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Financing Adaptation to Climate-Induced Retreat from Coastal Inundation and Erosion

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Climate projections suggest increased inundation and erosion of beachfront property on the east coast of Australia over the coming century. Protective measures and accommodation to the effects of flooding offer initial lines of defence, but managed retreat will ultimately be required for some property owners. Current and disaster management frameworks offer little policy guidance on who should pay for retreat, or how. Ordinary insurance, catastrophe insurance, group risk insurance, catastrophe bonds and reverse mortgages offer potential solutions, but are ultimately flawed. This paper examines an innovative proposal in the form of mortgage contingent loans which could minimise government involvement, and therefore the risk to taxpayers.

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Financing adaptation to climate-induced retreat from coastal inundation and erosion.

Leo Dobes and Bruce Chapman¹

Abstract

Climate projections suggest increased inundation and erosion of beachfront property on the east coast of Australia over the coming century. Protective measures and accommodation to the effects of flooding offer initial lines of defence, but managed retreat will ultimately be required for some property owners. Current and disaster management frameworks offer little policy guidance on who should pay for retreat, or how. Ordinary insurance, catastrophe insurance, group risk insurance, catastrophe bonds and reverse mortgages offer potential solutions, but are ultimately flawed. This paper examines an innovative proposal in the form of mortgage contingent loans which could minimise government involvement, and therefore the risk to taxpayers.

Introduction

Climate-induced coastal inundation due to expected rises in sea levels and more frequent and intense storm surges is expected to cause increasing beachside erosion and flood damage to buildings and infrastructure.

A House of Representatives Standing Committee (2009, p. 3) noted that 80 per cent of Australia's population lives in the coastal zone, with 711,000 addresses within 3 km of the coast and less than 6 m above sea level, although most of the addresses adjoin sea-connected lakes, lagoons and rivers rather than directly facing the open ocean. A more refined subsequent analysis cited in Australian Government (2009, p. 75) estimates that there are 'between 157,000 and 247,600 existing residential properties at risk of inundation with a sea-level rise of 1.1 metres', mainly along the eastern seaboard.

Coastal communities have traditionally adapted to inundation and shoreline recession in three major ways:

1. *protection* against the incursion of seawater has been sought through construction of sea walls and dykes. However, it is now acknowledged that hard infrastructure generally offers only a short term solution because erosion tends to continue naturally under and around it. It can also result in negative externalities, with reduced access to beaches for the community.
2. *accommodation* to flooding offers limited options in the case of existing residential buildings. Some home owners are able to raise houses or add storeys, but usually at

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considerable expense. They can also sandbag house entrances, take out insurance, or simply tolerate (i.e. internalise) occasional flood damage to house contents and structures.

3. *managed retreat*: chronically flood-prone areas may need to be abandoned, with residents moving to higher ground. As far back as 1817, Governor Macquarie urged this solution on those who had settled on the floodplains of the Nepean and Hawkesbury rivers². In more recent times, beach erosion and flooding has been experienced in residential areas such as coastal southern Queensland and northern New South Wales.

The emphasis in the Australian policy discourse has to date been on the ‘protect’ and ‘accommodate’ phases, with many local governments commissioning risk analyses. The key fear on the part of local governments is that they may become liable for damages claims in the future if they can be shown to have been negligent in approving housing developments potentially subject to inundation, or for failing to protect existing property threatened by inundation or beach erosion. In the words of one Council representative, if they act too early (by banning development in areas at risk), they incur the wrath of the community, but, if they act too late they open themselves to legal action³. By the middle of 2010, legal proceedings of one sort or another had already been instituted in all jurisdictions except the ACT⁴.

There has been comparatively little analysis or policy development regarding the longer term issue of managed retreat from coastal areas subject to chronic inundation. However, the case of Byron Shire Council’s refusal to undertake beach protection at Belongil Beach (McDonald 2007), and subsequent court action by owners of expensive beachfront property has brought the issue to the fore, at least from a legal perspective. On 21 October 2010, the New South Wales Parliament passed the *Coastal Protection and Other Legislation Amendment Act 2010* that allows councils to undertake protection activity⁵ and to charge property owners for doing so.

There has also been a notable absence in the public discourse of an economic perspective. Given that the issue of adaptation to climate change involves all the classic ingredients of economic inquiry, including externalities, resource costs, and efficiency considerations, this is surprising. While acknowledging that the issue is complicated by legal and administrative practice, combined with politics, there is considerable scope for exploring the key question of ‘who should pay for coastal retreat measures?’

As a first step towards contributing an economic perspective, we examine below seven possible mechanisms for funding coastal retreat. The last of these, Mortgage Contingent Loans, is analogous to the concept of income contingent loans that have been applied in several countries to student loans along the lines of Australia’s Higher Education

² Hawkesbury-Nepean Floodplain Management Steering Committee 2006, p. 13, reproduces the Order issued by command of Lachlan Macquarie.

³ Comment made by a participant at the 16 June 2010 ‘Abandon or Adapt’ workshop at the National General Assembly of the Australian Local Government Association (ALGA) in Canberra.

