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Insuring Disasters: A Survey of the Economics of Insurance Programs for Earthquakes and Droughts

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ABSTRACT

Natural disasters have adverse consequences. A combination of effective mitigation strategies and appropriate coping measures—decreasing both exposure and vulnerability—can reduce their detrimental impact. Further policies can reduce the consequent losses to the economy in the aftermath of catastrophic events. Although constituting no panacea, the evidence suggests that insurance enables improved recovery and increases resilience. Yet, insuring catastrophic risks is complex and not easily achieved. Different types of disaster insurance products are found globally, but to narrow our discussion, we focus on two types of insurance for catastrophic hazards: earthquake insurance and agricultural insurance (for floods and droughts). We survey strategies implemented by governments, the private sector and multilateral/regional organizations that aim to address several impediments to insurance adoption and also describe the available evidence about the performance of such insurance systems in the aftermath of disaster events. We conclude with some thoughts about future research directions.

1. Introduction

Natural disasters have adverse consequences on people and the economy. A combination of effective mitigation strategies and appropriate coping measures, decreasing both exposure and vulnerability to disasters, can reduce their detrimental impact. Further policy choices can reduce the consequent losses to the economy in the aftermath of catastrophic events. Although constituting no panacea, the evidence suggests that insurance and similar financial risk transfer instruments enable improved recovery and increase resilience (IPCC, 2012; UNFCCC, 2008). However, the literature also suggests that insuring catastrophic risks is complex and not easily achieved (Cummins & Mahul, 2009; P. Hazell, 2001; Howard Kunreuther & Erwann Michel-Kerjan, 2014; Jerry R. Skees & Barnett, 1999). An active research agenda aims to elucidate the obstacles that appear to reduce both the supply and demand for insurance and that may explain the current low levels of disaster insurance coverage globally.

Insurance is the most common financial risk transfer tool, but other informal and formal risk sharing arrangements also exist (e.g., mutual (informal) insurance, micro- and macro-contingent loans, catastrophic bonds, and contingent sovereign credit). A prudent combination of financial risk transfer tools and relevant disaster risk reduction measures such as early warning system, risk education and communication, and defensive infrastructure, can minimize disruptions and losses to societies when catastrophic hazards occur (Warner et al., 2013). Moreover, insurance can strengthen incentives for other risk mitigating behaviours (Surminski, Bouwer, & Linnerooth-Bayer, 2016). A recent evaluation, for example, estimates that if a 50% of insurance coverage were in place, disaster impact on growth caused by a very severe (1 in 250 years) disaster can be reduced by as much as 40% (S&P, 2015a, 2015b). Still, a survey commissioned by the World Bank in 2009 reported that insurance covers less than 10% of disaster losses in developing countries (Cummins & Mahul, 2009). In developed countries, the figure is higher, though only about 40% of disaster damages are typically insured.

Different types of disaster insurance products are found globally. Some examples are flood insurance in the United States, flood reinsurance (Flood RE) in the UK, micro-insurance for crop losses in Bangladesh and India, earthquake insurance in New Zealand and Turkey, tropical cyclone sovereign insurance for the Caribbean and Pacific island countries, drought sovereign insurance in Sub-Saharan Africa, and agricultural insurance in Europe. To narrow our discussion, we focus in this chapter on only two types of insurance for catastrophic hazards: earthquake insurance and agricultural insurance (for floods and droughts). With this focus, we seek to provide examples of the complexity of catastrophic-risk sharing mechanisms in urban areas (earthquake insurance), and in rural areas (agricultural insurance).

We survey strategies implemented by governments, the private sector and multilateral/regional organizations that aim to address several impediments insurance adoption such as correlated risk, limited availability, low uptake, and asymmetric information that leads to moral hazards and adverse selection. We also describe the available evidence about the performance of insurance systems in realized disaster events and their aftermath.

Earthquakes are a very significant hazard in many countries, in particular around the rim of the Pacific Ocean, in mountainous Central Asia and the Northern South Asian subcontinent, and in the Mediterranean. Other regions may not experience very strong earthquakes but in some areas very high vulnerability make them equally risky (e.g., Haiti in 2010). Coastal regions elsewhere are exposed to tsunamis generated by earthquakes (even if far away). Mortality from earthquakes can be very high, with more than half a million casualties in the three most lethal events since the turn of the century (2004 in Indonesia, 2008 in China, 2010 in Haiti). Earthquakes also destroy large amounts of assets, as the costliest disaster in recorded history, the 2011 earthquake in Japan, demonstrates.

Equally, weather events such as droughts and floods have adverse consequences for the overall economy and particularly for agriculture. Many middle- and low-income countries are especially reliant the agricultural sector as an important sector of their economies, and typically also as a main export sector. As such, these countries are more affected by adverse weather events that damage agricultural production. Many high-income countries also have important agricultural sectors (e.g., United States, New Zealand, France). In high-income countries, agriculture typically has very powerful interest groups supporting it, even if the size of the labour force employed in agriculture in these countries is fairly small.

Given these observations, it is not surprising that risk transfer tools, and especially insurance, play a significant part in policies dealing with earthquake risk and weather-related risk to agriculture. Here we focus on these two sectors and describe the reasons that are still impeding the many ways in which insurance can provide on its promise to reduce and transfer risk. We start by focusing on the demand for insurance by residential households (for earthquake cover) and by farmers (for extreme weather risk). We then analyse the supply of earthquake and agricultural crop insurance and the barriers that insurance organisations (private and public) face in providing adequate coverage. We then describe some of the existing insurance schemes for both risks, and continue with the very limited available descriptions of the actual performance of these schemes in the aftermath of catastrophic events. We conclude with some thoughts about future research directions.

2. Demand for Insurance

2.1. Demand for Agricultural Insurance

Globally, market penetration of agricultural insurances remains low. Slow market development of agricultural insurance, especially those products that directly insure crop and/or livestock production, is typically attributed to low demand because of under-estimated risks, and financial illiteracy, as well as limited supply (Howard Kunreuther & Pauly, 2009; Mahul & Stutley, 2010; V. Smith & Watts, 2009). This is true especially in low- and middle-income countries where agricultural insurance is almost non-existent, in spite of the importance of the sector in the economies of many of these countries. Elsewhere, catastrophic risk management in agriculture in high-income countries is often reliant on public interventions such as ex-post payments or price guarantees rather than explicit insurance tools (Jerry R Skees, Barnett, & Hartell, 2006; V. H. Smith & Glauber, 2012).

