and McAneney (2008) also concluded that the strong upward trend in losses was predominantly because of increases in population and wealth and that while there was no evidence that climate change had any impact from the loss data, this could emerge over time. Numerical simulations by Leslie et al. (2008) concluded that severe hailstorm events are likely to become more frequent and severe in NSW.

In a ten-year retrospective on the 1999 Sydney hailstorm, Risk Management Solutions (2009) concluded that losses from recent large events in Australia like the hailstorm were driving insurance prices up, making affordable insurance an issue. Most of the damage associated with the hailstorm was borne by the reinsurance market. However, this report suggested that there were complications in that a severe convective storm event could also adversely affect reinsurance, as conditions favourable to the formation of severe storms could persist for several days and cover large areas. Depending on a company's reinsurance arrangement and the cumulative losses from weather-related events in that year, the definition of such

events could determine the triggering of a reinsurance layer. In terms of additional complications, this report also highlighted that the hailstorm triggered shortages in roofing materials and the availability of skilled labour, causing severe delays in repairing damaged roofs.

While unrelated to the 1999 Sydney hailstorm, a similar event in Brisbane in November 2014 appears to bear out some of the concerns of large costs associated with densely populated urban areas. A hailstorm hit Brisbane on the afternoon of Thursday 27 November. As of writing, the total cost was expected to exceed A$1 billion, with $482 million thus far in insurance claims, comprising 17,509 home and contents claims and 51,472 car claims. It was also likely that there would be significant claims for commercial damage, with several planes flipped at the Archerfield airport, and damage to inner city buildings, potentially triggering business interruption claims. Together, this should ensure the 2014 Brisbane hailstorm is second only to the 1999 Sydney hailstorm in terms of normalised cost.

2.4.3 'BLACK SATURDAY' BUSHFIRES, VICTORIA, FEBRUARY 2009

Victoria endured one of its most severe and prolonged heatwaves during the final week of January 2009. The temperature in Melbourne was above 43°C for three consecutive days for the first time since records commenced. With Saturday 7 February forecast to reach temperatures in the low 40s, accompanied by strong winds, the Country Fire Authority (CFA) and the Department of Sustainability and Environment (DSE), the state's primary bushfire agencies, warned that Victoria's forests and grasslands were the driest they had been since the disastrous 1983 "Ash Wednesday" bushfires (Latham et al. 2010).

These fears were realised on Saturday 7 February when the CFA and DSE managed some 316 grass, scrub, or forest fires. Of these, 15 fires caused (or had the potential to cause) the greatest damage. In the aftermath of the bushfires, the Victorian Bushfires Royal Commission (VBRC 2010) was established, and this estimated that the cost of the bushfires was conservatively in the order of more than A$4 billion, made up A$593 million in supplementary funding by the Victorian government to fight the fires, A$1,200 million in general insurance claims (of which 84% were claims for property or contents and 16% for motor vehicles), A$77 million in damaged or destroyed infrastructure, $645 million in lost lives (from 173 bushfire-related deaths), A$658 million in lost timber, A$25 million in telecommunication asset damage, and A$90 million in funding the commission itself.

The scale of the damage associated with the 2009 Victorian bushfires, not least the lives lost, clearly marks it as one of the most significant natural disasters in Australia in living memory, and easily deserving of the attention of the Victorian Bushfires Royal Commission quickly established in its aftermath. Apart from examining the response of emergency services to the bushfire, the Commission provided a number of recommendations concerning fire prevention, as well as several concerning limiting the damage from bushfires. These included land use and planning controls and building regulations, land and fuel management, and disaster relief and recovery. Altogether, the Commission provided 67 recommendations. However, while noninsurance and underinsurance were noted by the Commission to have impeded

the rebuilding process, no recommendations were made concerning private insurance markets.

The only possible exception is that the VBRC (2010) looked at the funding of fire services, currently through a mix of contributions from insurance companies, the state and municipal councils, with insurance companies recouping the cost of their statutory contribution by imposing a fire services levy on insurance premiums for building and contents insurance. The Commission recognized that this link between the charges for fire services to the fire risk of individual properties via insurance premiums potentially provided a risk signal to households. However, the Commission was also of the opinion that the purported link was “at best tenuous” and that the current funding model lacked both transparency and equity as the uninsured and underinsured did not make a fair contribution to the funding of fire services, the suggestion being its replacement with a property-based levy.

2.4.4 FLOODS, SOUTHEAST QUEENSLAND, DECEMBER 2010-JANUARY 2011

The 2010-11 floods followed nearly 3 months of wet weather at the end of 2010. Altogether six major rain events took place from late November 2010 to Mid-January 2011, with December 2010 being the wettest December on record for Queensland. Many localities received more than 6 times their expected average December rainfall, including Brisbane, which received 480 mm of rainfall. However, analysis of the rainfall in southeast Queensland indicates that the peak rainfalls during the 2010-11 events were lower than during the 1974 major flood event and perhaps significantly lower than during the 1893 major flood event.

Because of this exceptionally high rainfall, major flooding occurred throughout most of the Brisbane River catchment, most severely in the catchments of its tributaries of the Lockyer Creek and the Bremer River. The flooding caused the loss of 24 lives (23 in the Lockyer Valley and one in Brisbane), with some 18,000 properties inundated wholly or in part in Brisbane, Ipswich and surrounding areas. Altogether, the flooding affected more 200,000 people, impacted 3,570 business premises, and damaged 19,000 kilometres of roads, around 28 percent of the Queensland rail network damaged and 3 major ports. According to the Insurance Council of Australia, insurers received almost 56,200 claims, with an insured cost of $2.55 billion. The estimated recovery cost of the floods, including the unrelated Cyclone Yasi in February 2011, currently stands at $6.8 billion, including the repair of damage to state-owned infrastructure and business disruption to ports, mines, agriculture, and tourism.

In a direct response to the 2010-11 Queensland floods, two inquiries were established. The Queensland Floods Commission of Inquiry (QFCI) was established in January 2001 to examine the flood disaster and the chain of events leading to the floods, and all aspects of the response and the subsequent aftermath. The final report made 175 recommendations relating to the preparation and planning for the flooding by governments, emergency services and the community, the supply of essential services during floods, the adequacy of forecasts and early warning systems, and dam operational procedures for safety and flood mitigation.

In terms of property insurance, the QFCI noted that some 88% of Australian households held home and contents policies that covered damage arising from most

natural perils. The exception was riverine flood (defined as the overflow from rivers and creeks following long duration rainfall over large catchment areas, or water rising up from flooding rivers, in contrast to flash flooding and water damage from rain and storm). The QFCI found that while some insurers offered riverine flood cover, many did not, such that during the 2010-11 flood event claims by insured victims of flash flooding in Toowoomba and the Lockyer Valley were generally settled by insurers, many others along the Brisbane River had claims denied, with the ICA putting the proportion of claims denied for this reason was about 15%. The perceived reticence of private insurers in meeting claims and confusion over policy conditions resulted in a significant social backlash. One result was that by the time of the 2014 hail event, insurers were much faster in responding to consumer concerns and providing media information about the claims process.

Subsequently, March 2011 saw the announcement of the Commonwealth Natural Disaster Insurance Review (NDIR), with key discussion points being a single unified and consistent definition of "flood" for insurance purposes and the availability and affordability of flood insurance, including the circumstances of noninsurance and underinsurance, consumer understanding and dispute resolution, flood risk measurement and mitigation, and aspects of government funding of natural disaster relief and recovery. The NDIR (2011) found that of Australia's approximately 6.6 million detached houses and some 1 to 2 million other dwellings, including terrace houses and home units, perhaps 5 to 10 per cent of dwellings were subject to flood risk. In its submission to the NDIR, the ICA (2011) opinioned that 7% of homes in Australia were subject to persistent flooding, with potential damage in the order of A$400-450m per year.

Among a number of recommendations relating to planning control and building requirements, the NDIR (2011) made recommendations that all home and contents insurance needed to include flood cover, that discounted insurance premiums were required in areas of medium and high flood risk to render flood insurance affordable, and that insurers would need access to a government-sponsored reinsurance facility to deliver these discounts. The recommendations also included that the Commonwealth Government guarantee the payment of claims by ensuring that, whenever a funding shortfall occurred in the reinsurance facility through claims exceeding the funds held in the facility, the Commonwealth would meet the shortfall and then seek reimbursement of a portion of the shortfall from the State or Territory government in whose jurisdiction the flood occurred.

However, while recommending that all home and contents policies include flood insurance, the NDIR recommended that such insurance not be made compulsory. Among its 47 recommendations, the NDIR also identified five principles underpinning the design of the system of premium discounts, such that premiums would rise with the level of flood risk, that homes without a flood risk should not pay a flood premium (no cross-subsidisation of premiums between policyholders, some limitations on discounts to high-value homes, and that the discount mechanism should be simple to understand for policyholders and straightforward for insurers.

