Theoretical Conditions to Reach Peaceful Denuclearization in Unequal Nuclear Rivalries*

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Introduction

This study depicts a necessary condition to promote peaceful denuclearization in unequal nuclear rivalries. Denuclearization means that only one side implements nuclear disarmament and gives up nuclear development. It differs from mutual nuclear disarmament during the Cold War, as it occurs between equal nuclear rivals for stability. Nuclear disarmament in equal rivalries has been studied based on Thomas Schelling's nuclear deterrence theory and arms control research (Schelling 1960; Schelling and Halperin 1961). Research on denuclearization is also based on his nuclear deterrence theory. However, previous studies on nuclear disarmament in equal rivalries aim to prevent nuclear war through the stability of nuclear deterrence. However, the success of denuclearization in unequal nuclear rivalries means making an unstable nuclear balance situation which never occurs in the success of mutual disarmament.

This critical difference makes denuclearization more difficult than mutual nuclear disarmament because maintaining nuclear weapons is often the best strategy for the weaker side in unequal rivalries. Maintaining nuclear weapons is a failure of disarmament, even if the hostility is finished in an unequal nuclear rivalry. Therefore, the theoretical conditions to achieve peaceful denuclearization in unequal nuclear rivalries that previous studies have not addressed must be clarified for international security. This study contributes to understanding the North Korean nuclear issue. In addition, it clarifies the cause and effect of the normalization of diplomacy between the US and China without denuclearization in the 1970s. This study primarily focuses on the strategic order effect, particularly the first-mover disadvantage, to analyze the theoretical conditions. It also uses a game-theoretic model to clarify its importance.

The main issue of a conflict in a nuclear rivalry is the prevention of nuclear war. Previous studies on nuclear arms control and disarmament have focused on decreasing the likelihood of nuclear war in equal nuclear rivalries (Brenann 1961; Bull 1961, 1965; Schelling and Halperin 1961).

However, previous studies have not focused on the effects stemming from the case of unequal nuclear forces. Nuclear arms control and disarmament need to be conducted in a way that

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maintains the stability of nuclear deterrence. An important reason to promote disarmament is the danger of accidental nuclear war.

Theoretical analyses based on mutual nuclear deterrence have contributed to the prevention of nuclear war in equal nuclear rivalries both in terms of conflicts and disarmament policies. However, current nuclear disarmament issues involve unequal nuclear rivalries, and the objective is the denuclearization of one side, not both sides. Previous studies have assumed equal rivalries and mutual nuclear disarmament. Thus, denuclearization of a new and weak nuclear power has not been theoretically discussed in detail yet, although it is one of the main issues related to nuclear nonproliferation and disarmament policies and is quite different from the issue of mutual nuclear disarmament in the Cold War.

To help fill this gap, this study focuses on the strategic order of negotiations for nuclear disarmament in unequal nuclear rivalries and constructs various models to promote denuclearization peacefully in such cases: the first offer of peace by the stronger side inevitably leads to a peaceful resolution without denuclearization, and establishing a second mover advantage for the stronger side is a key factor for denuclearization. In nuclear disarmament negotiations between equal nuclear rivalries, the first mover has an advantage. In contrast, the second mover has an advantage in nuclear disarmament negotiations between unequal nuclear rivalries due to the incentive for nuclear deterrence. The stronger side needs to build trust while putting pressure on the weaker side: the weaker side must be encouraged to make the first move and opt for denuclearization without war.

In a prisoner's dilemma situation, it is not always true that disarmament decreases the possibility of armed conflicts and that armament increases this possibility. Nuclear armament strengthens nuclear deterrence, but changing the nuclear balance could lead to nuclear war. If it is expected that military buildup is better for national security than disarmament, even the soft security type has an incentive to arm (Glaser 1998). However, the type of state is only one determinant of armament or disarmament choices. These choices also depend on relations with rival nations to determine whether disarmament positively affects national security.

