Chapter 6

Mitigation of the Earth's Economy: A Viable Strategy for Insurance Systems

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Abstract This paper proposes reflexive mitigation as an ecologically effective insurance system response to dangerous anthropogenic climate change. Reflexive mitigation is an adaptive approach to mitigating climate change recognizing (1) atmospheric CO₂e concentrations consistent with Earth system stability will vary over time in response to changes in the Earth system and the global economy, and in the relationship between them; and (2) relationships between the Earth system, the economy and the insurance system are evolving, and therefore understanding of them is necessarily incomplete. The paper presents a complex adaptive systems approach to anthropogenic climate change and demonstrates that the Earth system, the global economy and the insurance system are connected social–ecological systems. Current insurance system responses to anthropogenic climate change are generally adaptive and weakly mitigative rather than strongly mitigative. The paper argues successful insurance system adaptation to anthropogenic climate change depends on returning the climate to a stable, familiar and relatively predictable state: effective mitigation is therefore a necessary precondition for successful longer-term insurance system adaptation.

Keywords Adaptation with grace · Adaptive cycle · Climate change · Complex adaptive systems · Insurance · Reflexive mitigation · Social–ecological systems

Insurance Systems and Climate Change

This paper is about effective mitigation of climate change, and about the role the insurance system might play in this. We argue that whilst adaptation is essential for human welfare, mitigation is a strategic response to climate change for human

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social systems generally, and for the insurance system specifically. Climate change mitigation measures are those aimed at avoiding dangerous anthropogenic climate change by (1) significantly and rapidly reducing greenhouse gas emissions; and (2) protecting surviving carbon sinks (United Nations 1992).

Insurance has been described as “society’s primary financial risk manager” (Hecht 2008, p. 1959). Given the magnitude of the risks climate change presents human societies, the nature of insurance system responses are important. Beginning in the early 1990s, insurance was repeatedly characterized as the industry with most to lose in a climate changed world, and therefore the business sector most likely to take a lead on mitigation (Gelbspan 1998; Leggett 1993; Sachs et al. 1998). The characterization of the industry as particularly vulnerable to climate change impacts persists, for example (Pinkse and Kolk 2009, p. 93). Yet insurance industry responses to climate change have emphasized adaptive and some weakly, rather than strongly, mitigative measures (Phelan et al. 2008, 2010).

Adaptation to climate change is necessary because some climate change impacts are already manifest, others are imminent, and there is a warming commitment in the Earth system which implies further impacts (Hansen et al. 2005, 2008). We describe adaptive responses as tactical as opposed to strategic insofar as they do not directly address the causes of the threat. Tactical measures can also support strategic action: for example adaptation can “buy time,” while strategic mitigation measures take effect. However there is very little time available: mitigating climate change requires fundamental change urgently (Richardson et al. 2009).

The paper adopts a complexity theory approach (Bradbury 2003; Waltner-Toews et al. 2008). The complexity approach highlights dynamism internal to systems as well as cross-scale interaction between systems. This theoretical perspective is useful for engaging with disequilibrium systems such as the Earth system, characterized by non-linear change and capacity for surprise (Schneider 2004). We characterize the global economy and insurance system also as complex adaptive systems. We conceptualize the insurance system broadly as comprising all the participants and their relationships that together allow ongoing provision and use of financially viable insurance. This includes for-profit and mutual insurers, government providers of insurance, reinsurers, specialized service suppliers such as loss modellers and brokers, regulatory authorities and industry representative bodies. This system also includes the legal and institutional frameworks created and used to facilitate access to insurance. Investors in insurance companies as well as insurers’ substantial investments are also included (Phelan et al. 2010).

Relationships between the three systems are key to this analysis and are described in Sect. 6.2. Section 6.3 proposes a strong mitigation scenario for the insurance system and introduces two new concepts: reflexive mitigation and adaptation with grace. In contrast, Sect. 6.4 critiques the insurance system’s current adaptive and weakly mitigative approaches to climate change. Section 6.5 concludes the paper.