Studies of willingness-to-pay for insurance consistently show evidence that farmers are not willing to pay for the full actuarial cost of the insurance (P. B. Hazell, Pomareda, & Valdes, 1986; McCarthy, 2003; Sarris, Karfakis, & Christiaensen, 2006). The evidence suggests this is not because they are not risk-averse; farmers think there are cheaper ways to manage risks (V. H. Smith & Glauber, 2012). Many farmers are also simply constrained by their budget. Howard Kunreuther and Erwann Michel-Kerjan (2014) explain this willingness-to-pay puzzle with behavioural economics, by examining the implications of prospect theory models and goal-based models of choice.[1]

Another reason for low demand for insurance may be the availability of aid and financial assistance following a disaster. These responses, triggered by principles of solidarity and shared responsibility, contribute to underinsurance as they weaken the incentives to take ex-ante measures to reduce financial risk. Heavy reliance on government or private assistance is referred to as “Charity hazard” while the same from the donors’ perspective is typically termed the “Samaritan’s dilemma” (Coate, 1995). Raschky and Weck-Hannemann (2007), for example, identify empirical evidence that reliance on private charity has adverse efficiency effects.

2.2. Demand for Earthquake Insurance

Historically in California, a region very exposed to earthquake risk, there has been very little earthquake insurance. For the 1971 San Fernando earthquake, for example, none of the damaged residential properties had insurance cover (Anderson & Weinrobe, 1986). Rates of earthquake insurance coverage today are still very low; with the most recent data suggesting only about 13% of residential properties have cover. Prices for earthquake insurance are high, and local homeowners appear unwilling to purchase cover because of ambiguity in prices, disaster losses, and the probability of occurrence (H. Kunreuther & Pauly, 2004; Palm, 1981; Palm & Hodgson, 1992). Underinsurance, though, is not unique to California, and is found in other high risk places (Gurenko, Lester, Mahul, & Gonulal, 2006).

The decision whether to purchase insurance is influenced by people’s perceptions of risk, which is often formed by their personal experience. For very low frequency but destructive events, this leads to an underestimation of risk before a disaster occurs, and over-estimation of such risks in the immediate aftermath of a disaster (Hertwig, Barron, Weber, and Erev (2004). Browne and Hoyt (2000) estimate people’s risk perception based on previous experience with floods, and concluded that there is a positive relationship between risk perception and demand for insurance. This mechanism is especially important for earthquake events, and is

[1] In contrast with the neo-classical/expected utility theory– the model that is often used to assess the optimal demand for insurance.

somewhat distinct from insurance for more frequent events that are covered by agricultural insurance (or floods). For example, there was a 72 per cent increase in earthquake insurance purchases following the 1989 Loma Prieta earthquake (Palm, 1995). Behavioural economics suggests several reasons why we observe this. People assess the probability of an event by how often examples of disaster occurrence they can remember; this is called the 'availability bias' (Tversky & Kahneman, 1991). Additionally, following a disaster, people focus more on pursuing emotion-related goals such consolation, reduction in anxiety and avoidance of regret (Finucane, Alhakami, Slovic, & Johnson, 2000; Loewenstein, Weber, Hsee, & Welch, 2001). The purchase of an insurance policy can satisfy these goals, but eventually these interests in reducing anxiety and avoiding regret weaken and homeowners become, once again, less inclined to purchase cover. Some individuals even cancel their insurance policy after several years because they find it difficult to justify the spending on premiums that have not been paid on (Hogarth and Kunreuther (1995). Policyholder, in a sense, tends not to follow the maxim that "the best return on one's insurance policy is no return at all".

3. Supply of Insurance

3.1. Supply of Agricultural Insurance

Agricultural insurance has a long history in developed countries. Crop insurance was first offered to cover a natural hazard peril (hail) in Germany as early as the late 1700s. In the 19th century, crop and livestock insurance were already available in rural areas in many European countries and in the United States (Mahul & Stutley, 2010; V. H. Smith & Glauber, 2012).

In developing countries, agricultural insurance of any type has only been offered for less than 20 years (Mahul & Stutley, 2010); and the data suggests it is slowly becoming more widespread. Empirical evidence suggests that the increase in insurance penetration rates is correlated with the introduction of publicly subsidized schemes and when insurance is either made compulsory or a condition for provision of credit (FAO, 2011; Mahul & Stutley, 2010). This is not unique to low- and middle-income countries; a review by V. H. Smith and Glauber (2012) about agricultural insurance in high-income countries concluded that the expansion of crop insurance programs in the last fifty years has been largely accomplished because of public budgetary support.

Covariate risks, and asymmetric information—which lead to moral hazard and adverse selection, can both make insurance firms reluctant to offer insurance products for any catastrophic event. Previous research has identified several additional reasons for the under-supply of agricultural insurance, especially in low- and middle-income countries: limited domestic technical, actuarial, and financial expertise, limited financial capacity, limited access to reinsurance markets, lack of infrastructure support for agricultural risk management such as weather database or crop modelling research, and regulatory impediments (Mahul & Stutley, 2010).

In agriculture, maybe one of the highest obstacles is the covariate nature of weather risks, when adverse events such as drought and flood can affect very large areas and thus a very large number of policyholders at the same time. Classic capacity problems such as lack of insurance data (weather data, risk modelling, disaster statistics), low penetrations rates and knowledge of general insurance practices, and the absence of enabling regulations contribute to the limited availability (P. B. Hazell, 1992; P. B. Hazell et al., 1986).

Lastly, climate change increases the uncertainty about the frequency, location, and severity of weather disaster events and thus may intensify the informational barriers that lead to under-supply of agricultural insurance. This is especially true since most climate modellers predict more and more intense disasters, but there is little agreement on magnitudes (Botzen, van den Bergh, & Bouwer, 2010; Deschenes & Greenstone, 2007; S&P, 2015a; Warner et al., 2013).

3.2. Supply of Earthquake Insurance

As is true for any type of insurance, insurers need to make sufficient profit to generate returns to their shareholders in order to attract capital. H. Kunreuther and E. Michel-Kerjan (2014a) state that two conditions must be satisfied to ensure the availability of coverage against a natural catastrophe: The first condition is the ability to evaluate the probability of event's occurrence and predict the loss in the case of adverse trigger event. The second condition is the ability to set premiums for potential customers with different disaster exposures to create a competitive profit. Although there are constantly advancements in seismic science and loss estimation modelling, these forecast tools are yet to reduce the uncertainty to an acceptable level (from an insurance perspective).

Nevertheless, insurance companies may be reluctant to offer earthquake coverage even when both insurability conditions are met. Following the 1994 Northridge earthquake, insurers suffered losses of $US21.7 billion. After this costly event, affected private insurers decided not to offer earthquake coverage at any price, despite the existence of a significant demand for this insurance product in California.