2.4.2 CYCLONE 'YASI', FAR NORTH QUEENSLAND, FEBRUARY 2006

In the early hours of 3 February 2011, Cyclone Yasi, a Category 5 cyclone, crossed the far north Queensland coast near Mission Beach, between Cairns and Townsville, bringing peak wind gusts estimated at 285 kilometres per hour. The massive storm destroyed and damaged homes, businesses, crops, marinas and island resorts as it crossed the coast, and maintained considerable intensity as it tracked inland into the state's north-west, finally weakening to a tropical low near Mount Isa some 20 hours later. The towns of Cardwell, Tully, Mission Beach, and Innisfail were badly damaged, but not the major regional cities of Cairns and Townsville. One death is associated with the cyclone, but significant damage to agriculture, mining and other businesses in the area, infrastructure, and damage to marinas and boats along with homes.

Initial estimates were that Cyclone Yasi caused up to $800 million worth of damage, with state government costs met through the state and federal Natural Disaster Recovery and Relief Arrangements (NDRRA). The ICA reported that some 73,250 insurance claims resulted from the cyclone, with a total insured loss approaching $1.5 billion. One issue that did result from Cyclone Yasi was the affordability of insurance, with insurance premiums increasing strongly following the event. The ICA (2011), in its submission to the NDIR suggested that premiums had risen some 20-40% in some areas, largely as a results of reinsurance cost pressures. Combined with the almost concurrent floods in southeast Queensland in December 2010 and January 2011, this fed into the NDIR and the recommendations described above.

2.5 ROLE OF INSURANCE

As shown by the discussion of these four extreme natural disasters, including the outcomes of the various reviews and inquiries, property insurance access and affordability, and the rates of noninsurance and underinsurance, have become a persistent theme in the policy debate. However, there has been no consistent call for a national disaster insurance program, rather the acceptance that the private insurance market has largely met many of the challenges posed by these disasters, with some adjustments in terms of the clarification of terms and conditions for property insurance, the speed of processing claims, and in a small number of cases, the lack of affordable cover for very-high risk households with flood cover. In this regard, as part of an insurance industry undertaking to help the Federal Government monitor consumer choices concerning the purchase of residential flood insurance policies, the ICA (2014) collects data on the residential policies and the extent of active flood cover. As shown in Table 5 for the most flood-affected states of NSW and Queensland and for Australia as a whole, 85% of active policies include flood cover as standard, and while flood cover may also be on an opt-out basis, upwards of 90% of insured households have home and/or contents flood cover on either basis.

Table 5: Total number of active residential insurance policies, flood coverage, March 2014

	Type	NSW	QLD	Australia
No. of active policies	Home	654,791	414,888	1,987,184
	Contents	809,756	549,664	2,407,723
	Home and Contents	1,253,989	715,013	4,640,502

	Type	NSW	QLD	Australia
No. of active policies including flood cover as standard	Home	573,919	373,471	1,747,582
	Contents	717,274	500,395	2,112,130
	Home and Contents	1,054,322	599,780	3,926,746
No. of active policies including flood cover on opt-out basis	Home	37,540	11,747	75,800
	Contents	49,369	22,095	118,455
	Home and Contents	119,008	47,479	295,222
No. of active policies including flood cover on opt-out basis - flood cover inactive	Home	17,106	2468	24,476
	Contents	23,669	6374	42,432
	Home and Contents	35,490	10,641	63749
No. of active policies where flood cover active	Home	594,353	382,750	1,798,906
	Contents	742,974	516,116	2,188,152
	Home and Contents	1,137,840	636,617	4,158,210
% of active policies including flood cover as standard	Home	87.6%	90.0%	87.9%
	Contents	88.6%	91.0%	87.7%
	Home and Contents	84.1%	83.9%	84.6%
% of active policies including flood cover on opt-out basis	Home	5.7%	2.8%	3.8%
	Contents	6.1%	4.0%	4.9%
	Home and Contents	9.5%	6.6%	6.4%
% of active policies including flood cover on opt-out basis - flood cover inactive	Home	2.6%	0.6%	1.2%
	Contents	2.9%	1.2%	1.8%
	Home and Contents	2.8%	1.5%	1.4%
% of active policies where flood cover active	Home	90.8%	92.3%	90.5%
	Contents	91.8%	93.9%	90.9%
	Home and Contents	90.7%	89.0%	89.6%

Source: ICA (2014)

Elsewhere, a report by ASIC (2005) in the aftermath of the 2003 Canberra bushfires identified that the general level of underinsurance of homes and contents in Australia was high, with surveys suggesting that between 27% and 81% of consumers were underinsured 10% or more against current rebuilding costs. The report identifies the following reasons for underinsurance: the placing of the burden of estimating rebuilding costs on the consumer, the reliance of consumers on insurers for assistance in estimating rebuilding costs, which may or may be suitably forthcoming. They also included the failure for consumers and insurers to increase the sum insured over time to maintain parity with building costs generally, or after renovation. Lastly, home policies can be complex and difficult for consumers to compare, so that they may not appreciate the extent of underinsurance due to variations in the cover offered by different insurers. Tooth and Barker (2007) also considered noninsurance for homes and contents and found that house type and tenure were critical drivers. Demand for contents insurance also appeared to be more price sensitive than building insurance, and that state taxes therefore had the potential to affect insurance take-up.

2.6 SUMMARY

Australia, like most countries throughout the world, is exposed to natural disaster risk, most notably floods, bushfires, hail, and cyclones. The evidence suggests that while the impact of climate change is yet to be reflected in the insurance data, the scientific consensus is that some of these events, especially bushfires and floods, will become more frequent over the longer term. Nonetheless, it is clear that the average

cost of natural disaster events in Australia is steadily rising across all types of natural disasters. At the same time, increasing population and population density are associated with the increasing costs of natural disasters affecting capital cities, especially hail.

While a number of inquiries and reviews have been instigated to examine natural disaster prevention and damage mitigation, these have generally been very broad ranging and have address a number of disparate concerns, including mitigation, prediction, emergency services response, land use and planning controls and building regulations, and disaster relief and recovery. Some have also commented on insurance markets. However, few, even among the most extreme events considered, have called for a national natural disaster insurance program, and the consensus would appear to be that the role of insurance in helping meet private post-event costs have been appropriate and affordable. However, some insurance deficiencies have been identified, often in relation to inconsistent and misunderstood terms and conditions and the availability of insurance for some submarkets, including highly at-risk households, small businesses, and some regions and localities.

3. THE THEORY AND PRACTICE OF NATURAL DISASTER INSURANCE

3.1 INTRODUCTION

In recent years, and for all too understandable reasons, public concern regarding events and disasters (or catastrophes) of a natural origin has often fallen relative to those of human origin. However, natural disasters (including floods, storms, bushfires, hurricanes, cyclones, tsunamis, and earthquakes) continue to cause severe and increasing damage to global economies. In 2013 alone, Munich Re (2014) identified 890 major global loss events (defined as situations of substantial economic loss and considerable insured losses where interregional or international assistance was necessary with large numbers of people killed or made homeless) accounting for some 20,500 fatalities, US$135 bn in overall losses and US$35 bn in insured losses. Of these events, 44 percent were meteorological (tropical, subtropical, convective and local storms), 37 percent were hydrological (floods and other mass water movements), 10 percent were geophysical (earthquakes, tsunamis, volcanic eruptions) and 9% were climatological (droughts, forest fires). These respectively accounted for 38, 49, 5 and 8 percent of fatalities, 49, 37, 7 and 7 percent of overall losses, and 71, 27, <1 and 2 percent of insured losses.

In brief, the economic costs of these disasters are of two broad types. The first are *pre-event costs*, comprising the preventative and risk management costs used to prevent or minimize damage in advance of the event (Latham et al 2010). These may then include back burning to reduce the risk of bushfire, the setting of building standards to minimize earthquake damage, managing building approvals to avoid building on floodplains, or the building of levees and dams to contain floodwaters. In general, individuals, households, and governments incur these costs over a long period and they are usually not included among the overall and insured losses detailed earlier.

Further, it is usually difficult to measure these costs, especially as they sometimes are included in other costs and provide benefits unrelated to natural disasters. It is also difficult to determine whether these costs have been sufficient (or even excessive) in offsetting the actual losses incurred in future natural disasters. For these and other reasons, including information asymmetries, externalities and social costs, the products and services associated with these pre-event costs often display public good characteristics, and therefore offer a prima facie case for government intervention, largely through nonrivalry and nonexcludability in their consumption. For example, a levee used to manage floods will equally hold back the waters for one as for many households (nonrivalry) and it is not possible for a private provider to withhold or withdraw the protection for a single household (nonexcludability).