A new condition for nuclear disarmament after the Cold War was "denuclearization," in which a new or potential nuclear power gives up possession of nuclear weapons. This is typically initiated by the stronger country or international organizations rather than the new nuclear power, based on a violation of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) or international norms. For example, the case of North Korean nuclear development and confrontation with the US differs from the Cold War scenario. North Korea violated the NPT and disrupted the international order. The goal of this case was to make North Korea comply with the nuclear nonproliferation norm, unlike the case of nuclear rivalry between the US and the Soviet Union. However, some Cold War era cases demonstrate that coercion based on the international

norm alone to create denuclearization is challenging, and security assurance is necessary (Burr 1999, 2007; Kim 2001; Campbell, Einhorn, and Reiss 2004; Shibai 2015, 2019). Setting conditions promoting North Korea's disarmament is required; the US should not offer a peace treaty at first.

As mentioned above, this article's objective is to study theoretical conditions to achieve denuclearization in unequal nuclear rivalries. This study focuses on the first-mover disadvantage. It derives a new hypothesis: *Cooperative groundworks to avoid nuclear war by the stronger side never leads to denuclearization of the weaker side.* This hypothesis is an example of a security dilemma. The previous studies suggest the importance of resolving the security dilemma by taking the initiative (Crossley 1985; Kydd 1997, 2005; Montgomery 2006; Osgood 1960). Especially in nuclear rivalries, a player with the final turn in the security dilemma game has a decisive disadvantage (Figure 1). However, this study's findings concerning unequal nuclear rivalries are inconsistent with previous research, and making a second move is essential.

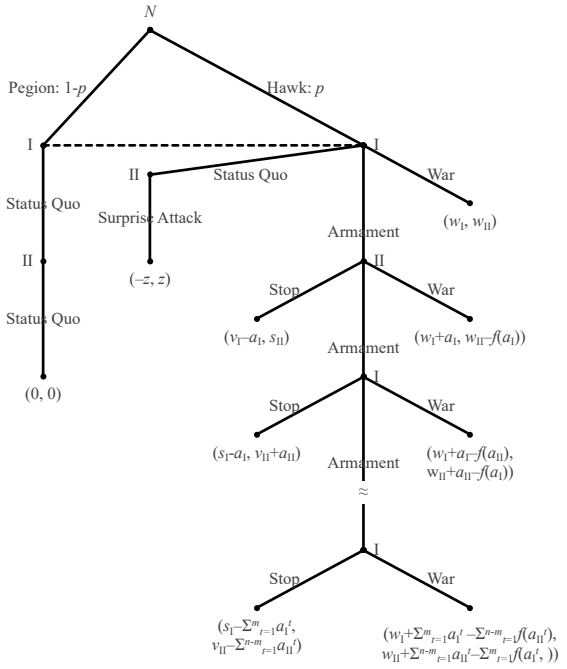

Figure 1 Escalation of Security Dilemma (Shibai 2023)

1 Nuclear Disarmament Negotiations

This study analyzes the nuclear disarmament negotiations between unequal rivalries and presents theoretical conditions for peaceful denuclearization. This situation is distinguished from equal rivalries and non-nuclear disarmament negotiations. There have been some cases of nuclear disarmament between equal powers. However, such mutual disarmaments as that between the US

and Soviet Union are not identical to the current denuclearization issues because these two countries were equal nuclear powers, and their goal was stable nuclear deterrence. The current denuclearization issues involve one side's disarmament and the end of the confrontation. Therefore, past nuclear disarmament cases have only involved successful mutual nuclear disarmament, but denuclearization is more complex than mutual nuclear disarmament. Because the weaker side surrenders its nuclear deterrence and makes itself more vulnerable, denuclearization is unacceptable as a matter of national security policy, even though it is justifiable under international law. Establishing a bargaining situation in which the weaker side can choose nuclear disarmament with the assurance of no deception and in which nuclear armament invites significant military sanctions is crucial.