⁴ Andrew Beatty (Partner, Baker & McKenzie) at the 16 June 2010 ‘Abandon or Adapt’ ALGA workshop.

⁵ <http://www.legislation.nsw.gov.au/sessionalview/sessional/act/2010-78.pdf>, section 55M.

Contribution Scheme (HECS): Chapman & Hunter (2009) provide an overview of various applications of income contingent loans. To the best of our knowledge, the concept of asset-contingent loans has not been applied before to the area of adaptation to climate change. We have sought to avoid the diffuse nature of the emerging debate on adaptation by focusing principally on the 'retreat' stage, primarily in the area of abandonment of established coastal residences, assuming implicitly that we are dealing with a slow-onset phenomenon rather than a sudden catastrophic event. Even though settlements may appear to be suddenly threatened when a severe storm event 'unexpectedly' erodes a large area of beachfront, coastal areas of Australia have typically been subject to advance and recession over long periods of history. The case of Belongil beach in Byron Bay is an example of erosion that had been foreseen by local government but appears to have come as an unwelcome surprise to some property owners.

Adverse selection, moral hazard and risk perception

Adverse selection and moral hazard are often encountered as consequences of measures that facilitate the sharing or the transfer of risk. Adverse selection, as the term implies, is generally associated with decisions to participate in a risk-sharing or risk-transfer scheme. Moral hazard, on the other hand, is more relevant in terms of those already participating in a scheme.

Famously explored by Akerlof (1970), adverse selection can arise where there is asymmetric information between two parties who face a common risk. The classic example is where an insurer cannot differentiate between individuals with different health profiles by charging them different premiums to reflect individual levels of risk. If an insurance company, for example, provides life insurance to everyone without first checking their health, people with heart problems or other life-threatening conditions are likely to take out policies, while healthy individuals will generally decline to do so. The higher number of payouts will drive up premiums, so that even fewer healthy people will take out the life insurance policy, thus further increasing the loss (relative to premiums) suffered by the insurer, until premiums become prohibitively expensive, or the insurer ceases trading.

In the case of coastal retreat, adverse selection is not a particularly important factor in an absolute sense, because people living in vulnerable areas are generally all at risk. Residences at more or less the same height above sea level are all equally subject to chronic inundation caused by sea level rise or storm surges or a combination of both. However, the time element involved is also important. Given that sea level rise or coastal erosion is an essentially slow-onset mechanism, houses at low elevation or closer to the shoreline will be affected before those higher up or further away from the beach. Depending on the length of time difference involved, one might reasonably expect that those less exposed to chronic inundation or serious erosion will choose to delay participation in schemes such as insurance or government assistance, particularly where a personal cost or co-contribution is involved. Entry into a scheme will be delayed until the risk is sufficiently imminent.

Moral hazard generally refers to a situation where someone is not fully exposed to a risk and therefore behaves differently than if they had faced the full consequences of that risk. In an insurance context, an example might be someone with flood insurance who feels secure in the

knowledge that any damage to the contents of the house will be recouped from the insurance company and therefore does not take as much care as they otherwise would have done to place expensive furniture above likely flood height. Zeckhauser (1995) canvasses some of the issues.

Because of the different stages involved in adapting to coastal risks, potential moral hazard may well affect the degree of adverse selection. In the case of retreat from coastal inundation, an individual who expects government assistance to retreat may reduce the amount of maintenance on the house, so that it deteriorates faster than it otherwise would have done, and so becomes uninhabitable sooner. Similarly, the availability of flood insurance for damage to house contents or structure may well reinforce decisions by residents to remain longer than they otherwise would have done. By the time that they abandon their residence, it may have totally lost its value (including as scrap), so that no equity remains with which to assist in buying a house elsewhere.

Moss (2002, pp. 11-12, 39-52) argues that adverse selection and moral hazard are not the only factors that may lead to failure in markets for allocating and distributing risk. Misperception of risk of death or injury in hazardous professions such as the defence forces may be just as important in preventing the efficient functioning of insurance markets. It was because of such misperceptions that legislative requirements were imposed on employers to insure their employees against on-the-job accidents. A key justification is that someone other than the individual worker is able to make a more rational evaluation of the risk involved.

Although more research is required, it is likely that a similar misperception regarding flood risk can occur. Reviewing experience in Australia, Canada, the USA and New Zealand, Yeo (2003) concludes that property values have been found to both rise and fall after floods, and that the evidence is similarly contradictory when areas have been designated as floodplains. However, the evidence is far from conclusive because the studies reviewed were undertaken for different reasons and used different data and definitions. Using studies of flooding in Cologne and drought in Zimbabwe, Grothmann & Patt (2005) argue that adaptive responses depend heavily on agents' perceptions of their ability to adapt, as well as on their perception of the need to do so.