The second type of costs are *post-event costs*, which include the cost of reconstruction following a disaster, losses from business interruption, rehabilitation for personal injury, and compensation payable from loss of life (Latham et al 2010). In contrast to the preventative or risk management costs, these costs are mostly a direct and measurable outcome of the natural disaster, and most cases are private, in the sense that it is easy to identify readily the party that has suffered loss, whether household, business, or government. The products and usually services used to

address these costs bear all the hallmarks of private goods in that they exhibit rivalry and excludability.

The nature of these post-event costs strongly suggests a role for insurance in managing natural disaster risk by transferring it to some third party. The insurance good provided is then rivalrous, in the sense that only one asset is insured by each purchased policy, and excludable, in that providers can prevent those that have not purchased a policy from benefiting in that cover is not extended. Post-event costs are then well suited to insurance because insurable risks are unexpected and random, but the losses associated with them are determinable and measurable. However, insurable risks are only manageable if they are distributed across time, and do not all materialize at one time: that is, they are not disastrous. Insurance premiums must also be high enough to cover any losses, but affordable enough so to attract the widespread purchase of policies and build a sufficiently sized risk pool. In many cases, insurance does not meet these requirements when we consider natural disasters.

The purpose of this section is to discuss the underlying theory and practice of national disaster insurance programs. Section 3.2 reviews the general role of markets and governments in disaster insurance. Section 3.3 outlines three specific roles for government in disaster insurance. Section 3.4 discusses six existing programs representative of these roles, especially in the developed world. Section 3.5 examines some of the program design considerations. Section 3.6 provides a brief summary.

3.2 GENERAL ROLE OF MARKETS AND GOVERNMENT IN DISASTER INSURANCE

The primary advantage of insurance is its ability to reduce the overall level of risk to society, in this case of natural disasters, which by their nature are necessarily social in the sense of being widespread. This reduction of risk occurs through three principal features of insurance: namely, the aggregation of individual risks, the segregation of individual risks into separate pools, and the control of moral hazard (Gollier 2006).

To start with, insurance operates where losses have a probabilistic character. It is not possible to insure losses that are certain to occur in a particular period, but it is possible to insure losses when there is some probability as to whether the loss will occur in a particular period (general insurance) or when the loss that is certain to occur will occur (as in life insurance). Insurance reduces the risk level to society by aggregating individual risks. For these statistically independent (uncorrelated) risks, the sum of the aggregated risks is less than the sum of the individual risks. As a result, individual risk is lower when pooled. However, with natural disasters, the benefit of this pooling of risks is lost in the sense that the losses are now statistically dependent (correlated) and the variability of the risk pool has increased. This means that the pool would have to maintain reserves greater than the reserves that each individual would have to maintain if uninsured. To provide the increased reserves, insurers need to increase the premiums for the disaster insurance they offer and if premiums increase sufficiently, the previously insured may choose (or are forced) to become uninsured.

However, it is still possible for market insurers to make this covariant risk insurable. The most common approach is to bundle together several types of risks. For example, fire, flood, earthquake, and storm risks could be bundled into a single policy, and as long as these separate risks are uncorrelated, the bundling of insurance cover will reduce the accumulated risk of any specific policy event. In terms of house and contents insurance, this may be where an insurer that once had only voluntary flood cover included in the policy, now makes it compulsory across all policies. This mandatory requirement is often necessary because most of the insured will know whether all of the risks in the bundle apply to their own situation and may be reluctant to pay for unneeded risk cover. However, even if the private insurer makes this bundled insurance mandatory for its own customers, they may not choose to continue the policy and will either shift to another insurer or become uninsured.

Despite this use of bundling, insurance works best when insurers can segregate risk by distinguishing between relatively high- and low-risk insured, and assigning them to narrowly defined risk pools through their underwriting process. Through risk segregation, insurers reduce expected losses. This arises through two processes. First, if there are both high-risk and low-risk policyholders, the variance of the segregated pools will be less than the variance of a single pool. This reduction in variance reduces risk. Second, insurers can set a premium that more accurately reflects the contribution to pool risk of an individual policyholder. This has a number of benefits, the most important being that the insurer sets a premium that informs the policyholder about the cost of some risky behavior. For example, a higher insurance premium for living on a flood plain could be a market-rationing device in that some property owners may choose not to live on the floodplain, or the higher premiums will signal the market to lower the price of existing housing, and this will lower the post-event costs of a flood for society as a whole. In much the same manner, risk segregation will involve lower premiums for lower-risk activities, and likewise reduce the costs of flooding.

The final way insurance reduces natural disaster risk is by controlling moral hazard. Moral hazard is the phenomenon where a person (here the policyholder) changes their behavior (regarding the insured asset) because the risk of loss is borne by another (here the insurer). In terms of disaster insurance, a policyholder may be less likely to clear combustible material from around their property prior to the bushfire season or remove household effects when a flood is imminent because the policyholder knows that the insurer will compensate for any losses via an insurance claim. The insurance industry uses a number of tools to reduce the impact of moral hazard, the most common being a deductible or excess where some fixed amount must be borne by the policyholder before the payment of the insurance claim. However, this is most useful in reducing the moral hazard associated with minor claims (amounts smaller than the deductible or excess), not the larger insurance costs associated with natural disasters where the fixed dollar cost of the excess spreads over increasing dollars of the insurance claim.

Another more effective way of reducing moral hazard with substantial claims is with coinsurance, such that the insurer and the insured share the losses in proportion to the level of the claim or coinsurance. The simplest way of achieving this is a percentage limit on the value of the insured asset, such that the insurer will pay for some percentage of loss (say 80%) and the insured the remainder (20%). The

insured then has an incentive to behave in such a way as to minimize their share of the loss. A final tool to reduce moral hazard is to exclude certain events from insurance coverage, particularly those where moral hazard is most likely. As an example, many standard house and contents insurance policies purposively exclude flood insurance, and this is an effective way of ensuring that the insured do not purchase properties in flood prone areas. Lenders may assist in this process by denying housing loans to especially highly leveraged properties that are not comprehensively insured.

In sum, insurance has the capacity to reduce societal levels of disaster risk through risk aggregation and risk segregation. It preserves this lower level of disaster risk using tools to control the problem of moral hazard. The fact remains that private insurers can and do provide significant disaster insurance (as indicated by the large insured losses with natural disasters) using these three key features. However, socially undesirable outcomes may result, thereby inferring a potential role for government. For example, risk aggregation by private insurers may not be able to facilitate insurance coverage in the presence of natural disaster risk without entailing very large and generally unaffordable premiums to cover the increase in reserves required. A government insurance provider may not encounter this problem in that premiums may be set artificially lower than their profit-making level or will supplement reserves at relatively low cost by government borrowing or through taxation when required. Similarly, risk segregation may create a subgroup of high-risk potential insured that are unable to access insurance at reasonable cost and/or are unable to separate out the affordable risk from that associated with the natural disaster risk. Even if the government does not choose to become a disaster insurance provider, it can still ensure the functioning of an insurance market here by either making insurance as a whole mandatory or by ensuring all insurers include bundling for the particular risk targeted. In the case of the later, there is still the possibility of the previously insured becoming uninsured by choice.

At first impression, governments appear to be a solution to the socially undesirable consequences of private insurance in managing natural disaster risk, namely, the unavailability of disaster insurance cover at reasonable cost. As low-risk institutions themselves, through the mandated spreading of risk across an entire population, taxation powers and commensurately lower borrowing costs, government is arguably the most effective mechanism for spreading insurance risk and losses. “It is profitable for all concerned that risks should be shifted to the agency best able to bear them through wealth and its ability to pool risks. The government, above all other economic agencies, fits this description” (Arrow 1992). The capacity of governments to absorb the cost of disasters at a lower cost than the private market is the compelling justification for their involvement in managing disaster risk. As the cost of private insurance increases, the willingness to draw on the financial resources of governments increases. Naturally, there are constraints on the ability of governments to act as catastrophe risk managers, the most obvious being budgetary constraints, with disasters being just one of a number of competing demands made on the risk spreading ability of governments. However, despite these budgetary constraints, governments remain significant providers of post-disaster aid. As such, whether governments receive premiums for bearing this risk as an insurance provider or as taxes to provide aid to those affected by disasters as a form of de facto insurance is not a major distinction.

As a result, the government is an apparently logical entity to provide cost-effective disaster risk insurance. However, the reliance on governments as risk managers is problematic, with government risk management and insurance programs plagued by problems of moral hazard (Priest 1996). One reason is that governments may be reluctant to use conventional tools in the insurance industry to control moral hazard because this involves treating different groups of citizens differently. For example, the moral hazard of homeowners in flood or fire-prone areas is naturally higher than for those in low-risk areas, and control of moral hazard may entail larger excesses, higher levels of coinsurance, or the exclusion of flood or fire coverage for the former. This is at odds with basic democratic principles. In fact, a perception of 'blanket cover' with government disaster insurance may even spread to low-risk groups, especially if it is difficult to psychologically separate disaster risk from other risks that may or may not be covered. Accordingly, with natural disaster risk we have the situation where governments are best able to spread the cost of risk but increase overall societal risk by not containing moral hazard. Private insurers, however, are able to control moral hazard, thus reducing overall societal risk, but lack the financial capacity to bear disaster risk and maintain disaster insurance at reasonable cost and coverage.

