ABSTRACT
Catastrophe risk has become one of the important factors threatening the sustainable development of the world. Facing the catastrophe risk, the government bears the responsibility of integrated disaster risk governance. The Chinese government’s involvement in integrated disaster risk governance begins with financial pressure, and the limited nature of existing public finance requires the government to optimize fiscal investment. How to achieve the optimization of the Chinese government’s public financial investment in integrated disaster risk governance is the core topic of this paper. This paper first analyzes the role of the government in the integrated disaster risk governance, and then analyzes the optimization problem of government public financial investment from the structural system and functional system of integrated disaster risk governance. This paper holds that the government needs to accurately evaluate the disaster risk and the cost and benefit of investment in the integrated disaster risk governance. Finally, this paper analyzes the difficulties faced by the government in terms of cost and benefit of integrated disaster risk governance, and proposes that the government’s ability to cope with catastrophe needs to be improved from the aspects of study and judgment ability of catastrophe chain, catastrophe impact and disaster relief resource reserve capacity.

PUBLIC INTEREST STATEMENT
The increasing disaster risk has become an important challenge to China’s sustainable development that cannot be ignored. In China, government public finance is involved in the whole process of disaster risk response, including pre-disaster risk prevention, emergency response and post-disaster recovery and reconstruction, which requires huge financial guarantee and undoubtedly puts a huge pressure on government public finance. Therefore, government public finance has to consider the issue of free optimization when dealing with disaster risks. Accurate assessment of disaster risks and accurate estimation of benefits and costs of public finance often become the focus of government public finance optimization. In practice, government public finance faces trade-offs in terms of costs and benefits, which is a difficult point for public finance to participate in comprehensive disaster risk prevention. To solve this difficulty requires strengthening the government’s response capacity to catastrophes, especially the research and evaluation of catastrophe chains, catastrophe impacts and resource reserve capacity.

1 Introduction
Natural disasters have caused increasingly serious economic and social impacts worldwide in the past 30 years (Alexander, 2006; Kong et al., 2018; Shi, 2019; United Nations International Strategy for Disaster Reduction (UNISDR), 2015). Global environmental change, characterized by global climate change, has increased the frequency and intensity of various natural hazards (IPCC AR5, 2013). At the same time, the increasing population and wealth in the high disaster risk areas, disorderly resource development and unreasonable land use planning make the vulnerability of social ecosystem to natural hazards rising (Meng et al., 2015; Shi et al., 2016). How to effectively deal with the challenge of disaster risk has become the focus of the world and the community (United Nations International Strategy for Disaster Reduction (UNISDR), 2015; Shi & Li, 2014; X. Shi, 2013).

At present, the consensus reached by the academic community is that disaster risk, especially catastrophe risk, can not be solved by single department, single subject and single region, but must be prevented by different subjects in different time and space scales, and the government is an indispensable and important
role (United Nations International Strategy for Disaster Reduction (UNISDR), 2015). Moreover, the government plays a multiple role in regional integrated disaster risk governance (Shi, 2019). From the pre-disaster stage of infrastructure construction, emergency supplies reserve, disaster monitoring system and early warning mechanism, public education, emergency response and relief in the disaster stage, to post-disaster recovery and reconstruction, there are a lot of work to be implemented and completed by the government with financial funds (Balli et al., 2013; Shi & Li, 2014).

The Chinese government has played a very important and unique role in integrated disaster risk governance for a long time. In the past 20 years, Chinese scholars have focused on the catastrophe insurance market failure and government intervention (Kong et al., 2018; Meng et al., 2015; Shi, 2019; Shi & Li, 2014; Yu, 2013). It is generally believed that the government should play a leading role in catastrophe risk transfer, especially in catastrophe insurance.

The Chinese government has clearly stated that it is necessary to establish a catastrophe risk insurance system supported by the state finance in 2006 (Shi et al., 2016). After the establishment of the Ministry of Emergency Management of the People's Republic of China in 2018, there have been more comprehensive leading government standing ministry in China’s integrated disaster risk governance work. The Chinese government has begun to play an all-round role in the national integrated disaster risk governance system (Zhang & Tong, 2016). The public financial funds of the central and local governments at all levels are allocated to the corresponding functional departments such as security fortification, disaster relief, emergency management and risk transfer, which are used for disaster preparedness, emergency response, recovery and reconstruction of natural disasters management, so as to effectively reduce the risk of natural hazards (Lv & Xue, 2016; Xue, 2010).