It is possible that flood-prone residents in Australia are confused about the precise nature of insurance coverage, where it is offered. If so, their perception of their ability to adapt by taking out insurance against inundation may be low. For example, the Insurance Council of Australia (2009) considered that :

'In Australia flood mapping is typically the remit of Local Council or a floodplain management authority. ... The general insurance industry made application in early 2008 to the ACCC for insurers to voluntarily adopt a common definition for flooding. This application arose as a result of consumer confusion regarding the different definitions for flooding available in the market. ... Unfortunately, consumer legal groups objected to the common definition for flood and as a consequence, the ACCC did not authorise insurance companies to adopt a common definition for this hazard. Consumers remain faced with an array of different definitions for flooding. Flood cover has now been developed by several insurers and there is no longer any scope for further attempts to gain authorisation for a common definition as many of these

products would then need to be redeveloped.’ [the internet site appears to have been disconnected sometime in 2011, following criticism of the Council after the early 2011 Queensland floods]

Nevertheless, the Insurance Council of Australia seems to have been generally criticised following the Queensland floods of early 2011 for not having developed a common definition of flooding (e.g. ABC News, 14 February 2011). It is therefore likely that ‘government failure’ may compound ‘market failure’, particularly in the face of the uncertainty that is the hallmark of climate change.

The potential problems of adverse selection, moral hazard and misperception of risk therefore need to be taken into account in assessing the viability of each of the alternative instruments explored in subsequent sections.

Private insurance

It is natural for most people to think of insurance as a viable means of protecting themselves financially against the loss of a business or residence in a coastal area that is subject to erosion or chronic, perpetual flooding events.

Insurance allows individuals who face specific hazards or risks (fortuities) to pay a fee in the form of a premium to an insurance company in return for a pecuniary benefit if a loss is incurred. A risk-neutral individual would be prepared to pay an actuarially fair premium that just covers any expected loss within a specified time period. Risk-averse individuals will be prepared to pay more. Because the insurance company is able to pool a large number of independent risks in its portfolio, it is able to cover losses from the premiums it receives from individuals. In effect, an individual who takes out insurance is able to share or ‘trade’ some of their own risk with other individuals through the agency of the insurance company.

In principle, and where premiums reflect the degree of risk, insurance can be an ideal instrument because it creates an incentive for the individual to reduce their exposure to a hazard until the premium they pay just equals the expected residual value of any loss. It is therefore preferable to other instruments such as grants or low interest loans that are often provided as part of disaster relief. Subsidised assistance may encourage individuals to neglect to take mitigative or preventative action to reduce the hazards they face.

Schanz (2010) argues that insurers and re-insurers will be able to cope with continued offerings of weather-related insurance, even in the face of climate change. He argues that there is sufficient regional diversity and independence of risk, and, if insurers are able to charge premiums accordingly, with no government intervention or rate-capping, insurance will continue to be viable.

In the case of retreat from coastal inundation, however, a specific insurance policy that covers the risk of abandonment of property is likely to be taken up only by coastal residents, rather than being shared by individuals across Australia. The insurer then faces a situation of correlated risk where a major storm may well erode a large section of the coast, resulting in an extraordinary number of similar insurance claims, but with insufficient income from

premiums to meet them. The likelihood of adverse selection means that a specific insurance market that covers the risk of perpetual inundation of low-lying coastal areas is unlikely to be viable without government subsidies.

More important is the ‘slow-onset’ or ‘creeping’ nature of coastal inundation and erosion. It is a basic precept of insurability that losses should be fortuitous, because insurance is intended to cover risks rather than certainties. As coastal recession progresses, coastal properties will face increasing levels of risk, until the risk finally becomes a near certainty. At some stage, premiums will need to approach the value of the property itself, if the insurer is not to go out of business. Alternatively, insurance companies may need to raise ‘excess’ contributions (‘deductibles’ in north American usage). It is therefore unlikely that insurance would be commercially viable in terms of compensating victims of chronic inundation and erosion.

Moreover, the fortuity doctrine in insurance law appears to specifically preclude insurance coverage for a ‘loss in progress’, or ‘known loss’. That is, where an agent purchases insurance for an event that is already in progress, payouts may be denied. In Australia, for example, health insurance excludes pre-existing and known medical conditions. Insurers would presumably be successful in obtaining the support of Australian courts against claimants who sought to obtain payouts involving retreat from coastal inundation or erosion that had been occurring over some time or had been predicted as likely by technical experts.

Although private insurance might initially appear to offer an attractive adaptive response to climate-induced retreat from coastal inundation and erosion, it is unlikely to provide a practical mechanism for dealing with losses.

A disaster management framework

There is no specific definition of disaster relief. However, terms such as ‘widespread damage’, ‘abnormally affecting lives and property’, ‘extraordinary fire, flood, etc’ (Government of the Northwest Territories 2005, section 21.04) are typically used to describe its nature. A more operational formulation is contained in s.13 of the *Queensland Disaster Management Act 2003*, which defines a disaster as a ‘serious disruption in a community ... that requires a significant coordinated response by the State ... to help the community recover ...’. The term ‘serious disruption’ encompasses illness, injury, or loss of human life, and ‘widespread or severe’ property or environmental loss or damage.