Even risk information that is potentially available is very costly to collect. For example, in most cases the quality of soil/rock base on which housing is located is largely unknown, as are the likelihood of earthquake-induced liquefaction. This information is very costly to collect, so insurers (private or public) have to rely on very limited information and find it difficult to determine risk-informed insurance premiums. This problem is maybe uniquely significant for earthquake insurance. For instance, California public earthquake insurance scheme (CEA) charges the same premium rates for areas with different seismic risks (as do most other public schemes). This creates adverse selection. Homeowners who live in earthquake-prone areas are more likely to purchase the CEA policy. This forces the CEA to charge high premiums and drive take-up rates down (Lin, 2014).

Correlated risk, a problem we already identified as plaguing agricultural insurance, is also significant for earthquake risk. Some of the largest insurance events in the past few decades were associated with earthquakes (in particular the 2011 East Japan earthquake, the 2010-11 earthquakes in New Zealand and the 1994 one in California). Because of this correlated risk, insurers are required to hold additional liquid capital, and thus significantly increase their costs.[2]

4. Existing Insurance Markets

The agricultural insurance provision is largely underwritten in high-income countries. Agricultural insurance contracts mainly consist of crop insurance (90%), despite long historical existence of livestock insurance (Mahul & Stutley, 2010; V. H. Smith & Glauber, 2012). Agricultural insurance is now growing fast, at an average of 20% annual growth rate, with an estimated globally-collected insurance premiums in 2014 reaching US$31 billion (Boissonnade, 2015). In developed countries, contributing factors to this growth are increasing subsidies and the introduction of new products such as revenue-based crop insurance. The same trend is observed in large middle-income countries such as in China, Turkey, and Brazil where governments encourage major expansion of agricultural insurance by offering premium subsidies and reinsurance protection (Mahul & Stutley, 2010). In low-income countries, development of agricultural insurance provision is slowly increasing with support from multilateral organization (e.g., the World Bank).

The United States is by far the largest market for agricultural insurance. Adding up the US market with agricultural insurance premiums collected in Canada, the total for these 2 countries accounts for 55% of the total global premium (Swiss Re, 2013). The second largest market for agricultural insurance is China, but market penetration rate there is still very low (Boissonnade, 2015).

The market for earthquake insurance is even less developed than in agriculture for almost all countries (except, maybe, in New Zealand). The impact of an earthquake can be enormous, but there is still limited coverage for earthquake risk even in very earthquake prone places like Japan and the West Coast of the United States. In middle- and low-income countries, almost no earthquake insurance is available. For instance, the 2008 Sichuan earthquake in China caused $US125 billion in losses but less than half a per cent of that was insured. In the 2010 Haiti earthquake, only 3 per cent of disaster losses were covered by insurance.

H. Kunreuther (2015) argues that the market failures in the case of disaster risks can be remedied through the design of Public-Private Partnerships (PPP) in insurance market. In these arrangments, the private insurance companies can be

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[2] AMI Insurance (AMI) was the second largest residential insurer in New Zealand. Because of its high market share in the affected region (35 per cent), the private insurer was exposed to a loss of $NZ1.8 billion following the 2010-11 Canterbury earthquake sequence. However, AMI only had $NZ300 million in capital reserves. Consequently, New Zealand Government had to bail out AMI by settling $NZ 1.5 billion of AMI earthquake claims, administrated through a state-owned entity, Southern Response.

providing claim services, marketing/distribution, responsibility for some tranches of the cover capacity, or some combination of these. The government may act as the primary insurer (e.g., Australia, Denmark, Mexico, and Poland) or by offering reinsurance coverage for larger losses (e.g., Japan, France and Indonesia). In addition, some governments take a "last resort" guarantor role that ensures the insuring entities will always meet all their obligations to cover the disaster risks (e.g., Spain and New Zealand).

PPP insurance systems can overcome some of the issues associated with asymmetric information if they are carefully designed, and by making cover mandatory (or near enough to it), they can also overcome some of the demand constraints. A PPP insurance scheme can charge risk-based premiums, set official standards and regulations, introduce education and applied research programs that help enhance resilience in the community, and also reduce costs through economies of scale and cheaper access to capital.

4.1. Examples of Agricultural Insurance

The main rationale for large public investment is usually to overcome market failures in insurance markets. These include: covariate risk, asymmetric information, limited access to reinsurance market due to small scale, and lack of public databases and risk models to support actuarial calculations. Government intervenes typically with premium subsidies, including administrative and operational costs. Crop insurance programs in China, Japan, India and South Korea receive significant subsidies. These programs account for 94% of the total volume of the agricultural insurance premium in Asia. (FAO, 2011) reports that agricultural insurance penetration rates are very low in other countries in Asia - Bangladesh, Indonesia, Malaysia, Nepal, Pakistan, Thailand and Vietnam.

Apart from premium subsidy, several governments support actuarial capacity building and resolve other supply-side issues through: insurance pools (e.g. in Mongolia, Spain, and Turkey), reinsurance protection (in China, Mexico, Brazil, Turkey, Spain, and the United States), by building and maintaining free access to reliable weather databases (e.g, the Caribbean Island States), or indirectly by commissioning regular risk modelling research, and enacting supportive regulations (Mahul & Stutley, 2010).

Government support for ex-ante risk transfer instruments like agricultural insurance is typically viewed as more cost effective than post disaster contingency assistance that can drain the public budget. Some critics, however, argue that agricultural insurance is relatively inefficient due to the high cost of delivery of the required subsidies, if compared to other government support programs such as direct payments (Babcock & Hart, 2015; Glauber, 2013; Mahul & Stutley, 2010).

A survey of existing schemes, FAO (2011), finds that the heavily subsidized public sector insurance schemes have mostly performed very poorly. Many of these programmes have ceased (Bangladesh), were reformed (e.g. Philippines and India) or replaced by public-private partnerships (PPP) schemes. PPP models have been increasingly popular across the region especially in China and South Korea. A private insurance approach has long been operating in Australia and New

Zealand. Lastly, new forms of small-scale initiatives are appearing, usually offered by microfinance institutions. Yet, the FAO study suggests that these more traditional or informal risk management practices cannot provide protection against infrequent catastrophic risks (see also, (IPCC, 2012; Janvry, Ritchie, & Sadoulet, 2016; Jerry R Skees, Varangis, Larson, & Siegel, 2004)

Public sector agricultural insurance schemes are usually characterized by a full government control of risk underwriting with one single insurance product that is exclusively delivered by a state-owned agency. Other features are deep subsidies (for premiums and for other delivery expenses) and the government acting as the main (or only) reinsurer. A major advantage of this model is its high penetration rate and therefore geographically-diversified portfolios (Iturrioz, 2009). Major drawbacks include: high operating costs, financial pressure for the government to assume full liability, and high fiscal cost.

