

WASEDA UNIVERSITY

DISSERTATION ABSTRACT

**A Study of Sustainable Flood Insurance System in Japan:
towards the Construction of a Public-Private Partnership**

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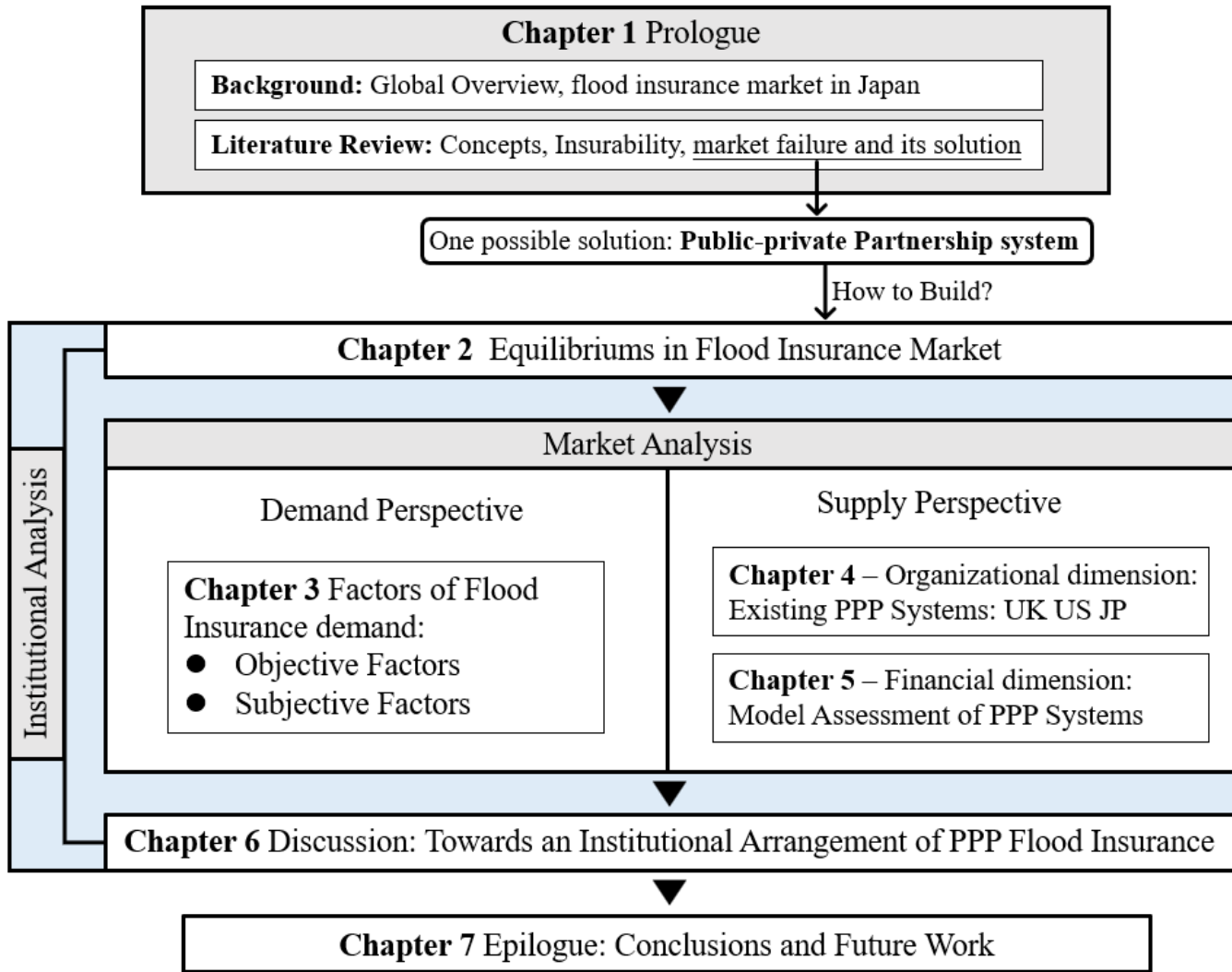
1. DISSERTATION ABSTRACT

Our society is faced with an increasingly large number of catastrophic flood events, especially in the context of climate change. Yet little action has been taken by society to control potential damage from these events until a disaster has wreaked havoc. As an advanced industrialized country with a well-developed insurance market, the flood insurance system in Japan is considered underdeveloped, especially compared with the earthquake insurance system. Proven by current literature and practical experience in some countries, a public-private partnership (PPP) system can address many tackles in the catastrophe insurance market. Hence it is of great importance to explore whether and how should Japan also find its own path towards a PPP flood insurance system, and the policymakers in other countries can also utilize this knowledge in designing their own flood insurance system for the future.