The social literature on disaster management tends to focus on case studies, managerialist and organisational aspects of preparation and responses by relevant organisations, community attitudes to preparedness, insurance issues, and the effect of disasters on communities. There is comparatively little corresponding economic research or literature (Yezer 2000, Cavallo and Noy 2009). The limited number of economic studies that have been undertaken to date tend to cover issues related to the impact of disasters on growth, general equilibrium effects nationally or regionally, damage to resources and infrastructure, and fiscal implications. However, World Bank (2010) provides a useful and systematic review of the key issues.

It is beyond the scope of this paper to develop an economic theory of natural disasters and to apply it to climate change issues. However, the question arises whether it would be appropriate to use a disaster or emergency management framework to analyse or make policy recommendations regarding the 'retreat' phase of adaptation to climate change. More specifically, would such a framing be appropriate for managing coastal inundation and erosion?

One potential advantage of an emergency management approach is that government fiscal and organisational arrangements are already established and operational. The use of existing organisational arrangements also obviates any need to distinguish between disasters that are due to climate change and those that are not.

On the other hand, natural disasters are generally considered to be extraordinary events that have an associated element of unpredictability and may be infrequent. In the case of coastal inundation and erosion, the associated natural processes are likely to be comparatively gradual. Changes in sea level and alterations to the Australian coastline have occurred over millennia and can be characterised as being 'slow onset' in nature. Even climate-induced changes in sea levels are expected to take place only gradually over many years. The effects of inundation and coastal erosion are therefore reasonably predictable, at least on a decadal timescale. Treating them in the same way as an unexpected and spatially extensive bushfire would seem somewhat incongruous.

A distinguishing feature of projected climate change is that it will affect the whole of Australia, not just some communities. Some parts of the country will suffer the effects of extended drought and others may be flooded. But if a disaster management framework is applied to all climate-related effects, large and small, taxpayers will compensate all those affected. Everyone will end up subsidising everyone else. The net result would simply be massive fiscal churn.

More importantly, expectations of an entitlement to disaster relief are likely to engender moral hazard in the form of Samaritan's dilemma ('charity hazard'), with recipients failing to institute precautionary adaptation measures to the same extent that they might otherwise have done. Naess et. al. (2005, p. 131) report that expectations of government assistance by those affected by major flooding in Norway in 1995 represent an institutional disincentive to proactive flood management. (Kunreuther & Michel-Kerjan (2009, p.122), on the other hand, argue that American evidence indicates that communities do not act as if they expect to receive government disaster assistance.) Alternatively, expectations of compensation may induce increased development in coastal areas, although American experience suggests (Cordes & Yezer, 1998) that rising incomes and consequential demand for recreation are more important determinants of coastal development than government shoreline protection.

The relatively slow and predictable nature of coastal inundation and erosion, the relatively small number of people likely to be seriously affected at any one time, and potential moral hazard associated with expected government payouts, all suggest that a disaster management framework is not a particularly appropriate means of responding in the 'retreat' phase.

Catastrophe insurance

Insurance markets such as those for car crashes or loss of airline luggage are based on large pools of people diversified by geography, driving experience, travel destination, etc. A loss incurred by any one person is independent of a similar loss by another. The probability of loss or damage can therefore be estimated with reasonable accuracy, and tends to be the same from year to year. Annual premiums can thus be set confidently to cover expected losses in the same year to ensure sufficient profits for the insurer, to enable it to continue operating.

In the case of catastrophes such as floods or earthquakes, on the other hand, the annual pattern of losses is far less predictable. Catastrophes are generally geographically widespread (so that the risk⁶ is correlated, rather than being independent for each insured person), have low, sometimes incalculable probability of occurrence, and have high value consequences. While an insurer need make no payments for some, or even many years, bad years may involve extraordinarily large payments. Because the requisite diversification is intertemporal, rather than geographic or demographic, it is a defining feature of catastrophe insurance that large capital reserves, or at least ready access to them, is essential.

Jaffee and Russell (1997, p. 208) point out that:

‘Unlike every other line of insurance, the contract of catastrophe insurance, as presently structured, requires that the seller have access to a large pool of liquid capital in every year in which the contract stands. In principle, the insurance company would require enough capital to cover the largest possible catastrophe loss that might occur. For example, for an event with a 1 percent annual probability, the expected loss (or the annual premium) would approximately equal 1 percent of the required capital. Put another way, the required capital would approximately equal one hundred times the expected annual loss [because the loss could occur in the first year after a contract is signed]. Since such large pools of capital do not exist, firms have withdrawn from this market rather than bear the risk of insolvency.’

Barnett (1999, p. 149) reports that ‘nine property and casualty insurance companies became insolvent after Hurricane Andrew [Florida, 1992]’, with firms in California ceasing to write both earthquake and home-owners insurance after the 1994 Northridge earthquake in Los Angeles.

