Research on Catastrophe Risk Financing Mode for Tailings Pond Dam Break

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Abstract. Aiming at disaster relief emergency fund for tailings pond dam break and financing channels of compensation after disaster in China, with the goal of achieving passing and decentralization of tailings pond dam break risk and reducing the impact on social economic to the utmost, this thesis studied on catastrophe risk financing mode for tailings pond dam break. Through analysis, four main problems were obtained, including risks in relevant system of tailings pond dam break risk financing have not been effectively transferred, occupying production funds of enterprises, insufficient total amount of financing and narrow scope of compensation. Further integrating with foreign catastrophe risk financing experience and application cases of floods, earthquakes and others, catastrophe risk financing mode and operating mechanism suitable for China’s tailings pond dam break were put forward, catastrophe risk financing management mode dominated by government and assisted by commercial insurance company was formed, with the effectiveness and feasibility of such mode guaranteed through insurance technology, engineering risk prevention and increasing of coverage of insurance program.

Introduction

Tailings pond, formed by damming for intercepting the mouth of a valley and exclosure, is a place for stockpiling tailings from metal and nonmetal mines after ore separation, which is an essential site for maintaining normal production of mine\cite{1}. At the same time, tailings pond is also a kind of man-made debris flows with high potential energy and dam break risk, making it a major hazard source to downstream safety. In the world's 93 kinds of accidents and public hazard hidden trouble, tailings pond accident ranks No. 18\cite{2}. Currently, the world's different kinds of tailings ponds in use are more than 20,000\cite{3}. Lemphers et al carried out statistics for 3,500 tailings ponds around the world and found that happen to an average of 2-5 tailings ponds were hit by dam break each year and the occurrence rate of tailings pond dam break was 10 times of that of reservoir dam break\cite{4,5}. By the end of 2014, there were still 11,358 tailings ponds in China, of which 772 were with potential risk\cite{6}. With changes in ecological and social environment and growing and concentration of human wealth, the impact of tailings pond dam break on social economy became more and more obvious. For example, a huge tailings pond accident of New Tower Mining Company in Xiangfen County, Shanxi on September 8 led to more than 90,000,000 Yuan of direct economic loss and had huge recessive effect on the local environment and economic development. Under this background, there are two important issues in theory and practice fields needing to be solved: how to achieve transfer and apportionment of tailings pond dam break risk; how to finance the losses caused by tailings pond dam break timely and effectively so as to minimize the impact of disaster on social economy. Therefore, to establish catastrophe risk financing mode for tailings pond dam break and to raise disaster relief funds rapidly are extremely important for dealing with tailings pond dam break.
Systems and Problems about China’s Risk Financing for Tailings Pond Dam Break

Currently, relevant systems of tailings pond dam break risk financing in China are “work safety risk deposits system” and “work safety liability insurance system”.

Work safety Risk Deposits System

Ministry of Finance, State Administration of Work Safety and People's Bank of China jointly formulated and issued Interim Measures for the Administration of Work Safety Risk Deposits of Enterprises in July 2006 with a view to strengthening work safety awareness and liability of enterprises and guaranteeing smooth implementation of accident and disaster relief. Work safety risk deposits refer to a special fund in a special bank account opened by an enterprise in the name of its legal person or partners for its own emergency and disaster relief in work safety accidents and afterward disposals.

But risk deposits system has the following problems for tailings pond dam break risk financing:

(1) The government urges enterprises to defend themselves by risk deposits system. It is not a way to transfer risks by a company’s own fund in deposits to take precautions against future trouble. Transfer of risks is that units or individuals that may be in danger transfer the risk to a third party by contractual or non-contractual means to avoid the losses caused by potential dangers.

(2) Risk deposits system directly freezes partial asset of the participating enterprise with a period of the enterprise’s life-span in its original product field and an amount of money varies from 300,000 Yuan to 5 million Yuan. Under the constant slowdown of mining market, the policy will make mineral enterprises have tenser capital chain, lower productivity effect and lower initiatives to relieve disasters.

