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Natural Catastrophe Risk, Insurance and Economic Development

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Abstract:

The economic costs of natural disasters in the global world have been increasing in recent decades. Natural catastrophe risk has become a heavy issue for human society. How to deal with it leads to wide concerns. Some people think insurance is the best method; In fact it is only a effective way; what's more, the role of insurance depends on insurance regulators, governments, consumers and capital market working together, other than insurers. In section one, this paper describes the global natural catastrophe risk; In section two, it analyzes the relation between natural catastrophe risk management and economic growth briefly; In the last part, it treatises the role of insurance for natural catastrophe risk management.

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1. The brief describes of global natural catastrophe risk

The economic costs of natural disasters in the global world have been increasing in recent decades. The main reason for this is more and more people living and working in hazardous areas where there are infrastructures, capital investment, and economic activity. After researches, we find that the distributions of damages from natural disasters are a joint product of nature and society. Besides the natural disasters, global catastrophes still include viral pandemics, wars and large-scale terrorist attacks; trends are demographic, environmental, economic, and political shifts that unfold over time.

Take the year 2010 for example, we have suffered so many global natural catastrophes. The 8.8Mw earthquake in Chile, the 7.3Mw earthquake in Haiti, the Windstorm Xynthia in the Europe, the hefty storm losses in the United States and Australia, combined with the deepwater horizon disaster such as the

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oil rig explosion in the Gulf of Mexico and the floods in France. All of these had lead to significant losses, both in economic and in staff. Inevitably, the catastrophe (re)insurance experienced one of the most costly first halves on record, about USD23 billion, which is double the first half loss average record since 2000 and close to the total for 2009 as a whole[1].

In detail, in case of Chile earthquake, it's which that left the (re)insurance industry with the heaviest loss in the first half of the year. The magnitude of the Chile earthquake is measured to be 8.8Mw and it was located around 100 kilometers northeast of Concepción City. The death toll was near one thousand. Chile's official reports said that about 1.5 million homes were damaged, among which there were about 0.5 million homes were scrapped. For this reason, hundreds of thousands of people were left homeless. Moreover, the copper mining operations, oil refineries, pulp, fishing and wine industries also turned to be victims.

2. Natural catastrophic risk management and economic growth

In recent decades, we've suffered so many global catastrophes. Losses from human-made and natural catastrophes were rapidly increasing and turned to be countless, especially for natural catastrophes . The adverse effects induced by the catastrophes were serious, involving communication systems, electricity supply and irrigation, consumption, savings, investments and other daily living. There is a number of methodological challenges—often neglected in policy discussions—involved in catastrophic risks management and are confounding our ability to effectively manage the catastrophe risks.

The first is data lacking. This is reflected in two aspects. Point of view from space, for any particular location catastrophes are rare events though it seems to be common from a global perspective. Catastrophes have different spatial patterns and quite differently affect locations. The existed rich data of catastrophes is just applicable on an aggregate regional level. The principal problem with the management of rare catastrophic risks is the lack of historical data on losses at any particular location. The solution is generating data by applying models and doing some integrated analysis under the existing data. Another point is the time. The occurrence of a catastrophe within a small interval time Δt is often evaluated by a negligible probability $\lambda\Delta t$, which means the corresponding data during this interval time is penurious. But the probability of a catastrophe in an interval [0, T] increases as $1-(1-\lambda\Delta t)^{(T/\Delta t)}\approx 1-e^{(-\lambda T)}$. So the proper assessment and management of rare risks requires long-term perspectives.

The second is complex interdependencies. Catastrophes produce severe consequences, characterized by mutually dependent in space and time losses. It can also be called as tail dependence and microcorrelations. Tail dependence means the propensity of severe losses to happen together. Such as a heave earthquake may cause debris flow or landslides, even fire disaster and a hurricane may causes both flood and wind damage. The multivariate distribution of these losses is in general analytically intractable. It depends on the clustering of values in the region and the patterns of catastrophes, even the policy variables. The main idea in dealing with this type of management problem is to concentrate attention on the most promising directions. You can also make use of random simulations of catastrophes such as Monte Carlo simulation optimization.