Insurers who wish to offer catastrophe cover may also face a number of other disincentives. Kunreuther & Michel-Kerjan (2009, p. 194) note that the cost of large reserves of capital ‘is a very important factor in determining insurance supply’. Jaffee and Russell (1997) note that American accounting practices in property-liability insurance ‘preclude an insurance corporation from earmarking capital surplus to pay for a future catastrophe loss ... even though the occurrence of the loss at some time is highly likely’. That is, the company is able to allocate earnings to a capital surplus account, but they cannot be hypothecated to catastrophe payments and might be drawn on for other purposes.

⁶ ‘risk’ is treated in this paper as a probability concept.

Moreover, retention of large capital surpluses may attract a corporate takeover. For example, Chrysler Corporation sought to self-insure against a catastrophic downturn in business, but attracted an attempted takeover bid by corporate raider Kirk Kerkorian in 1995 (Jaffee and Russell, 1997, p. 213). Where retained earnings are taxed at corporate income rates, there may be a further disincentive to accumulate funds. Unlike joint-stock companies, insurers incorporated as non-profit mutual companies are not at risk of takeovers, but large accumulated surpluses may attract the attention of regulators if consumer groups complain that premiums are too high and could be reduced by virtue of the surplus.

Even if an insurer is able to isolate capital in a trust fund or similar vehicle, it may be insufficient to cover losses. Jaffee and Russell (1997, p. 216) cite the example of the 20th Century Insurance Company, ‘which had the misfortune to enter the earthquake market in the year of the Northridge earthquake’. It is this ‘early hit’ problem which makes it essential for an insurer to have ready access to capital markets. Reinsurance markets may help provide access to capital, but Jaffee and Russell (1997, p. 217-8) argue that only relatively minor amounts can be obtained from reinsurers, and, in any case, most reinsurers are joint-stock companies, and so face problems such as hostile takeovers if they seek to accumulate substantial funds.

As with the option of a disaster management framework, however, the use of disaster insurance does not appear to be appropriate for addressing retreat from threatened coastal areas. It is not clear that insurers could offer products that would be sufficiently attractive to most property owners. In particular, the cost of insurance would rise significantly as the degree of certainty of retreat increased.

Catastrophe (‘Act of God’) bonds

One means of accessing private capital for insurance purposes is provided through catastrophe bonds, so-called ‘cat bonds’ or ‘Act of God bonds’. Used by some insurance companies as an alternative to reinsurance, catastrophe bonds continue to evolve in nature, but Cavallo and Noy (2009, p. 23) describe them as:

‘a tradable instrument that facilitates the transfer of the risk of a catastrophic event to capital markets. A typical structure is one in which the investors purchase a safe bond, such as a U.S. treasury bond, for the desired amount of coverage and deposit it with a Special Purpose Vehicle (SPV) institution, which is legally distinct from the parties. The investors collect the interest on the bond plus the insurance premium that is paid by the insured party while the disaster does not occur. If the disaster strikes, however, their claim is extinguished and the SPV sells the bond and transfers the funds to the insured.’

According to *The Economist* (2 August 2007), ‘property and casualty insurers were awash with capital and had little need to hunt for more’ in the decade after the Northridge earthquake, but hurricanes Katrina, Rita and Wilma soaked up much of global reinsurance capacity. In recent years catastrophe bonds have been issued for risks ranging from deaths from bird flu, acts of terrorism, various natural disasters, and even cancellation of the FIFA World Cup final (Minter Ellison, 2007). According to Kunreuther & Michel-Kerjan (2009,

p. 180, catastrophe bonds have been marketed since 1997, with the first one issued in Australia by Swiss Re in 2006 against earthquakes and tropical cyclone damage (Haynes, 2006).

As potentially attractive as such instruments might be, it is an open question whether they could be used in the case of inundation or erosion of coastal property induced by climate change. By their very nature, catastrophes are reasonably unpredictable and therefore accord with the basic insurance principle of fortuity. If sea level rise and the probability of storm surges that result in frequent inundation can be reasonably foreseen, however, then investors may not be willing to participate in bond offerings.

On the other hand, Wish (2008) quotes a UK actuary, Nick Silver, as saying that climate change is changing the underlying risk profile of natural disasters, and ‘cat bonds won’t cover that bit – at least not at the moment. It requires the next generation of cat bonds to be able to deal with the changing scale of risk and change of areas of risk’.

As their name suggests, catastrophe bonds are intended to cover large-scale and costly events that occur with little prior warning. They are typically issued for relatively short periods such as 3 years. Whether they would be offered in future in a form suitable for small-scale, relatively predictable events such as coastal inundation or erosion is unknown, but they do not appear to be a practical option at this stage.

Group risk insurance

The incidence of natural disasters is typically not independent, an essential requirement for the risk involved in normal insurance schemes. Because their effect is usually widespread, a large number of individuals can be affected jointly at the same time, so the risk is said to be ‘correlated’. However, Group Risk Insurance schemes can potentially address this problem.

Group Risk Insurance relies on the concept of a financial option. Financial options are tradable instruments that specify a contractual right, but not an obligation, to take some specific action within a specified time period. They are typically used where the future value of an asset is uncertain and the investor does not wish to commit up front the full amount of the investment. For example, an investor may wish to purchase a large amount of shares but is uncertain whether their future price will rise or fall. To commit the full amount immediately may entail unacceptable risk, so the investor may choose to buy an option on the shares instead. The option involves payment of a premium that is lower in value than the shares themselves.