Linked Social–Ecological Systems

Open social–ecological systems are complex adaptive systems comprising co-evolving human–social and ecological elements, and which interact with other social–ecological systems (Berkes and Folke 1998). A standard analytical approach to linked social–ecological systems describes smaller social–ecological systems as *nested* in larger social–ecological systems (Gunderson and Holling 2002). Our analysis focuses on the insurance system embedded in the global economy, in turn nested in the foundational Earth system, the largest social–ecological system. The emphasis on system dynamism and cross-scale, inter-system interaction (1) highlights phenomena which result from cross-scale interaction (i.e. carbon emissions from the global economy impacting the state of the Earth system, as well as opportunities to effect change in the relationship between the insurance system and the economy); and (2) is conducive to exploring opportunities for making changes in one system in order to drive changes in another system.

Complexity theory is still in its infancy and

“tends to employ an eclectic collection of theories and methodologies designed to deepen our limited understanding of the properties of complex adaptive systems” (Finnigan 2003, p. xi).

Complex adaptive systems (CASs) approaches have been applied in a range of disciplines (Anderson et al. 2005; Hartvigsen et al. 1998; Milne 1998). CAS approaches to social–ecological systems are still very much in flux, and continuing to be advanced (Gallopín 2006; Janssen and Ostrom 2006; Walker et al. 2006).

CASs theory explains systems' capacity to adapt and evolve as well the inherent unpredictability characteristic of complex adaptive systems. A complexity approach is useful and appropriate for our study of the insurance system because it (1) conceptualises integrated ecological and human social systems as social–ecological systems; (2) uses clear and economical language to describe system dynamics and cross-scale interactions between systems; and (3) supports multidisciplinary approaches to complex issues such as climate change. The theory accommodates the ambivalent role of the insurance system in dangerous anthropogenic climate change. Even as society looks to the insurance system for risk management, including management of climate risks, the insurance system simultaneously contributes to the creation of climate risks through the interconnectedness of the insurance system and the global economy.

Three Systems . . .

Both Lovelock's “Gaia” (Lovelock 2007) and Crutzen and Stoermer's “anthropocene” (Crutzen 2002; Crutzen and Stoermer 2000) convey the sense of a co-evolutionary process engaging ecological and human–social systems at global

scale. Increasing anthropogenic CO₂e emissions causing changes in the Earth's climate, which in turn drive changes in human societies, is emblematic of the linked and co-evolutionary processes of ecological and human social systems at global scale. *Earth system science* and *global environmental governance*, originating in the natural and social sciences respectively, are research areas grounded in an understanding of the Earth system comprising intertwined ecological and human–social elements (Biermann 2007; Schellnhuber 1999; Steffen et al. 2003; Young et al. 2006).

The global economy has also been analysed as a complex adaptive system (Arthur et al. 1997; Beinhocker 2006). Beinhocker (2006) makes a detailed case for the superiority of complexity theory's explanation of economies as disequilibrium systems over orthodox equilibrium accounts. However whilst Beinhocker grounds his economic theory in physical reality, his thesis fails to connect with ecological reality, for example the notion of limits (e.g. Meadows et al. 2004; Meadows and Club of Rome 1972). In contrast Daly's earlier "steady state economy" approach (Daly 1982) clearly recognizes the social–ecological character of the economy, and in so doing makes the strong argument for a theoretical understanding of economy that recognizes Earth system limits.

We use the term insurance "system" and not "industry" purposely to bring focus to all of the participants and their relationships that together allow ongoing provision and use of financially viable insurance. This explicitly includes welfare state-style social insurances such as universal health care, unemployment benefits and age and disability pensions. Also included are participants in what is more commonly understood to be the insurance industry such as for-profit and mutual insurers, government insurers, reinsurers, specialized service suppliers such as loss modellers and brokers, government regulatory authorities and industry representative bodies. Investors in insurance companies as well as insurers' substantial investments are also included. The term also includes the legal and institutional frameworks created and used to facilitate access to insurance (Phelan et al. 2010).

...in Relationship

The conceptual approach to linked social–ecological systems is articulated graphically below. Figure 6.1 includes the Earth system, the global economy, and the insurance system, together with key cross-scale interactions relevant for this analysis. Indicative financial values are provided for the global economy and the insurance system to convey a comparative sense of scale. Values where indicated are generally for 2007, the most recent year for which disparate data is available, providing a systems "snapshot" from that year.