3.3 SPECIFIC ROLES FOR GOVERNMENT IN NATURAL DISASTER INSURANCE

Latham et al. (2010) offers two options for governments at either extreme of the disaster insurance policy spectrum. The first of these is their so-called "everyone looks after themselves" approach. Under this approach, a government will play no role in funding the financial impacts of a natural disaster, with insurance being the main source of cost funding for most people. Key features of this approach would be that insurance cover would only be available to those choosing to purchase insurance from existing (mainly private) insurers, with market forces determining the price of insurance coverage. Further, this situation would be "fair" in the sense that all policyholders (or not) would have cover commensurate with the level of premium paid and risk borne by the insurer. However, this approach would entail a number of problems, the main ones being affordability (high-risk areas may require substantial premiums), market failure (insurers may deem some markets or events uninsurable and not provide cover at any price), and underinsurance (insurers and the insured may underestimate the surge in post-event costs, especially in regional locations).

At the other extreme, there is what Latham et al. (2010) refer to as a "government funded system". The features of this system will of course vary by the approach taken, but generally speaking most will entail guaranteed coverage (cover for all events and all households), affordability (cross-subsidies across different risk categories to ensure affordable coverage), and the absence of underinsurance (restoring the disaster affected to a pre-disaster state, rather than limiting funding to the sum insured). However, a number of problems are associated with this option, including risk disincentives (blanket affordable coverage will entail cross-subsidization and this reduces the price incentive for risk reduction), efficiency (the private sector is more efficient), and financing risk (the threat to government credit ratings from excessive disaster risk). More fundamentally, this may conflict with basic arguments concerning the proper role of government in a market-orientated economic system.

Overall, the task is to design programs that use the government's strengths in risk pooling and segregation, while limiting the impact of moral hazard. Generally, we categorize these roles in three broad areas. First, *government as insurer*: this is where the administrative capacity of the private market is used to assist in programs fundamentally directed and paid for by governments. Second, *government as reinsurer*: this is where the government provides support to the primary role of the private insurance industry. Finally, *government as underwriter*: this is where the setting of rules and regulations enables the private market to operate without direct governmental financial support.

3.3.1 GOVERNMENT AS INSURER

One approach is creating government-sponsored insurance programs. These programs take on the characteristics of private insurance but are neither guided by insurance principles nor financed principally by an identifiable fund of insurance reserves (Kane 1996). In essence, these programs primarily redistribute losses without the risk reduction functions of insurance discussed earlier (Priest 1996). For the most part, these types of programs suggest centralized decision-making with mandatory and uniform charges for insurance, further characterized by claim payments of set amounts regardless of the level of loss. The main difference between these types of programs and pure aid is that the government first collects something from the public as a condition of their participation in the program. The amount collected and the payments made are generally uniform. Being uniform, they do not have the full characteristic of an insurance premium: a charge related to the risk assumed.

Importantly, while governments are effective instruments for spreading risk, they are notoriously ineffective in limiting moral hazard. Virtually every study of government insurance activities shows moral hazard problems to be severe (Priest 1996). The government as insurer seldom makes proper efforts to control moral hazard. Government programs can incorporate the tools used in the private market to control moral hazard, but they rarely do so to the extent of the private market. We can best characterize the techniques used by the private sector as constraints on benefits to control moral hazard: deductibles, coinsurance, and policy limits are all tools that reduce benefits to control moral hazard, but voter interest in benefits is unlikely to permit the government to control moral hazard to the same extent as the private market.

Importantly, the dividing line between the government as insurer here, or as reinsurer, as discussed shortly, is not clear. The primary distinction is whether the government requires the private insurance market to retain some portion of the risk. If there is no risk retained by the private insurance market, the program is a government insurance program with the government as insurer. If the government retains some level of risk, the program is a reinsurance program and the government serves as a reinsurer. The generic natural disaster insurance program in Spain, the flood insurance program in the United States, and the recent earthquake insurance program in Turkey all qualify as government-sponsored or directed insurance programs.

3.3.2 GOVERNMENT AS REINSURER

In the literature, the government as reinsurer approach corresponds to market-enhancing view of government policy (Lewis and Murdock 1999) in contrast to market substituting view of government policy with the government as insurer approach. This view looks for the government to facilitate more efficient and effective private sector insurance. This is by the establishment of a government reinsurance program that has the ability to directly access the government's treasury after other resources have been consumed (Cutler and Zeckhauser 1999). Generally, the government requires the private market to assume and pay for some level of risk, with the government assuming the most expensive risk. The government relies on the administrative capacity of the private insurance market to perform needed services like marketing, premium collection, policy issuance, and claims handling, for which it pays a fee. This approach then blends the risk-spreading capacity of the government with the ability of the private market to apply key insurance principles. Formal government reinsurance programs for different catastrophe risks exist in New Zealand, Japan, South Africa, Norway, France, the United Kingdom, the United States, and the Netherlands, with programs directed at diverse disaster risks like earthquakes (Japan), terrorism (the United Kingdom), flooding (France), and civil unrest (South Africa).

3.3.3 GOVERNMENT AS UNDERWRITER

The third area of government involvement relates to governmental setting of rules and policies that assist the private market to insure disaster risks. For many manmade or human risks (as distinct from natural or nonhuman risks), the role of the government is to set the terms of liability so that the risks are insurable. There are two broad issues related to insurability or risks: the ability to identify the risk and the ability to set premiums for each potential class of customer (Freeman and Kunreuther 1997). Often, governments play a key role in setting the conditions related to a risk that make it insurable by setting underwriting standards that permit the private sector to develop suitable insurance products. In coping with manmade disasters, the primary issue is setting liability limits (Munich Re 2002).

With proper rule making, the private insurance market manages most manmade disasters. Fortunately, manmade disasters do not have the central problem of natural catastrophes, namely, covariant risk, in that they tend to be independent, non-correlated events. The main insurability issue relates to the potential size of the disaster, being the type of risks private insurance can handle. In the context of the relationship between the public and private sector in financing natural disasters, the government can play a distinctive role by more narrowly defining appropriate behavior and limiting liability. By so doing, it directly enhances the capacity of the private insurance market to manage risk.

3.4 SELECTED EXISTING PROGRAMS

In this section, we discuss in detail a number of selected national disaster insurance programs. This survey is naturally limited given the sheer number of programs currently in place. However, the programs selected provide a good reflection of the

diverse programs in place, especially in developed economies. We place particular emphasis on the roles of government and insurers, the types of natural disasters included, and the level of coverage. We also discuss some of the advantages and disadvantages of the approaches.

3.4.1 NATIONAL FLOOD INSURANCE PROGRAM (UNITED STATES)

In the aftermath of Hurricane Betsy, which hit Louisiana in September 1965 killing 76 people and causing US$1.5 billion in damage (nearly US$10 billion in 2010 terms), the US federal government established the National Flood Insurance Program (NFIP) to make flood insurance more widely available, given flood insurance at the time was not included in standard home insurance policies. The NFIP was broadened and modified with the passage of the Flood Disaster Protection Act of 1973, and further modified by the National Flood Insurance Reform Act (NFIRA) of 1994 and the Flood Insurance Reform Act (FIRA) of 2004. The NFIP is currently administered by the Federal Emergency Management Agency (FEMA), part of the US Department of Homeland Security (DHS). After nearly 50 years of operation, the NFIP is today one of the longest standing government-run disaster insurance programs, and with 5.58 million policies providing cover of US$1,301 trillion, with US$3,527 million in earned premiums and US$441 million in paid losses in 2013, the largest (if not effectively the only) provider of flood insurance in the US. However, despite being notionally a national program, the NFIP is spread unevenly across the states, with more than two-thirds of its policies written in just Florida, Texas, Louisiana, California, and New Jersey (Freeman and Scott 2006; CCS 2008).

In order to qualify for flood insurance under the NFIP, a home (including homeowners and renters) or business must be in a community (defined as any state, area or political subdivision) that has joined the NFIP and agreed to enforce sound floodplain management standards. Originally, NFIP insurance coverage was available to buyers via specialized insurance agents, but 1983 saw the introduction of a Write-Your-Own (WYO) program allowing participating insurance companies to write and service Federal flood insurance policies in their own names, with the Federal Government retaining responsibility for underwriting losses. All WYO providers, now accounting for some 90% of policies, provide identical coverage, and rates are subject to NFIP rules and regulations and do not differ from company to company (FEMA 2011).

