AXA

XL Reinsurance

Optimising Disaster Recovery

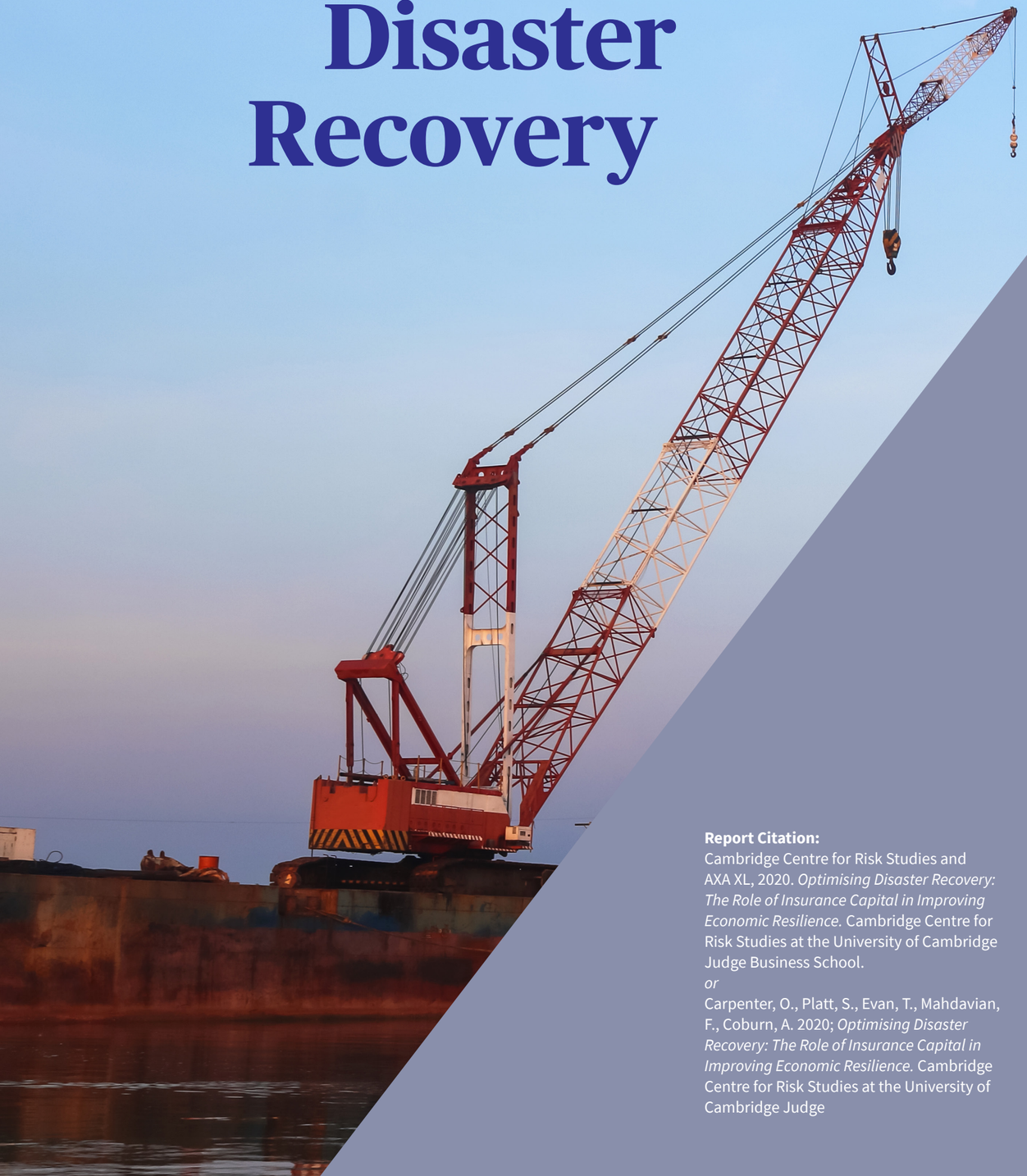
The role of insurance capital in improving economic resilience

In cooperation with

Centre for **Risk Studies**

UNIVERSITY OF CAMBRIDGE
Judge Business School

Optimising Disaster Recovery



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Contents

Foreword: To act for human progress by protecting what matters

Putting communities impacted by disasters back on their feet as quickly as possible, and in a better state, is just one example of how we make AXA's purpose a reality. (Re) insurers immediately inject capital into disasters in a structured and coordinated way (through insurance companies and their claims adjusters), complementing federal and local government, aid organisations, and impacted communities' own initiatives. This allows these communities to get back to normal quicker and in a more resilient position than before, with no debt overhang. The case for (re)insurance is clear but is seldom adequately explained.

We have collaborated with the Cambridge Centre for Risk Studies ("CCRS") at the University of Cambridge Judge Business School on multiple projects over the past 10 years, but we wanted to take more time to assess the impact that (re)insurance has on the speed and quality of recovery following a climate disaster or earthquake. This report looks at over 100 case studies, mainly occurring in the last 30 years and varied in terms of geography and the income levels of impacted communities. We wanted to bring out comparative information related to speed of recovery – how quickly employment and productivity returns to normal (economic) and how quickly people are back in their houses and power is restored (societal). We also wanted to focus on the quality of recovery, that is whether the post-disaster normal is better than the pre-disaster state in terms of the economy and the resilience of the community to future events from the perspective of infrastructure and economic resilience.

The report is deliberately comprehensive, and we have published a number of individual case studies alongside to understand complex issues on significant losses in more depth. We also plan to make the disaster event catalogue research available to all online and will build on the work by chronicling the historic development of future losses. The gap between well managed and badly managed disasters is striking and unfortunately it is always the poorer communities who bear the brunt, be it in developed or emerging economies.

A few facts from the report that stand out:

- Each percentage point increase in insurance penetration (non-life premiums divided by a country's GDP) reduces recovery times by almost 12 months.
- Events in countries with high insurance penetration (3% - 4% includes Western Europe, Japan, Australia, South Korea) have an average recovery rate of less than 12 months and events in countries with very low insurance penetration (Bangladesh, Haiti, Nepal, Philippines) have a recovery rate of more than 4 years.
- The US is anomalous – the US enjoys very high insurance penetration (>4%) but the fragmented nature of coverage, particularly flood, disaster response and scale of loss has resulted in a recovery rate average of just over 3 years (Andrew, Great Mississippi and Missouri Floods, Northridge, Katrina, Sandy).
- The quality of recovery for very high and high insurance penetration countries is better than pre-loss levels, and the reverse is true for countries with lower insurance penetration although the differences are quite small. There is potential for product development in terms of "building back better".

Each percentage point increase in insurance penetration reduces recovery times by almost 12 months

- Economic recovery is faster than societal recovery in almost 60% of the cases and is particularly pronounced in the first six months. The standouts are German flooding in 2013, with more than 600,000 affected and 80,000 displaced people recovering to economic and societal norms within 12 months, and Haiti suffering an earthquake in 2010 from which it has yet to recover.
- Speed and quality of recovery are not mutually exclusive – CCRS have identified a number of cases satisfying both outcomes.

There is much more detail in the report together with specific examples of good and bad disaster response.

Climate risk is at the heart of this study, and it is important to remember that risk is a function of hazard, exposure, and vulnerability. Changes in climate risk are not just driven by a changing hazard; understanding exposure change and the vulnerability of that exposure as values and wealth builds in cities, particularly in emerging economies, is critical to understanding the ever-increasing gap between economic loss and insured loss. It is incumbent on the (re)insurance industry to stimulate demand to provide protection to those poorer communities, which are usually the most affected, by reducing the gross cost of (re)insurance, be it by: reducing losses by investing in resilience; reducing expenses and cost of distribution; bringing cheaper capital to bear; and, developing insurance and reinsurance exposure where there is none currently. It is also incumbent on governments to understand what good and bad disaster management looks like, including "building better before" (better planning regulations), investing and encouraging resilience, disaster planning, and collaborating with the insurance industry to increase insurance penetration levels.

The quality of recovery for very high and high insurance penetration countries is better than pre-loss levels

This report shows pre-disaster financing (predominantly (re)insurance) with the ability to channel significant funds instantly and without recourse as the single biggest solution to catastrophic events. Unfortunately, private insurance penetration is not at sufficient levels, government pools do not have sufficient capacity, and disaster management is generally not coordinated or thought through enough. Good disaster management means reformative recovery within 12 months and bad disaster management may mean never recovering.

We are very grateful to CCRS and the team who have worked on this report for the last three years.

Please take time to read and study the report.

Jonathan Gale
Chief Underwriting Officer, Reinsurance, AXA XL

Section 1: Introduction

1.1 Trends in the Incidence and Cost of Disasters

Global economic losses from natural disasters are significant and increasing. In economic terms, the global annual average loss has risen by an order or magnitude (from an average of US$27 Bn in 1970-80 to nearly $200 Bn in 2010-19)[1] so that yearly totals in the hundreds of billions are the norm. This growth in catastrophe losses is primarily driven by global economic development and the accumulation and increasing value of assets in hazardous areas, particularly in fast-growing regions such as South East Asia. The greatest destruction is caused by earthquakes and tropical storms; 2011 remains the costliest disaster year on record, due the Tōhoku earthquake and resultant tsunami, followed by 2017 with its record Atlantic hurricane season. The insurance industry is growing accustomed to extreme years in which several major catastrophes occur in a single year.

The incidence of natural disasters is also growing, primarily driven by a higher occurrence of climate-related hazards, notably floods and storms. In the period 1979-2019, over 80% of hazard events were weather-related (floods, storms, extreme temperatures, drought, and wildfire). Global flood occurrence was about three times higher in the last decade than in the 1980s, while storm frequency (including tropical, extra-tropical, and convective storms) nearly doubled.[2]

The scientific field of extreme event attribution increasingly supports the link between cases of damaging weather events and human-induced climate change, and there is clear evidence that climate change is making certain extreme weather events more likely and more severe, especially those linked to heat.[3] Studies exist linking climate change to various types of recent catastrophes, including extreme temperatures, floods, wildfires, drought, and storms. However, moving from the detection of recent trends in event incidence to climate change attribution is complex, and it remains a challenge to identify a clear signal of climate change above the noise of natural variability. In recent history and the near-term future, the increasing exposure of people and assets to natural hazards through macro trends in economic development, population growth, and urbanisation remains the greatest driver of growing risk and economic loss.

Emerging economies are significantly more exposed to disasters than developed countries. Due to its geographic features and exposure to various natural hazards, Asia (particularly rapidly growing economies in South East Asia) has been affected the most in terms of disaster frequency and population disruption, while the Caribbean region has experienced the highest losses globally as a share of GDP. The average annual loss from disasters between 1980-2015 was 1.5% of GDP in emerging markets versus 0.3% of GDP in developed economies.[4] Climate change will affect hazard exposures in many global regions, but low-lying coastal regions stand to bear the greatest increase in this risk as sea levels rise. These regions host one third of the world's population along with most of the world's mega-cities, have the highest population densities, and are seeing a rapid acceleration of urbanisation relative to non-coastal areas.

Developing countries are disproportionately impacted by disaster events, exposed to a variety of hazards and vulnerabilities that compound their losses in times of crisis. These economies are also less insured against natural disasters as insurance sector development is typically higher in economically rich countries. On average, around 40% of the direct loss from natural disasters is insured in developed countries, while less than 10% of losses are covered in middle-income countries, and below 5% in low-income countries.[5]

The severity of impact and improvement in recovery outcomes can be reduced by investing in resilience measures. Improved resilience can in turn stimulate economic innovation and growth through greater assurance and stability. Transferring the risk through insurance purchasing is a critical and cost-effective mechanism to improve resilience. Insurance enables fast, effective, and equal distribution of finance following a disaster, reducing the reliance on ex-post financial aid. Nevertheless, many countries are reluctant to invest in resilience, due to higher up-front costs, misaligned incentives, and a lack of knowledge and clear evidence to justify spending. Despite this, it is paramount to consider the strong and proven cost-benefit arguments in favour of investment – on average, ex-ante investment in resilience outweighs the costs by a ratio of four to one.[6]

1.2 Report Overview

This report examines one of the greatest challenges facing the global insurance industry and wider society – the significant divide between economic losses and insured losses, commonly called the protection gap. This gap exists prominently in developing nations, including some of the regions most exposed to frequent and major disasters. Perhaps more surprisingly, a major protection gap also persists in some of the most developed parts of the world, where many people still choose to go without insurance coverage. As the protection gap continues to widen, there is an imperative for a collective will and effort on the part of insurance industries, governments, international organisations, academia, and beyond, to seize the opportunity that investing in resolving this protection gap provides.

To build the case for committing time, funding, and resources to address the issue of bridging the protection gap, it is critical to substantiate the role of insurance in addressing the post-disaster needs of affected populations and building resilience. Insurance is a reliable means of planning for events with pre-disaster finance, with the capability to compensate claims quickly. It is generally acknowledged that, following a disaster, areas with a high uptake rate and utilisation of insurance have a faster rate of recovery than those with a low uptake rate. However, the evidence that supports the idea of insurance effectiveness in improving this rate of recovery is sparse and largely anecdotal, and there is a need to better quantify the relationship between insurance penetration and an affected region's recovery time following a disaster.

The role of insurance in recovery must be considered in the context of a broader understanding of the dynamics of disaster recovery. This involves assessing the importance of the various controls on recovery, including pre-disaster socioeconomic conditions and the states of governance, preparedness plans, and policies, as well as post-disaster emergency response and recovery decision-making, and the sources, speed, and adequacy of post-disaster recovery funding.