In general disarmament and peace negotiations, the stronger side must make the first move and offer conditions that make the weaker side trust the stronger side. A typical example of this is peace negotiations, including disarmament of rebel groups in civil war. However, in unequal nuclear rivalries, the stronger side should not offer the peace condition before the weaker side offers nuclear disarmament. The cause of the difference is, of course, nuclear deterrence. In the context of nuclear deterrence, even the weaker side can maintain its national security. If a peace treaty and end of conflict are provided before denuclearization, maintaining nuclear deterrence is the best security strategy. In this article, the signing of a peace treaty and keeping nuclear weapons is referred to as "peaceful resolution" and is distinguished from "peaceful denuclearization," which refers to the signing of a peace treaty with the weaker side's nuclear abolition.

For the weaker side, the signing of a peace treaty and keeping its nuclear deterrence capability are ideal because keeping nuclear weapons while achieving a peace treaty is useful in contending with future threats, which could include future conflicts with a country with nuclear weapons.

2 Theory of Conflict Resolution in Nuclear Rivalries

Schelling (1960) used game-theoretic models to stabilize nuclear deterrence. The essence of these models is their focus on clarifying the equilibrium point to reduce the likelihood of nuclear war. As stated by Shelling (1960), "A strategic move is one that influences the other person's choice, in a manner favorable to one's self, by affecting the other person's expectations on how one's self will behave" (160). This principle has been a basis of strategic studies of nuclear rivalries, and it is also important in nuclear disarmament games. Powell (1985, 1987, 1988, 1989a, 1989b) rapidly developed game-theoretic analyses of nuclear strategies and stability for equal nuclear rivalries with dynamic game models. In these models, the credibility of nuclear attack stabilizes nuclear deterrence and depends on irrationality and the possibility of accidents regardless of who is the first mover (Powell 1989a, 1989b).

Previous studies have argued the importance of maintaining stable nuclear deterrence for

nuclear arms control and disarmament because the chance of winning induces a player to attack. However, nuclear deterrence in disarmament also involves the security dilemma and uncertainty. To solve the security dilemma and uncertainty in the context of international relations, many kinds of game-theoretic analyses have been carried out (Axelrod 1984; Jervis 1978; Keohane 1984; Kydd 2005; Powell 1999).

There are two important differences between nuclear disarmament in equal versus unequal nuclear rivalries. The first is the issue of credibility. Both scenarios depend on two countries succeeding in creating mutual trust and assuring each other there is no deception. For example, in equal rivalries, the reciprocal fears of a surprise attack increase the likelihood of nuclear war because the superior country has an incentive to win (Schelling 1960, Ch. 9). Likewise, credibility as no deception is also essential for denuclearization in unequal nuclear rivalries. However, in unequal rivalries, a situation in which one side is superior is inevitable. This important difference limits previous studies' findings for examining denuclearization in unequal nuclear rivalries.

Second and related to the first reason is the importance of the strategic order of a game. The strategic order has previously not been an important variable in nuclear deterrence strategies and disarmament negotiations. A first mover takes initiative if they have an advantage, and the order has no effect on the game if nuclear deterrence is stable. Nuclear deterrence makes even a crisis in nuclear rivalries stable even if the players do not know which is the first mover (Powell 1989a). However, the order has an important role in unequal nuclear rivalries: While the equilibrium path does not change according to who makes the first move in equal nuclear rivalries, in unequal rivalries, this path changes depending on whether the stronger or weaker side makes the first move. Therefore, to achieve peaceful denuclearization, how to create credibility in unequal nuclear rivalries and the effect of the order need to be clarified. Thus, the order is a focus of this analysis because credibility strongly depends on the effect of the order.