Originally designed to be self-funding, the NFIP has been for much of its history (Zhao 2011). However a series of disasters starting with Hurricane Katrina in 2005, which resulted in US$16.2 billion in insurance payouts, and Hurricanes Rita and Wilma, each with US$1 billion in claims, and more recently Hurricanes Ike, Irene, Lee and Sandy, have saddled the NFIP with more than $24 billion in debt to the US Treasury. One response has been a cut in the number of subsidized policies in the program for second homes, businesses or repeat-loss policies. This means about 438,000 policies are no longer eligible for reduced rates, leaving about 700,000 subsidized policies. One report has argued that NFIP policy rates are artificially low (UCS 2013) and do not reflect the true underlying risk of coastal flooding especially with climate change, nor do the flood maps used by the NFIP to determine rates, and that repeat-loss properties, which represent only 1.3 percent of policies, are expected to account for 15–20 percent of future losses. In addition, the NFIP's "grandfathering" clause exempts certain properties from complying with protective requirements and

allows them to avoid paying higher insurance rates even with rezoning into a higher flood risk, thus effectively cross-subsidizing them with less-risky properties (Newman 2013).

Michel-Kerjan (2010) argues that the NFIP faces five challenges. These are improving the accuracy of the Flood Risk Maps the NFIP uses to determine rates, increasing the level and tenure of coverage, especially in Special Flood Hazard Areas, where flood insurance is required but apparently not effectively enforced, for those with federally backed mortgages. They also include encouraging investment in risk-reduction measures by households, reducing the level of repeat loses, the number of subsidized properties, and operating expenses, and improving financial sustainability in the face of large-scale disasters, possibly with the use of catastrophe bonds. Likewise, Kousky and Kunreuther (2013) highlight the inbuilt problems within the NFIP in terms of risk cross-subsidization and fiscal management in public sector institutions. Overall, it would appear that the NFIP, while generally a successful example of a government-private partnership with the government acting as underwriter, is subject to a number of problems arising from moral hazard, adverse selection and the lack of the effective separation of risk.

3.4.2 NIHON JISHIN KAISHA/EARTHQUAKE REINSURANCE COMPANY (JAPAN)

The Japanese Earthquake Reinsurance Company (ERC) was established in 1966 in the aftermath of the June 1964 Niigata Earthquake. It principally acts as reinsurer for private insurers that sell earthquake insurance, with earthquake premiums currently totaling about US$1.5 billion per year across some 9 million policies. The 1966 Earthquake Insurance Law, which established the ERC, obliges private nonlife insurers to offer earthquake insurance as an optional rider to a fire insurance policy, and to cede 100 percent of their earthquake premiums and liabilities to the ERC. The ERC thus acts as a monopoly earthquake reinsurer for the private insurance market. The ERC is a form of earthquake reinsurance pool, retaining a portion of the liability and ceding the rest back to private insurers (based on their market share) and to the Japanese government through reinsurance treaties. The design of the reinsurance program is such that the liability of private insurers and the ERC itself does not exceed the accumulated reserves from earthquake insurance premiums. The total claims-paying capacity of the program is currently about ¥5,500 billion, which corresponds to the scenario of the 1923 Great Kanto earthquake with a return period of 220 years. Should insured earthquake losses exceed this amount, claims would be prorated across private insurers, the ERC, and the Japanese government (JER 2012, 2014).

The role of the Japanese government is central to the program (CCS 2008). The maximum liability of the government of Japan, the ERC, and private insurers is 87 percent, 10 percent, and 3 percent, respectively. Prior to May 2011, the government's liability was only 78 percent, with the remainder shared equally between the ERC and private insurers. The revision of the reinsurance program, leading to an increase in the government's liability share, is a direct consequence of a depletion of the earthquake reserves of both the ERC and private insurers after the March 2011 Great East Japan Earthquake (GEJE). Japanese accounting standards allow the insurers to build up catastrophe reserves (by accumulating the earthquake insurance premiums received, less expenses and any underwriting gains and

investment income) over time with separate resources to pay claims, the size of which is based on the probable maximum loss of the insurer's portfolio. Likewise, the government of Japan has set up a special account to accumulate its reserves (Freeman and Scott 2016).

In fact, residential property (including contents) earthquake insurance in Japan is actually a dual system (Zhao 2011; Mahul and While 2012). The most common, covering about 25% of Japanese households, is the system of private life insurers providing optional earthquake insurance to residential fire insurance policies with reinsurance compulsorily provided by the ERC and the Japanese government as just discussed. The second type of earthquake insurance is provided by cooperative mutual insurers, the largest being the National Mutual Insurance Federation of Agricultural Cooperatives or JA Kyosai, to about 11% of Japanese households, and which cover is automatically included in building endowment policies, with reinsurance through conventional private markets. Both cover damage from earthquakes, volcanic eruptions, and tsunamis. Under the ERC-related system, earthquake coverage is available at policy limits of 30 to 50 percent of the fire insurance limit, with current maximum limits of ¥50 million per dwelling and ¥10 million for personal property. Payouts are not proportional to damage, but based on a three-step system: total loss, half loss, and partial loss, which allow for 100, 50, and 5 percent of the earthquake insurance policy limit, respectively. The premium rates are risk based, and vary according to the prefecture (with the whole of Japan divided into eight risk zones) and the type of construction (wooden or nonwooden).

For an insured amount of ¥10 million, the annual premium varies between ¥5,000 for a nonwooden structure in Nagazaki, and ¥31,300 for a wooden structure in Tokyo. Discount rates of up to 30 percent apply when the building is earthquake resistant, according to the Japanese Housing Performance Designation Standards, including a 10 percent discount for buildings constructed after 1981. The premium rates, calculated by the Non-Life Insurance Rating Organization (NIRO), consist of the pure premium rate and a loading and the rates do not include any loading for profit. Despite this, and because of Japan's considerable earthquake exposure, premiums are high. In contrast, the insurance provided by JA Kyosai is available for insured amounts up to 50% of assets and is not region-specific, with different rates only for the type of construction (wooden/nonwooden). Further, in contrast to the ERC-reinsurance system, loss adjustment is proportional. In principle, both systems are not-for-profit, however rates under both systems are high, and this helps explain the roughly 64% of Japanese households that have no earthquake cover.

The biggest recent challenge to the viability of the ERC came from the GEJE centered on Japan's Tohoku region, recognized as the costliest natural disaster in history with a relative loss of 4% of GDP (compared with 9% for the 2011 Canterbury NZ earthquake and 10% for the 2010 Maule Earthquake in Chile). The GEJE caused major direct economic losses, with current estimates of ¥16,900 billion, of which residential, commercial, and industrial buildings represented 62 percent, and public infrastructure about 13 percent. Insured losses were some ¥2,750 billion, or 16 percent of total economic losses, of which 78 percent was residential. Private insurers and the ERC covered Fifty-six percent of the residential insured losses, and the remaining 44 percent by the cooperative mutual insurers.

Prior to 2010 and the GEJE, the government held about ¥1,343 billion in reserves under the ERC, the JER ¥424 billion and private insurers ¥489 billion, totaling ¥2,256 billion. Of the total insured losses of the GEJE, 42 percent were retained by private insurers, 13 percent by the ERC, and 45 percent retained by the Japanese government. This event severely depleted the earthquake reserves of both the private insurers and the ERC, leading to an increase in government liability in the revised reinsurance program of 2012. In contrast, the earthquake loss incurred by JA Kyosai was some ¥830 billion, 90 percent of which was residential, with reinsurance covering about 58 percent. The three-step earthquake claims settlement system implemented by the private insurance companies allowed the rapid settlement of claims. Of ¥1,200 billion generated by the 741,000 claim payments made after the GEJE, 60 percent were paid within two months and 90 percent within five months.

Putting aside the particular challenges of the GEJE it is generally regarded that the dual residential earthquake insurance system in Japan, including the role of the ERC as a significant reinsurer, is sustainable and effective, particularly in a country as earthquake prone as Japan. According to the World Bank (2012), its main positive attributes are the provision of multiple channels for delivery of earthquake insurance and the fact that the government can play an important role in the delivery of viable earthquake insurance alongside the private sector. However, earthquake insurance premiums have been consistently high since its inception. Although penetration is also relatively high, substantially more than half of Japanese homeowners remain uninsured for earthquake risk, with insured households face the risk of underinsurance due to restricted coverage limits. Finally, government liability under the ERC is exceptionally high.

3.4.3 EARTHQUAKE COMMISSION (NEW ZEALAND)

The roots of the Earthquake Commission (EQC) are in the 1944 Earthquake and War Damage Act with the EQC formally established by the 1993 Earthquake Commission Act. The EQC has a number of roles, including funding research and education on natural disasters and ways of reducing their impact, but its primary role is to provide natural disaster insurance called EQCover for residential property (including house and contents), principally damage caused by earthquakes and other seismic-related events such as volcanic eruptions, hydrothermal activity, landslips and tsunamis. For residential properties, it also covers storm, flood, and fire damage (within limits) related to any of these events. While the scheme is not compulsory, it is automatic for householders that insure their buildings and contents with private insurers with cover that includes fire insurance, with some 90 percent of New Zealand households currently covered (EQC 2014a, 2014b, 2014c, 2014d).