The global economy is valued (in 2007) at ~US\$54 trillion (Swiss Re 2008, p. 8). A definite figure for the value of the insurance system overall remains elusive: data is available for some elements of the insurance system including both the insurance industry and state-funded social insurance, suggesting that the value for the

Fig. 6.1 The insurance system, the global economy and the Earth system, and key interactions among them: a “snapshot” from 2007

insurance system overall is large. For example, premiums – the major source of revenue for the insurance industry totalled US\$4 trillion in 2007, and investment income generated an additional US\$1 trillion for insurers (Mills 2009; Swiss Re 2008). Data for social insurance is even less comprehensive but what data is available underscores the magnitude of the insurance system. Health expenditure alone financed through social insurance totalled US\$1.2 trillion globally (in 2006) (WHO 2009). Other key areas of state-financed social insurance expenditure are unemployment benefits and age and disability pensions (see OECD 2007, pp. 76–77). The modern welfare state, which includes forms of social insurance, is most developed in Europe, and some data and projections are available for European Union (EU) countries: unemployment benefit expenditure (for 2007) is projected at 0.85% of EU GDP (Economic Policy Committee and DG 2006, p. 190), i.e. circa US \$142 billion.¹ Gross public pension expenditure (for 2010) is projected at 10.3% of EU GDP (Economic Policy Committee and DG 2006, p. 71),² i.e. US\$1.8 trillion.

¹Unemployment benefit spending projection for the EU25 group of countries. Combined GDP for the EU27 countries in 2007 totalled €12.3 trillion (European Union 2009) Currency figures converted using mid-2007 rates.

²Figure for the EU25 group of countries (excluding Greece).

On the basis of the above information, limited sectorally and jurisdictionally, we conservatively suggest the value of the insurance system globally is at least US\$8 trillion (in 2007), at least 15% of the global economy and as such a significant subsystem. In Fig. 6.1 the Earth system remains unvalued in financial terms: for the purposes of our analysis it is sufficient to note the Earth system is without substitute and the existence of the other systems represented is wholly dependent on the Earth system (Daily 1997). The overall triangle shape of the figure with the Earth system placed at the base reflects this perspective.

Arrows between systems indicate cross-scale, inter-system relationships of interest for this analysis. Emissions from the global economy into the Earth system, and in return, future climate damages from the Earth system to the global economy are presented and valued in units of carbon emissions in 2007. Anthropogenic emissions are valued at 10 PgC,³ comprising 8.5 PgC of emissions and 1.5 PgC of losses in surviving carbon sink capacity (Global Carbon Project 2008). Whilst the figure presents a static “snapshot” from 2007, global emissions continue to increase and this is indicated by the upward-pointing arrow immediately following the emissions figure. In 2007 the Earth system sequestered 55% of anthropogenic emissions, leaving 4.5 PgC of emissions remaining in the atmosphere (Global Carbon Project 2008). In Fig. 6.1 this is represented as 2007’s contribution to future climate damages returning to the global economy as changes to familiar and reliable weather and climatic conditions. Future climate damages will result from shocks such as extreme weather events, and stresses such as longer-term impacts such as changes in the location and viability of agricultural zones.

As total anthropogenic emissions continue to accumulate the Earth system’s efficiency in sequestering emissions is reducing (Global Carbon Project 2008). In combination with increasing emissions, this suggests an increasing rate over time of global emissions that remain unsequestered, indicated by upward-pointing arrow immediately following the emissions figure.

In Fig. 6.1 the inter-system relationship between the global economy and the insurance system is dominated by a cycling of financial risk. The socio-economic function of the insurance system is to assume financial risk. The insurance system pools and transfers risks across the economy. Ultimately, the insurance system is wholly nested within the economy, and therefore financial risks, even when shifted via the insurance system, remain internal to the economy. Traditional examples include insurers’ substantial investments (in the case of the insurance industry) and governments’ treasuries (in the case of social insurance). More recently insurers have also begun to spread risk outside of the insurance system and onto capital markets through catastrophe bonds and other financial instruments collectively known as insurance-linked securities (Phelan et al. 2010). This allows access to the greater financial capacity of capital markets, and also demonstrates the cycling of financial risk between and across the insurance subsystem and the broader economy.