To explore the controls on disaster recovery, this report examines a significant number of global natural disaster case studies in detail. By analysing and comparing a diverse range of cases of recovery – with contrasting narratives of success and failure or fast versus slow recovery – we can better understand how insurance influences the rate and quality of recovery and how enhanced insurance penetration could improve outcomes for future catastrophe relief.

The report is structured as follows:

- **Section 2** explores the economics of natural disasters, discussing the mechanisms and dimensions of disaster impacts in terms of capital loss and disruption of economic output. The insurance protection gap is discussed in detail.
- **Section 3** provides the theoretical overview of disaster recovery: how recovery is defined and measured, and what factors influence recovery outcomes, including the role of insurance.
- **Section 4** gives an overview of the research approach of this study, introducing detailed recovery case studies and the disaster recovery event catalogue introduced in this work.
- **Section 5** explores the findings of this research, addressing the recovery outcomes of studied cases and the influence of key controlling variables, including disaster risk management and resourcing.
- **Section 6** discusses the protection gap in the context of these findings, assessing the potential opportunities and challenges facing the insurance industry in regard to disaster risk.

1 Inflation-adjusted 2016 US$ (Swiss Re 2020)
2 (EM-DAT and CRED / UCLouvain 2020)
3 (IPCC 2014)
4 (Moody's 2016)
5 (Moody's 2016)
6 (Mechler 2016)

Section 2: The Economics of Disasters

2.1 Economic Impacts of Disasters

Disasters disrupt the business activities of entire regions and can halt or weaken the economic output for lengthy periods of time, taking several years for the economy to recover, due to complications in exposure, vulnerability, and coping capacity. The effects can be immediate and localised, but are often prolonged and widespread, stressing the resource capacity of a society and often demanding external assistance. They have wide-ranging effects on real economies due to loss of life, livelihoods, and property. Major disasters are often followed by localised cost inflation resulting from a sudden increase in demand for certain goods, particularly repair and reconstruction resources, that outstrips supply. Weakened economies are more vulnerable to any other shocks that may occur coincidentally during the recovery period, and, where disaster event/s occur frequently, conditions of social and economic vulnerability are perpetually amplified.

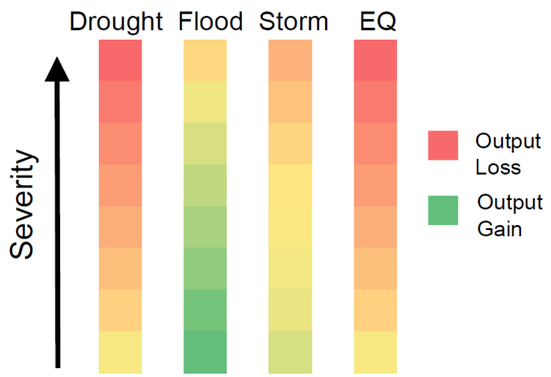
However, disaster events with contrasting characteristics affect economies in different ways. In general, storms and earthquakes are destructive and primarily impact physical capital, while floods and droughts disrupt productivity. There is also evidence to suggest that natural disasters are also able to promote long-term economic growth, in a process of 'creative destruction'. For example, floods may positively impact agricultural output, in turn leading to industrial growth. Other types of events may have similar effects where decisions are made to 'build back better', particularly via an injection of capital into an economy.[7]

Recent major disasters have demonstrated that physical damage no longer represents the only significant impact from a catastrophe. Indirect losses, such as business interruption, contingent business interruption, or the loss of a company's market share have assumed completely new dimensions. Increasingly, these losses are not limited to the damaged region but felt throughout globalised trade and finance systems. In the biggest catastrophes, the interconnectivity of modern business means that the spill-over effects result in consequential amplifiers of this shock throughout the global economy.

Very few historical catastrophes have caused measurable major macroeconomic effects at national or global scales. Nevertheless, a closer look at the economic impact of a disaster can show a more complex picture, with severe and disparate effects on affected regions and sectors of their economies. Inevitably, disasters have negative consequences on most within their radius, but there are winners as well as losers, with disparities favouring the sectors that gain from future reconstruction investment, and competitors of disrupted business gaining market share.

Disasters have further economic impacts where they are compounded by follow-on catastrophes. The 2011 Tōhoku earthquake in Japan triggered a tsunami that caused a nuclear meltdown. Similar cascading catastrophes can magnify the impact of a trigger event, such as widespread and lengthy power outages and disruptions to communications and information technology that would greatly amplify economic loss. Natural catastrophes and laboured recovery periods are also closely interconnected with geopolitical crises, and have resulted in social unrest, political and civil disorder, regional conflicts, and interstate wars.

Figure 1: Impact varies by disaster type, and disaster may even have a positive affect on economic output.
Based on findings from Skidmore and Toya 2002



7= (Strulik and Trimborn 2019; Skidmore and Toya 2002)

2.2 Physical Destruction vs Economic Output Loss

The most notable impact of natural catastrophes is the damage and destruction of physical assets, including property, machinery, and infrastructure. The severity of such impacts is typically measured in terms of the total cost of destroyed physical assets, usually as a repair cost, reconstruction estimate, or lost value of damaged property. This is also referred to as the economic loss, or 'ground-up loss', of which an insurance payout typically covers only a proportion of the total cost.

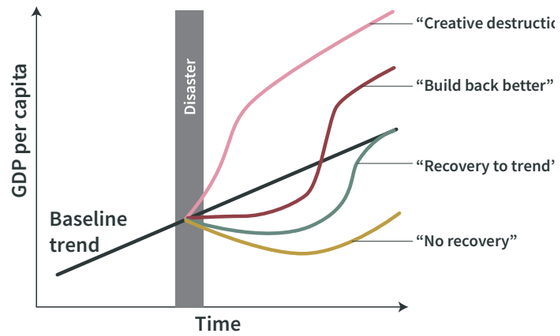
Estimates of the economic losses from an event may also account for business interruption (BI) loss, which is a limited value of lost revenue attributed to dependency on buildings damaged beyond usability. Insurance coverage often indemnifies business interruption loss from a damaged commercial property, so may be included in the calculation of economic loss as an input into the estimate of insurance liability.

BI does not typically capture all the lost economic output that results from a disaster event, and so the calculation of an initial destructive cost is distinguishable from the 'loss of economic output'. Economic output is lost during an event when the physical means of production are directly disrupted, or are unable to function due to the disruption of power, transportation, or utility infrastructure, or the labour pool is affected, displaced, and unable to work. Further, demand for goods typically reduces in the aftermath of an event as urgent needs shift and affected people endure a loss of earnings, thereby increasing the economic impact of the event. In the response and recovery phases of a disaster, stimulating a local economy by investing in reconstruction can alleviate the loss of economic output.
In economic terms, the difference between destructive cost and loss of economic output is one of 'stock' versus 'flow'. A natural catastrophe typically causes a major stock loss and, as a result, also causes a flow loss. The full impact of an event is the combined total stock and flow losses.

Flow loss is much more difficult to assess than stock loss and requires an understanding of the complex economic characteristics and dynamics of the recovery process. It is the product of a variety of controlling factors, including economic conditions prior to an event, as well as management decisions and financial interventions made in the immediate response to and subsequent recovery from a disaster. The trajectory of flow losses can vary significantly between individuals, locations, or sectors, with winners and losers, and response successes and failures. Assessing flow loss must therefore account for a diverse array of impacts throughout the recovery process, and flow loss can only be fully accounted for on completion of recovery.

Prior literature on the subject of long-run effects of disasters on income converges on four competing hypotheses that describe how economic output responds: '**creative destruction**', whereby an economy's growth is temporarily stimulated as demand for good increases and lost capital is replaced; '**build back better**', arguing that growth initially suffers but a gradual replacement of lost assets with modern units has a positive net effect; '**recovery to trend**', with a loss of growth for a finite period and subsequent rebound causing income to converge back to the pre-disaster trend; and '**no recovery**', whereby disasters slow growth and the various recovery mechanisms fail to outweigh the negative effects of lost capital.[8] The actual behaviour of economies in respect to these hypotheses remains widely disputed.

Figure 2: Four hypotheses that describe the long-term evolution of GDP per capita following a natural disaster.
(Hsiang and Jina 2014)



8 (Hsiang and Jina 2014)

Historical catastrophes of the early 20th century appear to have had significantly higher destructive costs than economic output loss, even in the most advanced and industrialised economies. However, as economic growth outpaces property appreciation and becomes more dependent on the growth of service industries and intangible assets, economic productivity is becoming more vulnerable to disruption. In addition, increasingly interconnected global trading networks are amplifying localised disruption to produce regional or global economic impacts. As a rule of thumb, the economic output (flow) loss is typically multiple times the destructive (stock) cost of the event. It is possible that, with further development, the largest natural catastrophe events of the future may amass even greater economic output losses far exceeding the destructive cost.

2.3 Macroeconomic Impacts

At the national level, natural disasters can directly impact a country's economic strength, government fiscal strength, and external vulnerability to catastrophe shocks. However, impact varies by disaster severity, as it may be that only the largest events matter in terms of GDP loss. Felbermayr and Gröschl (2014) found a non-linear relationship between disaster intensity and growth, lowering GDP per capita temporarily: a disaster in the top 1-percentile of the disaster index distribution was found to reduce GDP per capita by at least 6.8%, while the top 5-percentile disasters cause per capita income to drop at least by 0.33%.

The primary mechanisms of macroeconomic impact are summarised in the following points:

1. Contraction in economic output resulting from physical damages and loss of life and livelihoods, potentially followed by a boost to growth from reconstruction efforts;
2. Increasing poverty, as disasters disproportionately impact the poorer and vulnerable segments of society;
3. Deterioration of trade balances, as imports of reconstruction materials increase and exports suffer;
4. Downward pressure on the exchange rate and upward pressure on prices;
5. Declining fiscal balances, as tax revenues shrink with reduced economic activity and government expenditures rise to assist the emergency response and reconstruction;
6. Increasing debt-to-GDP levels, resulting from the decrease in GDP and increase in borrowing to finance the recovery.[9]

Few historical catastrophes have had major macroeconomic effects, and even the costliest natural disaster have had negligible market impacts.

Few historical catastrophes have had major macroeconomic effects, and even the costliest natural disaster have had negligible market impacts. The 2011 Tōhoku earthquake and tsunami in Japan had an estimated cost of around US$210 Bn, of which $38 Bn (18%) was insured.[10] The event caused initial market turbulence; the Tokyo Nikkei index declined 1.7% on the same day but later rallied. International markets across the world dipped slightly with European stocks down 1%, but US markets trended upwards and continued doing so after the earthquake. Hurricane Katrina made landfall in Louisiana in 2005 causing an estimated $125 Bn loss, of which $60 Bn was covered by the insurance industry. Similarly, the economic cost represents less than a single percentage point of movement on the New York Stock Exchange, and the markets were generally unmoved by the event: the S&P500 index saw an eight-day 3% rally in the days following the hurricane.[11] 2017 saw an unprecedented year of major floods, earthquakes, and hurricanes impacting major economies: including Hurricanes Harvey, Maria, and Irma in the US and southern Caribbean, an earthquake in Mexico City, and major floods and landslides in Southern Asia. Nevertheless, national economies and global trade volumes do not appear to have been impacted.

However low in probability, extreme magnitude natural catastrophes have the potential to cause major macroeconomic impacts on financial markets. Cambridge Centre for Risk Studies analysis[12] proposes a number of catastrophe scenarios resulting in the destruction of a trillion dollars of physical property and infrastructure, disrupting populations of millions of people and halting the economic output of entire regions for prolonged periods. It is suggested that such events could trigger reduced global GDP growth through spill-over effects amplifying shocks throughout global networks.

9 (Moody's 2016)
10 (EM-DAT and CRED / UCLouvain 2020)
11 (Cambridge Centre for Risk Studies 2018)
12 (Cambridge Centre for Risk Studies 2018)

2.4 The Insurance Protection Gap

The insurance market transfers risk through a hierarchal cascade of losses from the insured policyholders to the (re)insurers as the ultimate bearers of the risk. When a natural catastrophe occurs, the extent of physical damage determines the total value of economic losses.

A portion of losses are borne by the global (re)insurance market: claims first affect the primary insurers, who absorb only a part of the loss and transfer the remainder of to reinsurers. Among reinsurers, this concentrated risk is diversified through retrocession, and only a fraction of the losses are passed on to the broader financial markets and other institutions through securitisation. Therefore, (re)insurers retain most of the insured loss.

However, insured losses generally comprise only a small portion of the total loss generated by natural catastrophes. Historically, a substantial natural catastrophe insurance protection gap, defined as the uninsured portion of losses caused by a hazard event in relation to the total economic loss, has existed globally. In 2017, of the $330 billion natural catastrophe-related losses, under $140 billion (42%) was recovered through insurance. The global protection gap for natural catastrophe risk amounted to over $190 billion.

The protection gap continues to widen (Figure 4, next page). Increasing exposure to risk (represented in the figure by global GDP) is outpacing insurance uptake, leaving individuals, households, commerce, and the public sector underinsured. In absolute terms, the US, China, and Japan account for most of the global protection gap. Emerging economies, however, are subject to losses that are significantly higher in relation to their GDP, and are more vulnerable to major disruptions caused by uninsured

Figure 3: Natural disaster risk transfer within the global insurance industry

Data source: (von Dahlen and von Peter 2012); Cambridge Centre for Risk Studies reanalysis.