China’s public financial revenue has reached 19 trillion yuan RMB in 2019, accounting for 19.18% of GDP in that year. How to ensure that the limited public financial funds are invested in different preventive measures and reasonably distributed among many departments is still lack of relevant research and discussion. How to effectively integrate and optimize the large amount of public financial funds used by central and local governments in the field of integrated disaster risk governance, so as to better play the leverage role of public financial funds, promote the vigorous development of integrated disaster risk governance in China, and provide reliable risk guarantee for social development and residents’ life? This is an urgent problem to be discussed in the public financial investment of integrated disaster risk governance.

In order to solve this problem, this paper first explains the necessity of government participation in the integrated disaster risk governance. Then it analyzes the problem of optimizing government financial investment in the integrated disaster risk governance from two aspects: structural system and functional system. In order to promote the optimization of government financial investment in the integrated disaster risk governance, it is necessary to work in key directions, including accurate assessment of disaster risk degree and accurate estimation of benefits and costs of prevention investment. This paper presents a comprehensive analysis of the difficulties of governmental public financial participation in the integrated disaster risk governance in terms of costs and benefits, and finally proposes countermeasures. Based on the above, the paper attempts to answer the core questions of the Chinese government’s financial investment optimization in achieving integrated disaster risk governance.

2 The important role of government in integrated disaster risk governance

In today’s world, where the frequency of natural disasters, especially major natural disasters, and the damage they cause are on the rise (Jason et al., 2020), it is impossible to effectively address disaster risk prevention by relying solely on any one risk transfer tool, but rather, a safety net for disaster risk prevention must be formed by bringing together the public sector, the private sector, international financial organizations, and NGOs (Figueiredo & Martina, 2016). The government has an unparalleled advantage in the integrated disaster risk governance, which determines its basic position and role (Kong, 2020).

Firstly, disaster risk governance is a public utility, and effective disaster risk mitigation is one of the basic functions of government. Although risks are currently being repackaged and traded as commodities in the risk transfer market, the losses caused by disasters cannot be mitigated through transfer, but only from one entity to another (Liu et al., 2016). It is government investment in disaster risk preparedness, particularly in disaster prevention utilities, that can effectively reduce losses rather than simply transfer them. The knowledge, engineering and technology required for disaster risk prevention are public goods, and there is no exclusivity in the consumption of them by various social groups, including the government itself, enterprises and communities (Li, 2016). According to the basic principles of economics, the private provision of public goods is inefficient and
must therefore be implemented by the government on behalf of the relevant private sector, or intervene. In the event of a disaster, access to government-provided relief and assistance for affected people and groups is necessary for the government to use public resources to reduce the harm caused by the disaster. Although there is a dispute over the substitution between government relief and insurance compensation provided by disaster insurance, the government is not exempt from this important disaster response input. The recovery and reconstruction after a major natural disaster is a task that cannot be accomplished solely by the strength of the disaster area (Kong, 2020). At this time, a higher level of government must come forward to integrate and allocate resources so as to achieve global and holistic optimization and ensure the rapid recovery of the national and regional economy and society from the effects of the disaster (Shi, 2019).

Secondly, the government has a greater advantage over the private sector in the allocation of resources for disaster risk governance. The basic principle of disaster risk dispersal and allocation is to spread and distribute natural disaster risks that cannot be mitigated by engineering and technical means among different groups of people, in different geographic areas, and over different periods of time (Li, 2016). In different political systems, although the government's capacity and power are constrained to different degrees, its power to integrate and allocate resources between regions allows it to effectively transfer and distribute disaster risks among different regions within its jurisdiction through financial transfers and counterpart aid (Shi, 2019). At the same time, the government’s sovereign credit enables it to have a high borrowing and repayment capacity, so that it can effectively smooth out the losses caused by disasters between different periods through such means as issuing national bonds, thus improving the welfare of the whole society. This advantage of the government is closely related to the territory and economic strength of the country (Shi, 2019). For less developed countries with weaker economies and small borders, government finances may also be seriously threatened by disaster risk and have received widespread academic attention. A centralized government with a higher degree of resource allocation power in response to major natural disasters can effectively respond to natural disasters and accordingly mitigate the damage and subsequent indirect losses. This has been demonstrated by the Chinese government’s response to the 2008 freezing rain and snowstorm, the 2008 Wenchuan earthquake, and several subsequent major natural disasters (Li, 2016). In summary, the government’s financial investment in disaster risk preparedness both meets its basic functional requirements and reflects its resource advantages over the private sector. Government input is indispensable in the integrated disaster risk governance.