In the case of the investor purchasing an option to buy shares, the option contract may specify that the investor has the right to purchase the shares at today’s value at any time within the next 6 months. (American options allow purchase within a so-called ‘exercise period’, while European options specify the exact date on which the purchase may be made.) If at some stage during the next 6 months the price of the shares (the ‘index’) rises above today’s value, or an otherwise agreed ‘strike’ price, the investor has the option of buying them at today’s value and make a profit by selling them at the higher market value. On the other hand, there

is no obligation on the investor to purchase the shares if their price falls below, or remains at the specified 'strike' price.

Where the option is valuable because the associated 'index' rises above a strike price, it is termed a 'call' option. A 'put option', on the other hand, becomes valuable when the index falls below the strike price. Farmers might, for example, buy a put option early in the growing season in case the price of their crop falls at the time it is harvested. Even if the price falls below the strike price, the farmer has a right, but not an obligation to sell the crop to the issuer of the option at the pre-agreed strike price rather than the lower market price. Barnett (1999, p. 151) gives as the corresponding example of a call option a food processor who buys a farmer's crop at an agreed price, in case the price increases at harvest time. If the price does increase, the food processing company has the right, but not the obligation to buy the crop at the lower, contracted price.

Barnett (1999, p. 151) reports experimental U.S. Government provision of a group crop-insurance product, called the Group Risk Plan, that is 'essentially a European put option that uses county-average yields as the index':

'The National Agricultural Statistical Service (NASS) county-average yield estimate for the crop is the index value on which the contract is settled. Farmers choose a strike yield and pay below the strike yield and pay a premium. If the NASS county-average yield estimate for that growing season is below the strike yield, the farmer is owed a payment. The further the NASS yield is below the strike, the higher the payment received by the farmer ... [such] policies are not susceptible to adverse selection since individual farmers can no better estimate end-of-season county-average yields than can [federal agencies] ... [They] are not susceptible to moral hazard since the policies are only sold in counties where no individual farmer is large enough to have a significant impact on the county-average yield.'

Wang (2000) adds that county-level averaging may be inefficient if farmers' conditions of production differ. For example, a farmer on a hillside may have less water due to runoff than a neighbouring farm in the valley below. Homogenous, smaller than county-level zones may be required.

Abandonment of inundated coastal properties generally involves correlated risk where settlements have been established around low-lying lagoons, estuaries or other low-elevation sites, because they would tend to be flooded at much the same time. Utilisation of group insurance options may thus be appropriate. For example, property owners could be encouraged to purchase American call options based on an index of frequency of flooding such as the number of days per year above a specified height above sea level. A strike price could be set on the basis of the number of occurrences per year that is considered to be unacceptable for continued habitation.

Beachfront properties are generally expensive. It is therefore likely that claims for losses would amount to substantial sums. Whether private insurance companies would be willing to offer group cover on terms that are financially acceptable to most beachfront property owners is debatable. It would also be difficult to define an index, because of the difficulty of

distinguishing between flooding due to natural causes and that due principally to climate change, or, indeed, what degree of flooding justifies 'retreat'.

Reverse mortgages

Reverse mortgages are a financial product that is generally available to people of about 60 years of age or older who own their own home. It is possible for such homeowners to borrow against a proportion (usually between 15 and 40 per cent) of the equity of their home. The loan is generally not repaid like a normal loan, with the debt (principal plus interest) accumulating until a trigger point is reached. The trigger point depends on the agreement with the lender, but can include events such as the death of the owner (in which case the loan is repaid by the deceased's estate), the owner moves house, or a specific level of debt is reached. The advantage to 'house rich, cash poor' homeowners is that they are able to utilise their equity while continuing to live in their own house. Further details are available from individual banks and the Australian Securities and Investments Commission (<http://www.fido.gov.au>).

The Australian Government's Pension Loans Scheme offers a form of reverse mortgage to 'people of pension age ... who cannot get a pension because of their income or assets (but not both) , or those who only receive a part pension' (<http://www.centrelink.gov.au/internet/internet.nsf/publications/fis018.htm>). Eligible applicants can borrow against the security of their property, but can only receive money in the form of fortnightly payments up to the value of the age pension. Unlike commercial reverse mortgages, they cannot obtain a lump sum payment.

The question arises whether it would be possible for a property owner in a coastal area to obtain a commercial reverse mortgage on an existing coastal property, and use the funds to purchase a house further inland.

Despite the finding by Yeo (2003) that property values in some areas of Australia remain unaffected by floods, a homeowner in a coastal area that is subject to frequent inundation is likely to see a fall in value of their property, particularly if evidence of climate-induced inundation becomes progressively more evident over time. In other words, the equity in the house would be likely to fall drastically, especially as the necessity of abandonment became increasingly apparent. Clearly, it would be difficult, if not impossible, to find a financial institution willing to provide a reverse mortgage on a soon-to-be abandoned property.