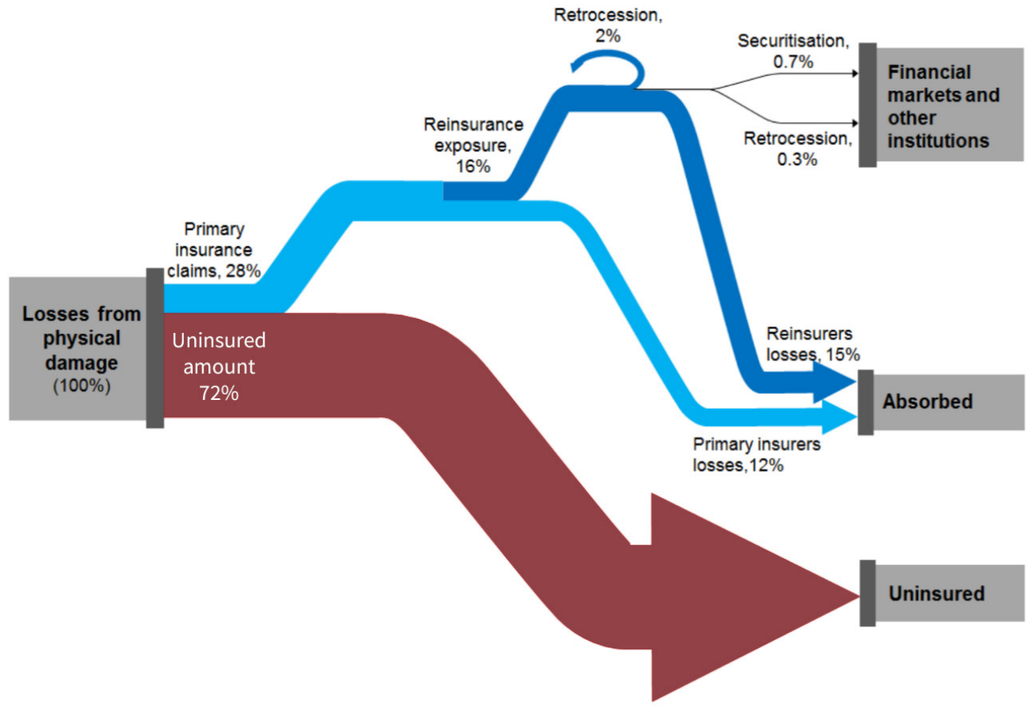


Figure 4: Global total (blue) vs insured annual (red) losses caused by natural catastrophes – the growing protection gap evidenced by divergence between these two lines – in the context of global GDP growth and the number of events, 1970-2019.
Data: (Swiss Re 2020; The World Bank 2020)

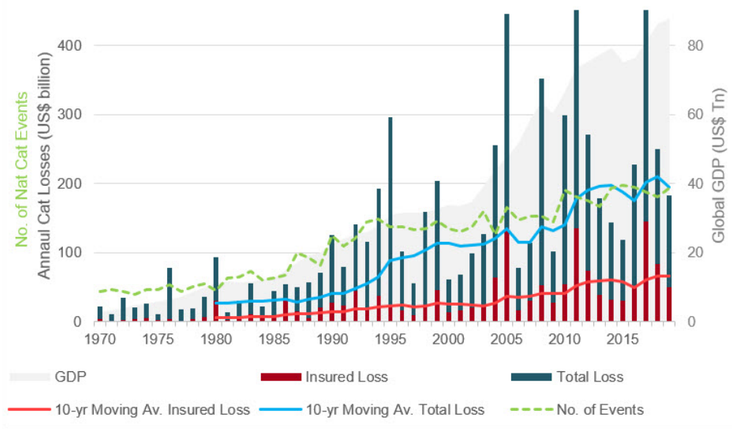
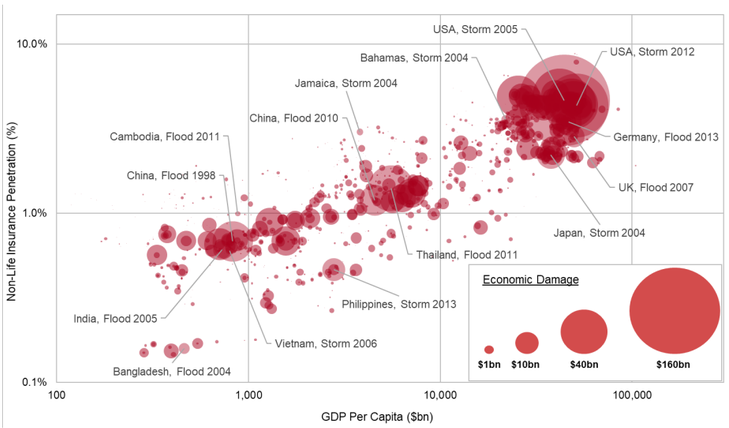


Figure 5: Natural disaster event occurrence by country non-life insurance penetration versus GDP per capita, 1990-2019. Circle size represents total economic damage.
Cambridge Centre for Risk Studies analysis.



disasters. Most of the growth in losses can be attributed to economic development and the shift of growth to underinsured emerging economies.

Figure 5 demonstrates the strong, positive control of GDP per capita on insurance penetration. Emerging economies have consistently larger protection gaps compared to developed economies. Their rapid economic growth and higher share of uninsured losses results in a global protection gap that is widening faster than GDP. Smaller, emerging economies therefore account for an increasing proportion of exposure to global uninsured losses as well as being less resilient in coping with the economic impacts caused by large catastrophes.

Generally, economic development is the most important factor affecting insurance penetration. Increased income allows for greater spending on insurance while economic development increases the stock of assets at risk, leading to greater demand for insurance to protect those assets.[13] The relationship between the insurance sector and economic growth is complex, however, and research on the insurance-growth relationship is inconclusive in establishing whether insurance development causes economic growth, or if economic growth promotes insurance penetration.[14]

13 (Holzheu and Turner 2018)
14 (Peleckienė et al. 2019)

Narrowing the protection gap demands either creating a significant reduction in the losses resulting from catastrophes, which are becoming more frequent and more severe, or increasing the proportion of these losses total that are insured. A powerful effort is required to the increase awareness, appeal, access, and affordability of insurance.[15] Insurance in developed countries is a mature, slow-growing business, while in emerging markets, increasing insurance penetration drives the growth of more resilient businesses. As countries transition from agricultural to industrial societies, cities grow in importance as the engines of economic development, changing traditional values and risk perception. Therefore, exposed assets require additional sources of financial security. Insurance offers this protection, and the concentration of potential customers in cities facilitates its growth.

15 (Holzheu and Turner 2018)

Section 3: The Dynamics of Disasters – Resilience and Recovery

3.1 Recovery After Disasters

Resilience is defined by a society's level of preparedness to resist or respond to a disaster and its ability to recovery quickly and effectively.[16] Recovery is a complex process that starts immediately following a disaster. Recovery is broadly defined as the act or process of returning to normality after a disaster, although the 'normal' may not be a return to the pre-event state; in fact this may be undesirable, or a 'new normal' may be established.[17] The concept of recovery as a return to 'normality' is used in this work.

Disaster recovery manifests tension between speed and deliberation. It is critical to quickly fulfil the immediate needs of those affected, resume economic activity with minimal disruption, and rebuild damaged infrastructure. Delays in recovery and reconstruction can exacerbate the immediate impacts of a disaster into persistent long-term consequences. Affected communities will work to reconstruct their lives regardless of decision-maker involvement, but all stakeholders must take an active role to facilitate a swift and successful recovery.[18] Therefore, rapid decision-making is required to rebuild communities and restore normality. This requires a multitude of complex and challenging decisions to be made under urgent pressure, which may reverberate long into the future.[19] As a result, reactive policies often fail to address the root causes of risk and may even exacerbate vulnerability in the long term.

However, disasters also provide windows of opportunity for positive change – to build back better – whereby vulnerability is reduced, and an improved state of resilience is instated. It is therefore important to also take sufficient time to plan recovery and reconstruction with longevity in mind. However, this window of opportunity is narrow, often lasting only six months to three years after an event, and varies by country according to different political regimes.[20] In the aftermath of an event, the need to respond to an emergency promotes disaster management and risk reduction up the political agenda, but in time, other pressing issues take precedence and divert the attention of governors.

Economic recovery is likely the most significant concern for communities facing the impacts of a recent disaster and is a focal concern of interventions by national authorities in every major catastrophe. Economic recovery is heavily influenced by the state of the local economy prior to a disaster event; a disaster may either or both severely aggravate economic troubles and or provide opportunities for economic growth. The present overreliance on post-disaster financing creates economic insecurity on account of the uncertainty regarding the timing and amount of available public funding. Therefore, there is a pertinent need to invest in ex-ante disaster risk reduction measures.

3.2 Investing in Resilience

The 2015 Sendai Framework for Disaster Risk Reduction (DRR) identified 'investing in disaster risk reduction for resilience' as one of four priority actions between now and 2030.[21] This emphasises the need to prioritise pre-disaster risk reduction over the biased reliance on post-disaster relief and reconstruction assistance. One factor explaining this bias is the limited evidence regarding the benefits of risk reduction, and, if this ambition is to be met, a stronger economic case must be made for ex-ante investment in both structural and non-structural prevention and mitigation measures.

Increasing the resilience of infrastructure (structural resilience) and the services that buildings, transport networks, and utilities provide, alleviates disaster impacts. Resilient design can reduce damage, repair costs, fatalities, injuries, displacement, and the duration of downtime. Critical services such as power and water can continue to function, and people can remain at or return to homes, workplaces, or schools quickly. Investment in resilient infrastructure generates a quantifiable resilience dividend – a return on an effective investment in risk mitigation or transfer. This dividend should, in turn, help finance the costs of more resilient development and 'building back better.' If structures damaged by hazard events are rebuilt to be more resilient, losses will be reduced from possible events across the range of hazard magnitudes. Expected losses will be reduced for frequent, lower magnitude events as well as low probability and more extreme catastrophes.[22]

16 (Davis and Alexander 2015)
17 (Platt 2018)
18 (Zack 2010)
19 (Ingram et al. 2006)
20 (Platt and So 2017)

21 (United Nations Office for Disaster Risk Reduction 2015)
22 (Lloyd's of London and Centre for Global Disaster Protection 2018)

While physical resilience measures can play a crucial role in limiting damages, especially from relatively frequent and moderately severe events, the most extreme events still threaten catastrophic damage and disruption. In such cases, the capability to deliver rapid finance to initiate recovery and reconstruction is critical. Risk transfer solutions allow for rapid payouts to enable recovery and reconstruction within days or weeks of the event, compared with the four to nine months often needed for multilateral financing or humanitarian aid to reach the intended recipient.[23] The quantity and purpose of funds made available by the latter is often also uncertain, and often dependent on circumstances outside an effected economy – for example, if multiple major catastrophes create competition for international resources. Therefore, external aid should not be overly relied on.

Resilience remains undervalued despite the return on resilience investment nearly always being positive. There is limited quantitative evidence on the net economic benefits of disaster risk management interventions. Nevertheless, the economic case for disaster risk management is strong and the benefits of investment outweigh the costs of doing so, on average by about four times the cost in terms of avoided and reduced losses.[24]

Individual studies of specific hazards or regions generally support this case. For example, focussing on federally funded (primarily structural) hazard mitigation grants in the United States, the National Institute of Building Sciences reported that, on average, every US$1 spent on mitigation saves US$6 in future disaster costs.[25] Further, the benefit to cost ratio of constructing buildings that exceed minimum code requirements is also significant at 4:1 (and even higher when considering individual hazards: beyond code storm surge mitigation has a benefit-cost ratio of 7:1).

A cost-benefit analysis is important to provide support for prioritising DRR interventions in both the public and private sectors. It is best suited where benefits can be well quantified in monetary terms, which is generally the case for structural resilience options (such as flood risk prevention) but is more difficult to justify for 'softer' interventions (such as preparedness or risk transfer measures). As a result, the brunt of reported evidence concerns risk prevention, particularly for flood hazard, and less is known about other DRM measures such as preparedness and financing.

Amidst the current shifting emphasis from structural resilience options to systemic measures, it is also necessary to consider other, more holistic analyses that capture less tangible benefits to assess the efficacy of investments in resilience. For example, robust decision-making is an increasingly popular approach that shift the focus from optimal decisions (such as supported with cost-benefit analysis) to options that minimise regret, although methods are complex and demand statistical expertise.[26]

3.3 Who is Responsible for Resilience and Recovery?

Disaster Risk Reduction requires awareness and action at all levels of society and for partnerships to be built between the public sector, NGOs, the people and enterprises at risk, and the financial sector, particularly the insurance industry. The role of public authorities is to reduce the underlying risk to society as a whole. They provide hazard observations and early warnings, regulate the use and development of exposed areas, and prepare emergency plans, including strategies to recover after disasters.[27]

23 (World Bank 2017)
24 (Mechler 2016)

25 (National Institute of Building Sciences 2017)
26 (Lempert and Kalra 2011)

In certain contexts, there is evidence to suggest the role of the state in disaster recovery may be decreasing. In the US, the Federal Emergency Management Agency (FEMA) has endured responsibility for numerous unprecedented disasters in recent decades. FEMA was designed decades ago to operate in a far less complex world than exists today – the size scope, cost, and complexity of natural disasters has grown drastically. Concurrently, various emerging threats that are now prominent in today's risk landscape, notably technological threats and terror, also fall within FEMA's jurisdiction. In 2018, the then FEMA Administrator Brock Long spoke of three fundamental truths about the agency: that it is broke; that the system is broken; and that if the frequency and severity of recent disasters is the new normal, "Americans can't rely on a federal cavalry when disaster strikes; they will have to take care of themselves".[28]

Ultimately, FEMA, like many other governmental emergency management agencies, needs a radical and expansive plan to prepare for future disasters. This includes increased private sector involvement and capital investment in risk management to diversify and transfer risk. Nevertheless, as Long suggested, exposed and vulnerable individuals, communities, and businesses should bear greater responsibility where they are able. They must perceive their risk and be educated to control the exposure of their assets and be prepared for disaster. Where markets exist, this includes taking financial precautions, namely through insurance purchasing, and so the sector must endeavour to assume a greater role in risk reduction.