One of the most cited success stories of a public scheme is the AgriInsurance program in Canada. The financial performance of AgriInsurance has been sound: the average loss ratio (proportion of payable claims to premiums collected) in the period 2003-2007 was 73% (Porth & Tan, 2015). The AgriInsurance program is managed by 10 provincial governments that formed crop insurance corporations in the early 1960. The program insures production or quality losses for specific crops such as wheat, corn, oats and barley as well as horticultural crops such as lettuce, strawberries, carrots and eggplants. The federal government fully backs up the program by subsidizing the premium (farmers pays 40% of the actuarial cost of the premiums and administrative and operational costs), and provides reinsurance protection to some of the provinces.

Another example is India's modified National Agricultural Insurance Scheme (mNAIS), which is the world's largest crop insurance program in terms of area and number of policies under cover (195 million hectare/14% of arable land and 20 million policies/15% of all Indian farmers). This is a reformed version after failures of several public sector schemes. This large subsidized program insures production from losses against multi perils and is implemented by the Agricultural Insurance Company of India (AIC), a state-owned agricultural crop insurance company. The government makes this program compulsory for all farmers taking agricultural loans from any bank or another financial institution. The premium is subsidized for farmers who own less than 2 hectares. The agricultural insurance scheme however does not underwrite individual farmers' risks rather it insures designated production areas against crops losses due to floods, drought, landslide, hails, storms and inundation. The mNAIS program offers area-yield index-based insurance and weather index based Insurance for crops and livestock insurance. The losses for the NAIS program have been reinsured by the Indian government under a 50:50 excess of loss agreement between the federal government and participating states. In the period of 2003-2007, financial performances statistics of NAIS' crop insurance products show that premium collected was on average US$103.4 million/year (where premium subsidies on average of US$6.7 million/year and A/O subsidies were on average US$3.3 million/year) and payable claims were on average US$ 324.3 million/year of which US$ 228 million/year were paid by the Indian government (FAO, 2011). The loss ratio in that period was 314% per year. To date the NAIS program still operates at a loss, and the Indian government is reportedly considering changing the scheme into a more actuarially sound model.

A similar recent program was introduced in Indonesia in 2015; where the government offers crop insurance for rice farmers having less than 2 ha land to reduce the impact of revenue shocks following droughts and floods. The scheme applies multi perils crop insurance (MPCI) concept, therefore it also protects production risk because of pests, and as long as the adverse event reduced the harvest by 75% (the harvest failure threshold set by the government). The main feature is premium subsidy of 80% that is paid by the government, and is implemented by a state-owned insurance company.

Following well-publicized failures of public schemes due to very high operational costs and very high loss ratios, some reforms have been introduced to strengthen them. Reforms include combining operational management with private entities. These public-private partnership models ideally implement sharing mechanism of gains and losses in underwriting natural hazard risk between participating private companies and the government. Mahul and Stutley (2010) categorize PPP models into 3 types: 1) National agricultural insurance schemes with monopoly agricultural insurer (typically state-owned); 2) Commercial competition with high level of control; and, 3) Commercial competition with less control. The most comprehensive PPP arrangements, which fall into type 1, are Agroseguro Pool program in Spain and the Tarsim Pool in Turkey. Type 2 schemes are ones where competition among participating private companies, with subsidization, is allowed under strict compliance with the regulatory regime. This group includes the United States Federal Crop Insurance Program (FCIP) and the Portuguese Protection of Climatic Risks program. The last model is the one where the PPP arrangements allow private insurers to operate under a loose partnership, with governments providing premium subsidies and/or reinsurance to the private insurers.

In terms of uptake, the FCIP has one of the highest uptake rates in the world—in 2014 it covered 119 million hectares (almost 90% of total area). Participating farmers will get, on average, about 62% premium subsidy from the federal government and the insurers receive A/O payment for delivering the FCIP products as well as reinsurance compensation if they experience losses (Shields, 2015).

There are several PPP arrangements in Latin America. The Seguro Agrícola Catastrófico is a subsidized agricultural insurance program in Peru implemented by private insurance companies to protect small to medium-size farms from catastrophic weather events. Uniquely, farmers do not directly enrolled, instead community leaders suggest lists of beneficiary farmers who have suffered losses (Solana, 2015). The Component of Assistance against Natural Disasters (CADENA) program in Mexico is another PPP example. The CADENA program facilitates catastrophic risk sharing mechanism between private insurance and reinsurance companies with federal and state government agencies through a federally coordinated scheme to protect agricultural losses (Solana, 2015). CADENA covers almost all perils from meteorological (drought, frost, hail, snow, torrential rain, floods, tornadoes and cyclones) to geological-seismic events (earthquakes, volcanic eruptions, tsunamis and landslides). Janvry et al. (2016) evaluate CADENA's implementation and conclude that despite some drawbacks the program's benefits outweigh its costs.

In pure market-based agricultural insurance systems, government intervention is minimal and schemes do not receive government subsidies. Yet, some government provision of supports such as an appropriate regulatory framework and supporting public goods and services (research, education, weather information) are still required as they provide the enabling environment. Government in these markets also sometime still provide support in the case of catastrophic disaster events. Obviously, one of the major advantages of private systems is the absence of a fiscal obligation. However, private agricultural insurance systems are constrained by high start-up and operational costs, which can lead to a monopolistic market with very few suppliers, high premiums, vulnerabilities to systemic risk exposure, and low penetration rates. Beyond the high-income markets, some private schemes are offered in middle-income countries such as Argentina and South Africa, but in most cases only some risks are covered. Often, risk to agricultural production due to weather shocks is not included.

4.2. Earthquake insurance schemes

The risk of earthquakes is higher only in some specific regions, especially the Pacific Rim (on both sides of the Pacific), the Alpide belt which stretches through the Mediterranean and the Middle East to the Himalayas, and the Western edge of Indonesia. In order to contribute to their seismic resilience, many countries in these higher risk regions introduced earthquake insurance systems. In low risk and high income areas, the private insurance sector is typically willing to sell earthquake insurance (e.g., Israel), but in higher risk locations the earthquake insurance programs have deep public sector involvement. Here, we focus on the biggest programs to date: in Japan, Turkey, California, and New Zealand. Other high-risk regions do not yet have very well developed earthquake insurance markets (e.g., the West Coast of the United States). We describe these arrangements chronologically based on the time they were introduced.

4.2.1. New Zealand Earthquake Commission (EQC)

New Zealand is seismologically very active. There are 15,000 earthquakes in New Zealand every year, although most are not large enough to be felt. Following two major earthquakes in 1931 and 1942, the Earthquake and War Damage Commission was establishes in 1945. It was established as a State Owned Entity owned by New Zealand Government and managed by a board of commissioners. It became the Earthquake Commission (EQC) in the 1993 EQC Act, the last time the law was revised.