3 Problem of public financial fund investment optimization in government’s integrated disaster risk governance

3.1 The structure system optimization of integrated disaster risk governance

The government’s public financial investment in integrated disaster risk governance must be operated through the establishment of government institutions, and reflect its functions in all aspects of disaster risk prevention, so as to realize the reduction of disaster risk. In view of the practical work of China’s disaster reduction, the government’s public financial investment in integrated disaster risk governance includes structural system and functional system for integrated disaster risk governance (Figure 1) (Shi, 2019; Shi et al., 2016). The structural system refers to the four dimensions of security protection, disaster relief, emergency management and risk transfer, and its specific composition is the government’s institutional setting for integrated disaster risk governance.

The security protection agencies in China mainly refer to the relevant functional departments of disaster prevention capacity building and infrastructure construction, mainly using the planned project funds arranged by the National Development and Reform Commission and the Ministry of Finance of the People’s Republic of China. Disaster relief in China is mainly aimed at the Ministry of Emergency Management, which mainly uses the central government’s disaster relief funds arranged by the Ministry of Finance and the relief funds prepared by local governments at all levels. The emergency management work is mainly carried out by the Ministry of Emergency Management and the Emergency Office of the State Council to comprehensively coordinate the work of various ministries and commissions, and make unified arrangements. The risk transfer is mainly aimed at the financial system, including China Banking Regulatory Commission, China Securities Supervision Commission and China Insurance Regulatory Commission. Various financial instruments are used to realize the effective transfer of disaster risk (Shi, 2012).

The key question to be answered in the structural system optimization of the government’s integrated disaster risk governance public finance investment is how to allocate the limited public financial funds among different government departments, and how to allocate
Disaster preparedness involves the pre disaster arrangement of security fortification and risk transfer. Emergency response mainly corresponds to emergency management. Recovery and reconstruction involves the payment of funds for disaster relief and risk transfer (Kong et al., 2018). The realization of a system function needs one or more system modules to implement together. Therefore, in the above-mentioned comprehensive disaster risk prevention function system, usually involves several government functional departments.

The key question to be answered in the functional optimization of government’s integrated disaster risk governance public finance investment is how can the government’s limited public financial funds be invested in disaster preparedness, emergency response, recovery and reconstruction functions or stages to minimize disaster risk.

4 The key points of public financial investment optimization of government’s integrated disaster risk governance

4.1 Accurate assessment of disaster risk

Objective quantitative disaster risk assessment is the prerequisite for optimizing the government’s public financial investment in the integrated disaster risk governance system, and the basis for quantitatively estimating the cost and benefit of various input measures (Colquitt, Hoyt & Lee, 2010). The assessed disaster risk should be the uncertainty of property loss and casualties caused by one or more hazards in the area under the jurisdiction of the first level government and within a given time range (Assmuth et al., 2010). The results of disaster risk assessment can be expressed in quantitative form, such as the curve or surface of the loss exceeding probability (Kong et al., 2018). Therefore, it is necessary to build a regional integrated disaster risk assessment model, especially the multi-disaster risk assessment model, and improve the vulnerability database of regional exposures, so that the regional integrated disaster risk assessment model has the ability of current situation assessment and scenario simulation (Shi, 2012).

To develop an integrated disaster risk assessment model for the optimization of public financial investment, it is urgent to establish and develop a comprehensive model of multi-disasters, as well as the modeling of indirect economic loss risk. Because the public financial investment planning and budget of government’s integrated disaster risk governance is oriented by regional integration, and also needs to be

The government’s public financial investment in integrated disaster risk governance

![Diagram](image)

Figure 1. The government’s public financial investment in integrated disaster risk governance.