3.4 The Role of Insurance

Insurance is a powerful ex-ante risk transfer strategy, providing monetary compensation for damaged assets or lost income resulting from a disaster. While financial aid from public sources is generally slow to be delivered due to prolonged bureaucratic decision-making and administration, insurance companies generally act comparatively quickly to reimburse their clients. Further, public aid payments seldom equal the amounts promised immediately after a disaster, insurance payouts usually reimburse the policyholder the majority value of their loss.

However, vulnerable people with lower incomes, limited resources, and daily survival struggles (for food, health, and shelter) do not prioritise preparing for a future disaster and so are rarely insured. Further, in many emerging economies, insurance products do not yet exist to serve those with modest economic means. Where mandatory insurance schemes exist, the necessity to spend huge amounts of public money on financial relief and reconstruction of private property is reduced. But potential insurance purchasers are generally unwilling to subsidise those with a much higher hazard exposure than their own.

Conversely, voluntary insurance schemes often fail to reach large parts of society due to a lack of risk awareness, and so these people are dependent on state aid. Therefore, insurance cover must be based on adequately risk-priced premiums that somewhat cross-subsidise to make them affordable but are nevertheless acceptable to the majority. Nevertheless, in the most extreme catastrophes the capacity of the (re)insurance sector and financial sector to bear the loss is limited, and so the state must always serve as a reinsurer of last resort to assume losses that exceed this capacity. Governments are inevitably reluctant to assume this role and reserve capital that could otherwise be spent.[29]

Insurance can also help to achieve other broader DRR and development goals through interventions before and after disaster events, including establishing safer building practices, disseminating risk information, and promoting financial responsibility.[30] Insurance also offers leading scientific and technical expertise, through risk assessment and modelling, to understand risks that communities are exposed to in all aspects of the risk equation: hazard, exposure, and vulnerability.

27 (Kron 2015)
28 (Cooper 2018)
29 (Kron 2015)
30 (Franco 2015)

Section 4: Research Approach and Methods

4.1 Research Objectives and Hypotheses

Over the past three years, the Cambridge Centre for Risk Studies has conducted extensive research into the socioeconomic impacts of natural disasters and the characteristics of and controls on disaster recovery, to better understand how insurance influences the rate and quality of recovery and has the potential to build resilience. The research was framed with the following primary aim:

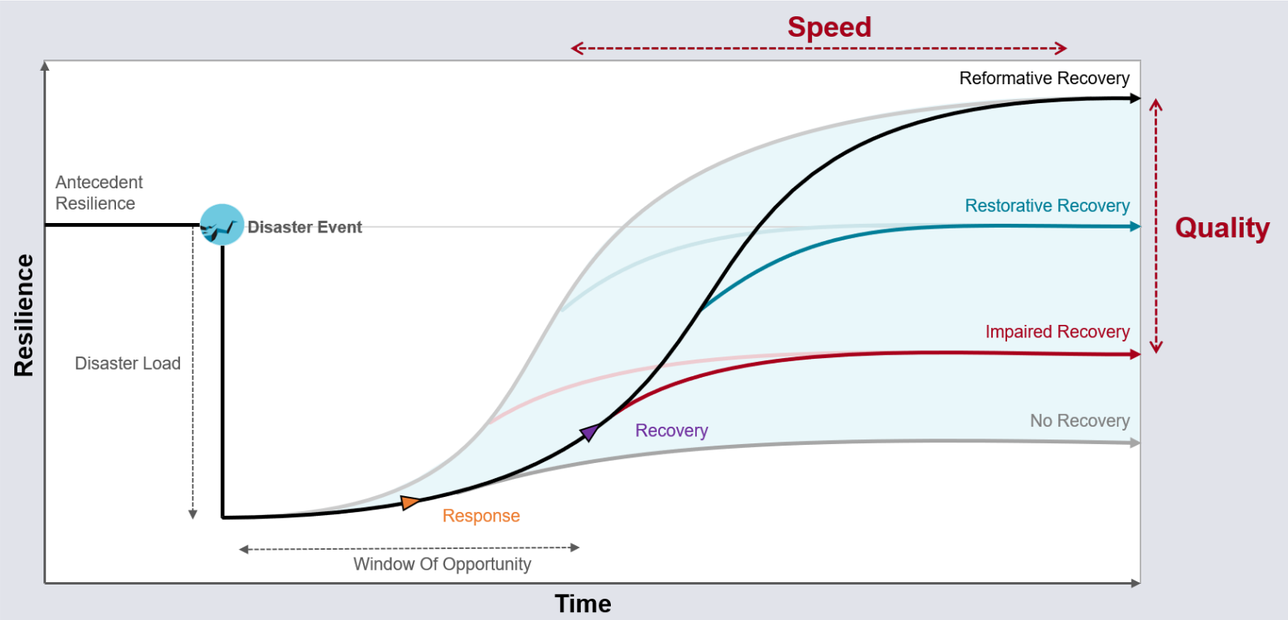
To understand and quantify the impact of (re)insurance on natural disaster recovery.

Specifically, three key research questions were addressed concerning the dynamics of disaster recovery and the relative contribution of insurance penetration to recovery outcomes:

1. **What are the similarities and differences in recovery dynamics across case studies?**
2. **What are the key controls on socioeconomic recovery from natural disasters?**
3. **What is the role of insurance in controlling recovery outcomes and resilience to disasters?**

The success of recovery can be measured in terms of two dimensions: the time taken to return to normality and the quality of recovery. Quality concerns whether the affected region has been restored to a similar state to that prior to the event, in terms of physical, social, and economic resilience, or whether it has been built back better in a reformative process of recovery to an improved state. Conversely, it is possible that the socioeconomic state of the region is impaired compared to that before the event, due to deficiencies in the recovery process, or even that the region has not recovered at all (Figure 6).

Figure 6: Conceptual framework of recovery as a process of building resilience. In this context, disaster risk reduction in the recovery process means having a steeper trajectory (faster recovery) and a higher eventual outcome (more resilient).
Adapted from (Lallemant 2013).



4.2 Methods

Over the past three years, the Cambridge Centre for Risk Studies has conducted extensive research into the socioeconomic impacts of natural disasters and the characteristics of disaster recovery. This work involved a significant number of case studies of natural disasters – specifically floods, storms, earthquakes, and tsunamis. These hazards are characterised by sudden-onset shock events that emerge quickly or unexpectedly and cause acute physical impacts, and have distinct period of response and recovery, as opposed to slow-onset trend phenomena that emerge gradually over time (such as climate change driven sea level rise or water stress).

Detailed Disaster Recovery Case Studies

The research involved two approaches with differing levels of detail. First, eight case studies of floods and storms were chosen for detailed research on the nature of impacts and characteristics of recovery through extensive literature review of reliable source material (Table 1). A range of natural disaster case studies was chosen to include major events in recent decades across the globe, and ensure coverage of a global geographic distribution, a variety of economy types and income levels, and a ranging levels of insurance penetration and market maturity. The focus is on documenting the narratives throughout the recovery process to understand the key events and timelines of recovery, how the recovery was managed and financed, what decisions were made and when, and what were the eventual outcomes in terms of the speed and quality of recovery.

Some of these studies were supported by either field study surveys (in the UK, Germany, and Vietnam) or remote surveys (in the Philippines) to gather insights on recovery outcomes from samples of affected people and involved disaster managers or academic experts. These eight case studies have each been published in a series of Disaster Recovery Case Study Reports.[31] In addition, one of the authors has investigated recovery after major earthquake-related disasters in 10 countries (Table 2) through principally ethnographic field studies.[32] This series of 18 case studies form the foundation of this report, providing contrasting narratives of recovery.

31 See also (Platt et al. 2020)
32 See (Platt and So 2017; Platt 2018)

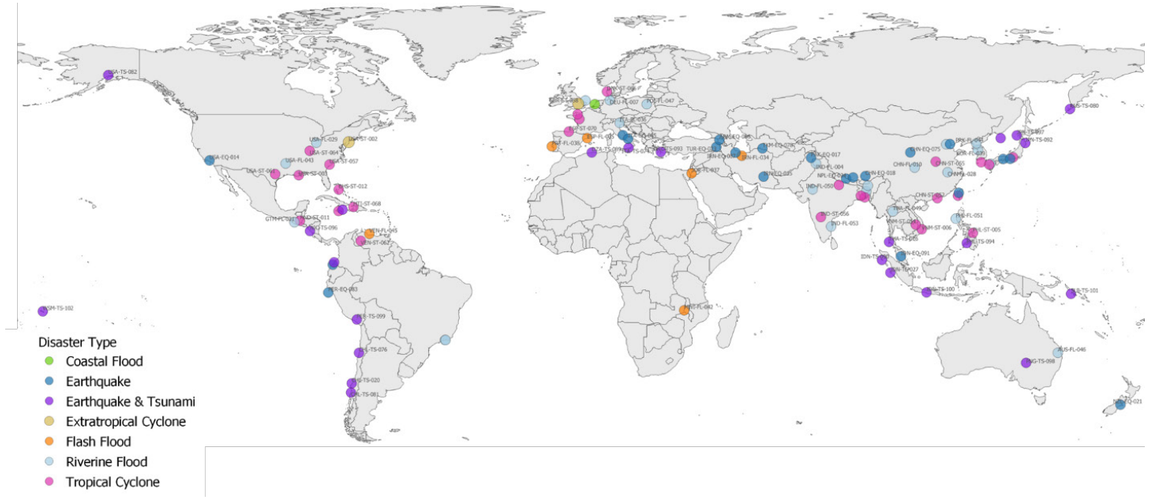
Table 1: Overview of Storm and Flood Case Studies
Data: EM-DAT and CRED / UCLouvain 2020

Disaster Name	Disaster Type	Year	Country	Income Group	Economic Loss (2019 US$ Bn)	Insured Loss (2019 US$ Bn)	Fatalities	Displaced	Affected
Bangladesh Floods	Riverine Flood	2004	Bangladesh	Lower middle	3.0	<0.1	730	38,000	36,000,000
Hurricane Katrina	Tropical Cyclone	2005	United States	High	164.0	79	1,836	1,500,000	500,000
UK Summer Floods	Riverine Flood	2007	United Kingdom	High	4.9	0.8	13	30,000	1,000,000
Hurricane Sandy	Extratropical Cyclone	2012	United States	High	56.0	25	54	776,000	8,000,000
Central European Floods	Riverine Flood	2013	Germany	High	14.0	1.8	4	81,000	1,000,000
Typhoon Haiyan (Yolanda)	Tropical Cyclone	2013	Philippines	Lower middle	11.0	0.8	7,354	4,000,000	16,000,000
India(-Pakistan) Floods	Riverine Flood	2014	India	Lower middle	7.6	0.6	53	1,300,000	920,000
Typhoon Damrey (Ramil)	Tropical Cyclone	2017	Vietnam	Lower middle	1.0	<0.1	123	36,000	4,330,000

Table 2: Overview of Earthquake and Tsunami Case Studies
Data: (EM-DAT and CRED / UCLouvain 2020)

Disaster Name	Disaster Type	Year	Country	Income Group	Economic Loss (2019 US$ Bn)	Insured Loss (2019 US$ Bn)	Fatalities	Displaced	Affected
Northridge Earthquake	Earthquake	1994	United States	High	52	24	72	114,000	3,800,000
Bam Earthquake	Earthquake	2003	Iran	Upper middle	0.7	<0.1	30,000	75,600	100,000
Indian Ocean Tsunami	Earthquake & Tsunami	2004	Thailand	Upper middle	41	3.7	9,311	1,800,000	2,133,784
Kashmir Earthquake	Earthquake	2005	Pakistan	Lower middle	6.8	<0.1	87,000	3,200,000	10,143,700
Sichuan Earthquake	Earthquake	2008	China	Upper middle	154	0.4	87,587	5,000,000	15,000,000
L'Aquila Earthquake	Earthquake	2009	Italy	High	14	0.2	308	65,000	72,000
Maule Earthquake	Earthquake & Tsunami	2010	Chile	High	35	6.4	547	800,000	5,540,000
Christchurch Earthquake	Earthquake	2011	New Zealand	High	17	14	181	70,000	348,435
Tōhoku Earthquake	Earthquake & Tsunami	2011	Japan	High	239	40	20,350	5,150,000	9,630,000
Van Earthquake	Earthquake	2011	Turkey	Upper middle	1.7	0.2	601	180,000	1,000,000

Figure 7: Geographic distribution of disaster event cases



Disaster Recovery Event Catalogue
The second component of this research involves the construction of a catalogue of 103 disaster recovery events (including those mentioned previously). The catalogue captures numerous explanatory variables representing various dimensions of the risk context and disaster impact and recovery characteristics. This dataset offers a way to understand and measure socioeconomic recovery with quantitative and statistical methods to further support the findings of the detailed case studies.