EQCover is limited to land that is within the property boundary, including land under homes and outbuildings, land within eight meters of the home and outbuildings, and the land under or supporting the main access way, from the boundary up to 60 meters from the home (but not driveway surfacing). EQCover costs 15 cents + Goods and Services Tax (GST) for every NZ$100 of home or contents fire insurance. The maximum yearly premium for one home and its contents is $180 (+GST), with a maximum cover of $100,000 (+GST) for homes and $20,000 (+GST) for contents for insured residential land. This amount of insurance is available for each natural disaster event causing damage and there is no risk rating. The EQC handles its own

claims through independent claims assessors and adjusters. Claims must be made within 30 days from the date of damage with NZ$200 deducted for property claims of NZ$20,000 or less and 1% of the total amount for claims over NZ$20,000. Land claims have NZ$500 deducted for each claim of $5000 or less and 10% of the total amount for claims over NZ$5,000, to a maximum of NZ$5,000.

The private insurers include the earthquake premium with their own premiums, and subsequently forward it to the EQC. In 2012/13, the EQC received NZ$241 million in premiums, with all premiums paid into a Natural Disaster Fund (NDF) with claims paid from this fund. The EQC purchases external reinsurance in the market, which currently absorbs around 40% of the premiums collected (NZ$132 mil. in 2012/13). The scheme is subject to a government guarantee, such that if the NDF is exhausted, the NZ government pays the remaining claims. The major challenge of late to the NDF is the 2010 Canterbury earthquake. In the 12 months to June 2013, the EQC paid out $1.8 billion relating to the Canterbury earthquake, taking the total amount to $5.7 billion. The EQC has currently recovered $1.8 billion in reinsurance money from an anticipated $4.5 billion of reinsurance recoveries. In 2011/12, the EQC through the NDF had a net loss of NZ$436 million followed by a net gain of NZ$222 million in 2012/13. However, the balance of the NDF remains negative at NZ$1,370 mil. with the expectation that all assets of the NDF, which currently stands at NZ$2.9 billion will be fully exhausted by the Canterbury earthquake claims, even after all reinsurance claims are met (EQC 2014a, 2014b, 2014c, 2014d).

In contrast to the Japanese system of residential earthquake insurance, coverage in NZ is more widespread. However, the likelihood of under coverage is high because of the claim limits set. However, it would appear that premiums in the past have been low (perhaps too low), with the EQC levy on home and/or contents insurance only increasing from NZ$0.05c (which had been in place since the inception of the NDF in 1993) to NZ$0.15 per NZ$100 of insurance cover in February 2012. The uniform premium rate regardless of geographic location also suggests some cross-subsidization among households.

3.4.4 CAISSE CENTRALE DE RÉASSURANCE/CENTRAL REINSURANCE AGENCY (FRANCE)

The French government sponsors two natural disaster-related insurance programs: the National Disaster Compensation Scheme (CAT NAT), and the Fonds National de Garantie des Calamites Agricoles, of which the state-guaranteed public reinsurance program known as the Caisse Centrale de Réassusrance (CCR) backs the CAT NAT. While the initial impetus for national disaster insurance in France relates to serious flooding in 1981, CAT NAT covers earthquakes, floods, landslides, hailstorms, avalanches, tsunamis, and droughts. Payment requires a government declaration of a natural disaster, determined by a set of criteria pertaining to the disaster's scope and magnitude. The program covers both personal and commercial losses on insured property above the amount reimbursed by private insurance companies (CCS 2006; Freeman and Scott 2006).

Reinsurance with the CCR is not compulsory, and insurers are free to contract with other reinsurers. However, reinsurance with the CCR is attractive because the reinsurance premiums charged are generally lower and because it can provide unlimited cover through a French state guarantee. Additionally, the company also

writes some traditional reinsurance business not covered by the French government's stop-loss guarantee, but with natural catastrophe reinsurance accounting for more than half of its gross written premiums. CCR is currently the main reinsurer of natural catastrophe risks underwritten in France with an estimated market share of around 90%. The CCR offers two types of reinsurance contracts: proportional contracts (for a given percentage of premium income, the CCR covers a given percentage of claims) and stop-loss contracts (CCR covers all claims that exceed a given multiple of annual premium income). CCR offers unlimited reinsurance coverage guaranteed by the French government in the event that it exhausts its resources (Zhao 2011).

Private insurance companies sell the insurance. Any nonlife insurance policy taken out in France contains an additional mandatory surcharge (6% on auto insurance policies and 12% on all other nonlife policies) that covers losses in the event of a natural disaster. In brief, cover for wind damage (storms, cyclones, and hurricanes) is compulsory and must be included in any insurance policy that also includes cover for fire damage. All insurance companies offering property insurance in a specific area are also obliged to include protection against natural disasters. Natural disaster premium rates are set as a percentage of other property insurance premiums, while excesses are per contract, per event and fixed. About 90% of French homes have property insurance and therefore coverage against natural hazards. Since the program commenced in 1982, the government has declared some 110,000 separate natural disasters with about €6.4 billion paid in compensation, more than half of which has been for floods. In 2001, the government introduced a program to encourage cities to implement loss prevention measures by increasing deductibles in the event of repeat natural disasters, such as floods, for cities without a prevention plan.

Currently CCR has an A.M. Best Europe financial strength rating of A++ and issuer credit rating of aa+. A.M. Best (2014) declares that these ratings "…reflect CCR's superior risk-adjusted capitalization, good operating performance and excellent business profile in France and abroad and the explicit unlimited guarantee provided by the Republic of France to CCR's state-backed business". The ratings are similar for S&P (2014). CCR is among the world's top-25 reinsurers.

3.4.5 CONSORCIO DE COMPENSACION DE SEGUROS/INSURANCE COMPENSATION CONSORTIUM (SPAIN)

Founded in 1954, the Consorcio de Compensacion de Seguros (CCS) is a public corporation providing insurance cover for 'extraordinary risks', comprising both natural disasters and human-related or manmade risks (terrorism, rebellion, sedition, riot and popular uprising) including deeds or actions by the Spanish armed forces or security forces in times of peace. The CCS indemnifies property and personal claims resulting from these extraordinary events and thus extends to a range of natural disasters, including 'floods, earthquake, seaquake, volcanic eruption, atypical cyclonic storms, and the falling of astronomic (sidereal) bodies or meteorites', of which floods are the most common in Spain. The CCS payments are in addition to payments made by private insurers with the CCS paying only when the risk is either not covered by insurance (for both the insured and the uninsured) or if the insurance company fails to pay because of bankruptcy or liquidation. Outside the provision of

cover for natural disasters, the CCS is also the Spanish government insurer for auto liability insurance and multi-peril crop insurance (CCS 2008).

The extraordinary risk protection is mandatory coverage added to any policies relating to property damage, including house and contents, motor vehicle, etc. The CCS surcharge is automatically included in the base policy's premium and credited to CCS every month (Freeman and Scott 2006). Deductibles for property loss amount to a maximum of 1% of the insured total and a minimum of €150.25. The private insurers set the base policy premium. The surcharge varies by the type of policy offered, but reflects the base rate charged on the primary policy. In 2013, the CCS collected premiums of €704 million covering 'extraordinary risks' comprising €638 million for property risks, €22 million for personal industry risks and €44 million for income exposure risks, and paid claims of €207 million, comprising €191 million for property damage, €1.5 million for personal damage and €14 million for income risks (CCS 2014a, 2014b).

Like the French system, disaster insurance is compulsory in Spain and included in any property-related policies, premiums are uniform for the whole country, and there is a wholly state-owned reinsurance company. However, in Spain, reinsurance is compulsory, cover is 100%, insurers keep 5% of premium income to cover their expenses, and the CCS handles claims. In France, reinsurance with the state-owned reinsurer is optional, with insurers retaining 24% of premium income to cover their expenses and the handling of claims (CCS 2012). As such, compared with the French system of disaster insurance, it is sometimes felt that the Spanish system is more sustainable and effective in building reserves, whereas the French system involved unexplainably large costs for covering the administrative expenses of insurers, the inability to build reserves, and adverse selection with mostly higher risk contracts reinsured with the state reinsurer. As a result, in 2000, the French government increased premiums by about 40%, removed the high level of coverage for administrative expenses, and restricted reinsurance to only 50% proportional and stop-loss cover.