³1 Pg (petagram) = 1 billion (or 1,000 million) tonnes.

The focus of this paper is the theoretical potential for gearing the insurance system to drive or at least support cuts in anthropogenic emissions from the economy sufficiently rapidly and deeply to avoid dangerous climate change. In Fig. 6.1 this system interaction is also located in the relationship between the insurance system and the economy and represented by the downward arrow.

The insurance system is depicted as nested within the global economy, and in turn within the Earth system. Financial risk cycling (semi-circular arrows) by the insurance system pools and spreads climate (and other financial) risks across the global economy. Reflexive mitigation action by the insurance system may create beneficial dampening (or negative) feedback effects between the insurance system and the global economy (downward arrow from the insurance system to the global economy), and so encourage or even drive reduction in anthropogenic emissions from the global economy. The value of insurance system activity in 2007 is at least US\$8 trillion⁴ or 15% of the global economy, valued that year at ~US\$54 trillion.

The Earth system incorporates the physical and chemical environment, the biosphere and also all human activities. The Earth system is without substitute and for the purposes of our analysis the Earth system remains unvalued in financial terms. Current anthropogenic CO₂e emissions and future climate damages are the key interactions between the global economy and the Earth system (this figure represents CO₂ only, the major greenhouse gas). In 2007 the atmospheric “insult” from the global economy comprises CO₂ emissions totalling ~8.5 PgC⁵ and destruction of CO₂ sinks of ~1.5 PgC totalling an additional 10 PgC. “↑.” In 2007 around 45% of CO₂ emissions remained in the atmosphere, destined to return to the global economy as increased climate-related damages. The proportion of CO₂ emissions that remain unsequestered by the Earth system is also increasing over time, also indicated by an “↑”. Stern (2006) estimates future climate damages in the order of 5–20% of global GDP each year in the absence of strong mitigation.

Why Mitigation Is a Necessity for Insurance Systems

“Insurance is a means of constructing the promise of economic security in a precarious and uncertain world.” (Knights and Vurdubakis 1993, p. 734). Yet the insurance system is a human–social system and not immune to the impact of anthropogenic climate change on Earth system stability. Fundamentally, financial risk in the global economy is manageable in the Earth system because of familiar system stability. Where the system remains in a familiar and stable state, past experience provides a reasonable guide for future experience. However a changing climate renders the Earth system unstable and characterized by unpredictable change (Schneider 2004).

⁴1 trillion = 1,000 billion.

⁵1 Pg (petagram) = 1 billion (or 1,000 million) tonnes.

On a timescale of interest to humans and our societies, the sum of climate change-related feedbacks in the Earth system is positive, i.e. climate change leads to feedbacks that reinforce rather than dampen changes in the climate (Allen and Frame 2007; Roe and Baker 2007). With warming, net positive feedback leads to further increases in warming so that climate pushes the Earth system further away from a familiar stable state to an alternate state which, whether stable or unstable, is unfamiliar. The non-linear quality of the change means the rate of the shift is continually increasing. Some aspects of non-linearity are reflected in recent predictions of the magnitude and timing of climate change impacts: in practice observed rates of climate change are repeatedly underestimated (Phelan et al. 2010). Additionally, Earth system thresholds means rates of change are uneven and unpredictable. Over time, increasing unpredictability tends to undermine the viability of the insurance system (Phelan et al. 2010).

Insurance responses to climate change to date are generally adaptive and weakly mitigative (Phelan et al. 2010). On the basis of a strictly linear understanding of insurance, adaptation measures appear as reasonable insurer responses to the threat of catastrophic losses. Adapting the insurance system to climate change allows greater capacity to take on risk short term. However, given the Earth system is a non-linear system, the long-term viability of adaptation strategies is limited. What appears to be an adaptation may in fact prove to be a maladaptation. In Sect. 6.3 we make a normative argument for the insurance system to pursue a strongly mitigative path. In contrast, Sect. 6.4 describes the current adaptive and weakly mitigative trajectory of the insurance system with reference to climate change.