The selection of disaster events to be included in the catalogue aims to include an even distribution of cases across disaster types, income groups, and global geography (see Figure 7 on preceding page; Table 3, at right. The cases are concentrated in the past three decades, but a number of notorious natural disasters that occurred earlier in the 20th century are also included, although reliable information about these events may be sparse so the recorded data has a lower confidence level. Cases were defined by events and affected regions rather than by country and year since multiple events may occur in a single year with overlapping impacts and because events may not cause impacts to the whole of a country. Indeed, the largest country-year losses are usually dominated by single events. The cases have a defined 'locus' that represents the affected area in terms of scale within a country: national, regional, or local.

Table 3: Distribution of disaster event cases by disaster type and national income group

Disaster Type	Income Group				
	Low	Lower Middle	Upper Middle	High	Total
Flood	2	6	10	12	**30**
Coastal Flood				1	**1**
Flash Flood	1		3	2	**6**
Riverine Flood	1	6	7	9	**23**
Storm	2	8	4	15	**29**
Extratropical Cyclone				2	**2**
Tropical Cyclone	2	8	4	13	**27**
Earthquake	1	3	10	6	**20**
Earthquake & Tsunami	1	7	6	10	**24**
Total	**6**	**24**	**30**	**43**	**103**

Each case is assigned a level of confidence depending on the research approach: level 1 implies the lowest confidence, relying on principally literature-based research, including academic papers and government, international agency, private sector, or news reports; level 2 cases are based on remote surveys and highly reliable, detailed source material; and level 3 represents the highest confidence, with sites visits to observe and interview, including surveys of households and experts.

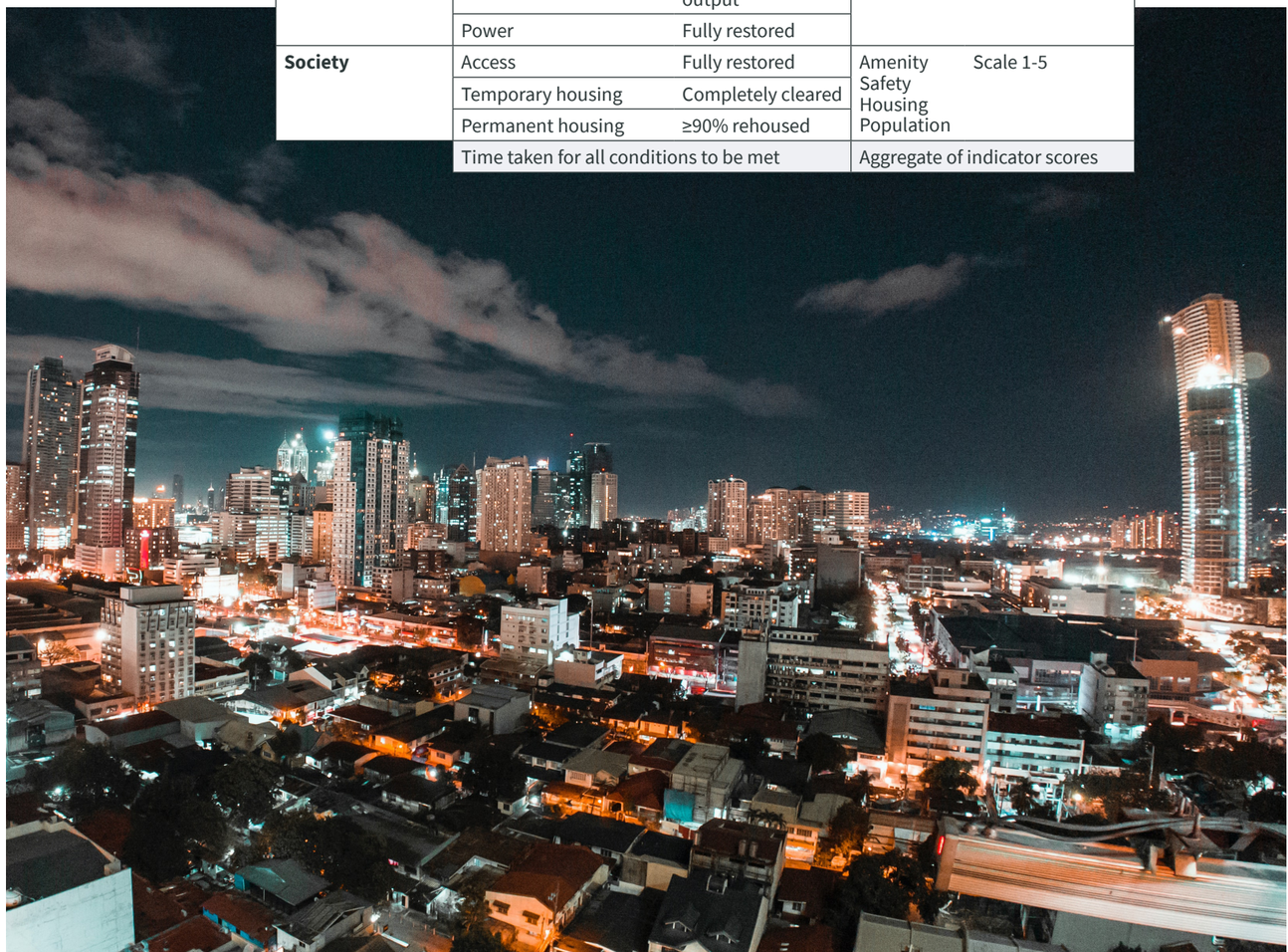
The variables captured in this catalogue are key factors relating to the various dimensions of risk and recovery, indicative of the states of exposure, vulnerability, and resilience at either the national or regional level. This data was gathered from a range of sources, including global databases (e.g. the EM-DAT (2020) international disasters database), academic and other source material concerning specific events, and in certain cases qualitative assessments of speed, adequacy, and efficacy of recovery characteristics was made. Factors are analysed as either exogenous, meaning they are outside the control of decision-makers and planners, or endogenous factors, those that are amenable to decision-making. These factors are further categorised into the following:

- **Antecedent Conditions:** Inherent socioeconomic factors summarising the vulnerability and coping capacity of the region. This includes economic composition and performance, development, income, equality, governance, and DRM organisation and practices.
- **Disaster Impacts:** Measures of the human, physical, and economic damages and losses of individuals, communities, public bodies, and the private sector, which necessitate the need for and complexity of recovery.
- **Financial Resourcing:** Sources of finance required to fund the recovery process, whether communal and informal, or from external sources, including governmental and international aid or insurance payouts. The speed of delivery and adequacy of funds are key controls on recovery.
- **Recovery Management:** Indicators of how the response and recovery was managed, the justification and efficacy of decision-making, and whether stakeholders participated in decisions.
- **Recovery Outcomes:** Measures of the success of recovery in terms of the time taken to return to 'normal' and the quality of recovery – whether the process was restorative, reformative, or the state of resilience was subsequently impaired. The recovery of an economy and community are distinguished and calculated using multiple indicators.

Measuring the Speed and Quality of Recovery
The speed of recovery was measured as a single value for 'economy' and 'society' separately, based on the time taken in months or years of key indicators to return to 'normal' – defined as the return to 90% of the pre-event level, or a new stable norm – and comply with a number of conditions (Table 4). Recovery quality was measured on a five-point scale in terms of whether the recovered state was worse, the same, or better than the pre-event state. Similarly, a set of indicators were aggregated to give a single measure of the quality of recovery from each disaster event (Table 4).

Table 4: Indicators of Speed and Quality of Recovery

Recovery of:	Speed Indicators		Quality Indicators	
Economy	Employment	≥90% back in work	Economic growth	Scale 1-5
	Productivity	≥90% economic output		
	Power	Fully restored		
Society	Access	Fully restored	Amenity Safety Housing Population	Scale 1-5
	Temporary housing	Completely cleared		
	Permanent housing	≥90% rehoused		
	Time taken for all conditions to be met		Aggregate of indicator scores	



Section 5: Understanding the Controls on Disaster Recovery

5.1 Recovery Outcomes

Rate of Recovery

A key measure of recovery is the time taken for an affected region to return to normal after a disaster event. The catalogue of disaster events includes only major natural events that demand substantial effort, resource, and therefore time to recover from. Figure 8 shows the distribution of case studies by speed of recovery. The majority of the 103 cases took between six months and five years to complete a full recovery. Few cases (3%) saw a societal recovery within six months, while 13% of cases had economically recovered within the period of three to six months. After five years, 78% of cases had economically recovered and 72% of cases had seen societal recovery. After 10 years, recovery had been completed in over 95% of cases. A small number of cases took longer to recover, and five cases never recovered in terms of either economy or society (only one of the cases was found to have never recovered in either dimension).

These results indicate that, on average, economic recovery is faster than that of the wider society. Indeed, in 58% of cases economic recovery took less time than that of society – in most instances one to three years less – while 30% of cases saw both dimensions recover at the same rate.

There are extremes at either end of the speed scale of cases that recovered very quickly (within a few months) or not at all. For example, the 2013 central European floods saw extensive major flooding across most major catchments in Germany. The floods affected 600,000 people, displaced over 80,000 residents, and cost almost $13 Bn in economic losses. Nevertheless, the German economy experienced a negligible impacts and local economies largely recovered within a matter of months. Further, according to a household survey conducted in Passau, Bavaria, which was among the worst affected areas in Germany, half of respondents that had been displaced returned to their homes and recovered within a year, and over 90% had recovered with 18 months. Return to housing is a key measure of social recovery, and this case represents one of the fastest rates of recovery in terms of both the economy and society.

In contrast, the recovery effort in Haiti following the January 2010 magnitude 7.0 earthquake, which killed over 200,000 people and destroyed hundreds of thousands of homes, is yet to be completed. This disaster is among the deadliest in recent history and substantial economic and social impacts remain. A decade later, residents in certain districts remain displaced, and the real economy has yet to return to its pre-earthquake state. In this respect, the disaster persists to the present day, and the country has yet to return or adapt to a stable state. Haiti continues to face multiple crises, including food insecurity and malnutrition, water-borne disease epidemics, and high disaster vulnerability exacerbated by the 2010 event.[33]

33 (Nesbitt and Miks 2020)

Figure 8: Speed of social and economic recovery of disaster catalogue cases

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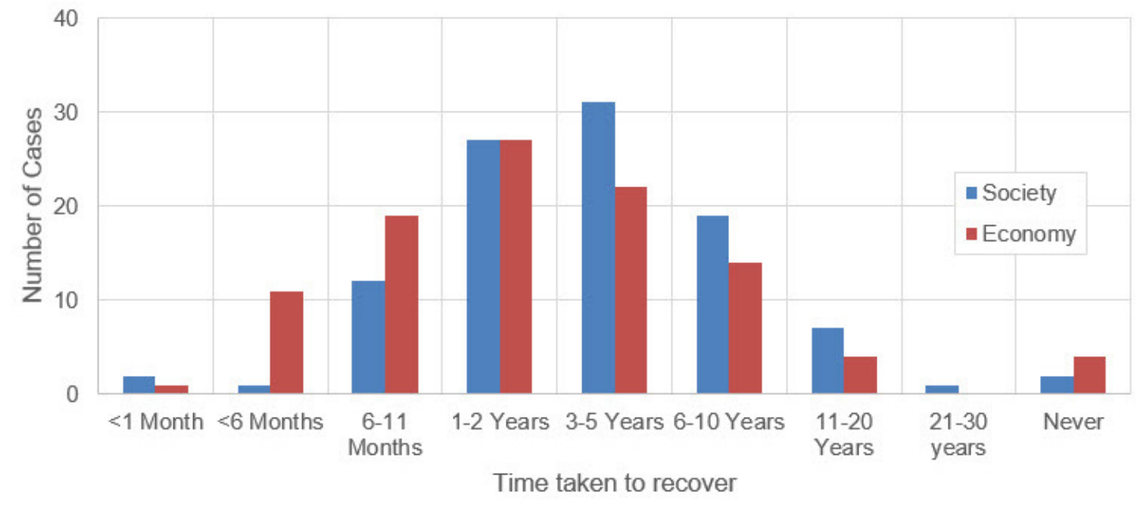

Table 5: Hypothesis of socioeconomic controls on the rate of recovery, statistically tested with a regression between independent variables and recovery speed for disaster catalogue cases

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Category	Hypothesis for rate of recovery	Hypothesis accepted	Independent variables
Disaster Impacts	1. Places suffering smaller disasters recovered faster	☑	Hazard magnitude
	2. Places with a lower damage severity recover faster	☑	Damage severity, economic loss, no. of fatalities, displaced, affected
	11. Places suffering frequent disasters recover faster	☒	Frequency of disaster
State of economy	3. Economies dominated by services recover faster	☒	Economy type
	7. Richer countries with buoyant economies recover faster	☑	GDP per capita, GDP growth
Governance & decision making	6. Countries with authoritarian governments recover faster	☑	State of democracy
	9. Places with greater equality recovered faster	☒	GINI coefficient
Disaster Risk Management	12. Better prepared countries recover faster	☑	Preparedness, scientific basis of decision-making
	5. Places with extensive community participation recovered faster	☒	Public participation
	10. Places with better DRM decision-making recover faster	☑	Authority, management, DRM quality
Disaster Financing	4. Places with adequate and speedy funding recovered faster	☑	Funding adequacy and speed
	8. Places with higher insurance penetration recover faster	☑	Insurance penetration

Controls on the Rate of Recovery

To answer the research question "what are the key controls on socioeconomic recovery from natural disasters", a series of key hypotheses were constructed to be tested both qualitatively and quantitatively. These hypotheses aim to assess the relative importance of numerous independent variables in controlling the speed of recovery in an effected region. Table 5 outlines these hypotheses, categorised into categories representing components of the disaster and recovery context, and measured with a few key independent variables that were captured for each case study. These hypotheses were made based on anecdotal evidence and previously made conclusions about recovery, to test more rigorously with statistical regression. The results show that most hypotheses can be accepted – i.e. the evidence from the case study catalogue provides support that these conclusions are statistically significant.