However, it may be possible for an owner of a coastal property who has sufficient savings, or who sells their coastal property well before it is seriously threatened, to make some use of a reverse mortgage.

For example, the owner of a coastal home purchased for \$500,000, may realise in 2015 that its value has fallen by \$100,000 as public awareness has grown of the risks of inundation. If the owner sells the coastal residence for \$400,000 and buys a house for this sum further inland, they may be able to obtain a reverse mortgage over the new house of, say, \$120,000, being about 30 per cent of the 'new' house value. They might then use \$100,000 to upgrade the 'new' house to an equivalent standard of their original coastal residence; reserving

\$20,000 for other purposes. Assuming that the ‘new’ house retained its upgraded value of \$500,000 up to the time of their death, the estate would repay the \$120,000 plus accumulated compound interest on the loan to the lender, with any balance retained by whatever heirs there may be to the estate. Note that, depending on the lender, it may not be possible to borrow additional funds first and buy a more expensive inland house because lenders will generally require that the reverse mortgage is the only lien on the house.

In theory, therefore, it is possible for owners of coastal property to employ an existing market instrument to adapt to slow-onset inundation or erosion. But this avenue would only be open to people who are sufficiently old; that is, those whose probability of mortality is sufficiently high for commercial providers of reverse mortgage to recoup their loan with a reasonable return. (Younger home owners would need to wait to qualify for a reverse mortgage from market lenders, by which time the value of their coastal home may have fallen so far as to make use of a reverse mortgage facility all but impracticable.) Further, if one of the conditions of a reverse mortgage is the upkeep and maintenance of the house in a condition that at least maintains its purchase value, commercial providers of reverse mortgages may be reluctant to make them available to the very elderly and the infirm.

And not all owners who are eligible for a reverse mortgage will wish to adapt to climate change by moving away from an area that is subject to increasing inundation or erosion. There is evidence (e.g. Patt and Schroeter, 2008) that procrastination may well occur, due both to the endowment effect and to omission bias.

Omission bias can occur where someone bears personal responsibility for both action and inaction, but prefers a harmful omission over an equally harmful commission. For example, they may prefer not to vaccinate a child even though the risk of death without the vaccine is much greater than the risk of death, say, from a contaminated vaccine (Ritov and Baron, 1992, p. 50). A coastal resident may similarly not wish to bear responsibility for financial loss due to reduced equity in a home under a reverse mortgage (an act of commission), preferring instead to avoid moving and to therefore sustain an even greater loss from the fall in value of the existing coastal home (an omission to act). Where a combination of the endowment effect and omission bias results in a preference for the status quo, even those who could potentially take advantage of a reverse mortgage solution may not do so.

Reverse mortgages, while remaining a possibility for some, are therefore likely to be too limited in scope and take-up to offer a satisfactory solution to the problems of those wishing to leave areas at risk. Most importantly, however, they do not solve the problem of those who purchase properties from those who leave, or of those residents who remain until there is no choice but to physically abandon their property.

Mortgage contingent loans

It is already the case that both state and local government bodies have purchased threatened properties, removed structures and rehabilitated sand dunes (New South Wales Government 1990, section 5.2.1(d)). Despite apparently favourable community sentiment, this approach is unlikely to be financially sustainable into the future if the number of threatened properties increases significantly.

The ethical and equity basis of buying out owners of threatened property is not entirely clear. Wealthy property owners with other assets or income streams should presumably be able to absorb the loss, without necessarily losing a place to live. On the other hand, impecunious residents who were house-asset rich, but cash poor before losing their house, might well require assistance. The allocation of public housing, or provision of rental assistance, offers one possible solution consistent with government's role as social insurer. However, an intermediate solution might be to assist them through loans that would permit the purchase of an equivalent or similar property elsewhere.

In designing the Higher Education Contribution Scheme (HECS), Chapman (2006) drew on the concept of income contingent loans. As their name implies, the repayment of such loans is tied closely to a person's income. Normal loans are repaid according to a time schedule agreed with the lender, a schedule that must be met irrespective of whether the person has the ability to do so or not. Income contingent loans, on the other hand, have no fixed time schedule but repayments are determined as a proportion of income once a specific earning level has been reached. Similar income contingent loan schemes have been proposed for other public policy purposes, including drought relief (Botterill and Chapman 2006), payment of fines for white collar crimes (Chapman and Denniss 2006), etc.