Reflexive Mitigation: A Viable Insurance System Approach

Reflexive mitigation offers the insurance system's an alternative to adaptive and weakly mitigative responses to climate change. In this section we apply a four-phase *adaptive cycle* (Holling and Gunderson 2002) used to represent the evolving state of social–ecological systems, to demonstrate change in the insurance system as it travels a reflexive mitigation path. The adaptive cycle has been developed as an heuristic to explain change processes in social–ecological systems.

In this section we make a normative argument: reflexive mitigation ought to be pursued by the insurance system because in contrast to adaptive and weakly mitigative approaches, it offers the potential for ongoing viability of the insurance system. Given broader human societal reliance upon the insurance system, the approach supports the insurance system to make a significant contribution to the sustainability of human–social systems more generally, consistent with insurance's role as society's primary risk manager. The section concludes with a brief note on the relationship between climate change mitigation and adaptation measures.

Our argument is that reflexive mitigation is an ecologically effective – and therefore strategic – response to climate change. We use the term *reflexive* in two ways. First, in the Beckian (Beck 1992, 1995) sense: climate change is a creation of our own

making, rather than a risk originating in the natural world. Further, climate change risk is large-scale and challenging spatially (i.e. global) and temporally (i.e. multi-generational in the making, requiring at a minimum many decades to mitigate, with varying aspects of the phenomenon manifesting at varied timescales, and with some committed impacts effectively permanent (Solomon et al. 2009). Climate change is a characterizing feature of Beck's late-modern civilization. The obvious corollary to this analysis is that halting and reversing anthropogenic climate change centres on changes in human–social systems.

Second, using the term *reflexive* emphasizes that we advocate adaptive policy-making (TERI and IISD 2006) in relation to mitigation. Such an approach recognizes that the Earth system, the global economy and the insurance system are connected social–ecological systems at varying scales. Accordingly (1) maximum atmospheric CO₂e concentrations consistent with achieving and maintaining Earth system stability will vary over time in response to changes in the Earth system, the global economy, and the relationship between them; and (2) relationships between the Earth system and smaller component systems including the global economy and the insurance system are evolving and therefore understanding of them is necessarily, and permanently, incomplete.

Ecologically effective mitigation refers to mitigation that delivers cuts in anthropogenic emissions sufficiently rapidly and deeply to avoid dangerous climate change. Industrialization has produced a rise in atmospheric CO₂e concentrations from pre-industrial levels of 280 ppm to current levels of 385 ppm – and concentration levels continue to rise. In contrast, a drop in concentrations to at least 350 ppm – and perhaps lower – is required (Hansen et al. 2008). A reflexive approach to mitigation aims for specific atmospheric concentration levels whilst acknowledging that scientific understanding of what levels are necessary will likely continue to change.

Figure 6.2 presents a reflexive mitigation scenario for the insurance system. The initial *conservation* phase describes the current state of the insurance system: the system has accumulated substantial financial and intellectual capital, is founded on a linear understanding of the Earth system, and is viable on the basis of the Earth remaining in a familiar and relatively stable state, where past experience provides a reasonable guide to future experience. The insurance system is therefore vulnerable to anthropogenic greenhouse gas emissions pushing the Earth system out of its current familiar and stable state.

Potential *release* phase events are combinations of sudden shocks and accumulated stresses, originating in climate changes in the larger Earth system, that increase the insurance system vulnerabilities indirectly through impacts to the global economy as well as directly. Shock events include weather catastrophes such as floods and heatwaves (Allen et al. 2007). Stress events include climate impacts such as multi-year droughts, effectively permanent shifts in rainfall patterns, and sea-level rise (Solomon et al. 2009). Climate change impacts can cascade through the global economy, impacting the insurance system in multiple ways. Over time uncertainty increases and predictability and insurability decrease. Insurance system stability decreases, as does societal faith in the insurance system.