(3) Risk deposits system can’t raise compensation funds for disaster relief quickly. Interim measures provided that work safety risk deposits of enterprises in principle should not exceed 5 million Yuan; however in recent years, the loss arising from tailings pond dam break accident in china, such as the “9.8” major accident of tailings pond dam break in Xiangfen county, Shanxi Province, the direct economic loss was more than 90 million Yuan. A 5-million-yuan risk deposits can’t have urgent effect and it would take a long time to get disaster-relief funds, such like financial contingency fund and social contributions, which will delay the disaster relief and proper settlement of the victims.

Work Safety Liability Insurance System

Work safety liability insurance is a product that production and operation entities implement compensation liability for the dead and the crippled after work safety accidents. Compared with work safety risk deposits, work safety liability insurance won’t freeze a large amount of the enterprise’s fund at one time and can quickly integrate into a relatively large amount of fund for emergency and disaster relief. But today, the work safety liability insurance in China’s insurance market doesn’t have an effective solution for the risk financing problem of tailings pond dam break. Work safety liability insurance mainly provides death and disability compensation for employees of the insurants and the third party related to accidents. The property damage, environmental damage and dam break caused by natural disaster will not be compensated. There are both human factors and natural factors in causing the dam break of tailings pond. Negative externalities involve many aspects, such as personal injury, property loss, environmental damage and the slowdown of economy, so the work safety liability insurance obviously can’t entirely transfer the risk of dam break.

Catastrophe Risk and Experience of Catastrophe Risk Financing in Foreign Countries

Catastrophe and Catastrophe Risk Financing

According to the qualitative definition of United Nations Environment Programme (UNEP), catastrophe is a kind of serious social dysfunction that causes human, material and environmental damage on a large scale, and such damage has outweighed the capability that the society can bear
with its own resources[7]. Swiss Re has defined catastrophe quantitatively and revised data regularly to adapt to catastrophe insurance market of different periods; Table 1 shows the catastrophe criteria in 2013 published by Swiss Re in Sigma:

<table>
<thead>
<tr>
<th>Table 1. Sigma catastrophe criteria in 2013.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insured losses</strong></td>
</tr>
<tr>
<td>Shipping</td>
</tr>
<tr>
<td>Aviation</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td><strong>Or total economic losses</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Or casualties</strong></td>
</tr>
<tr>
<td>Dead or missing</td>
</tr>
<tr>
<td>Injured</td>
</tr>
<tr>
<td>Homeless</td>
</tr>
</tbody>
</table>

Financing, namely, accommodation of funds, has two economic characteristics in essence: first, it promotes funds to flow from surplus side to demand side; second, with flow of funds, it redistributes cash flow related risks generated in tangible assets between fund supply and demand sides[8]. Catastrophe risk financing refers to risk transfer activities carried out before the catastrophe with the purpose of avoiding uncertain losses caused by catastrophe. Risk bearers conduct fund restructuring or risk apportionment through insurance, reinsurance, capital market, government participation, etc. Some developed countries already have mature experience in catastrophe risk financing; they make full use of indemnity insurance and risk apportionment to safeguard the stable and safe running of society, economy and finance market, and reflect different running modes based on individual situation of catastrophe and financial insurance markets. From the worldwide average level, insurance assumes about 30% of the economic losses caused by natural disasters and even over 60% for developed countries[9].

**Catastrophe Risk Financing System in Foreign Countries**

Currently, the world's catastrophe risk financing systems mainly rely on catastrophe insurance management and can be classified into three categories represented by the UK, the US and Japan respectively.

Flood insurance of the UK is voluntary catastrophe insurance where insurance companies can voluntarily determine whether to underwrite flood insurance according to its own demand in business and market development as well as its cooperation with the government. Usually, the flood insurance is bonded in the insurance coverage of standard property policy for family and small enterprise, and the policy owner can voluntarily choose to buy property policies covering different kinds of flood insurance. The government is mainly responsible for investment in and construction of flood control project, but it’s not directly involved in operating management of flood insurance or risk assumption.