3.2 The functional system optimization of integrated disaster risk governance

The functional system of government’s integrated disaster risk governance public financial investment refers to the government’s public financial investment in four aspects of disaster risk governance cycle, such as disaster preparedness, emergency response, recovery and reconstruction (Figure 1). Functional system is the embodiment of system output and the result of system structure. There is a relationship between the functional system and the structural system, but there is a big difference (Meng et al., 2015).
optimized among various departments and functions, the disaster risk assessment model must be an integrated disaster risk completed on the basis of a single disaster risk. However, multi-disaster risk is not equal to the simple sum of single disaster risk. It is very important to clarify the relationships of temporal and spatial clustering among various natural hazards in the region, which is also a frontier research problem in the current disaster risk assessment model research.

The indirect loss of disaster events must be expressed quantitatively in the disaster risk assessment model, otherwise, the public finance investment benefit of integrated disaster risk governance will be underestimated (Meng et al., 2015). Researchers generally use input-output model and computable general equilibrium model to estimate indirect economic loss in disaster events at present, and some progress has been made (Kong et al., 2018; Shi, 2019). However, the development of disaster risk assessment model considering indirect loss is still slow, which can not meet the needs of public finance investment optimization of integrated disaster risk governance.

4.2 Accurate estimation of cost and benefit of public finance investment

The cost and benefit of public financial investment in government’s integrated disaster risk governance have a high “opportunity” nature. Mr. Yu Guangyuan, an economist in China, once put forward that the economics of disasters is “reducing the negative and increasing the positive”. He called the economic benefits of disasters “two negatives make a positive “, that is, the loss caused by disasters is an economic negative, but the cost of rebuilding and repurposing the economy brought about positive economic development (X. Shi, 2013; Yu, 2013).

On the one hand, in practice, if a public financial fund is used for a certain kind of disaster risk prevention measures, it will give up the opportunity to use it in other departments or undertakings to obtain benefits, which is the opportunity cost of investment for integrated disaster risk governance. On the other hand, the public financial investment can also recover or avoid certain disaster losses, which is the benefit of investment for integrated disaster risk governance (Assmuth et al., 2010).

The benefit of public finance investment in integrated disaster risk governance is similar to many “non-use” or “non-market” values such as the value of ecological environment services. The cost and benefit of public finance investment in integrated disaster risk governance have high “opportunity” nature (Shi & Li, 2014), and its estimation process depends on the scenario assumption of disaster risk, that is, the scenario comparison between no disaster risk governance investment and disaster risk governance investment (Colquitt, Hoyt & Lee, 2010).

5 Difficulties of government’s integrated disaster risk governance

5.1 Difficulties in the cost of public finance investment

The scale of public financial investment for integrated disaster risk governance is large, and the investment behavior will inevitably have an impact on the economic structure and normal operation (Meng et al., 2015). For example, if the government carries out large-scale anti-seismic reinforcement project, its engineering demand will be bound to bring great development opportunities for the construction industry. If the government vigorously supports disaster insurance and invests a considerable amount of public financial funds for premium subsidies, it will also have a positive impact on the development of the insurance industry (Shi & Li, 2014). In order to fully consider the above effects in the integrated disaster risk governance model, we must use the general equilibrium framework, otherwise it is difficult to accurately estimate the opportunity cost of public financial investment. In this case, we must rely on the input-output model or computable general equilibrium model. However, the government’s public financial investment in integrated disaster risk governance is scattered in various departments at present, and the barriers to data acquisition among different departments make it very difficult to compile appropriate input-output tables or social accounting matrix and test model parameters.

5.2 Difficulties in the benefit of public finance investment

In terms of benefit, the indicators that can be directly measured, such as benefit, cost or GDP growth and stability, are often used in current research. In fact, welfare economics generally uses the social utility function when discussing social optimum, which requires that the unit marginal social positive utility brought by investment is exactly equal to the social marginal negative utility it brings (Shi & Li, 2014). Because the public generally hold the risk aversion preference, reducing the uncertainty of disaster loss without reducing the expected loss can also improve the utility. Therefore, the simple use of the direct econometric indicators used
in the existing research will lead to the underestimation of the social benefits of public finance investment in the integrated disaster risk governance.