The extent of disaster impacts is shown to exert influence on recovery, with increasing hazard magnitude and damage severity (which is not determined solely by the hazard but also by physical vulnerability) both correlating with longer recovery periods. In the studied events, hazard event frequency does not show a clear relationship, although qualitative evidence from recovery cases and from other literature sources suggests that frequency of – and therefore experience with – disasters is a key determinant of preparedness. Those communities with high and regular exposure to natural hazards may have a greater capacity to cope and adapt, and in certain communities are simply considered part of the norm. The results show that better prepared countries do recover faster.

Potential economic determinants of recovery include economy type, composition (measured by the relative importance of key sectors), and performance. With lesser reliance on physical assets and infrastructure, service-oriented economies are less vulnerable to physical damage than agricultural- or manufacturing-based economies. However, this is not represented statistically in the results. Income level and rate of growth are found to be closely linked to recovery outcome and are intuitively also correlated with insurance penetration.

A key determinant of fast rates of recovery is the efficacy of disaster risk management and decision-making in an affected area. Well-governed societies with clearly defined roles, often via a specific disaster management agency, and robust plans and processes for when a disaster hits are able to respond and mobilise resources quickly and effectively. In terms of governance and decision making, authoritarian governments are generally found to have faster rates of recovery than democratic nations, on account of a faster decision making and actioning process. On a related note, extensive community participation in the decision-making process after an event is found to slow recovery since it often takes time to satisfy all stakeholders with proposed rebuilding plans and actions.

As will be discussed in Section 5.2 on the role of insurance in recovery, disaster financing is a critical determinant of recovery outcome. The case studies support the conclusion that the adequacy and speed of delivery of funds, from external aid sources and insurance payouts, control the ability of a community to recover. The hypothesis that insurance penetration leads to faster rates of recovery is statistically significant here, and will be covered in greater detail in the later section.

Figure 9: Quality of social and economic recovery of disaster catalogue cases
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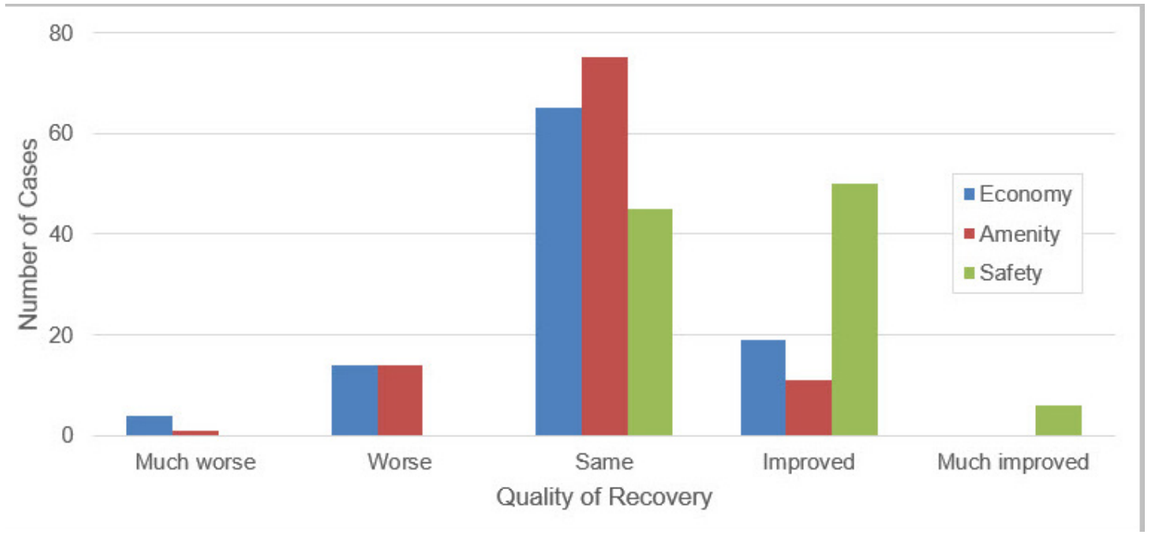

Quality of Recovery
Quality of recovery is a measure of the change in resilience – whether the post-disaster 'normal' is a return to the same status as before the event, or recovery has stimulated the improvement of an economic or social system to enhance resilience. Figure 9 displays the distribution of cases in the event catalogue in terms of recovery quality, measured qualitatively on a 1-5 scale from much worse to much better.

Here, social recovery is separated into amenity and safety, presented alongside economic recovery states. Amenity is defined by the condition of a community and the provision of services within, measured by indicators including population change, cultural change (for example whether households have been separated), and availability and quality of social services and community spaces. Societal safety, in contrast, is defined by the vulnerability of the built environment to hazard events, and by initiatives to improve resilience so that the built environment is more resistant to failure and a population has an improved capacity to cope with a disaster.

In terms of economy and amenity, the most common recovery outcome was a return to the same pre-event state of resilience – with 64% and 74% of cases, respectively. A small number of cases had negative outcomes, whereby the recovery process resulted in a state of worse resilience by any measure of either economy or amenity. In contrast, outcomes of societal safety were generally positive, measured with indicators such as improvements of the built environment to be more resistant to failure in hazard events. The modal outcome (45%) was a moderate improvement in the level of safety relative to before the event, and six cases saw a major improvement. Significantly, no cases were assessed to have resulted in a worse state of safety, suggesting that this dimension is valued more highly or can be better controlled in the recovery process relative to social amenity and economic outcomes.

Success and Failure in Recovery Outcomes
There is a deliberation in recovery between speed and quality, with a desire to achieve both a fast recovery and a reformative recovery that enhances resilience. Successful outcomes can be defined as those that satisfy both requirements to a certain degree – with a relatively fast recovery to a stable state that is an improvement on the conditions of resilience before the event. Figure 10 and Figure 11 (next page) show events in the catalogue measured by both dimensions of speed and quality, for economy and society, respectively. The cases with the most successful outcomes are plotted in the top right of the graphs, indicating an improvement in resilience and short duration of recovery. On both figures, only a small number of cases satisfy both requirements.

For example, the 2008 magnitude 8.0 Sichuan earthquake, with a significantly high death toll and economic losses, demanded immense efforts to recover from, but judgements of the response and reconstruction efforts have largely been positive. The speed and efficiency with which the Chinese government was able to mobilise government agencies, the private sector, and the wider population was profound, while also capitalising on the opportunities presented by the disaster to build back better and further develop the economy through investment – resulting in a much improved economic outcome. For example, all public-service facilities in the affected areas were reconstructed with high seismic standards and modern equipment, and public preparedness has improved. However, the rapid rebuild effort was somewhat insensitive to the environment and cultural character of the region, and the amenity of the region was assessed to have been left worse off.[34]

In Figure 11, quality of recovery is calculated as a function of both amenity and safety outcome. As already discussed, many disasters are found to result in improved safety and physical resilience measures, and the most successful cases in this Figure (i.e. plotted top right) have also seen an improvement in amenity. This includes the 1995 Kobe (Japan) earthquake, 2010 Maule (Chile) earthquake, and 2012 Hurricane Sandy (US east coast), which all achieved a successful balance of speed, seeing full recovery within five years, and quality to produce improvements in resilience.

In the case of the Maule event, which destroyed some 370,000 houses and affected two million people, the government showed strong leadership in implementing initiative to 'build back better'. Within two years, recovery was well under way, with 54% of homes having been repaired or rebuilt, with a further 30% under construction. Several factors contributed to a rapid recovery, especially the efficient and collaborative nature of post-disaster urban planning: bringing together architects/planners, local authorities, academics, and affected people and businesses. Recovery efforts focussed on restoring livelihoods and economic functionality in the immediate term, and balancing speed with a desire to make communities safer in the long-term.[35]

34 (Bernal and Procee 2012)
35 (Platt and So 2017)

Figure 10: Speed of economic recovery and change in economic resilience of disaster catalogue cases. Bubble diameter represents the value of economic loss

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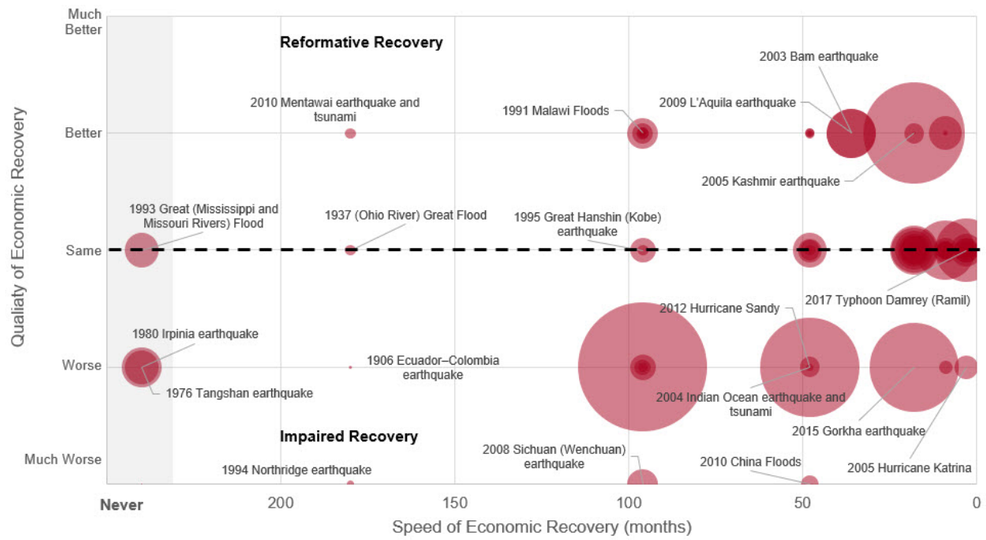

Figure 11: Speed of societal recovery and change in resilience (safety and amenity) for disaster catalogue cases. Bubble diameter represents the number of displaced people

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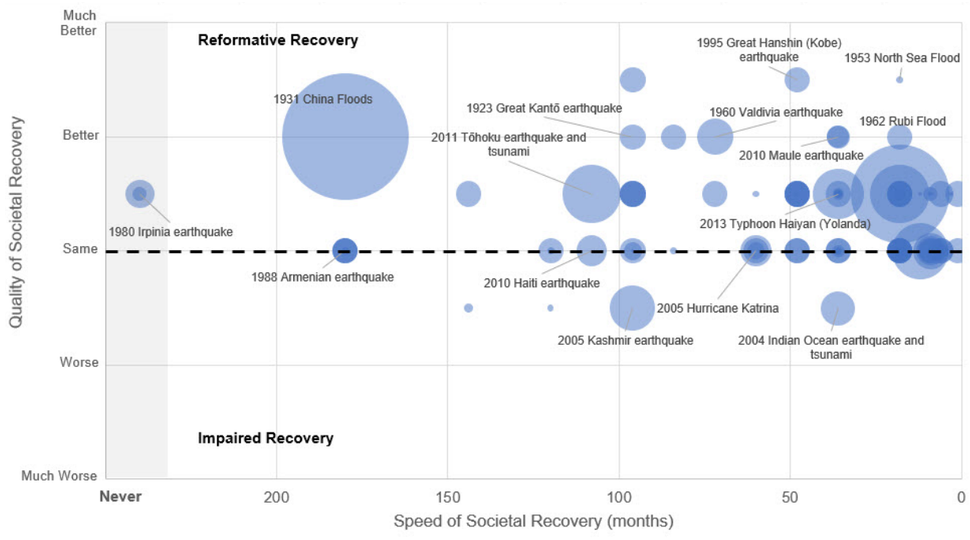

Failure to Recover

At the opposite end of Figure 10 and Figure 11 (i.e. bottom left), are the cases that might be considered a failure in that recovery was slow and ineffective, resulting in social and economic conditions worse than those prior to disaster. A small number of extreme cases were deemed to have never recovered; each saw extreme catastrophic damage and major losses to physical building and infrastructure stocks and significant impediments to recovery. Each of these events represent earlier events in the catalogue, having occurred in the mid-20th century. Two cases never recovered societally – the 1952 Kamchatka earthquake in Russia and a 1963 outburst flood of the Vajont Dam in Northern Italy. In each case, the affected populations chose or were instructed to relocate away from the impacted area.

