



Game Analysis of Japan's Nuclear Wastewater Discharge and China's Countermeasures

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Abstract. This article first introduces the timeline behind Japan's announcement of direct discharge of nuclear wastewater into the Pacific Ocean and the effects of discharging nuclear wastewater. Then it introduces the non-zero-sum game. After that, using the prisoner's dilemma in game theory, this article analyzes why Japan persists in discharging nuclear wastewater despite social opposition. Then, it uses the prisoner's dilemma theory in game theory to explore the reasons behind the event. Furthermore, through the theory of two-level game theory, this paper explores the reasons behind the incident at the national and international levels. Finally, it discusses China's Remedy as a country affected by Japan's nuclear wastewater discharge.

Keywords: Japan nuclear wastewater, prisoner's dilemma, two-level game theory.

1 INTRODUCTION

Since the accident at the Fukushima Daiichi nuclear power plant on March 11, 2011, radioactive wastewater has been discharged into the Pacific Ocean. Nuclear power plants did not first acknowledge contaminated groundwater leaks until 2013. [1] Following the disaster, the Japanese government attempted to authorize the discharge of treated and diluted nuclear wastewater into the Pacific Ocean in 2021. The action caused a sensation worldwide. The Japan Atomic Energy Regulatory Commission planned to officially approve the Fukushima nuclear wastewater discharge plan on June 22, 2022, and TEPCO aimed to start emissions around spring 2023. The decision of the Japanese government to discharge nuclear wastewater has caused controversy around the world. In fact, as a result of the nuclear sewage discharge, the marine ecological environment will be severely damaged, and seafood will become contaminated. Moreover, from the discharge date, Japan's nuclear sewage will pollute half the Pacific Ocean in 57 days and affect the United States and Canada three years later [2]. The possible consequences have also made the Chinese people anxious. Even in my country, rumors began to appear that everyone could not use sea salt after Japan's discharge of nuclear wastewater, inciting everyone to snatch well salt. Faced with this situation, it is necessary for us to find out why Japan insists on discharging nuclear wastewater despite these

serious consequences. Because, on the one hand, there is little research to explain this event to the masses of our country. Only after the people of our country fully understand the incident, will there be no fear of the environment, life, survival after Japan began to discharge nuclear wastewater. On the other hand, figuring out the reasons for Japan's discharge of nuclear wastewater will help China to take countermeasures.

2JAPAN'S NUCLEAR WASTEWATER DISCHARGE
FROM THE PERSPECTIVE OF GAME THEORY

2.1The Meaning of Non-Zero-Sum Games

Before discussing the Prisoner's Dilemma, we first explain non-zero-sum games. In game theory, a decision-gain (or loss) maker's does not always result in other decision-makers' loss (or gain). It is known as a non-zero-sum game, a win-win game in which neither the victories nor defeats of any player equal zero. [3]

2.2The Meaning of Prisoner's Dilemma

The prisoner's dilemma is a representative example of a non-zero-sum game in game theory. The "prisoner's dilemma" was developed by Merrillflood and Melvin Dresher in the RAND Corporation in 1950. Known as "prisoner's dilemma," it describes a situation in which two inmates are questioned in separate rooms after being apprehended for a crime. It is known that both perpetrated the crime, but the evidence against them is insufficient to convict them (they have hidden the stolen goods), so one (or both) would need to implicate the other for a conviction. A deal is presented to each prisoner: if neither "talks," they are released. Both inmates are sentenced to a specific length of jail if they implicate the other. In the case of one prisoner who "talks", he is released while the other is imprisoned for an ever-increasing period. [4] There is a paradox in the prisoner's dilemma. Prisoner paradox is a contradiction in game theory, which reflects that the best choice of individuals is not the best choice of groups. For example, if a person pleads guilty and gives evidence to prosecute the other party, and the other party keeps silent, the person will be released immediately, and the silent person will be sentenced to 10 years in prison. If both keep silent (the relevant term is "cooperation"), they will be sentenced to half a year in prison. If both report each other (betray each other), they will be sentenced to two years' imprisonment.