However, how to accurately estimate the change of social utility level itself is a difficult problem. At present, there are some methods to show and state preferences in the field of resources, ecology and environmental economics. In addition, how to measure the benefits of more non-pure economic dimensions such as casualties and psychological injuries reduced by public financial investment needs to be further discussed.

6 Enhance the government’s ability to deal with catastrophe

Catastrophe is one of the biggest challenges that the government faces in the integrated disaster risk governance. Therefore, it is urgent to strengthen the ability of decision makers in the government to deal with catastrophe.

6.1 Strengthening the study and judgment ability of catastrophe chain

It is urgent to strengthen the ability of decision makers in the government to study and judge the catastrophe chain under the background of interconnection (Kong et al., 2018). The mobility and connectivity of people are growing rapidly in the context of interconnection. Whether it is in the humanities fields, such as the economic interdependence between regions, trade exchanges, information exchanges, personnel exchanges and telecommunications networks, or the biological and abiotic processes in the natural field, the degree of connection between the two aspects is strengthening, which leads to the rapid transfer of catastrophe between the market and society, and is in constant change (United Nations International Strategy for Disaster Reduction (UNISDR), 2015). Therefore, scientific understanding of catastrophe disaster chain can effectively avoid, coordinate and transfer, reasonably resolve the potential significant impact of the complexity of disaster events in the context of interconnection.

6.2 Strengthen the study and judgment ability of the impact of catastrophe

It is urgent to strengthen the ability of decision makers in the government to study and judge the impact of catastrophe. After the occurrence of the catastrophe, the impact of the catastrophe is constantly shifting and evolving in the Internet of Things, production chain, supply chain and ecosystem. Therefore, it is necessary to identify and scientifically judge the acceptable risks, convertible risks, preventable risks and unacceptable risks. On the one hand, it is necessary to develop effective tools to help decision makers make correct judgment on potential impact in case of catastrophe. On the other hand, decision makers need to fully understand which existing risks in the current economic, social and ecological systems exceed the current government’s coping capacity, and actively develop the disposal process of unacceptable risk events, so as to resolve or transform them into the familiar risk disposal process. In the governance of catastrophe risk, it is urgent to create synergy effect from multiple prevention levels under the perspective of multi-agent, multi-scale, multi-factor and multi-process, so as to transform the catastrophe into a risk that can be dealt with by existing reasonable methods and systems.

6.3 Strengthen the resource reserve capacity in disaster response and disposal

It is urgent to systematically evaluate the resource reserve capacity in dealing with catastrophe. After a comprehensive scientific assessment of the impact of a catastrophe in the shortest possible time, government agencies need to use the existing resources to respond to the catastrophe quickly and accurately, coordinate the balance of emergency resources in demand and supply, and take diversified measures to ensure the smooth and orderly production and social life by taking advantage of institutional advantages, market mechanism and social organization security. The government creates an environment, enterprises actively respond, and all parties cooperate to resolve potential major risks.

7 Summary

With the advancement of integrated disaster risk governance practice in China, especially the previous experience in dealing with catastrophe, and the active discussion of the government function in dealing with catastrophe risk in academic circles, the role of Chinese government in national integrated disaster risk governance is increasingly comprehensive and deepening. However, how the government should use the limited public financial resources in different government departments, different public utilities and different government functions, so as to minimize the risk of natural hazards and improve the level of social welfare is a problem worthy of study.

This paper combs the key problems and difficulties of public financial investment optimization in the integrated disaster risk governance. In the future research,
accurate assessment of the disaster risk to be prevented is the basis of optimization. The multi-disaster risk assessment of is the difficult point in the research area. Determining the appropriate optimization standard is the core to obtain the optimal preventive investment scheme. The measurement method of cost and benefit will become the key point and difficulty in the research. Considering the transparency of China’s integrated disaster risk governance system and public financial investment, empirical research methods will be greatly limited in the actual research process, and the scenario simulation method based on simulation model should be given priority.

Data availability statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by the Beijing Social Science Foundation Project (19JDGLA008).

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