In Italy, the Vajont dam was lauded as a showcase of Italian engineering expertise, and the centrepiece of the Italian government's hydroelectric power scheme in the Alpine foothills. Reservoir filling began in 1960, but geological instability soon became evident and, in October 1963, a 500 million tonne landslide collapsed into the lake, generating a catastrophic outburst flood that swept down the valley and killed 1,909 people in a matter of minutes.[36] After the event, the destruction was such that survivors were moved by the government into a newly built village, Vajont, 50 km away, and return was strongly discouraged. Therefore, the affected area never recovered, while the risk was reduced for the relocated community (although as the dam was not rebuilt either the flood hazard ceased to exist). Further, the government used the disaster to promote the industrialisation of north-east Italy, injecting financial support through business loans and subsidies, thereby improving the economic productivity of the region.

Three cases never achieved economic recovery, or at least resulted in highly deficient economies. This includes another Italian earthquake – the 1980 Irpinia earthquake, which left over 4,500 dead and 300,000 displaced. The event attracted significant international attention and major governmental and international aid contributions. However, this case was characterised by a major corruption scandal. An estimated US$20 Bn of the $40 Bn allocated to aid and recovery found its way to a minority of corrupt wealthy, politicians, and the organised crime syndicate

36 (Kilburn 2000)

Figure 12: Relationship between insurance penetration and average months to economic recovery for disaster catalogue cases.

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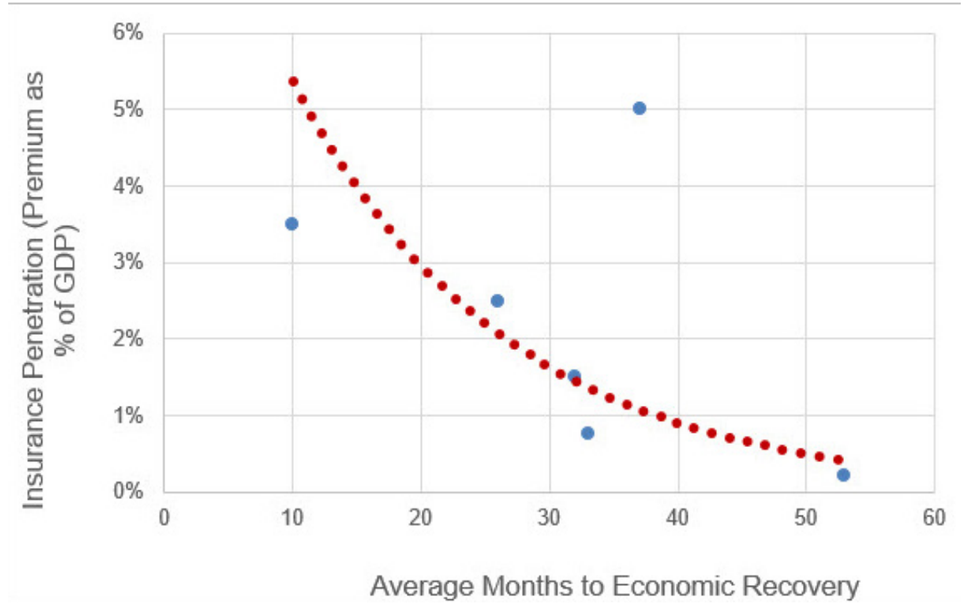

Camorra. Only a quarter of the total amount was spent on recovery costs. The Camorra also infiltrated construction contacts in the rebuild and have been found to have significantly impeded recovery.[37]

In other cases, economic recovery was limited as entire industries failed to recover, reducing the long-term economic output of the affected region and thereby increasing the risk. As a result of these events, communities were left more vulnerable to future events, with less capacity to cope and recover from future events.

5.2 Insurance Influence on Recovery

Rate of Recovery

Analysis of the relationship between insurance penetration – measured as the value of non-life premiums in a country as a percentage of GDP – and speed of economic recovery outcome shows a clear correlation, substantiating the role of insurance in recovery. With each percentage point increase in insurance penetration, there is an average of almost one year improvement in time to recovery (Figure 12, previous page; Table 5, page 21). On average, cases in countries with high insurance penetration (premiums equal 3-4% of GDP) see economic recovery to normal in under one year, while countries with the greatest protection gap, in the low (premiums 1-0.5% GDP) and very low (premiums <0.5% GDP) insurance categories, experience much longer recovery periods. On average, cases in low insurance countries take nearly three years to recover, while cases in the very low insurance category take more than four years to achieve economic recovery.

Table 6: Comparison of recovery speed and insurance gap between levels of insurance penetration for disaster catalogue cases. Insurance penetration categories based on value of non-life insurance penetration as a % of GDP
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Insurance Penetration	Non-life premiums as % of GDP	Av. Insured loss % (insured loss/ economic loss)	Economy Speed (months)
Very High	>4%	47%	37
High	3 – 4%	16%	10
Higher Middle	2 – 3%	36%	26
Lower Middle	1 – 2%	8%	32
Low	0.5 – 1%	2%	33
Very Low	<0.5%	7%	53

37 (Behan 2005; McKenna 2016)

Table 7: Comparison of average recovery quality (1-5 scale where 1 is 'much worse' and 5 is 'much better' state) between levels of insurance penetration for disaster catalogue cases
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Insurance Penetration	Non-life premiums as % of GDP	Quality		
		Economy – Quality	Society – Amenity	Society – Safety
Very High	>4%	3.1	3.1	3.8
High	3 – 4%	3.2	3.2	3.7
Higher Middle	2 – 3%	2.7	2.8	3.6
Lower Middle	1 – 2%	3.1	2.9	3.7
Low	0.5 – 1%	3.1	2.9	3.6
Very Low	<0.5%	3.0	3.0	3.5

Quality Outcome Key
Improved
Same
Worse

In this very low insurance penetration category are countries such as Nepal, Bangladesh, the Philippines, and Haiti, each of which have experienced major natural catastrophes in the 21st century and have relied heavily on major international aid efforts to finance disaster response and recovery. Insurance mechanisms remain underdeveloped in such markets and the lack of timely finance proved a key inhibitor to economic recovery.

In contrast, developed economies in the higher insurance penetration categories, including nations in western Europe, as well as Japan, South Korea, and Australia, saw insurance payouts play a key role in contributing to fast (within one year) recovery times. Note that the average recovery speed of cases in 'very high' insurance countries is anomalous to the trend, with studied cases (nine cases) taking on average around three years to restore economies. These cases are almost exclusively major catastrophe events in the United States, including Atlantic hurricanes such as Hurricanes Andrew (1992), Katrina (2005), and Sandy (2012), as well as the Northridge earthquake (1994) and Great Mississippi and Missouri River Floods (1993).

There is variation in economic recovery speed between these US cases and in insurance uptake by geography and coverage. While insurance penetration at the national level is highly developed, there are issues in the availability and coverage of insurance protecting against natural hazard losses, particularly when examined at the regional or local levels. In the cases of Hurricanes Sandy and Katrina, flooding was a major driver of impact for which a significant insurance gap remains and the complexity of insurance products sold (with multiple policies to cover different hazards) may have impacted the efficacy of insurance. New York and New Jersey experienced a rapid economic recovery within months of Hurricane Sandy, with productivity of the region's service-based economy able to resume quickly after initial job losses and businesses able to rely on insurance support. This was not the case for the recovery of residential damages, and a considerable protection gap existed with the National Flood Insurance Program, despite the compulsory nature of certain coverages (for example for homeowners with a mortgage). Despite being the primary source of flood insurance protection, the scheme only provided cover for 20% of inundated houses.

This analysis is complex; the different factors relating to recovery financing as well as disaster management and socioeconomic context, which contribute to recovery outcomes are highly co-dependent and interlinked.

Quality of Recovery
In terms of the influence of insurance on recovery quality, the results show consistent positive outcomes across measures of economy and society where insurance penetration is highest (Table 6). Comparatively, when insurance penetration is low, the outcome is generally less positive. This is particularly true with regard to the amenity metric, which shows marginally negative outcomes meaning amenity is in a worse state than it was before an event. Various case studies have shown the positive influence of insurance on processes of reformative recovery, with timely access to insurance capital contributing to improvements in the state of resilience to future hazard events.

This correlation between available insurance capital and rate of recovery was evident following the 2011 earthquake in Christchurch, New Zealand. The relatively small magnitude earthquake caused an estimated $26 Bn in economic loss, of which more than 50% was insured. Despite the devastation of the Canterbury region, which comprises 12% of the nation's GDP,[38] New Zealand was able to maintain positive growth in 2011. This growth was driven by an increased volume of funds being channelled to the afflicted area in order to boost economic activity.

New Zealand has a complex insurance market due to the state-owned Earthquake Commission (EQC), which issues insurance products for residential risks as an extension to private fire policies purchased through private insurers. Around 95% of homeowners have access to earthquake insurance through this scheme. Payments made by the EQC have been found to have assisted the recovery in Christchurch – "for every 1% increase in insurance payment for building damage, economic recovery increased by 0.36%" – and businesses who were paid promptly experienced a more successful than those without insurance.[39]

However, despite the generally positive story of recovery, the EQC has since been subject to intense criticism due to the slower response times in delivering payouts relative to payouts from private insurers. In this case 90% of claims were finalised within three years, which, in comparison to typical delivery times for sources of external aid, remains relatively fast.

Analysis of additional metrics measured in each case study further supports the conclusion that higher insurance penetration improves recovery rate and quality. Figure 13 illustrates various measures of success in financing recovery according to the level of insurance penetration. Recovery in higher levels of insurance penetration can rely on external aid, including insurance, to finance recovery. In cases of low insurance penetration, there is a greater need to draw on individual or communal capital, thereby potentially exacerbating existing financial vulnerability (Figure 13a). When it comes to the speed of delivery for this external aid, higher levels of insurance penetration return faster rates, and 60% of those cases that saw in countries with higher insurance penetration, funds were delivered within one year of the crisis. In contrast, cases with slow delivery of aid are primarily those of lower insurance levels (Figure 13b). Significantly, cases with higher insurance mostly received sufficient funds to facilitate recovery, while those cases in lower categories were nearly always challenged by insufficient finance to enable rapid recovery (Figure 13c).Success in "building back better" is perhaps most tangible at a localised scale where well-governed processes and supportive communities together with timely access to insurance capital have collectively contributed to economic and residential recovery. Further, access to information concerning alleviating vulnerability and growing resilience is also important to stimulate "building back better", empowering individuals and communities to act independently without overly relying on external interventions.

The case studies in this report demonstrate that while there are often cases of success within segments of a community, this is rarely the case for the whole affected population and there is inequality in the rate and eventual outcomes of recovery across a larger area. The idea of a systemic process of reformative recovery across a whole affected region or country, enabled by insurance capital, remains largely unproven. The incentives to foster "build back better" disaster planning at these levels remain underdeveloped, particularly where such incentives are driven by insurance products. For private insurers, consumers in underdeveloped markets remain difficult to reach, with significant barriers to overcome, including access to and perception of insurance mechanisms. Instead, success may be found where the industry focuses on partnering with governments and non-profit entities through public-private partnerships to protect taxpayers and relieve the financial burden on governments. In addition to transferring the risk to government balance sheets, insurers can increase insurance penetration through participation in risk-pooling opportunities.

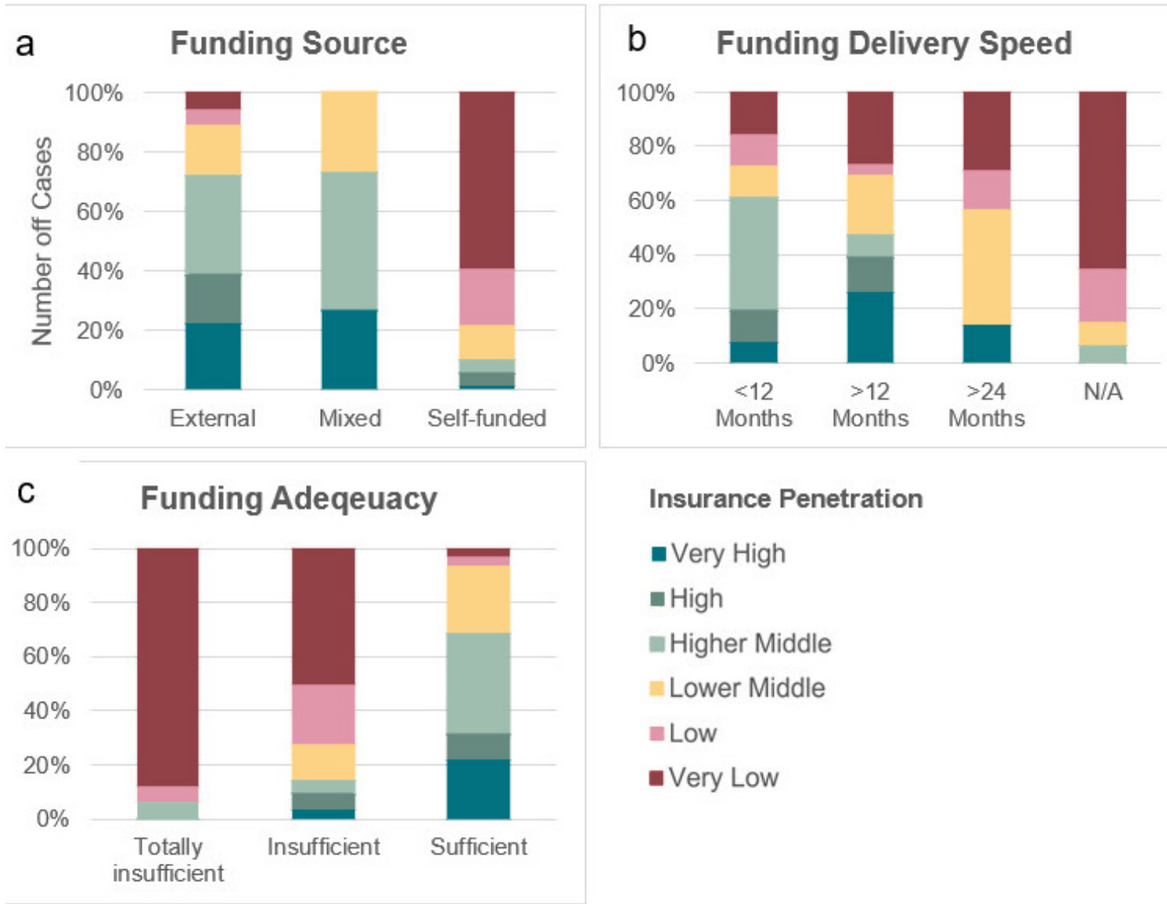
5.3 Conceptual Framework of Disaster Recovery

To better understand the variety of controls in disaster recovery, the datagathered for each disaster event is analysed in terms of the following framework:

1. **Pre-disaster characteristics** consider the socioeconomic conditions that exist in a place prior to a disaster, such as the economy type, composition, level of development, and performance (in terms of output and growth), as well as the structures of government and equality. Pre-disaster conditions also include factors of disaster resilience, such as disaster risk management and reduction plans, policies, and practices. This is supported by scientific and public awareness and understanding of the risk, of which previous experience of disasters is a key influence. These components are differentiated in terms of '**givens**' (red boxes), or exogenous factors – i.e. those factors that are outside the control of decision-makers and planners, and '**managed**' (Blue boxes) or endogenous factors – i.e. those factors that are responsive to decision-making by the disaster risk management community.