Compared with this, microcorrelations are negligible correlations that may be individually harmless but very dangerous in concert, which may be better felt by insurance companies. Microcorrelations are correlations between variables at or beneath the limit of detection even with lots of data. Indeed, using traditional statistical tools, about 91% of the correlations would not be statistically distinguishable from zero but that does not mean they are zero. Identifying this type of correlation and creating insurance diversification strategies across areas or lines that are truly independent is essential.

The last but not the least one is uncertainty. Uncertainty is associated with every facet of catastrophe risk assessment. The exact evaluation of all complex interdependencies is impossible and thus risk

assessment will yield poor estimates. In this situation the most important task seems to be the design of robust management strategies. That's to say the evaluation of the optimal decisions is achieved without exact evaluation of all possible alternatives.

Besides what I've said above, the cooperation of various agents such as governments, insurers, investors and individuals is still indispensable during the catastrophic risk management.

In view of what we have analyses, we could find that catastrophe modeling is urgently needed now. Stochastic optimization provides a framework for incorporating decisions into the catastrophe models. First subdivide the study region into cells j= 1,..., 2 , m under certain standard. A catastrophe is simulated by a catastrophe model. It affects at random different cells and produces mutually dependent losses L_j^t . I f $x = (x_1, x_2, \dots, x_n)$ is the vector of decision variables, then losses L_j^t are transformed into $L_j^t(x)$, which indicates the special corresponded relationship between decision variables and the certain losses. In general cases vector x comprises decision variables of different agents, since the management of catastrophic risks requires the cooperation of various agents. In a rather general form the economic growth of each cell is modeled by the following equation. If y_j^0 is the initial wealth of the cell j , then its wealth at time t+1 is

$$y_j^{t+1} = y_j^t + I_j^t(x) - O_j^t - L_j^t(x), t = 0,1,\dots$$

where $I_j^t(x)$ represents the income induced by decisions x and O_j^t stands for outcomes. Thus vector x affects losses and the growth path of wealth y_j^t . If I_j^t includes returns from investments of different cells, then the growth of y_j^t can be endogenous with respect to catastrophic risks by introducing appropriate decisions.

Besides visible direct damages, catastrophes have long-term indirect effects. A large catastrophic loss may absorb domestic savings and force government into debt. The low-income countries lack the budgetary resources that would enable them to undertake the necessary growth adjustments. Let's use a stylized model to illustrates the importance of stochastic versus deterministic approaches to the economic growth. Let us assume that the wealth of the economy is defined by two factors: capital and labor, and constant returns to scale. So, the equation is Y=f(K,L), where Y, K, L means output, capital and labor respectively and f(.) is the production function. Define y=Y/L, k=K/L then we get the equation y=f(k).

$$\ln y(t) = y_0 + (s\theta - \gamma - \delta)t - L_1 - L_2 - \cdots - L_{N(t)} \quad (1)$$

Where γ is an exponential population growth rate, and δis the capital depreciation rate, s is the ratio of investments to output, θ is the constant ratio of output to capital. N(t) is the random number of shocks in the interval [0,t]. Let us also assume that random sizes of shocks L1…are independent, identically distributed with a mathematical expectation μ, they are also independent of the intershock times and the intershock times have a stationary distribution with mathematical expectation λ.

$$E\ln y(t) = y_0 + (s\theta - \gamma - \delta - \lambda\mu)t \quad (2)$$

The ignorance of risk is equivalent to the substitution of the complex jumping process lny(t) by deterministic linear function (1.1.3-2). This function still shows the exponential growth, although with a greater depreciation rate δ+λμ, but it ignores possible stagnation of the economy in the interval [0,T], even the uncertainty analysis. A challenging situation arises when shocks are endogenously defined by dynamic and spatial patterns of the growth. The growth path in such cases may exhibit thresholds and traps. Starting from the same initial conditions, the economy may end up at different traps without appropriate assistance and stagnate within these traps thereafter[2].