EQCover is the seismic insurance cover provided by the EQC. It provides capped insurance to residential buildings, land and personal contents against the risk of earthquakes, volcanic eruptions, landslips, hydrothermal activity and tsunamis. It only covers residential properties and the land on which they are sited; commercial, industrial, and agricultural properties are covered by private insurers. The EQCover insurance is a de-facto compulsory addendum to standard fire insurance policies (that are typically required by lenders for home loans). Homes without standard fire insurance are not covered by EQCover, but in practice more than 90% of residential properties in New Zealand have it.

The EQCover has strict caps on both structural and contents cover, but anything above the cap has to be insured by the private insurer; the same insurer that issued the fire insurance policy through which the EQCover premiums are collected. Uniquely, EQCover also insures the land beneath the residential properties. [3] The deductible excess is much lower than other international schemes. The EQC buys reinsurance internationally, and also purchases annually a government full 'last resort' guarantee. Any collected premiums that are not used annually are accumulated and transferred to a Natural Disaster Fund (NDF). By 2011, the NDF had accumulated almost $NZ6 billion.

In February 2011, a strong and shallow earthquake very close to the Central Business District of Christchurch, New Zealand's second largest city, damaged much of the city. In the aftermath of this event, the cost of reconstruction was very high, and even though the EQC had about $NZ4 billion in re-insurance coverage, it also had to use practically all of the $NZ6 billion that previously accumulated in the NDF over the last few decades.

The EQCover has a flat premium rate irrespective of evaluated risk, and it is significantly more affordable than other international earthquake insurance schemes. Coverage costs 15 cents for every $NZ100 of cover. [4] Maybe not coincidently, New Zealand also has one of the highest take-up rates of residential insurance cover for natural disasters in the world. In the above-mentioned 2011 Christchurch earthquake, practically all residential damages were covered by insurance.

4.2.2. Japanese Earthquake Reinsurance (JER)

Japan is the world's most earthquake afflicted country. Following the 1964 Niigata Earthquake[5], the government and general insurance organizations decided to establish an earthquake insurance system. In 1966, Japanese Earthquake Reinsurance (JER) scheme was initiated and the Government of Japan undertook the role of reinsurer for earthquake risk.

JER offers coverage on buildings for residential use and their contents. The JER coverage per insurance policy varies between 30 and 50 per cent of the property value. The claim payment is dependent on the degree of loss. "The Act Concerning Earthquake Insurance" defines the earthquake damage on property and content

[3] The insured amount is the lower value of either the damaged land's market value or the cost to repair the land to its pre-event condition. This proved to be a contentious issue in cases where the 2011 earthquake caused liquefaction.

[4] The cost was tripled from 5 cents after international reinsurers increased their premiums in the aftermath of the 2011 earthquake.

[5] The Niigata Earthquake (M 7.5) happened on June 16, 1964, and damaged nine prefectures. The earthquake, ground liquefaction and flooding caused significant damages to infrastructures and residential properties in the region.

to three levels: total loss, half loss and partial loss. According to the "Insurance Claim Total Payment Limit", JER system sets the maximum insured amount to ¥JP50 million for residential property and JP10 million for c¥ontent for a single earthquake. The deductible fee equals the annual premium paid by policyholder with the maximum amount of ¥JP50,000 .per policy

The JER insurance was at first compulsory but has become optional since 1979. Private insurers must enrol in JER scheme which offer optional earthquake insurance as part of a comprehensive fire insurance policy. The earthquake insurance premiums paid by policyholders are passed-on from the private insurer and managed by the government and the JER system. Both institutions are responsible for reinsurance and providing a limited state guarantee. The maximum liability of the government, JER and private insurance are 87 per cent, 10 per cent and 3 per cent, respectively.

The Tohoku earthquake in 2011 was the costliest earthquake in history. Marsh (2014) reports that the earthquake caused an economics loss of $US210 billion of which only about $US35.7 billion was insured. This devastating disaster wiped out half of the insurance program's reserves and reduced its capacity limit significantly (Paudel, 2012).

JER sets the annual basic premium rate for every ¥JP1,000 of amount insured. The premium rate varies across zones, classified by their seismic exposure and building structures. The premiums paid by homeowners are between 0.05 per cent (risk zone 1 and wooden) and 0.35 per cent (risk zone 4 and non-wooden). The epicentre of 2011 Tohoku earthquake was located in the risk zone 1 which was thought to be associated with the lowest earthquake risk. The penetration rate for the JER scheme is not very high; according to 2015 Japan's Insurance market report, it is increasing but still below 30%.

4.2.3. California Earthquake Authority (CEA)

As is true for New Zealand and Japan, California is also very exposed to earthquakes. In 1985, California policymakers required that insurers offer earthquake insurance coverage to dwellings with one- to four-units. The Northridge earthquake of 1994, damaged more than 40,000 buildings, and caused losses of $US21.7 billion to insurers. This created a surge in demand for earthquake insurance. However, Roth (1998) maintains that after paying claims and re-evaluating earthquake exposures, private insurers decided to reduce their earthquake risk underwriting and had placed restricting terms on the remaining polices. As a result, the California Earthquake Authority (CEA) was established in 1996.

In California, private insurers now provide earthquake insurance coverage to homeowners by ceding their exposure to the CEA. The CEA provides coverage to both residential structures and content. The scheme allocates 14 per cent of premium revenue to the participating insurers for distributing and administering the policies and handling claims. Insurance companies that do not participate must offer their own earthquake coverage to their customers. About 30 per cent of the collected premium goes toward purchasing reinsurance and other financial risk transfer products. The rest is pooled in a CEA Fund as reserves. The CEA's overall claim-payment capacity is approximately $US12.1 billion. The components of this capacity include CEA accumulated capital ($US5.1 billion), reinsurance ($US4.37 billion), bond revenues and insurer assessments ($US2.6 billion) (CEA, 2016).

The CEA premium rates are calculated based on the property's construction type, the year it was built, and the earthquake risk for its location (19 different rating zones). The high premium rates and the low collectable claim-payment (deductible excess is 15% of the claimed amount), makes homeowners reluctant to purchase the CEA coverage. H. Kunreuther and E. Michel-Kerjan (2014b) find that only 12 per cent of California households have seismic coverage.

4.2.4 The Turkish Catastrophe Insurance Pool (TCIP)

The Turkish Catastrophe Insurance Pool (TCIP) is a compulsory earthquake insurance scheme that, as in all the other previous cases, commenced its operations in 2000 following the devastating Marmara earthquake in 1999. The TCIP focus is on high-risk urban dwellings as these proved to be very vulnerable in the 1999 catastrophe. The TCIP insurance is mandatory for residential buildings located within municipal boundaries; properties in smaller villages can purchase coverage on a voluntary basis. Households in rural areas who cannot afford insurance are eligible to receive direct financial assistance from the government following a disaster event.