This dissertation sheds light on the approach towards a PPP flood insurance system under the framework of economic analysis from two sides of supply and demand for insurance. Chapter 1 sets up the background and introduces the basic concepts of the dissertation. A brief history of the flood insurance system in Japan, the methodology and structure of the dissertation can also be found in this chapter. Chapter 2 theoretically analyzes the market equilibrium from each player's perspective under the structure of Evolutionary Game Theory. Chapters 3, 4 and 5 further explore the path to a PPP system empirically. Chapter 3 investigates how personal risk perception affects people's insurance demand after floods and how to utilize this knowledge to approach a better PPP flood insurance system from the demand perspective. Chapters 4 and Chapter 5 summarize some representative current existing PPP insurance system models in the world and assess them based on a Monte Carlo simulation. Chapter 6 extends the theoretical analysis based on the preceding results from Chapter 2 to Chapter 5, and further discusses how should the public sector intervene to make the flood insurance system better and sustainable.

From demand, supply and institutional perspectives, the overall findings offer strong support for a holistic view of the construction of a PPP model for flood insurance in Japan. Although a best practice in one country may not be so in another, the generalized analytical framework of market agents and their behaviours may provide valuable implications for stakeholders when implementing their own systems.

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3. ABSTRACTS OF EACH CHAPTER

Chapter 1 first introduces the background (the impact of climate change, the relationship between flood risk and flood insurance) and the research questions of this dissertation. Then the literature review of Section 1.2 sheds light on the basic concepts of this dissertation: flooding, flood risk and flood risk management. Through a literature review, Section 1.3 illustrates the motivation of this dissertation: the insurability of flood risk causes insufficiency of both supply and demand for flood insurance, which leads to a failure in the private insurance market in almost every country, and an institutional arrangement called PPP system is a possible solution to this dilemma. Therefore, this dissertation will also try to find a path to a suitable PPP flood insurance system in Japan. As a cornerstone of the analysis that follows, Section 1.4 provides the background of the flood insurance market in Japan. Subsection 1.4.1 gives a brief history of the flood insurance system in Japan. The provision of flood coverage started in 1938, and experienced several major revisions afterwards. In the beginning, flood coverage took the form of separate flood insurance, but with the risk increasing rapidly, it was difficult for the industry to provide specialized insurance solely. Then in 1956, the industry started to underwrite flood risks through a special additional rider to fire insurance policies. In 1984, the house fire insurance was revised to cover floods as in standard clauses. Until now, policyholders could choose whether catastrophes were included in their policies with various coverage options. The details of the current situation of flood insurance in Japan is introduced in subsection 1.4.2. In the last few decades, with climate change on its way, the increasing trend of claims paid by the home insurance sector caused this business line to be in deficit. As a result, the premiums of home insurance in Japan have been raised several times in recent years. Yet the take-up has been decreasing instead. The system is now in crisis. Some substitutes of insurance, such as Kyosai cooperatives and super insurance are also introduced in this section. At last, Section 1.5 shows the methodology and organization of the rest of the dissertation.

Chapter 2 analyzes equilibrium in the flood insurance market using an Evolutionary Game model which includes players of government, insurance companies and consumers. To reflect the influence of people's risk perception, value functions based on the Prospect Theory are integrated into the model. Section 2.1 introduces the research background and the advantage of using the Evolutionary Game model and the Prospect Theory. Then Section 2.2 describe the model and parameters in detail, especially how we use the value function and weighting function to reflect the influence of people's risk perception. Assumptions of are also made in this section. After the construction of the payoff matrix in Section 2.3, an analysis of static Nash equilibrium is conducted. Furtherly, the dynamic analysis of evolutionary game is conducted next. The dynamic analysis results can be retrieved from the phase diagram on page 32. The discussion of the stabilities of the equilibriums finds out why the flood insurance market is hard to evolve into an effective equilibrium and how to facilitate the market to evolve into a more effective equilibrium where trade can be made between agents in the game. Based on the results, Section 2.5 analyzes the possible factors influencing the market equilibrium in the system. The analysis finds out (1) high expense ratio, insufficient public subsidy, and spillover of insurance service may help to explain why the flood insurance market cannot reach an equilibrium where trade can be made between consumers and insurers. To help the market evolve into a better equilibrium: (2) consumers' subjective risk perception of flood risk should be improved. (3) the insurers can increase the compensation percentage of flood coverage, and lower the expense ratio and spillover services. (4) the government should reduce searching costs for consumers to find flood coverage, increase the opportunity costs for insurers not providing flood coverage and the premium subsidy to the consumers. This chapter provides a solid theoretical foundation for the following empirical analysis in Chapter 3, Chapter 4 and Chapter 5. Chapter 6 in the end will extend the contents of Chapter 2 based on the following empirical results and adopts the same Evolutionary Game framework to further deeply discuss how to achieve an institutional arrangement of PPP flood insurance in Japan.