A similar concept is explored here in terms of coastal retreat, but in the form of an asset contingent loan rather than an income-based one⁷. More specifically the proposal can be described as a mortgage contingent loan that would be offered to coastal residents subject to chronic inundation and erosion without the means to buy a house elsewhere. A loan of this nature could have the following features:

1. The property owner would cede the abandoned property to the government:
 - to ensure that a new owner could not also later take advantage of the scheme
 - a financial saving would be achieved by governments that would have otherwise purchased properties at risk, presumably at prevailing market rates for unthreatened properties in the same neighbourhood.
2. The government would act as guarantor for a commercial loan taken out by the evacuee who would purchase a new house elsewhere:
 - the total amount of the loan (including the costs associated with abandonment of the property) would be capped at some proportion of the value of a comparable coastal residence that is not subject to flooding to avoid the moral hazard of owners 'trading up' with the assistance of the government.
 - the loan would incorporate a sum that covered costs associated with abandonment of the property, including demolition of any abandoned structures, removal of hazardous material, an administrative fee for participating in the scheme, etc.
 - the borrower would be responsible for insurance and interest payments. Poorer borrowers would be able to capitalise a portion of expected future insurance and interest payments into the loan. Note that this condition would reduce the amount available for purchasing a new house because of the cap on the total value of the loan.

⁷ Owners of abandoned property who have income streams that could be used to repay income-contingent loans would also be able to obtain commercial loans. Unlike student loans, there is no market failure that would exclude them from the property market, and hence no justification for provision of a loan by government.

3. The government would hold the first mortgage over the new property:
 - subject to normal checks of structural soundness, flood risk, etc.
 - the new owner would provide an undertaking to maintain the property to a given standard to ensure that the government's equity were preserved. Where elderly owners or others are not able to do so, a commercial caretaker would need to be engaged at the owner's expense, with the cost capitalised against the mortgage.
 - the property would be sold by the government on the death of the owner, or if the owner moved to another residence, with net equity retained by the government.
4. The government may sell the mortgage into the commercial market
 - sale of the mortgage would transfer the risk from the taxpayer to the private sector.

The proportion of the loan that would actually be available for purchase of a new house would be reduced by the portions hypothecated to demolition of the abandoned property, as well as capitalised administrative fees and future interest and insurance payments. Because the residual value of the loan would therefore be well below the market value of a comparable beachside property, those contemplating making use of the scheme would be likely to end up with a less desirable residence than if they had sold today and moved to higher ground. The risk of adverse selection can therefore be considered to be relatively low. As a corollary, however, a government offering a mortgage contingent loan scheme would need to ensure that only existing residents (at the time of introduction of the scheme) were eligible.

A source of moral hazard might involve the upkeep of new residences acquired with a mortgage contingent loan. A desirable feature of a mortgage contingent loan scheme is that the value of the newly acquired property increases over time, so that taxpayers are eventually compensated fully for the costs of the scheme. However, a resident may fail to maintain the full potential value of the property because of inadequate repair and maintenance. Such negligence may not be entirely deliberate because elderly residents in particular may not be physically capable of routine repair and maintenance tasks.

Should governments assist retreat by owners of coastal property?

Why should taxpayers, through the agency of a government, support owners of property at beachside locations? Salubrious beachside property is usually expensive and owned by those in affluent suburbs. It therefore seems inequitable for taxpayers in less affluent suburbs to subsidise them. Moreover, any case for assistance would need to be justified by cost-benefit analysis.

However, it could be argued that people didn't know, or were unable to foresee the problem of climate change or beachside erosion. In human timescales, the ocean looks static even if occasional storms cause inundation, and the Australian 'coastline has in fact been remarkably stable over the historical period' (Australian Government, 2009, p. 34). Further, planning bodies and councils with technical expertise and resources have allowed development of low-lying areas, presumably under the same understanding. That is, government failure, as much

as externalities or market failure, can be held responsible, so justifying at least some government intervention to rectify the problem.

Further, governments have long, and increasingly, accepted the role of acting as risk managers of last resort, either directly or through legislation. Moss (2002) traces developments in America, from providing security for business in the form of joint-stock companies in the nineteenth century, income security for workers in the early twentieth century through social insurance programs, and security for consumers in the late twentieth century through consumer protection legislation ranging from the purchase of goods to credit card guarantees.

Whether the expanded role of government in managing risk is an optimal one from the perspective of society as a whole is difficult to answer. However, it is an established social and institutional fact⁸, and it is difficult to envisage today's governments leaving the risk of adaptation to climate change entirely to the private sector. It must therefore be assumed that owners of coastal property that is destroyed by inundation or erosion will, at a minimum, be offered public housing like other homeless persons. Broadly speaking, the alternatives are full compensation by purchase of the affected property by government, or an intermediate solution of a mortgage contingent loan.

In the case of retreat from coastal inundation or erosion, the issue may therefore be less one of cost-benefit analysis than of cost-effectiveness analysis, tempered by policy settings that avoid or ameliorate adverse selection and moral hazard. Generalisations are difficult because of the location specific nature of adaptation, but a hypothesis that warrants further research is that purchase of threatened coastal properties by government is the most expensive option, provision of public housing the cheapest, with mortgage contingent loans somewhere in between.

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⁸ In their seminal survey article on cost-benefit analysis, Prest and Turvey (1965, p. 693) give the example of an analysis of an irrigation project that would have increased the production of beet-sugar in the Missouri river basin. They point out that the analysts ignored the fact that sugar-beet production quotas would have precluded the forecast increase in production; the point being that cost-benefit analysis must take into account legal and institutional realities.

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