The policy covers dwelling damages with no cover offered for household contents. Similar to the other insurance systems described above, commercial and public buildings are not covered. The sum insured for each claim depends on the construction type (steel, concrete, masonry or others) and the size of the property. The TCIP coverage is capped for dwellings with value over $US83,500 (as of January 2013). More expensive dwellings can voluntarily purchase additional coverage from private insurers.

The General Directorate of Insurance (GDI) of the Turkish Treasury plays the leading role in creating, operating, and implementing changes in the TCIP's policies. A private insurance company manages the program, and is responsible for information systems, claim management and reinsurance. Domestic insurers collect premiums, and take a 17.5 per cent commission. Revenue is also used to purchase international reinsurance. In 2015, the total payment capacity of TCIP, including the available reinsurance, was $US6 billion. The TCIP scheme aims to settle claims within a month and also provide partial fast payment following an earthquake; but this has not yet been tested in a large event (Başbuğ-Erkan (2007).

The TCIP sets 15 premium tariffs, which are calculated using the level of local earthquake risk (5 zones) and the type of building structure (3 types). The premium rate varies from 0.44 to 5.50 per cent of the insured property value, depending on the seismic resistance and geographic location of the property (Gurenko et al., 2009). There is a 2 per cent deductible fee (of the sum insured) for each claim. The earthquake policy is sold separately from the standard household insurance. Basbug-Erkan and Yilmaz (2015) show that there was dramatic increase in the TCIP penetration rate from 4.6 per cent in 2000 to 38.9 per cent in 2015. Regulations are applied to encourage wider participation in the TCIP scheme such as the requirement for TCIP policy documentation to buy/sell a house or to register for water and electricity services.

4.2.5. Multi-national risk pools: CCRIF and PCRAFI

Caribbean Countries (CCs) and Pacific Island Countries (PICs) are both highly exposed and vulnerable to adverse natural events, especially to tropical storms (cyclones/hurricanes) or earthquakes and their associated tsunami risk (Noy, 2016). Both CCs and PICs have very limited financial resilience to catastrophes due to their small size, inadequate building code, limited reinsurance availability and borrowing capacity. Lack of economic diversification between countries also makes cross-subsidization for recovery efforts more difficult (especially in the Caribbean, where a single event can easily hit multiple countries). In 2007, the Caribbean Catastrophe Insurance Facility (CCRIF) was established following the collaborative work between the Caribbean Common Market and Community, donor partners and the World Bank. Currently, seventeen out of 20 CCs participate in this multi-national risk pool (CCRIF, 2015).

Following the establishment of CCRIF, the Pacific Catastrophe Risk Assessment and Financing Initiative insurance pilot program (PCRAFI) was launched in 2013. The scheme was managed by the Secretariat of the Pacific Community (SOPAC), supported by the Asian Development Bank and the World Bank, and financed by donor countries (in particular Japan) and the Global Facility for Disaster Reduction and Recovery (GFDRR). Five PICs are currently participating in the insurance component of the program.

The insurance programs in both the Caribbean and the Pacific function as a not-for-profit risk pool facility, providing coverage against earthquakes and cyclones (CCRIF also has a separate program for excess rainfall). In the Caribbean case, a portion of the collected premium is retained in the risk pool as reserves. The rest is used to purchase reinsurance and catastrophe financial derivatives. For instance, according to the World Bank's analysis, CCRIF's claim payment capacity is such that it can pay for a 1-in-1,125 years event. Each participating country has its owned attachment point (deductible), and exhaustion point (capped payout).[6]

Both schemes provide parametric coverage. While traditional insurance requires assessments of individual disaster damage, the parametric insurance claim payment in both schemes is based on the estimated (modelled) emergency costs associated with the disaster. Since the parametric coverage does not require on-the-ground inspections, it reduces the insurance cost, makes quick claim payment possible, and provides the affected government liquidity in the disaster's

[6] For the 2014/2015 policy year, for example, member countries selected attachment point return periods in the range 10-30 years for tropical cyclones; 20-100 years for earthquakes and 5 years for excess rainfall events. CCRIF member countries also selected exhaustion point return periods in the range of 75 - 180 years for tropical cyclones; 100 - 250 years for earthquakes and 25 years for excess rainfall events, with maximum coverage of approximately US$100M currently available for each peril (CCRIF SPC, 2016).

emergency aftermath. For example, Vanuatu received from PCRAFI a claim payment of $US1.9 million less than a month after Tropical Cyclone Pam in early 2015.

Parametric insurance also reduces moral hazard because the pay-out only depends on the intensity of the event. The most significant disadvantage of parametric coverage is the possibility of divergence between the incurred damages and the estimated/modelled ones (so-called basis risk). Since the modelling in both these schemes is very conservative, it appears that the most plausible discrepancy is for the model to underestimate the level of damage, rather than to overestimate it (UNESCAP, 2015). For instance, the Solomon Islands government discontinued its participation in the PCRAFI scheme after the modelling did not trigger payments after an earthquake in the Santa Cruz archipelago and floods in the capital of Honiara – the model underestimated the emergency costs associated with the earthquake and the floods were an uncovered hazard (Mahul, Cook, and Bailey (2015).

4.2.6. Private Earthquake Insurance: Indonesia

There are more than 12 million people living in the earthquake-prone areas in Indonesia. The estimated economics exposure to seismic risk is $US79 billion. The Indonesia government established a reinsurance scheme against earthquake exposure in 2003 (PT Asuransi MAIPARK). Its shareholders are 82 non-life insurance and reinsurance companies. MAIPARK functions as a reinsurer and shareholders' clearinghouse for earthquake risk. The Indonesian private scheme sets a benchmark for earthquake insurance pricing. It also invests in public education, research, risk mitigation and risk management activities (MAIPARK, 2015b).

Private insurers offer coverage for agriculture, commercial, industrial and residential properties. The insured objects are comprised of the material damage (building, foundation, stock) and business interruption (gross profit, wages, increase working cost). Earthquake coverage is provided as a voluntary extension of fire policies. The insurance cost is classified based on the property location and its structure type. In the underwriting year 2011-2015, the highest insurance exposure to earthquakes is for commercial policies (41 per cent of total risks), while the much of the collected premiums are from industrial properties (47 per cent of total premiums). More than 90 per cent of the incurred claim value has been allocated to the commercial sector (MAIPARK, 2015a).

5. Take-up of Existing Schemes

In the last decade, agricultural insurance has grown substantially, marked by a sizeable increase of global agricultural insurance premiums from an estimate of US$8 billion in 2005 to $31 billion in 2014. Nevertheless, the penetration rate—defined as the ratio of agricultural insurance premiums to agricultural GDP—in emerging markets and developing countries is still very low (0.2-0.4%). The average penetration rate in developed economies is ten to fifteen times larger;

which is still quite low. Studies suggest that the recent expansion of agricultural insurance in both developed and developing countries is largely driven by increasing government subsidies, and by the introduction of newly innovative insurance products such as index-based or revenue-based crop insurance (Boissonnade, 2015; FAO, 2011; Mahul & Stutley, 2010).