3.4.6 DOĞAL AFET SIGORTALARI KURUMU/CATASTROPHE INSURANCE POOL (TURKEY)

The most recent example of a disaster insurance program instituted in the OECD is the Turkish Catastrophe Insurance Pool (CIP). Prior to 2000, earthquake insurance in Turkey was mostly an additional peril included in fire policies. At the time, the coverage rate was quite low, especially for residential buildings at only about 5 percent across the country, made up of about 15% of residential buildings in the capital Istanbul, and less than 2% outside Istanbul. One obvious reason for the low level of coverage was that the existing National Disaster Law required that the government freely fund replacement housing for any destroyed in an earthquake (Yazici 2003). However, a series of earthquakes starting in June 1998 with the Adana earthquake followed by successive Marmara earthquakes in August and November 1999 resulted in extensive damage, estimated at US$10.2 billion. Most of this cost was borne by the public sector, with the total budget impact of post-earthquake reconstruction between August 1999 and December 2002 amounting to US$6.4 billion, or 3 per cent of Turkish GDP (OECD 2004). As a result, 2000 saw the introduction of a compulsory earthquake insurance scheme, the CIP, with the World

Bank playing a major role in providing technical advice and financing (Gurenko et al. 2006).

Under the CIP, all residential homeowners are required to purchase a separate earthquake insurance policy. To ensure compliance, the authorities will only register property transactions for insured buildings and municipalities are required to check insurance policies when connecting water or gas services to residential properties. The CIP is the sole source of earthquake insurance in Turkey for the first US$50,000 of losses, with private insurance available for higher limits. The basis of premiums is 15 rating categories based on hazard zone area and type of dwelling, with insurance sold through authorized insurance companies performing underwriting, the collecting of premiums, the issuing of policies and the settling of claims. The insurance companies earn a commission for these services. There is a deductible of 2% on each policy. A consortium of international insurance companies and the World Bank provide reinsurance, with the Turkish government as the reinsurer of last resort (GFDRR 2014).

Remarkably, the CIP has enjoyed only limited success to date in terms of increasing earthquake insurance coverage as a mandatory program. Nationally, the percentage of residential housing with earthquake insurance has trebled, but only to about 16%, although coverage in the capital Istanbul on occasion has been as high as 32%. A recent World Bank report highlights that some of the problems relate to not only the low level of awareness of earthquake risk in Turkey, but cultural attitudes to property ownership and perceptions of the role of the state, a lack of confidence in the processing of claims, and a deficiency of distribution channels, particularly in rural areas. The confusion over the role of the state is particularly understandable given that in two of the most serious earthquakes in Turkey since the establishment of the CIP (Afyon in 2002 and Bingol in 2003), the government waived the legal provisions requiring the purchase of insurance and declared all citizens eligible for government support, whether insured or not. Another problem identified has been the apparent lack of commitment to the CIP by insurance companies, with one solution proposed being that insurers could package CIP policies with their own home and contents insurance policies, to be able to recognize paid CIP premiums on their own financial statements, and to retain some percentage of CIP business.

3.4.7 OTHER PROGRAMS

Apart from these particular national disaster insurance programs, there are many other examples from around the world. However, not all of these correspond to what we would formally recognize as insurance. For example, in Mexico there is the National Fund for Natural Disasters (FONDEN), designed with the assistance of the World Bank (2011, 2012), representing merely a defined and ongoing government budget allocation for disaster relief and reconstruction. In 2006, FONDEN issued the world's first government catastrophe bond, which was renewed in 2009. Others like the Natural Disaster Relief and Recovery Arrangements (NDRRA) in Australia only stipulate the arrangements the Commonwealth government uses to reimburse eligible relief and recovery costs to the Australian states and territories. The NDRRA does not provide funding directly to individuals, but does reimburse part of the expenditure on personal hardship and distress assistance, generally for emergency aid (including clothing, food, accommodation, repairs to housing and replacement of

essential household items and personal effects). The NDRRA also includes some commitment to the restoration or replacement of public infrastructure (such as roads or bridges) and the provision of concessional interest rate loans to small businesses, primary producers, non-profit bodies, and needy individuals.

However, many others more closely resemble the insurance programs discussed. For example, in Norway, insurance companies that write fire insurance are required to have natural disaster insurance through membership of the Norsk Naturskadepool (Norwegian Natural Perils Pool), which provides reinsurance for its member insurance companies. In Norway, natural disaster insurance covers damage caused by storms, floods, landslides, floods, earthquakes or volcanic eruptions. In Taiwan, the Residential Earthquake Insurance Program (REIP) comprises private insurers, with the Residential Earthquake Insurance Fund (REIF) providing reinsurance. Lastly, in the UK, insurers commit to offer flood insurance under a Statement of Principles in place between the Association of British Insurers (ABI) and the UK government (Zhao 2011). Under this agreement, insurers commit to renew existing customers' home insurance if not at significant risk of flooding, renew the insurance of existing customers considered to be at significant risk of flooding, and continue cover for the new owners of a previously flooded or at-risk property if the original customer sells. On 27 June 2013, the ABI and the government agreed to develop Flood Re, a not-for-profit scheme designed to ensure widely affordable and available flood insurance for high-risk homes. Insurers would pass these policies to Flood Re, funded by insurers with a levy of £10.50 on household premiums, reflecting the estimated level of cross-subsidy that already exists between low and high flood risk premiums. The UK government would take primary responsibility—working with the industry and Flood Re—to distribute any available resources to Flood Re policyholders should claims exceed the available reserves.

3.5 PROGRAM DESIGN CONSIDERATIONS

It is clear even from this limited survey of extant national disaster insurance programs that a great variety of approaches have evolved to meet the problem of disaster insurance. However, discussing these programs separately does not fully illustrate the trade-offs that exist and that are necessarily embedded in the type of program, with no two existing programs being alike. This is because both private insurance markets and government supported or provided disaster insurance programs must deal with a series of issues to operate effectively, at least some of which are contextual. Nevertheless, other concerns are more general, principal among these being the problems of adverse selection and moral hazard.

Following Zhao (2011), the upper panel in Table 6 summarizes the defining features of each of the national disaster insurance programs discussed and compares these with a purely private insurance market in the first column. As shown, the type of program will obviously first depend on the nature of disaster risk in the country. Of the six programs discussed, four are disaster specific, relating to either floods (NFIP) or earthquakes and earthquake-related activity (ERC, EQC and CIP) alone, and two are more general (CCR and CCS). Freeman and Scott argue that the disaster insurance programs developed in each country directly reflect its relative disaster risks. For example, Japan focuses its government disaster insurance program on the high-risk broad geographic exposure to earthquakes, whereas France and Spain,

which have no very high risk but several low and medium risk exposures in selected geographic areas, covers a wider range of hazards. As we move from left to right, the more a program moves away from a purely private insurance market to a system characterized by a larger direct role for government. These include the progression from reinsurer through to insurer, a diminishing role for private insurers from insurance and reinsurance to agents for government, and various levels of insurance compulsion for the insured, increasing from voluntary to mandatory. Very generally, programs that entail a cooperative approach between the private and public sectors tend to be voluntary.

Table 6: Key features of selected national natural disaster insurance programs

	Private Insurance	ERC	CCS	CCR	NFIP	EQC	CIP
Country		Japan	Spain	France	US	NZ	Turkey
Establishment		1966	1954	1946	1968	1993	2000
Disasters included	Subject to insurer provision	Earthquake, tsunamis, volcanic eruptions	Floods, earthquake, seaquake, volcanic eruption, atypical cyclonic storms, and astronomic bodies	Earthquakes, floods, landslides, hailstorms, avalanches, tsunamis, and droughts	Floods	Earthquakes, volcanic eruptions, hydrothermal activity, landslips and tsunamis	Earthquakes
Program type	Private, voluntary	Public-private, voluntary	Public-private, voluntary	Public-private, compulsory	Public, semi-compulsory	Public, compulsory	Public, compulsory
Coverage	Commercial and residential	Residential only	Commercial and residential	Commercial and residential	Commercial and residential	Residential only	Residential only
Role of government or agency	-	Reinsurer	Insurer	Reinsurer	Insurer	Insurer	Insurer
Role of private insurers	Sales, insurance and reinsurance	Sales, insurance and reinsurance	Insurance	Sales and insurance	Sales	Reinsurance	Sales
Potential for adverse selection	High	Medium	Medium	Low	Medium	Low	Low
Potential for moral hazard	Low	Low	Medium	High	High	High	High
Cost of insurance to policyholders	High	High	Medium	Medium	Low	Low	Low
Loss potential to insurer and guarantor	Low	Medium	Medium	High	High	High	High
Subsidization from low to high risk policyholders	Low	Low	Medium	Medium	High	High	High

The lower panel in Table 6 details the insurance characteristics of these programs. To start with, the potential for adverse selection is the likelihood that that only those at high risk of losses through natural disasters will purchase insurance. As discussed, the problem of adverse selection is troublesome for private insurance markets. This is because many natural disasters, including floods and bushfires, are often limited to specific and sometimes very narrowly defined geographic areas, information generally known by prospective policyholders. Even in Japan, a geographically small and uniformly earthquake-prone country, earthquake risk varies markedly across its 8-12 geographic zones, as reflected in three basic zonal rates provided by the ERC. For example, the basic rates for Zone 3, the zone of greatest earthquake risk, for both Class A (fireproof and semi-fireproof buildings) and Class B buildings (all other buildings) are more than three times higher than that for Zone 1, the zone of least

risk. In contrast, the NZ EQC includes no provision in its premiums for geographic differences in earthquake risk.