3. The role of insurance in natural catastrophe risk management

3.1 The problems about the insurability of natural catastrophe risk

Compared with traditional standards, natural catastrophe risk is facing:

1. Fat tails. Many distributions we encounter in daily life are "thin tailed". That's to say, we don't observe extreme values. However, damage distributions from many disasters are "fat tailed" and there is a greater possibility of extreme values[2]. Natural catastrophe risk can be considered as an extreme event. But the fact is that the probability of an extreme event declines slowly, relative to how bad it is. As a result, natural catastrophe risk reveals to be fat tails. This kind of distribution defies normal methods for analyzing risk. One of the challenges associated with fat-tailed risk is data lacking, which will impact the evaluation of the potential for and amount of damages. Without enough catastrophic historical experience, it's difficult to properly price the policy. As a result, insurance companies is hard to provide the catastrophe insurance, it impacts the insurable of the natural catastrophe risk.

2. Tail dependence. Tail dependence refers to the tendency of dependence between two random variables to concentrate in the extreme high values. Simply speaking, this means bad things happen together. We know that catastrophe claims refer to loss caused by any single event affecting a large number of insured policies within the same time frame. That's to say, natural catastrophe risk has highly interdependence. It has the propensity that severe losses happen together. For instance, a heave earthquake may cause debris flow or landslides, even fire disaster and a hurricane may causes both flood and wind damage. Failure to consider this tail dependence could lead an insurance company to underestimate its exposure and thus court insolvency. Since insurance companies face the risk of insolvency, they have no incentive to provide catastrophe insurance.

3. Microcorrelations. Microcorrelations are correlations between variables at or beneath the limit of detection even with lots of data. Neighbouring countries will be correlated if they suffer the same disaster, but most correlations are around 0. One thing should be noticed is that, when the[3] correlations actually are 0, the correlations between aggregations of countries will also fluctuate around 0. Ballooning correlations will put limits on diversification by insurance companies and are particularly alarming since they could so easily go undetected. Negligible correlations that may be individually harmless may be very dangerous in concert. This also impacts the insurable of natural catastrophe risk.

3.2 Conditions under which natural catastrophe risk can be insurable

1. Government intervention in catastrophe risk management.

Governments can smooth losses over time in a way which is difficult for private sector. Some proposals have been advanced, such as financing claims through the backing of state bonds after a severe event, federal reinsurance for state programs, and so on. However, there is a big problem in these proposals—moral hazard. It's not difficult to realize that, if the government subsidizes state insurance programs, it would encourage the state to provide insurance at quite low rates which couldn't cover the risk at all. To avoid this negative result, as an alternative, government can intervene the insurance market through allowing insurance companies to create tax-deferred catastrophe reserves. In this way, insurers could choose to allocate funds to a trust or to a separate account with a firm-specific cap[4]. The funds would accumulate tax-free and can be used only for predefined claims, which could be based on specific events or firm-specific catastrophic loss levels. In this way, it can ensure that when catastrophic claims happen, insurance companies can have more available capital to cover claim. It can potentially increasing the availability and affordability of insurance in natural catastrophe risk management. Thus, the government should try its best to stimulate the natural catastrophe risk-bearing capacity of the insurers or reinsurers. Besides, the government should emphasize personal responsibility among policyowners or policyholders. It should encourage and support prior risk precautions ,such as the standards of building quality ,related laws and so on.

2. The sound development of the reinsurance market

As the insurance of insurers, the development of catastrophe reinsurance market can support the development of catastrophe insurance market. With the developed reinsurance market, insurance companies can share natural catastrophe risk with other insurance companies at home and even aboard. This can increase the underwriting ability of insurance companies; besides, it can help to decentralize natural catastrophe risk in larger areas, and then make natural catastrophe risk insurable to some degree. Catastrophe reinsurance capacity is available for developing countries as long as their risk portfolio is properly structured and adequately priced. Reinsurance companies are more and more interested in allocation capital to middle- and low-income countries in order to diversify their portfolios. The development of catastrophe insurance and reinsurance markets in low-income countries is impeded by kinds of demand side and supply side market imperfections. As a result, catastrophe insurance is lowly developing; besides, catastrophe reinsurance is currently almost non-existent in most low-income countries, except a few deals on agriculture insurance supported by the donor community. To develop the reinsurance in these countries, overcoming these problems is an essential step.