Fig. 6.2 An alternative path for the insurance system: reflexive mitigation and insurance system sustainability. Source: Adapted from Holling and Gunderson 2002, p. 34

The four-phase adaptive cycle is an heuristic developed to explain change processes in social–ecological systems. It is applied here to demonstrate the insurance system's potential transition from a linear to a non-linear operational basis. The cycle begins (at “1”) with a description of the insurance system in its current form, characterized by a linear understanding of the Earth system. In the current *conservation* phase, past experience remains a reliable guide to future experience, giving meaning to terms such as “1 in a 100 year flood.” The *release* phase (at “2”) sees the insurance system's resilience undermined by unanticipated climate change-driven shocks and stresses, reflective of climate change having pushed the Earth system from a state of relative predictability to relative unpredictability. The implications of climate change on the insurance system are acknowledged and the *reorganization* phase (at “3”) sees the insurance system rebuilt on a new foundation which recognizes (1) the Earth system is a complex adaptive system, and (2) interdependence of systems, and in particular, the dependence of the insurance system and the global economy on the Earth system remaining in a stable and familiar state. The *exploitation* phase (at “4”) sees the insurance system geared to climate change mitigation through rapid and deep cuts in greenhouse gas emissions and protecting surviving carbon sinks. New governance arrangements see the insurance system used to encourage the alignment of the global economy with Earth system limits. Climate change is effectively mitigated and the insurance system enters a new *conservation* phase (at “5”), remaining viable on the basis of the Earth system remaining in a stable and familiar state.

At the *reorganization* phase, a new sustainable foundation for the insurance system is created, grounded in acceptance of system non-linearity, system interdependence, and in particular, the dependence of the insurance system and the global economy on

the Earth system. This implies substantial change to insurance system structure and practice. The insurance system disengages from climate change risk-creating activity (e.g. insuring and investing in the fossil fuel sector). This action alone supports reflexive mitigation policy and action in other social–ecological subsystems that are components of the overall economy. Instead, the insurance system is reoriented around strongly mitigative and adaptive approaches to climate change.

At the *exploitation* phase, characterized by rapid growth, the insurance system is fully geared to mitigate climate change through supporting cuts in emissions and protecting surviving carbon sinks. The global economy is rapidly decarbonized. Such a shift is not wholly due to changes in the insurance system, however the larger change process in the global economy creates new risk management and opportunities for the insurance system. This is a significant shift for the insurance system and for the economy overall, and is achieved through many failures and some successes. Managing financial risk remains an important function in the economy.

This path leads to a genuinely new *conservation* phase, characterized by accumulation of financial and intellectual capital, where the insurance system is reconstituted on the basis of a non-linear understanding of the Earth system and recognition of system interdependence, and remains viable on the basis of the Earth system remaining in a familiar and stable state. A decarbonized global economy implies significant socio-economic change, include the nature of risks covered and the manner in which they are covered by the insurance system.

Did a Reflexive Mitigation Path for Insurance Appear Post-Katrina?

Unprecedented events in the production and certification of catastrophe modelling in Florida in the aftermath of Hurricane Katrina can perhaps be described as an abortive transition by the insurance system to a reflexive approach to insurance in a climate-changed world. The Florida Commission on Hurricane Loss Projection Methodology (FCHLPM) was created in 1995 to evaluate computer models and other recently developed or improved actuarial methodologies for projecting hurricane losses, to ensure reliable projections of hurricane losses so that rates for residential property insurance are neither excessive nor inadequate (FCHLPM 2009). Catastrophe loss modellers submit their loss models to the FCHLPM annually for accreditation. Once accredited, loss modellers can provide their models to insurers as a basis for pricing hurricane risk.

In April 2007 the FCHLPM refused to accept Risk Management Solutions (RMS) RMS's US Hurricane Model (version six) because it gave more weight to higher levels of hurricane activity in recent years rather than simply averaging hurricane activity over the longer term (RMS 2007). The standard approach since the first generation of hurricane catastrophe loss models has been to base hurricane activity rates on the "average of history" (Muir-Wood and Grossi 2008, p. 310). In the US this generally means the period since 1900. However, in the period since 1995, and in comparison to

the period 1970–1994, hurricane activity in the Atlantic basin has increased by 60%, with an increase in intense category 3–5 storms of 120%. In 2004 and 2005, storms including Katrina also made landfall in the US. “Acknowledging that the long-term historical baseline is no longer the best measure of current hurricane activity means it is necessary to be explicit about the intended time horizon of the catastrophe model” (Muir-Wood and Grossi 2008, p. 311). From a CAS perspective, the more important point is it also means acknowledging non-linearity in the Earth system.