The National Flood Insurance Program (NFIP) of the US is mandatory catastrophe insurance mainly administered by the government. In essence, NFIP is a national insurance system authorized by law and managed and financed by the government; in general, the operating expenses and insurance claims of NFIP are paid for through the collected premiums and its operation, but if its losses exceed the historical average, NFIP has the authority to borrow up to 1.5 billion dollars from the U.S. Treasury, and the United States Congress may also offer special appropriation, indicating that the government is involved in risk assumption[10]. Private insurance companies are only responsible for issuing flood insurance policy and get the corresponding remuneration.

The earthquake insurance system is catastrophe financing system involving both the government and the insurance companies, and its main carrier is Japan Earthquake Reinsurance Co., Ltd. (JER). The commercial insurance company first sells earthquake insurance as additional insurance of fire insurance, then it reinsures the underwritten earthquake insurance to JER in full. JER will divide the risk insurance into three parts: one part recovered by the commercial insurance company, one part
reinsured to the government, and one part retained for itself, forming a risk apportionment mode involving three parties of two levels. In the event of earthquake losses, the three parties assume the losses on five levels according to the predetermined rules (see Table 2). With the total insurance compensation of 5.5 trillion yen, the government assumes 4.3915 trillion yen, and JER and the commercial insurance company assume 877.81 billion respectively.

Table 2. Proportion of loss apportionment of each level for earthquake insurance of Japan.

<table>
<thead>
<tr>
<th>Insurance compensation for single earthquake [billion yen]</th>
<th>JER</th>
<th>Government</th>
<th>Direct insurance company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st level 0-115.0</td>
<td>100%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2nd level 115.0-1,122.6</td>
<td>0</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>3rd level 1,122.6-1,925.0</td>
<td>50%</td>
<td>50%</td>
<td>0</td>
</tr>
<tr>
<td>4th level 1,925.0-3,712.0</td>
<td>0</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>5th level 3,712.0-5,500.0</td>
<td>5%</td>
<td>95%</td>
<td>0</td>
</tr>
</tbody>
</table>

Feasibility analysis for China to Build Catastrophe Risk Financing Mode for Tailings Pond Dam Break

Broadly speaking, tailings pond dam break is classified into catastrophe due to its following features: (1) small probability of occurrence; (2) impossible to overcome to some extent; (3) possibility to cause huge casualties and property losses in a short time and even affect many aspects of the national economy, such as finance, insurance and other industries. The catastrophe risk financing system has not been formed in China, but the serious catastrophe situation makes its establishment extremely urgent. The relative academic fields in China have been conducting theoretical studies for a long time and Some Opinions of the State Council on the Reform and Development of the Insurance Industry published in 2014 proposed to “integrate insurance into disaster prevention and relief system” and specified specific measures. Therefore, the study on establishment of risk financing mode for tailings pond dam break can refer to theories and practice of catastrophe risk financing.

In addition to the common features as catastrophe, tailings pond dam break also has its own characteristics: (1) tailings pond is an artificial structure with large volume and potential energy; compared with natural disasters, the dam break risk is more controllable, but it’s easy to become secondary disaster of natural disasters; (2) disaster caused by tailings pond dam break is of great externality, that is, the affected people, property and environment are always outside mining enterprise’s jurisdiction. Therefore, different from catastrophe risk financing system, the risk financing mode for tailings pond dam break takes mining enterprise as the policy holder and populations within the dam break risk area as the insured.

Accordingly, the administrative objectives of risk financing mode for tailings pond dam break should be: (1) drawing mining enterprises’ attention to safe operation of tailings pond and improving disaster prevention and reduction measures in operation of tailings pond through appropriate incentives; (2) managing funds of risk financing through commercial insurance, improving product mobility and realizing transfer of tailings pond dam break risk to a third party; (3) ensuring ideal coverage of insurance program through mandatory administration of the government, and ensuring that the non-profit activities proceed smoothly during establishment of financing mode.
Mechanism Design of China Establishing Catastrophe Risk Financing Mode for Tailings Pond Dam Break

Select Governance Mode Guided by the Government

The government is the participator who plays an important role in the catastrophe insurance system. It is responsible for formulating and promoting the establishment of financing mode, maintaining laws and regulations of stabilizing financing mode, repairing disaster prevention and reduction facilities, providing risk insurance rate map, hydrology, geology and climate research data and disaster warning and mobilization and diffusion before the disaster. While, in the NFIP plan of US, the government also plays an important role in the management and operation of the whole risk system. The insurance market of China is not mature, the social insurance consciousness is indifferent, so we the compulsory management measures from the government to promote the establishment of catastrophe risk financing mode for tailings pond dam break.