3. The participation of the capital market

Given that insurance companies face pressure on the industry itself to respond to the threat from catastrophes; as a result, insurance companies are making greater use of the capital market. A major mechanism is securitization of natural catastrophe risk. Under this mechanism, insurance companies can transfer the risk of a catastrophe to the investors in the bond—catastrophe bonds. This mechanism has several important effects: increase the underwriting ability of the insurance companies which provide insurance for natural catastrophe risk; stabilize the operating of insurance companies; improve the welfare of the insured; increase the benefits of the investors; dilute the government's role as a "last reinsurer"; improve the capital structure of the insurance and capital market. Since capital market supplies so many positive effects, we should make full use of it in the management of natural catastrophe risk, and finally improve the economic growth.

3.3 The functions of insurance for natural catastrophe risk management

3.3.1 The special economic protection functions

Insurance serves lots of valuable economic functions that are largely different from other types of financial intermediaries. These are mainly embodied in those services that are not provided by other financial services providers.

The first is the indemnification and risk pooling properties of insurance. It facilitates commercial transactions and the provision of credit by mitigation losses as well as the measurement and management of non diversifiable risk more generally.. The main role of it is to prevent potentially severe losses and avoid excessive and costly bankruptcies. With insurance, risk averse entrepreneurs willing to undertake higher risk, which will promote higher productivity and growth. The scope of an economy's insurance market affects both the range of available alternatives and the quality of information to support decisions.

The second one can be seemed as the insurance industry rules[5]. Insurers have an incentive to control losses which is related to management odds or profitability. They will offer discounts for smoke detectors or other measures to help insured reduce the frequency and severity of losses then the eventual claims costs. The third one is that life insurance terms. Life insurance can provide capital to infrastructure and other long term investments on the basis of the policy cash value. Of course, this is a precondition that is insurance providers invest a substantial portion of their portfolios domestically in markets. Further speaking, all these unique functions of insurance are complementary to banking and financial sector deepening more broadly. All in all, the well functioning insurance markets' main roles in economic growth and development are better greater efficiency in the overall allocation of capital and mix of economic activities, pricing of risk and higher productivity.

3.3.2 Positive contribution to economic growth

With the deepening of insurance markets, it makes a positive contribution to economic growth. As we know, insurance can be easily divided into two categories: life insurance and nonlife insurance. Some research shows that: life insurance can give a positive contribution to economic only in higher income economies, except developing economies[6]; however, nonlife insurance makes a positive contribution in both higher income and developing economies. Besides, it also suggests that the positive contribution of insurance to economic growth is mainly through the way of financial intermediation and long term investments. However, from my point of view, it also makes important contributions to economic growth through risk management, and then gives contribution to individual and social welfare, which can give a good basis for economic growth.

3.3.3 Better contribution to natural catastrophe risk area

As we know, among nonlife insurance, natural disasters, weather, and crop insurance play an important role in catastrophe risk management, especially in poor economies. In poor economies, they tend to be more vulnerable to high volatility in incomes due to commodity price fluctuations and natural disasters due to poor building codes and infrastructure[7]. Thus there should be enormous potential for natural disaster and weather insurance to improve the performance of poor economies. If governments can incentive the insurance industry to developing this potential market, it will obviously improve the contribution of insurance to economic growth through natural catastrophe risk management, especially in the lower income economies. It's anticipated that climate change will exacerbate the incidence of weather patterns and natural disasters in many poor areas. To reduce the impact of climate change on the economic growth of poor areas, current investments in new products and innovations in weather and natural disaster insurance should be followed closely.

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