Table 1. Different consequences between Prisoner A and Prisoner B (Photo Credit: Original)

		Prisoner B	
		Keep silence	Talk
Prisoner A	Keep si- lence	(1/2, 1/2)	(10, 0)
	talk	(0, 10)	(2, 2)

Like other examples of game theory, the Prisoner's Paradox assumes that each player (the "prisoner") is self-interested, that is, each seeks his own best interests, regardless of the interests of the other player. If the benefits of a player's strategy are lower than other strategies in any case, this strategy is called "strict disadvantage", and rational players will never choose. In addition, there is no other force interfering with individual decision-making, and participants can choose strategies entirely on their own terms. Due to the isolation and imprisonment, the two prisoners do not know the other's choice; as far as the rational choice of the individual is concerned, the sentence for indicting the betrayal of the other is always lower than the silence. So, the rational thinking of the two will come to the same conclusion - choose to betray. Betrayal is the dominant strategy of the two strategies. Therefore, the only possible Nash equilibrium in this game is for both players to betray each other, and as a result, they both serve 2 years in prison. The Nash equilibrium of this game is obviously not a Pareto optimal solution considering the interests of the group. In the interest of the whole, if both participants cooperate and remain silent, both will only be sentenced to half a year in prison, the overall interest is higher, and the result is better than the situation where the two betray each other and sentenced to 2 years in prison. However, according to the above assumptions, both are rational individuals and only pursue their own personal interests. The equilibrium situation will be that both prisoners choose to betray. As a result, the two prisoners are both judged to be higher than the cooperation, and the overall interests are lower than the cooperation. There is a paradox here.

2.3 Game Theoretical Model Analysis of the Event

The sea separates China and Japan, and nuclear pollution could directly affect people's lives, national agriculture, national economy, etc. Assuming that both countries discharge nuclear wastewater will cause severe nuclear pollution, we set this terrible result to -10. If only one country releases it, it will cause little nuclear pollution, so we put it as -4. In addition, the treatment of nuclear wastewater will cost substantial financial expenditure, and we set it as -6. Then we obtain Table 1.

Table 2. Prisoner's Dilemma situation between China and Japan (Photo Credit: Original)

		Japanese	
		Discharge	Not Discharge
Chinese	Discharge	Despite the high levels of contamination in both nations, there is no need to pay for wastewater treatment.	The two nations had a small amount of pollution. Japan must pay for nuclear wastewater treatment; China does not have to spend money on this.
	Not Discharge	The two nations had a small amount	The oceans are not polluted, and both must deal with nuclear wastewater.

		of pollution. China must pay for the nu- clear wastewater treatment; Ja- pan does not have to spend money on this.	
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Table 3. Different consequences between China and Japan (Photo Credit: Original)

		Japanese	
		Discharge	Not dis-charge
Chinese	Discharge	(-10, -10)	(-4, -10)
	Not discharge	(-10, -4)	(-6, -6)

As can be seen from the table, the optimal choice is that neither Japan nor China discharges nuclear wastewater, the benefits for both countries are -6. This is also the best result for the environment. However, if Japan chooses discharge, its payoff will be -14, while if Japan decides not to discharge, its gain will be -12. For Japan, emissions are better than no emissions at all. Therefore, the discharge of nuclear wastewater is a dominating strategy. The same is true of China. The country only cares about its own development and interests, so it will only choose to discharge nuclear wastewater, and will not choose to cooperate with other countries to deal with nuclear wastewater. Also, the choice of the state and the choice of prisoners are similar, they are both in a state of isolation. If they choose to cooperate in the treatment of nuclear wastewater, neither Japan nor China can be sure that the other party will abide by the agreement. Under such circumstances, both Japan and China will choose to discharge nuclear wastewater.