After refusal, a modified model incorporating the standard long-term historical baseline was submitted, which the FCHLPM subsequently accepted. The impasse was resolved simply by RMS complying with the provisions of the law. Nevertheless RMS continues to assert that the medium-term basis for projecting hurricane activity is better than the traditional long-term basis (RMS 2007). This highlights questions of sustainability of the insurance system in the longer-term. Muir-Wood et al. (2006) suggest that after accounting for changes in population and wealth, changes in extreme weather events may be responsible for a growth in insured losses by about two percent a year since the 1970s, and that this corresponds with rising global temperatures (Muir-Wood et al. 2006; Ward et al. 2008).

A Stable Basis for Adaptation with Grace

We argue that mitigation and adaptation approaches are linked: effective mitigation is a precondition for effective adaptation. We consider *adaptation with grace* as effective adaptation undertaken in an orderly and planned manner, embodying important principles of justice and equity, and with some hope of longevity. Adaptation with grace is wholly dependent on relative system stability provided by reflexive mitigation.

Adaptation to anthropogenic climate change in support of human welfare is necessary, given manifest climate change impacts and existing warming commitment in the Earth system (Hansen et al. 2008). Limits to climate change impacts – and therefore a basis for effective adaptation over the longer-term – relies on urgent mitigation action so that the Earth system remains in its current familiar and stable state. In the absence of familiar Earth system stability, potential adaptation efforts will be limited to *ad hoc* and reactive measures with reduced prospects for reflecting widely-shared ideas of fairness and equity, and with the term of benefits constrained by further changes in the Earth system.

Adaptation to Climate Change: Business-as-Usual

Attempting to survive changed circumstances under varied, even extreme conditions is standard practice for human beings, human institutions, and for living organisms generally. For this reason we suggest the insurance system’s generally adaptive

and weakly mitigative responses to climate change (Phelan et al. 2010) may be reasonably described business-as-usual (BAU). Adaptation measures may be characterized as proactive or reactive and may be successful or unsuccessful in result. Whatever the character or outcome of an adaptive response, adaptation is always a reaction to context as opposed to a conscious shaping of context. In this section we reprise the four-phase *adaptive cycle* used in the previous section to contrast the insurance system's current response to climate change. The key limitation of adaptive and weakly mitigative approaches to climate change is their basis in a linear rather than non-linear understanding of the Earth system: this is the source of risk in the approach.

In conceptualizing the insurance system pursuing an adaptive, BAU path, the initial *conservation* and *release* phases representing the current state of the insurance system and the impact on the system of climate risks are common to both the adaptation scenario and the mitigation scenario explored previously.

Paths diverge at the *reorganization* phase: in the BAU scenario, the extent of reorganization is minimal and the linear understanding of insurance remains. The insurance system adapts by making internal changes to compensate for climate change impacts to the global economy and to the insurance system itself. The system overall and elements within it are rebuilt and consolidated around reset linear understandings of the Earth system and cross-scale interactions. Examples include recalculation of maximum probable losses, increases to deductibles and limits to cover, industry withdrawal of cover from high-risk areas in extreme cases, and governments establishing state-backed insurance schemes to compensate for industry withdrawal. The insurance availability crisis is understood and responded to as a market failure and is not recognized as a system failure and instead: from this perspective, industry consolidation and government bailouts appear to be sound solutions. The insurance system have travelled this path previously, in relation to climate change and other risks. Examples include: insurers withdrawing cover for hurricane damage in Florida; and governments instituting state-backed insurance coverage in the face of industry withdrawal (Mills et al. 2005).