The China’s insurance industry starts late that the business area is narrow; risk management, actuarial technique, payment ability management, insurance and compensation checking technique, accumulation of experience data and other key techniques are not mature; the suiting support of laws, systems and capital market is not perfect; the public recognition is not high. However, China has a lot of middle and small tailings ponds, disease reservoirs and upstream type of dams; the surrounding areas are allocated with crowd gathering places, other industrial zones and ecologically sensitive areas; in addition, the crustal activities of many areas are frequent, the risk of dam break is huge, and the disaster loss may exceed the bearing ability of the insurance industry. But the insurance industry is specialized in related businesses of risk transformation, and it can provide powerful help for the funds management, product sales, service feedback and drawing of risk geographic map for the catastrophe risk financing mode for tailings pond dam break in risk evaluation, risk control, risk and insurance product management, product sales and service and other aspects. So, the risk financing model of tailings pond dam break of China needs commercial insurance company as the most important support.

Ensure Efficient Operation of Financing Mode through Insurance Technique

It determines insurance rate through actuarial technique. Any catastrophe risk financing mechanism should adopt actuarial technique to determine catastrophe risk rate which is suited with the risk standard of target risk standard to both ensure the sufficiency of rate and further ensure the repayment ability of insurance company, and show the principle of fair and reasonable, which is good for strengthen the motivation of disaster prevention and loss reduction, and avoid adverse selection to some degree[10].

Different with China catastrophe risk financing researched by many scholars, tailings pond dam break risk financing should not provide subsidy rate on the basis of actuarial rate, as the policy holder is not the farmer or other natural person with low insurance fee payment ability, but the mineral enterprise. Of course, in the initial stage of establishing catastrophe risk financing mode for tailings pond dam break, in order to improve the initiative of mineral enterprises participating in financing mode or on the basis that in the initial stage of building tailings pond for some mineral enterprises, some objective factors (such as natural disasters caused by local environment and climate change) exist information asymmetry, so it can give qualified mineral enterprises appropriate insurance fee subside or the subside used for repairing, renovating and on-line monitoring tailings pond.

In addition, use the insurance technique of “coinsurance percentage” to help mineral enterprises invest small insurance amount and gain more funds used in disaster relief and recovering social influence after disaster. Besides, audiences influenced by the disaster and local social benefit can be safeguarded, which can better exercise the economic encouragement of disaster prevention and reduction measures.

Highly Emphasize on Engineering Risk Prevention

Ensure the construction quality and daily maintenance of manually constructed buildings in the
risk area is the prerequisite for insurance industry participating any catastrophe risk financing system and important controllable link of reducing the happening percentage of reducing catastrophe risk. For example, if the community frequently suffered from flood wants to apply into NFIP, it must formulate practical flood prevention plan, establish effective flood prevention facility and repair and fix some buildings with poor flood prevention ability. And it can enter NFIP after all engineering risk prevention measures meeting the requirement.

Tailings pond is a kind of manual debris flow with high potential energy, and it is also industrial building with grand scale. From Table 3, it can be seen that even the tailings pond with small level, the height of dam is around 30m. Based on the data provided by the survey report of USCOLD (1994) and complementary UNEP (1996), 63% dike branching accidents are happened in the dam with the height lower than 20m; the majority of dike branching accidents are happened in the upstream type or unknown type of tailing dam; the main reasons of tailing dam accidents are unstable slope, earthquake and overtopping, and the upstream type of dam is the same[11].