However, experiences in countries such as Canada, the Netherlands and Spain show that subsidies cannot solve many of the demand and supply constraints we identified earlier (OECD, 2011). Attempts to address these market failures should focus on reducing asymmetric information in the agricultural insurance market through the development of supporting infrastructure (e.g. risk databases and models), and improving the incentives in insurance contracts (e.g. incentivising risk reduction through premium discounts).

The increasing interest in public-private partnership schemes have to some extent addressed poor financial performance of public insurance since the involvement of private partners usually improves the application of actuarial principles, and overcomes market failures facing private insurers by enlarging market uptake and insurance capacity. However, V. H. Smith and Glauber (2012) warn that private partners can use the political process to gain benefits from the public support in partnership schemes (see also (V. H. Smith, Glauber, & Dismukes, 2016).

Another development in the agricultural insurance landscape is the index-based insurance, as a response to information asymmetries and high verification costs faced by conventional indemnity-based agricultural insurance. Rapid growth of index insurance is largely predicated on the availability of public goods such as weather data, improved real-time meteorological measurement systems (i.e. automated rain-gauge stations) and remote-sensing and satellite technology as well as computational modelling that analyses the quantitative relationship between agricultural losses and natural hazard events. Since index-based insurance applies more transparent procedures, access to reinsurance is cheaper.

Demand and uptake for index-based insurance is relatively low as new products are challenged by lack of trust. An exception is an index insurance program in India, the world's largest index insurance program. It has high uptake as farmers are required to take this insurance when they apply for farm credit (FAO, 2011). Other than in India, large index-based insurance programs are operating in Canada and US (for forage crops), drought insurance for African countries (Africa Risk Capacity – ARC), and livestock index insurance in Mongolia. Smaller mostly pilot programs include a typhoon-based index in the Philippines for rice, flood index insurance in Peru, and weather–indexed crop insurance in China.

A challenge in designing an effective agricultural insurance scheme is the development of actuarial models based on the quantitative links between crop losses and natural hazard indices. The development of catastrophic risk modellings has been limited among academics and insurance industry, and is mostly done by a small set of specialized firms using proprietary models. Government can facilitate this knowledge acquisition through research funding and pilot projects, as an effective insurance market needs a range of agricultural catastrophe risk models. Modelling biological dynamics such as agricultural production in association with its exposure to natural hazards (e.g. drought, flood, frost, hail, storms) is a complex spatial task. These agricultural models are extremely useful for insurers and reinsurers (as well as government) in underwriting the risks. Further, these models can assist in the development of risk-based pricing approaches (Boissonnade, 2015).

Lastly, supporting regulations in insurance market are considerably underdeveloped, especially for agricultural insurance. This is especially true for many low- to middle-income countries that have little history of agricultural insurance. On the other hand, product innovations in agricultural insurance (e.g., weather index insurance) require specific enabling regulatory frameworks, or supporting policies to encourage wider access to weather databases.

The picture is not very different for earthquake insurance. Most insurance schemes have low market penetration even in high seismic risk countries and with government involvement. This is even the case when insurance is mandatory, but the requirement is not adequately enforced by the authority (as is the case in Turkey). The New Zealand scheme, with its very high penetration rate is the one successful outlier. Furthermore, state guarantee and public reinsurance are not a panacea as they can create 'hidden' financial obligations for governments and may end up placing significant costs on taxpayers.

6. The Consequences of Having Insurance

It is well recognized that disasters caused by natural hazards could result substantial damage and losses to a specific sector like agriculture (FAO, 2015) and eventually affect economic growth (Felbermayr & Gröschl, 2014; Strobl, 2012), while the magnitude of the impact may depend on country's socio-economic structures (Noy, 2009). There is only limited evidence to suggest that insurance may help a country reduce spill-overs of physical destruction of stocks into the flow of economic activity, and that with insurance the dynamic impacts are smaller and of shorter duration. Some indirect evidence is provided by Warner et al. (2013), who find that general insurance availability (but not necessarily take-up) is associated with better economic recovery after weather-related hazard events. Similarly, Melecky and Raddatz (2011) find that, following a large weather catastrophe, GDP recovers better when the general insurance penetration rate is high. These findings are instructive and relevant only if general insurance takeup is correlated with the penetration rates of insurance for natural hazard risks and is not correlated with other growth-inducing variables (such as the rule-of-law).

Evidence from crop insurance in the United States show that availability of insurance schemes provides farmers with effective risk management tool to recover from natural disasters as well as functions as a farm safety net (Shields, 2015). As an example, a multiple-peril crop insurance that cover about 90% of corn and soybean total acreage in Nebraska and Iowa helped farmers smooth the revenue losses from floods in 2010 (Edwards, 2011) and reinsurance protection helped both crop insurer and farmers deal with the huge losses of severe drought incidence in the US Midwest (Porth & Tan, 2015). Still, critics argue the US Federal government over-subsidises the insurance premium for farmers and the costs for the private operators (Babcock & Hart, 2015; Glauber, 2013; Shields, 2015).

A recent World Bank study analysed the ex-post effects of the large scale crop insurance program in Mexico implemented between 2005 and 2013, and found that income and expenditures of participating households increased during the survey period or few years after the insurance program starts (Janvry et al., 2016). Bertram-Hümmer (2015) evaluated the impact of commercial Index-Based Livestock Insurance program in Mongolia and finds that asset recovery (herds) of households participating in the program was much better than those who were not participating, 1-2 years following a severe winter in 2009/10. The study also suggests that the program contributed to recovery since payouts prevented herders from selling or slaughtering their animals. Participation in the program, also allowed households better access to credit.

Tadesse, Shiferaw, and Erenstein (2015) review several pilot projects for weather-based crop insurance in drought-affected areas in Northern Sub-Saharan Africa (Ethiopia, Kenya and Malawi). The review finds that actual net benefits of the insurance schemes are not so easy to identify, but suggest some ways these programs can be improved and net benefits manifest better.

A study of the Munich Climate Insurance Initiative (MCII) conducted by Warner et al. (2013) suggests that another potential benefit of agricultural insurance programs, a benefit realized in some countries, is the incentivising of loss reduction and resilience building behaviour (e.g., the India NAIS program as discussed in Surminski and Oramas-Dorta (2011)), provide tools for decision-making support (refer to experience in Ghana rainfall crop insurance as discussed in Cutter et al. (2012) and Karlan, Osei, Osei-Akoto, and Udry (2012)).