At the *exploitation* phase adaptive responses include efforts to increase capacity for accommodating risk internally to the insurance system and efforts to shift risk up scales beyond the insurance system. Examples include recalculating estimates of maximum probable losses on a linear basis, risk swaps to spread uncorrelated risks such as hurricanes in the Caribbean and earthquakes in Japan (Cummins 2007), and insurers creating insurance-linked securities is one example noted above. Shifting financial risk up a scale from the insurance system to the global economy without effectively dealing with the source of climate risk comes at a price: larger-scale risk and therefore higher stakes. The 2008 Global Financial Crisis is an example of larger-scale risk impacting the global economy as a whole and with specific implications for insurers by virtue of inter-system linkages. Whilst successful adaptive measures can increase system capacity to manage financial risk in the short term, they mask the cost of larger-scale failure later.

At the second iteration of the *conservation* phase, the "new" state of the insurance system resembles the previous state. The risks to insurance system

viability are greater. Over time the cycle of system collapse and rebuilding is repeated, perhaps at accelerating frequency, and certainly at greater magnitude. Overall the potential for viable the insurance system is much more constrained: repeated shocks and accumulated stresses take their toll on the overall system. Ultimately, insurance system resilience is undermined to the extent the system flips into an alternate state. Even as the current state of the system no longer remains, it may be that insurance in some form remains viable. For example, insurance for risks could remain viable at significantly reduced geographic and temporal scales. Insurance for total losses may be replaced by partial loss insurance. Thus BAU insurance system responses constitute a high-risk approach to climate change, one in which the longer-term viability of the insurance system overall is unclear.

Conclusion

We suggest the future viability of the insurance system in its current state is dependent on decarbonizing the global economy. A CAS analysis demonstrates this by highlighting the non-linearity of the Earth system as a complex adaptive system, and linkages between the Earth system, the global economy, and the insurance system. In contrast, the insurance system currently operates on the basis of an incompatible linear understanding of the Earth system. In this context apparent adaptive responses of the insurance system to climate change may prove to be maladaptive responses. Adaptation is not an ecologically effective response to climate change for social–ecological systems nested within the economy, including the insurance system.

The implications of this conclusion are profound. Insurance formalizes risk pooling and shifting. Given contemporary societal reliance on insurance, large sections of the global economy would be radically reshaped were the insurance system substantially transformed, or were access to insurance to become more difficult. Depending on the extent and pace of the transformation of the insurance system, this might imply rapid socio-economic change on an unprecedented scale.

Despite insurance's long history (Pfeffer and Klock 1974; Trennery 1926), large populations globally continue to survive with minimal engagement with formal the insurance system such as the welfare state and insurance markets. As we've argued, attempted adaptation is possible under all sorts of conditions. Risk sharing is also arranged informally, for example within families and communities. Societies can exist without insurance systems: even the end of insurance as we know it does not mean the end of human societies.

The insurance system may still function if pushed into an alternate state, though perhaps in a way that is currently unrecognizable. For example, insurance coverage may be available but in a substantially reduced form. This includes reductions in the spatial and temporal scales at which insurance operates, the type and magnitude of risks that are insurable, and the degree of compensation available for losses.

Decarbonizing the global economy is an extraordinary challenge but one that the insurance system can address proactively. Commitments to carbon use in human–social systems are infrastructural, financial, political economic and socio-cultural. The insurance system is as ensnared by such commitments as other sectors in the global economy. In contrast, the existing warming commitment in the Earth system implies processes and impacts that cannot be wound back: commitments to warming already present in the Earth system are non-negotiable. Forcing the ecologically necessary shift in the global economy is an enormous challenge, but an attractive one to the extent that it offers an upper limit to climate impacts.

The challenge of decarbonizing the global economy calls for thinking at large scale, spatially and temporally. The insurance system alone cannot achieve this; equally, decarbonizing the global economy will not be achieved without a full contribution from the insurance system. Reflexive mitigation is proposed here as an insurance system response to climate change. It may be that reflexive mitigation strategies are appropriate for other social–ecological subsystems of the global economy also. Successful reflexive mitigation of climate change holds out real prospects for effective adaptation to climate change, adaptation with grace.

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