Chapter 3 analyzes the demand side of the flood insurance market in Japan. Section 3.1 introduces the research background, literature and the main objectives: first, empirically proving the hypothetical impact of flood events on people's flood insurance purchase decisions; and second, investigating how this impact may differ among people with different characteristics. After the literature review and hypotheses built in Section 3.2. The methodology and data are illustrated in Section 3.3. The dataset contains prefectural panel data and also some cross-section data to test some time-insensitive variables. The general model is a two-way fixed-effect model to explore the function of the flood insurance take-up rate with flood-related variables, socioeconomic controls, and fixed-effect controls. Heterogeneous effects among people with different characteristics are tested using the method of grouped regressions. The empirical analysis in Section 3.4 tests the influence of socio-economic factors to provide a baseline for our main purpose. Section 3.5 tests the hypothetical impact of floods on people's flood insurance purchase decisions from three perspectives: intensity (DR), public loss (PD), and human casualties (CA), and how this impact may differ among people with different characteristics, for example socioeconomic factors such as income, savings, age, education, and other time-insensitive factors such as risk level and financial literacy level etc. Section 3.6, in the end, discusses the implications of the empirical results. The results show that: (1) there is a nationwide revision in risk beliefs after flood events, the intensity and scale of private asset loss, public property damage, and human casualties all have significant positive impacts on the take-up rate of flood insurance. However, the impacts only last for 1 year. (2) people with different socioeconomic characteristics, such as age, education, and the story level of their residential building, have different levels of demand for insurance after floods. (3) people with different risk characteristics respond differently to floods. Financial literacy can improve the take-up in flood insurance. This chapter is based on Jie Shao, Akio Hoshino, and Satoshi Nakaide, (2022). How Do Floods Affect Insurance Demand? Evidence from Flood Insurance Take-up in Japan, *International Journal of Disaster Risk Reduction* 83: 103424.

Chapter 4 traces the evolution history of policy approaches and institutional arrangements of the flood insurance system in the UK and the US, and the earthquake reinsurance system in Japan, which can be respectively deemed as the representatives of market-oriented systems, government-oriented systems and the systems that have well embedded in the country.

The flood insurance system in the UK has experienced four major stages. Flood coverages were available since 1916, but such products were not widespread in the interwar and early post-war periods. After World War II, along with a series of serious floods, the demand of flood insurance increased significantly. In 1960, the government and the private insurance industry reached an agreement that flood insurance products would be provided by the private sector. This is widely known as the Gentleman's Agreement. Since then the flood insurance market has experienced substantial development until the 1990s. After 2000, insurance companies gradually found it difficult to provide flood insurance for those high risks. The discussion of a PPP arrangement was on the table. Finally, in 2013, Flood Re was established. High-risk properties can thus be covered by this quasi-public institute. This part of the dissertation, along with some analysis in Section 4.5, will be published in *the General Insurance Studies* in Japanese.

The flood insurance system in the US has experienced a different path. Private insurance companies have retreated from the flood insurance market since 1929 considering the massive damages caused by floods. The government then took the responsibility to reimburse flood-damaged properties. In 1968, the National Flood Insurance Act set up the NFIP (National Flood Insurance Program) and the FIA (Federal Insurance Administration) under the Department of HUD (Housing and Urban Development), to offer flood insurance products. In the 1980s, private insurance companies were included in the game via a significant breakthrough of the "Write Your Own" (WYO) approach, under which insurance companies were able to market and administer flood insurance products under their own names. The take-up increased steadily making NFIP financially self-sustainable. Since the 2000s, several huge floods and hurricanes have jeopardized the finance

of the program. Until now, NFIP is still struggling with this issue.