The Chinese tailings ponds are mainly small type of tailings pond at or below three level, and the majority of them are upstream type of tailings ponds, and the construction standard and online monitoring are not standard at all. Many Chinese tailings ponds are located in complicated places, belonging to the natural disaster prone area of earthquake, debris flow and flood. China is a county with large population, and the construction of many tailings ponds cannot avoid densely populated area, industrial park or ecological sensitive area. Therefore, once the tailings ponds break, the negative externalities are very huge. According to the research, the earthquake prevention requirement should be upgraded from 7 to 8, and the buildings should increase the cost of 5%-10%[12]. However, from the characteristics of Chinese tailings ponds, improve the construction standard of tailings ponds and strengthen the daily supervision, management, maintenance and other engineering risk prevention works on tailings ponds by mineral enterprises can bring greater general benefits to the society.

<table>
<thead>
<tr>
<th>Level</th>
<th>Full capacity V [ten thousand m³]</th>
<th>Height of dam [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Items with the upgrading condition of level □ pond</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>V≥10000</td>
<td>H≥100</td>
</tr>
<tr>
<td>III</td>
<td>1000≤V&lt;10000</td>
<td>60≤H&lt;100</td>
</tr>
<tr>
<td>IV</td>
<td>100≤V&lt;1000</td>
<td>30≤H&lt;60</td>
</tr>
<tr>
<td>V</td>
<td>V&lt;100</td>
<td>H&lt;30</td>
</tr>
</tbody>
</table>

In addition, we can borrow the experiences from other countries on the construction engineering quality insurance to ensure the successful implementation of engineering risk prevention of tailings pond, such as Construction Responsibilities and Insurance in France requires that the contractors must shoulder corresponding quality defect responsibility for the engineering and construction equipment for 10 years and 2 years respectively, and they must have insurance; otherwise, they cannot contract related engineering project[13]. And Japan also has mature construction insurance market with 4 types of construction insurance types, covering risks from construction design, construction to installation and usage; moreover, the construction insurance market also receives the intervention from the government. Ministry of construction will evaluate engineering contract companies each year to provide reliable information for the construction insurance market, and exercise differential rate for engineering contract companies with different construction qualities.

**Improve insurance Participating Rate of Catastrophe Risk Financing Mode for tailings Pond Dam Break**

Due to the characteristics that the happening probability of catastrophe risk is small and the loss
is huge, people are easy to have fluke mind and they are unwilling to insure for catastrophe risk, so it is a difficult problem of insurance participating rate of catastrophe risk financing system. In order to ensure that large number of people can participate into the flood insurance plan, NFIP mainly adopts two measures:

(1) Regulate “statutory flood insurance purchase requirements”. For example, if one community doesn’t take part in NFIP after it is determined as flooded area for a long time, the federal institution will not provide any fiscal support for the community to purchase or repair buildings, or provide certain disaster assistant. In addition, when the federal institution and lending institution participating federal insurance or regulated by the federal provide fund or loan to assigned special flood risk area in the acceptance insurance community of NFIP to purchase and construct, they all require the community has flood insurance[10].

(2) Draw flood risk map. NFIP takes advantage of risk map to determine flood coverage scale and flood insurance rate map based on flood prevention engineering condition and staff and assets gathering condition in the flood risk area to provide sufficient information for reasonably determining insurance rate. It can also clearly show flood risk situation to the targeted public in the flood risk area to make them get rid of fluke mind and insure based on reasonable expectation.

For the Chinese catastrophe risk financing mode for tailings pond dam break, we can collect many factors, such as construction type and level of tailings pond, usage and monitoring situation of tailings pond, geographic location where the tailings pond is located, possible submerged scale of tailings pond dam break, local geographic and climate characteristics, downstream ecological environment and historical relic distribution situation of tailings pond, personnel density and asset property concentration of the downstream of tailings pond and building structure, type and usage of the downstream of tailings pond. We can also make detailed research and investigation of national tailings ponds, draw tailings pond dam break risk area map and insurance rate map to provide as much as reliable and comprehensive information for the division of tailings pond dam break risk area and the determination of tailings pond dam break insurance actuarial rate. Meanwhile, use the actual data and risk area map to improve self-protection conscious of downstream residents of tailings pond, importance degree of local government and initiative of mineral enterprising of entering into catastrophe risk financing mode for tailings pond dam break.