6.1 Case Study: The Great East Japan earthquake

The Tohoku Region was hit by a M9.0 earthquake on 11/3/2011. The resultant tsunami was the main cause of causalities and damages, though the earthquake also led to meltdown of the nuclear reactors in the power plants in Fukashima Prefecture. 88,000 residents were evacuated, with some unlikely to ever be able to return to their homes. The disruption to many manufacturing facilities and supply chains led to slowdowns or stoppages in some production lines and adversely affected manufacturing plants in far away countries. The electric power shortages due to the stopping of all nuclear power plants in Japan caused difficulties for many industries, and potentially led to a nationwide economic slowdown.

The insurance loss was estimated at $US35.7 billion. Nevertheless, the impact of the catastrophe on insurance companies was limited because of the Japanese Earthquake Insurance mechanism. The total limit of liability the Japanese government assumes, as the reinsurer of JER, is $US54 billion out of a capped liability of $US69 billion for JER. The JER's loss from the GEJE was approximately $US15 billion. There was thus limited impact on the balance-sheets of insurance companies. There is no government support for commercial earthquake insurance coverage. Due to the confidential nature of private insurance deals, it is hard to estimate the effect of the catastrophe on this sector, and we are not aware of (English language) reports describing the performance of this sector in this case.

Based on the lessons from 1995 Kobe earthquake, the General Insurance Association of Japan (GIAJ) had collaborated in efforts to settle claim payments rapidly. Eleven months after the GEJE, JER scheme has settled 99 per cent of reported claims - 885,000 of them (GIAJ, 2012). The JER rapid insurance payments summing $US15 billion likely allowed local residents to rebuild damaged structures, repurchase necessary living appliances and stimulate production for this demand.

Nagamura (2012) states that the residential insurance take-up rate in the affected regions was approximately 33.6 per cent, which was much higher than the national average of 23.7 per cent because of the local government efforts to encourage it. Overall, and in spite of the higher than typical take-up, no insurance company was made insolvent after the most costly insurance loss in Japanese history. Yet, there is little empirical evidence of its effects.

6.2 Case Study: The Christchurch Earthquake Sequence (2010-11)

The earthquake sequence started in September 2010 with an event that damaged the eastern suburbs of Christchurch city that were vulnerable to liquefaction. The earthquake caused over 150,000 residential property claims to the public insurer (the EQC) and 5,000 commercial and business interruption claims to private insurers. On 22th February 2011, a M6.3 earthquake struck closer to Christchurch's center, and led to significantly more damage. The Canterbury earthquake sequence was the most devastating catastrophe in New Zealand's history (Simpson, 2013), and damage was very high (especially relative to the size of the economy). The severe seismic damages resulted in over 500,000 residential insurance claims (buildings, land and contents from 160,000 properties in and around Christchurch) and more than 30,000 commercial and business interruption claims. The number of submitted claims was twice as large as the EQC's expectation of the worst foreseeable event (King et al. 2014).

To stimulate the region's recovery post event, the government decided to require the insurance industry (including the EQC) to offer their customers a rebuild/repair settlement rather than the typical cash payment. As a result, the Canterbury Home Repair Programme was introduced by EQC and has been operating since 2012.

The process of repairs and the closing of insurance claims has been slow, for numerous technical, legislative, legal, institutional, administrative, and practical reasons. It is not yet finished six years after the event. These delays in insurance settlements following the earthquakes has been reported as a major cause anxiety and stress among delay-impacted households. In some cases, residents were unable to live in their partially ruined dwelling but also unable to have it fixed or sell it for extended periods of time (King, Middleton, Brown, Johnston, & Johal, 2014). The duration and persistence of these negative impacts on residents' wellbeing are largely unknown.

Similarly to residential claims, the commercial insurance claim settlement process also faced significant delays, even though the legal and institutional issues deferring claims were quite different. As elsewhere, however, the details of commercial claim settlements often remains confidential so research about its impact is much more limited. Based on firm surveys, Stevenson, Seville, Kachali, Vargo, and Whitman (2011) find that affected organisations financed their recovery primarily by their cash-flow instead of claim payment as these were delayed. A further complicating factor for any speeding of claim resolution and recovery was the cordon placed around the city center for more than two years because of the fear of aftershocks leading for further destruction.[7]

Also using the same firm surveys, Poontirakul, Brown, Noy, Seville, and Vargo (2016) find in the short-term, business survival was not any different between the insured and uninsured firms as payments were anyway paid slowly. However, in the medium-term, firms which were paid promptly and in full experienced better recovery in term of performance and profitability than those that had incomplete or delayed claim settlements. Interestingly, the latter performed worse than firms that had no insurance.

7. Caveats and Conclusions

To summarise, there is little doubt that a well-designed insurance system is desirable as a central tool for disaster risk reduction. A well-designed scheme has to provide financial risk transfer products that are affordable, fairly priced and efficient, that its contracts are widely used and penetration rates consequently are high, and that provides and efficient and successful claim settlement process once a catastrophe hit. The potential role for insurance as a risk transfer mechanism was therefore acknowledged and encouraged in the most recent international agreement on disaster risk reduction (the Sendai Agreement signed in March 2015).

Despite these clear potential benefits and prospects, insurance is yet to deliver on this promise in most cases. For agricultural insurance, there are numerous challenges in designing adequate insurance products that can serve the very diverse needs of different crops and livestock, different very local natural environments (soil conditions and weather patterns), different institutional and governance details, and very different farming households. There are very few cases where insurance contracts that are successfully sold are not heavily subsidized by governments. Without high level of support, agricultural insurance remains expensive and largely unavaialbe for very vulnerable groups like poor farmers (Surminski et al., 2016). Equally, challenges of local implementation, and in particular the low interest in these products from farmers in middle- and especially low-income countries, are major hurdle.

[7] Businesses were not entitled to full business interruption insurance if their building was located inside the cordon but was unaffected by the earthquakes.

These challenges in the supply and demand for insurance are not unique to agricultural insurance. Earthquake insurance markets, however, face additional hurdles as damaging earthquakes are frequently very large-scale events and designing effective processes for the speedy resolution of claims in such large events remains a challenge.

Governments and the international community can and should actively facilitate the dissemination of insurance tools and products through the design of appropriate legal and institutional tools, in conjunction with private insurance entities. Governments should also ensure that the insurance markets that are present operate effectively and indeed deliver on their promises if a triggering event occurs. Much of the details about how these goals can be achieved, however, are not very well understood. There is a real and surprising scarcity of careful research about markets for natural catastrophe insurance. The only corner of this issue that is more researched is the demand for agricultural (micro) insurance in low-income countries. And in that corner, results are regrettably not very encouraging.

In any case, it is important to remember that insurance only transfers the financial component of risk. It most certainly does not save lives directly and may only indirectly improve people's wellbeing after catastrophic events. It should therefore only follow important risk reduction measures and mitigation strategies that should be prioritized. These measures and strategies can be facilitated and incentivized through insurance markets, but that is another area where both research and policy are still in their infancy.

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