The evolution of the earthquake reinsurance program in Japan was pushed by several huge earthquakes. Shortly after the 1964 Niigata earthquake, the draft of *the Act on Earthquake Insurance* and *the Special Account of Earthquake Reinsurance Bill* were submitted to Congress and passed in May 1966. The reinsurance program in Japan has developed steadily throughout its history. Each huge earthquake in general made the program more financially sustainable and available to normal citizens. Thus, the lessons learned from the earthquake insurance system are highly informative for the future design of flood insurance systems in Japan.

After the historical review, the in-depth analysis in Section 4.5 finally demonstrates the catalytic role of the flood events, the actors involved (the government, the private insurers and property owners), the distribution of the financial burden and the fairness and justice of the system. Chapter 4 finds out: (1) Huge catastrophe events may have different impacts in different countries. (2) The insurance industry is extremely powerful in the UK, but for NFIP and earthquake insurance in Japan, political elements were more important. (3) In all three systems, policyholders especially those who live at lesser or no risk have been paying the most to the system because of the cross-subsidies involved. The financially deprived households in high-risk areas that cannot get coverage are supposed to be the biggest loser. (4) the public sector protects the lower limit (high risk) and the private sector guarantees the upper limit (market competition and efficiency).

Chapter 5 then empirically demonstrated the financial effectiveness of the three PPP insurance systems in Chapter 4, namely the Flood Re system in the UK (market-oriented), the NFIP system (government-oriented), and JER (current existing system in Japan), through an analytic framework based on model assessment. Section 5.1 first introduces the widely-observed market failure phenomenon in the catastrophe insurance sector and how PPP systems may serve to avert this failure, then Section 5.2 shortly reviews the characteristics of the three PPP insurance systems analyzed in Chapter 4. Section 5.3

proceeds to simplify and model the three candidate systems respectively using a surplus model with ruin theory. Subsequently, Section 5.4 explains how this study assesses flood risks. Section 5.5 introduces the data source and data preprocessing. Section 5.6 explains the process of Monte Carlo simulation in detail. First, we find suitable distributions to fit the frequency, insured loss of flood events and the percentage of high-risk areas. With fitted distributions, we simulate the surplus process following 5 steps. Section 5.7 finally explains the simulation results and implements a sensitivity analysis of the results. The results show that: (1) the US model requires minimum social cost (premium-wise), the UK model provides the best affordability. (2) For insurance companies, the deficit probability of the UK model is lower than the Japan earthquake insurance model. (3) For the government, the US model requires the greatest amount of public expenditure, while the UK model requires the least. The flood risk assessment part in this Chapter is based on Jie Shao. "A Simple Assessment of Flood Risk from Insurance Perspective: Based on Historical Data in Japan." *The Bulletin of the Graduate School of Commerce*, No.91(2020):61-78, and the rest are based on Jie Shao. "Model Assessment of Public-Private Partnership Flood Insurance Systems: An Empirical Study of Japan." *The Geneva Chapters on Risk and Insurance - Issues and Practice*, 47(2020): 79–102.

Chapter 6 finally concludes and discusses. Section 6.1 first summarizes the concluding remarks from Chapter 2 to Chapter 5. Section 6.2 discusses how to build a sustainable flood insurance system in Japan based on the proceeding chapters' analysis. Subsection 6.2.1 first introduces the concept of an institution as a summary representation of an equilibrium path and one of the qualities of institutions which is self-sustainability. Then in subsection 6.2.2, the current institution of flood insurance in Japan is analyzed with the aforementioned concepts. The analytical framework is the same as the game model in Chapter 2. The results show that the current institution in the flood insurance market is or at least is institutionalizing to the situation that deals cannot be made between consumers and insurers in Japan. The involvement of external forces is expected to have the ability

to institutional change. Therefore, subsection 6.2.3 discusses how should the government intervene to construct an institutional arrangement of PPP flood insurance in Japan. Some suggestions are proposed. Subsection 6.2.3.1 suggests that the roles of government and the private sector should be more clearly distinguished. The private insurers should be allocated tasks such as differentiating low-risk and high-risk, risk-based premium rating etc., and the government should be responsible for maintaining social fairness, centralized, third-party organization administration and coordination of cross-section collaborations. Subsection 6.2.3.2 suggests that the flood insurance system should be embedded in institutions of other domains, in other words, merged into a holistic flood risk management system. The last Section 6.3 outlines the limitations and intended future work.

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