3

INCIDENT ANALYSIS OF JAPAN'S NUCLEAR
WASTEWATER DISCHARGE FROM THE
PERSPECTIVE OF TWO-LEVEL GAME THEORY

3.1

The Meaning of the Two-Level Game Theory

American scholar Robert d.putnam first developed the two-level game theory. It was put forward in the article "diplomacy and domestic politics: the logic of two-level game" in 1988. Putnam recognized that the whole game process of international nego- tiation could be regarded as a two-tier game between domestic and foreign countries. In the negotiation and game, each country's domestic and international politics interact with each other. Putnam emphasized that the most essential part of the two-tier game model is the interactive process in international negotiations.[5] Japan's announcement regarding the discharge of nuclear sewage to various countries reflected the mutual

game between domestic and international politics. The next chapter attempts to understand the dual role of domestic and foreign interaction in Japan's sewage discharge by combing the event of Japan's sewage discharge announcement and using the two-tier game model's main content and key content.

3.2 Two-Tier Game Theory Framework

The two-level game theory integrates three basic elements: system level, national level, and foreign economic policy. They are integrating to explore the main factors affecting the foreign negotiations between countries. Putnam stressed the importance of observing the dual role of domestic voters' reactions and the attitudes of other negotiating countries when formulating international agreements and implementing foreign economic policies in international negotiations. Putnam regarded the political process of domestic politics and foreign political negotiations as a two-tier game in which domestic and international politics constantly interact. The two-tier game model focuses on the interaction of international negotiations. Putnam considered the national leader or "primary negotiator" as the vital link between domestic and international politics. He also divided the international negotiation process into two stages: Level I or Li, the game at the international level, refers to the negotiation stage, i.e., the process of a temporary agreement reached by negotiators through bargaining.

The second level (Level II or LII) is the domestic level game, referring to the approval stage, i.e., discussing whether to approve or implement formally or informally within each election group. In the first level, to deal with domestic pressure at any time, governments utilize various policies and means in the negotiation process to maximize their own interests and minimize adverse diplomatic consequences. In the second level, interest groups with close interests would pressure the government to reverse the government's policy preferences and then seek profits. The process of political leaders maintaining votes and power by establishing alliances between groups does not occur independently. International and domestic levels are intertwined and appear at the same time.

3.3 Two-Level Game Analysis of the Event

At the international level, a win-win situation exists in the game negotiation between Japan and the United States. With its strength and influence in East Asia, Japan exerted pressure and lobbied the United States to allow discharging nuclear wastewater. The United States extended its control and power over Japan through this permission. This is the perfect solution for the senior leaders of the two countries.

Yoshihide Suga addressed the nuclear wastewater treatment, and Biden strengthened his control in Japan, the frontline of the confrontation between the United States and China in East Asia. So, after Japan announced its discharging plan, US Secretary of State Antony Blinken tweeted to "thank" Japan for its "transparent efforts" in dealing with nuclear wastewater publicly on Tuesday morning (Beijing time). In March of the same year, the Secretary of state and the defense minister of the United States traveled to Japan and then issued a joint statement between the two countries to grossly interfere

in China's internal affairs. After the United States expressed its support, the International Atomic Energy Agency (IAEA) issued a statement welcoming Japan's decision regarding Fukushima nuclear sewage. It was ready to provide technical support to monitor and review the safety and transparency of the relevant plans.[6] The overall attitude of the west was acquiescence. Let's take another look at Asian countries. The countries that have the most speak around Japan are China and South Korea, whose attitudes are completely different. China held a negative attitude towards this incident, while South Korea changed from strong condemnation to support. The reason is very simple. South Korea and the United States are allies. The US-ROK alliance was formed after the Korean War, and its symbol was the US-ROK mutual assistance defense agreement signed in October 1953 and implemented in November 1954. Therefore, South Korea will take a similar attitude to the United States. Under such circumstances, Japan and most developed countries led by the United States have agreed and allied to this event. However, China's first condemnation of the incident induced little effect.