For private insurance to work, low-risk policyholders must be included, in the absence of which either insurance may not be available or only at very high premiums. National disaster insurance programs avoid this problem by making participation mandatory or at least difficult and costly to avoid. Consequently, as the degree of compulsoriness increases as we move from left to right in the table, the potential for adverse selection generally diminishes, with one benefit being that the cost of insurance per policyholder (but not necessarily to the population as a whole) tends to decrease. In part, the increase in costs can be constrained, just like in the private insurance industry, by compulsorily bundling disaster risk protection with other more general risks. For example, in our selected cases, several of the programs require disaster insurance for policies offering fire insurance, including the EQC and the ERC.

However, the more compulsory programs have a high risk of loss potential in that the more widespread the disaster insurance in a population, the greater the aggregate (insured) losses in the event of a disaster. As shown in the selected programs, these have the potential to overwhelm very quickly the reserves held in a program, and depending on the extent of any government guarantee, the sustainability of the program itself. In general, compulsion implies greater moral hazard. With mandatory insurance, there is little incentive for insureds to reduce their risk if they must purchase insurance, especially if the rates they pay for the insurance are uniform. If premiums reflect risk, such as through the identification of separate regional disaster risks, or if deductibles or excesses apply to any claims, this can help reduce moral hazard.

Overall, compulsory programs also have a much higher level of loss potential, reflecting the higher level of moral hazard, balanced by lower levels of adverse selection. Voluntary programs correspondingly have a high risk of adverse selection and cost of risk assessment, but lower levels of loss potential. Once again, we can reduce the loss potential of compulsory programs if graduated premiums or deductibles are used. Lastly, compulsory programs also entail cross-subsidization among policyholders. The subsidy measure is an indicator of the extent to which low-risk policyholders subsidize high-risk policyholders.

3.6 SUMMARY

In recent decades, many developed and developing countries have implemented functioning disaster-specific or generic disaster insurance programs based on their own unique disaster risk profile. In nearly all instances, while plans may have been in place for a program for some time, it has been the occurrence of a particularly severe disaster or series of disasters that has provided the final impetus for their creation. In particular, especially severe disasters tend to highlight existing deficiencies in private insurance coverage and the cost of disaster insurance, either in terms of the premiums paid by policyholders or in terms of the call made on government budgets for relief and reconstruction. Almost no developed country now relies solely on market forces to encourage individuals to take reasonable efforts to reduce their exposure to known disaster risks, including insuring against them.

Which particular approach to disaster insurance a government chooses is a direct reflection of the level and diversity of disaster risk, the current and expected financial condition of the government, especially budgetary conditions, the strength of the private insurance market, and the country's political culture and preferences regarding the mix of public and private service provision. Generally speaking, most of the programs implemented target a particularly severe and specific disaster risk, mostly earthquakes, where adverse selection and limited risk pooling has made insurance particularly or potentially unaffordable and therefore narrow in terms of coverage, and a result, financially unsustainable and unable to majorly reduce country-level disaster risk. Far fewer programs are of the form of generic disaster insurance, which tend to be of lesser risk for any particular type and where the market failure argument is much weaker in the presence of private insurance and reinsurance markets.

Once a government decides upon the principal of a natural disaster insurance program, there are two basic models. The first is more direct where the government acts as an insurer of disaster risk. In this model, the government collects premiums and provides insurance services, including claims and reinsurance, often using private insurers to target the desired insurance by compulsorily bundling it into existing home and contents policies and as providers of sales and reinsurance. This type of program is generally mandatory with government set premiums and because of this coverage should be high. However, because the government-sourced disaster insurance 'piggybacks' on existing policies, it is limited by the extent of general property cover in the population. The nature of the government's role with this model is also generally clear to the insured, with either disaster insurance being a separate policy or identifiable within the existing policy as a separate item.

The second model is more indirect where the government acts as reinsurer. In this model, the government provides financial support to existing private insurers and the private market retains a portion of disaster risk, passing other risk to the government, and in some cases, private reinsurers. These programs can be either mandatory or voluntary, but with set rates and defined reserves. With the government as reinsurer model, and unlike the government as insurer model, the role of the government in disaster insurance can be more difficult to discern. However, it is also more difficult to rationalize the role of government here where the global reinsurance market can adequately provide these services at reasonable cost to insurers.

It is clear from the survey of existing national disaster programs that there are many advantages associated with the provision of insurance through a close partnership between the government and its agencies, the private insurance industry, and the public or policyholders. While the private insurance market has some difficulty in coping with disaster insurance in terms of adverse selection and the lack of risk pooling, a government insurer similarly faces difficulties in controlling moral hazard, so the potential loss, the cost of insurance, and the level of policyholder cross-subsidization can be much higher. If present, an existing private market can help absorb some of the disaster risk that would normally fall on the reserves held by the government or its agency, and ultimately taxpayers. At the very least, private insurers can help perform services like marketing, premium collection, and claims processing and payment.

An additional benefit is that the tools commonly employed by private insurers to combat the problem of moral hazard apply well in these contexts, including the use of deductibles or excesses and different rates determined according to risk. However, it is also clear that this mixed private-public model is also potentially more sustainable because of the risk sharing by private insurers, the national disaster insurance agency, and the government, as evidenced by the relative success of the Japanese ERC over the NZ EQC in coping with very recent catastrophic events. As a final point, interaction with the public and policyholders is also important. All of the national disaster insurance programs discussed here have very informative websites and information packages enabling policyholders to understand fully the role, coverage, and costs of disaster insurance. In terms of the Turkish FIP, the newest program discussed, there is also a particular effort to encourage policyholders to be aware of the benefits of insurance markets more generally.

4. CONCLUSION

Australia, like most countries throughout the world, is exposed to natural disaster risk, most notably floods, bushfires, hail, and cyclones. The evidence suggests that while the impact of climate change is yet to be reflected in the insurance data, the scientific consensus is that some of these events, especially bushfires and floods, will become more frequent over the longer term. Nonetheless, it is clear that the average cost of natural disaster events in Australia is steadily rising across all types of natural disasters. At the same time, increasing population and population density are associated with the increasing costs of natural disasters affecting capital cities.

While a number of inquiries and reviews have been instigated to examine natural disaster prevention and damage mitigation, these have generally been very broad ranging and have addressed a number of disparate concerns, including mitigation, prediction, emergency services response, land use and planning controls and building regulations, and disaster relief and recovery. Some have also commented on insurance markets. However, few, even among the extreme events considered, have called for a national natural disaster insurance program, and the consensus would appear to be that the role of insurance in helping meet private post-event costs has been largely appropriate and affordable. However, some insurance deficiencies remain, often in relation to inconsistent and misunderstood terms and conditions and the availability of insurance for some submarkets, including highly at-risk households, small businesses, and some regions and localities.

In recent decades, many developed and developing countries have implemented functioning disaster-specific or generic disaster insurance programs based on their own unique disaster risk profile. In nearly all instances, while plans may have been in place for a program for some time, it has been the occurrence of a particularly severe disaster or series of disasters that has provided the final impetus for their creation. In particular, especially severe disasters tend to highlight existing deficiencies in private insurance coverage and the cost of disaster insurance, either in terms of the premiums paid by policyholders or in terms of the call made on government budgets for relief and reconstruction. Almost no developed country now relies solely on market forces to encourage individuals to take reasonable efforts to reduce their exposure to known disaster risks, including insuring against them.

However, the theoretical case supporting these programs is often not strong, if ever it was, especially as private insurance markets often currently provide services in parallel to these public sector insurance services. The fact that there is little agreement among the various programs about in what aspects of insurance provision governments should be involved, suggests that existing approaches are ad hoc. Moreover, the programs themselves suffer elements of nonmarket failure, accompanied by problems with moral hazard and adverse selection, and questions remain concerning their longer-term financial sustainability. However, the better programs include a very specific role for government, mostly as a reinsurer, with close relationships developed between governments and insurers. Nonetheless, at present, there would appear to be little justification for the implementation of a national disaster insurance program in Australia. This is in light of the apparent widespread availability and affordability of property insurance in relation to natural disasters and the significant costs and uncertain benefits of a national program, especially, but not alone, in relation to moral hazard.

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