The experience of upgrading insurance participating rate of England is different from America. Although in recent year, England is more vulnerable to be suffered from flood, the quick development of flooded area increase assets loss amount, and insurance company of accepting insurance of flood should pay higher payment items; from the real index, the average cost of asset insurance of family and small enterprises is reduced instead of increasing, and the insurance participating rate of flood insurance reaches around 80%, which owns to the high competitiveness of England insurance industry.

If China wants to ensure the pretty high insurance participating rate of catastrophe risk financing mode for tailings pond dam break, it needs to ensure that insurance companies participating the financing mode have strong competitiveness, which can ensure the market order of insurance industry can bear the change of frequency of dam break happening, which can also reduce the average cost of related insurances and improve the initiative of mineral companies to insure.

**Concept of Chinese Catastrophe Risk Financing Mode for tailings Pond Dam Break**

Based on the above mechanism design, the Chinese catastrophe risk financing mode for tailings pond dam break should be:
Table 4. Concept of Chinese catastrophe risk financing mode for tailings pond dam break.

<table>
<thead>
<tr>
<th>Participating projects</th>
<th>Main responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central government</td>
<td>Formulate and implement related policies and supporting laws of financing mode to ensure the executable degree, market operation mechanism and implementation situation of financing mode; organize professional team to divide tailings pond dam break risk area and draw corresponding insurance rate; build and repair public facilities of disaster prevention and reduction; motivate the initiative of participators through tax stimulation and insurance fee subsidy; exercise appropriate re-insurance of excessive loss of tailings pond dam break disaster.</td>
</tr>
<tr>
<td>Local government</td>
<td>Monitor safety situation of the construction and operation of tailings pond in the residency, and the situation that mineral companies insure tailings pond dam break risk from the insurance company, and report to the central government timely to revise policies and regulations of financing mode.</td>
</tr>
<tr>
<td>Insurance company</td>
<td>Cooperate with government to design financing mode as micro benefit business insurance with policy factors, and popularize it with the method similar to “Compulsory Traffic Accident Liability Insurance”. The insurance company can directly operate this kind of insurance type, and it is responsible for selling insurance policy, managing insurance fee and certain proportion or share of risk responsibility after check.</td>
</tr>
<tr>
<td>Other financial institutions</td>
<td>Cooperate with government and insurance company to popularize financing mode compulsorily and continue to disperse tailings pond dam break risk through risk securitization to exercise re-insurance for insurance companies participating the financing mode.</td>
</tr>
<tr>
<td>Mineral company</td>
<td>Ensure the regular design and excellent construction of tailings pond of the company, improve monitoring facilities, precisely manage the operation situation of tailings pond, participate in the catastrophe risk financing mode for tailings pond dam break and cooperate with government and insurance companies to complete disaster relief and compensation after the happening of dam break disaster.</td>
</tr>
</tbody>
</table>

Conclusion

The speed of population increase and wealth gathering in China is very quick, while the rectification speed of a large number of small, dangerous and sick tailings ponds is very slow, and due to the severely global climate change in recent years, many places in China become the natural disaster prone area, resulting in the huger negative social and economic influence caused by tailings pond dam break. Up to now, the discussion and practical experience on catastrophe risk and catastrophe risk financing around the world are bountiful, and many developed countries have explored the whole suit of catastrophe risk management system which suits their own characteristics. On the basis that there is close connection between the tailings pond dam break disaster and natural catastrophe, we can learn from existed successful catastrophe risk financing experience and combine with the condition of Chinese tailings ponds and our national condition to set up s suit of catastrophe risk financing mode for tailings pond dam break that the government is the dominant, business insurance industry is the main assistant, mineral companies of tailings ponds are the main bodies of insurance participants and financing institutions and international re-insurance industry are the assistants. However, due to China doesn’t set up mature catastrophe risk financing system, lacks supporting laws and policies and catastrophe management experiences with Chinese characteristics to provide experience for the designer of catastrophe risk financing mode for tailings pond dam break; therefore, this thesis tries to initially discuss the establishment of Chinese catastrophe risk financing mode for tailings pond dam break. The time is urgent for setting up this financing mode, and it is a long term and arduous task.
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