2. **Recovery variables** measure key characteristics of the immediate response and recovery phases of a disaster. The disaster load refers to the event impacts that create a conceptual 'load' on a society from which it must recover. This includes the severity and value of damages and human

Figure 13: Quantitative assessment of financial resourcing for disaster recovery, categorised by insurance penetration, in the disaster catalogue cases, including: a) dominant source of funding (external includes all sources of aid and insurance); b) time taken to deliver funds; and c) overall assessment of whether funding from all sources was sufficient to enable recovery
Cambridge Centre for Risk Studies Analysis



38 (Stats NZ 2013)

impacts, which demand resources for recovery. This load is a given after a disaster, being a function of the event's characteristics, such as its location, magnitude, and timing, as well as those pre-disaster characteristics which define a society's vulnerability and capacity to cope with disruption. The other two controlling components of recovery are financial resourcing and disaster management, which are both considered endogenous and manageable.

Financial resourcing of recovery, which has been discussed in detail in this work, is defined in terms of self-finance, i.e. individual or communal capital, versus external finance from governmental or international aid sources as well as insurance. As has been discussed, communities that can rely on external aid generally experience faster and more successful recovery outcomes than those that must fund rebuilding out of pocket. Critically however, it is the speed of delivery and adequacy of funds that determine the efficacy of aid efforts, and ineffective delivery may well slow recovery – hence timely insurance payouts have greater advantages over bureaucratic aid programmes.

The power of finance to enable recovery is also dependent on the disaster management context – key decisions made by the authorities in the immediate and long-term recovery which define how, and where, and to whom resources are channelled. As has been discussed, decision-makers must balance speed and deliberation, with ambitions to restore normality as quickly as possible while also exploiting the window of opportunity to "build back better." Public participation in democratic decision-making processes is important to ensure the needs of all stakeholders are met but may well slow or hinder the rate of recovery.

3. **Outcomes** are the measurable results of recovery, with distinctions made between economic sectors which recover at different rates and with their own unique narratives. As this work has shown, recovery outcomes are determined by the time taken to return to a stable norm, and the eventual state of resilience – social, economic, and of the built environment – and socioeconomic conditions at the point of recovery.

Figure 14 outlines three key components of the process, including the pre-disaster characteristics, recovery variables, and eventual outcomes of recovery.

Figure 14: Framework of disaster recovery, capturing the key controls and recovery outcomes following an event
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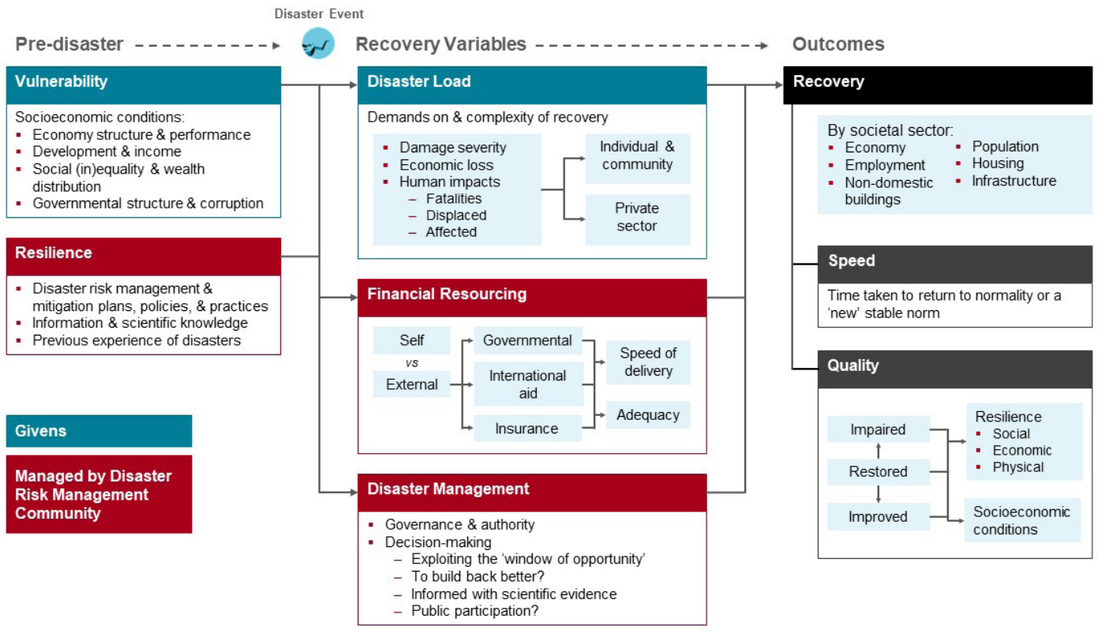

Section 6: Addressing the Gap – Opportunities and Challenges

The insurance industry must (and is beginning to) respond to the opportunities and challenges of the rapidly evolving risk landscape. The risk transfer industry is uniquely placed to help populations and their governments, particularly those in developing countries, who are prone to costly natural disasters. Despite the extreme and challenging situations that natural catastrophes create, relief efforts in the immediate aftermath of an event are often well coordinated by aid agencies who can mobilise quickly. However, it is when the immediate emergency is over and often attention is diverted, that the transition to a recovery phase begins and funds are needed to rebuild and restart an economy.

This report has presented a valuable evidence base comprising a catalogue of over 100 major natural disaster case studies, from which key insights on the dynamics of disaster recovery have been gained. It was clear that those communities that relied on post-disaster finance from external sources struggled with uncertainty about if and when funds would arrive, with publicly pledged sums not always reaching those in need. Post-disaster finance is often inadequate and delivered slowly, thereby inhibiting an effective recovery.

In contrast, timely insurance payouts to the policyholder are a critical enabler of recovery. Intuitively, we know the speed and scale of protection provided by insurance dramatically reduces the recovery time for communities which have suffered through extreme catastrophes. However, this study has strongly demonstrated that, on average, with each percentage point increase in insurance penetration (measured as the value of non-life premiums versus GDP) recovery times are cut by nearly one year. Further, countries with higher levels of insurance penetration show consistently positive outcomes in terms of the quality of recovery – the comparative state of resilience of an economy and society when recovery is completed to the state it was in prior to a disaster. While the most common outcome is a return to this previous state, with similar rates of productivity and unchanged socioeconomic conditions, a small number of recovery cases were successful in that they engaged in a process of reformative recovery.

Risk transfer through insurance constitutes a key component of pre-disaster risk mitigations and management strategies. The value of ex-ante finance is now widely recognised, and governments, international bodies, and private agencies are shifting their focus towards novel ways to proactively mitigate risk. The strong and proven cost-benefit arguments in favour of ex-ante investment justify such efforts. The benefits of mitigating, preparing for, and adapting to future disasters outweighs the costs of doing so, in terms of avoided losses, by at least four to one. While the value of insurance capital in facilitating a timely and successful recovery is apparent, it is clear that the industry's role in disaster risk reduction still represents an untapped opportunity. The impact of insurance on resilience can be measured not only through post-event financial relief, but in pre-event risk reduction, and these mechanisms are only beginning to be translated from theory to practice. The (re)insurance industry needs to provide greater incentives, via extra limit and contractual stipulations, for "building back better" practices to minimise the impact of future disasters.

Compared to post-disaster action, it is more difficult to quantify pre-disaster interventions in terms of their mitigating effect in a disaster. Nevertheless, there are a variety of initiatives through which insurance can more directly impact risk mitigation efforts, such as through partnerships with public agencies where the cost to benefit ratio of such efforts is profound. Further, insurance companies offer great value in terms of their understanding of risks and technical expertise to quantify the components of hazard, exposure, and vulnerability, as well as risk transfer solutions, especially at the macro scale. The insurance industry should be seeking opportunities to partner with government risk managers and development entities to increase public risk awareness and also influence additional factors, such as constructive regulation.

The key to tackling the protection gap is to develop new and innovative ways to mitigate risk, primarily by improving the availability and affordability of products in underinsured economies, thereby also growing the private market. Technological solutions and different funding structures offer broad opportunities to invest in new types of cover. Micro-insurance schemes are specifically designed to cover low-income people against specific hazards, targeting those without access to mainstream commercial and social insurance schemes.

Further, (re)insurers have a vital role to play in strengthening governments' risk management capacities, providing financial certainty and enabling capital to be invested elsewhere in disaster risk reduction and resilience measures. Insurance products do already exist that fulfil this brief but are today underused. Therefore, it is important that the industry can inform governments' understanding of the value that insurance brings in terms of the cost of an annual insurance premium versus public spending towards other initiatives. Nevertheless, the industry can also offer more by expanding its product offering to address a broader range of needs, and innovative financial products are emerging that combine incentives for resilience with risk transfer.

A report by Lloyd's of London and Centre for Global Disaster Protection (2018) report presented broad product concepts that offer opportunities for the international finance and insurance industries. Insurance-linked loan packages, for example, would explicitly integrate risk transfer solutions into concessional loans provided by financial institutions, specifying that loans should only be spent on infrastructure where resilience has been explicitly incorporated into the design. Reduced upfront insurance premiums and more favourable lending terms upon completion would provide further incentives for resilience. Resilience impact bonds could transfer the risk of providing resilient services to private investors, who provide upfront funds to ensure that critical services are more resilient. Returns would be outcome-based according to either the ongoing provision of resilient services or other conditions that aim to proxy this, such as natural catastrophe risk insurance coverage. Resilience bonds account for the impact of resilience measures with reduced bond coupon repayments. Following an eligible disaster, investors would lose some capital value of the bond, which is transferred to the bond sponsors. Resilience measures would also reduce bond interest payments to reflect the lower risk bond investors bear.

While insurance in developed countries is mature and embedded (though by no means fully adequate), emerging markets offer opportunities for business growth with increasing rates of insurance penetration as well as the potential to offer inventive solutions that cater to different cultures and needs. Lessons can also be learnt from mature markets where deficient mechanisms of risk transfer have been shown to perpetuate risk – for example, where insurance covers property in hazardous areas and repeatedly funds deficient repairs that remain vulnerable to the next event. Historically, a lack of incentives has discouraged resilient design, showing there is also a need for a stronger regulatory environment that defines policies conducive to positive change.

However, insurance is still a low priority in the hierarchy of needs for populations in developing economies. In some global regions, insurance is not a cultural norm. A key prerequisite for the success of new insurance schemes in emerging markets is raising risk awareness and educating people on the benefits and value of insurance in their lives. A drive to grow the demand for insurance must come from responsible governments partnering with the insurance community along with international financial organisations and governmental agencies. The goal is to convey with certainty to governments what insurance penetration means to the population they serve. It is hoped that this report will support the dialogue between parties, evidencing that existing insurance products can and do help the communities they serve.

Closing the insurance protection gap in both developed and emerging markets is an immediate priority for an insurance industry challenged to stay relevant in a global economy that continues to grow riskier. Perhaps more importantly, however, insurers are uniquely placed to play a prominent role and work with other organisations involved in disaster risk reduction to improve natural disaster resilience. The stakes are high, and without innovation and leadership from the industry, the costs will fall entirely on governments (i.e. taxpayers), aid organisations, and on at-risk communities. Opportunities already exist for insurers to engage and solve the problem, and there is a business case to further expand the role of (re)insurance in society.

Next steps for research on disaster recovery and the protection gap

The factors affecting the rate and quality of recovery, particularly the role that insurance plays in this area, is a promising area for further research. This work has constructed the first known database of case studies concerning recovery after disaster events across a variety of countries, contexts, and disaster types. This catalogue of events has already proved a powerful resource to analyse recovery outcomes, with a standardised approach to assessing recovery with key qualitative and quantitative metrics. We hope to further analyse this database to understand the controls and relationships between variables more deeply, while also further expanding the work with additional cases and information.

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