The second level, the domestic level, is only in Japan. While the public opposes the discharge of nuclear wastewater, the whole Japanese high level, regardless of faction, supports it. The Japanese government has proposed five schemes to treat this nuclear wastewater: (1) Evaporation. Nuclear waste is evaporated using high-temperature heating. This method is expensive and poses a significant risk of air pollution. (2) The electrolytic process. This is an improved variant of the evaporation method, which electrolyzes nuclear wastes to produce hydrogen and oxygen before releasing them into the atmosphere. Although it is more expensive than the evaporation plan, this option is best for the environment. (3) Send it down below. The radioactive wastewater can contaminate the groundwater if released through holes drilled from the surface to 2500 meters deep. (4) An underground dump. Put it in the ground after mixing it with cement. Cement and nuclear waste are combined to create cement blocks, which are buried underground. It is relatively safe but still costly. (5) Discharge into the sea. Compared with the five methods, discharging into the sea is the most convenient and preferred solution by the Japanese government. Relying on seawater to dilute and degrade, this approach is easy, fast, and cost-effective. It costs only 1.7 billion to 3.4 billion yen (about 100-200 million yuan). According to the estimation of Japan's private think tank, the Japan Economic Research Center (Tokyo), it is estimated that Japan will spend 500000-700000 yen (3.1-4.3 trillion yuan) to deal with the costs of reactor scrapping, decontamination, and compensation.

With such a huge cost, the treatment of nuclear waste (wastewater) accounts for a considerable part. If we simply calculate that the nuclear wastewater safety treatment plan accounts for 20% of the overall cost, this plan alone will cost 620-860 billion yuan. However, discharging directly into the sea will only cost 100-200 million yuan. Japan's fiscal revenue is not high, so saving this part of the expenditure may be a good choice for Japan.

4 WHAT SHOULD CHINA DO UNDER SUCH CIRCUMSTANCES?

First, we need to take peaceful measures. The use of force, such as waging war against Japan, is the least desirable. The main reason is the cost of war. The biggest cost component is the investment of military equipment and personnel. The consumption of military equipment in war is extremely huge. The consumption of military equipment in modern warfare has become the most important direct cost of war. According to Sebastian Roblin, the bomber underwent a pricey modification for low-altitude penetration, pushing development costs above \$42 billion and igniting political controversy. [7] The second is the cost of sanctions. Now in the era of peaceful development, once China launches a war against Japan, China may be subject to sanctions from countries such as the United States. Just like this Russia-Ukraine war, since the outbreak of the war, Russia has encountered various financial, economic and diplomatic sanctions from Western countries. According to BBC News, the US has forbidden Russia from paying its debts using the \$600 million it has deposited in US banks, making it more difficult for Russia to repay its international obligations. The assets of Russia's central bank have also been frozen to prevent it from using its \$630 billion in foreign currency reserves. [8]

Then, we can take the environmental nuclear pollution issue as a breakthrough. China can take this opportunity to gain a consensus of opposition along the Pacific coast and win over countries like South Korea and Vietnam. As the proverb goes, the enemy of the enemy is a friend. China can use it to weaken the influence of Japan and the United States on East and Southeast Asia and expand Chinese impact. China can gain more support in the struggle against the west and strive to take control of international organizations. For example, using the United Nations framework, China can widely mobilize other countries to condemn Japan strongly, requiring the United Nations to send specialized agencies to verify whether the wastewater discharged by Japan meets the nuclear safety standards declared and exposing the great lie jointly concocted by the United States and Japan. In addition, the means of collective claims against Japan in the future should also be reserved. Let Japan compensate China for the losses caused by its actions.

5 CONCLUSION

This article uses game theory to explain why Japan chose to discharge nuclear wastewater into the ocean. This article starts from the Prisoner's Dilemma theory and reveals through the chart that it is the best choice for Japan to discharge nuclear wastewater into the ocean. Secondly, through the two-layer game theory, combining the national and international levels, with the support of the United States externally, the support of various factions internally, and the cost of sewage treatment, the reasons for Japan's discharge of nuclear wastewater are revealed. Finally, some advice is given to Japan's neighbor China on how to deal with Japan's discharge of nuclear waste into the sea. In any case, because of the fluidity of seawater, the nuclear wastewater discharged by Japan will not only affect neighboring countries, but may also affect the

whole world, which will have a great impact on people, animals, and the ecological environment all over the world. I hope that in the future countries will find better ways to deal with nuclear wastewater.

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