The order of a game often has an effect on the outcome because the first mover sets the stage and determines the direction of the negotiation. If the player's credibility (subjective probability) is insufficient, the negotiation breaks down. The first mover has a chance to change the rival's subjective probability at the first choice, which can lead to the desired outcome. Especially in denuclearization negotiations, losing nuclear deterrence increases the fear of the weaker side, and the stronger side also has a fear of being deceived. The uncertainty impedes disarmament. Next, the effect of the order of move on the negotiations in military rivalries is analyzed.

3 Effect of Strategic Order

3-1 First Mover Advantage in Nuclear Negotiations

There are many analyses of nuclear disarmament and arms control negotiations, mainly from during the Cold War period. However, there is one factor that has not received much attention:

the order of proposals. The player that moves first affects the results of a negotiation.

In a general negotiation, the first mover has an advantage, and the agreement favors them (Ausubel, Cramton, and Deneckere 2002; Benton, Kelley, and Liebling 1972; Binmore, Osborne, and Rubinstein 1992; Chertkoff and Conley 1967; Fudenberg, Levine, and Tirole 1985; Galinsky and Mussweiler 2001; Lieberman and Montgomery 1988; Liebert, Smith, and Hill 1968; Kennan and Wilson 1993; Muthoo 1999; Osborne and Rubinstein 1990; Rubinstein 1982, 1985; Sobel and Takahashi 1983). Rubinstein (1982, 99) depicts models wherein the first move gives a relative advantage to the first player when each player alternates their offers and certain conditions are fulfilled because the alternate offer is based on the first offer. In summary, the first proposal serves as an anchor and gives the first mover an advantage (Loschelder et al. 2016); the first mover's first offer restricts the scope of the second mover's strategy for as long as the negotiation is continued. When the initiative is taken by a rival, another player cannot reclaim the initiative. They have no choice but to reject it and end the negotiation if they complain.

There is a limit to the number of times an offer can be rejected. It is difficult to maintain the status quo on nuclear issues because nuclear powers always develop nuclear technologies and increase nuclear weapons for their own and allies' securities. If a nuclear power in an inferior position develops nuclear weapons and equalizes forces, conditions for nuclear stability are changed and conflicts are more likely to occur. To prevent the nuclear power balance from changing to an undesirable situation, a player must continue the negotiation or become a first mover at some point.

The objective of nuclear disarmament is to decrease the possibility of nuclear war (including stabilizing nuclear deterrence), not to win a nuclear war. Therefore, the first mover's advantage is especially useful for nuclear issues because the first mover can make an offer to gain or keep its superiority and nuclear stability. The second mover must consider amendments that do not destabilize nuclear deterrence. However, it is more difficult for the second mover to make an offer that gives them superiority over the first mover because the necessity of nuclear stability restricts the second mover's overall strategy scope, not just the first offer.

In summary, a first mover has an advantage in disarmament negotiations between equal nuclear rivals and in general disarmament talks between unequal rivals. However, in nuclear disarmament negotiations between unequal nuclear rivals, the first mover has a disadvantage.

3-2 First Mover Advantage in General Disarmament Talks in an Unequal Rivalry

"Unequal rivalry" refers to a situation of an obvious disparity in forces, especially nuclear weapons, such that the weaker side cannot win a war against the stronger side, even with nuclear weapons. The only option for the weaker side is to aggressively deter attacks with nuclear threats. The weaker side is skeptical and strongly anxious about its survival. Therefore, if the stronger

side hopes for peaceful conflict resolution, it must use the first mover advantage to achieve it.

For a peaceful agreement in general disarmament talks, the stronger side should move first and assure no deception to the weaker side. In this agreement, the weaker side is able to be easily defeated after it disarms and thus does not choose disarmament without the assurance of no deception. However, the non-disarmament action of the weaker side leads to the stronger side's distrust, and the security dilemma thus becomes more serious. Resolving the security dilemma is a critical task in international conflict (Glaser 1992; Jervis 1978; Kydd 1997, 2005, Ch. 3; Montgomery 2006). To avoid the spiral of fear in the non-nuclear disarmament negotiation, the stronger side must take the initiative.

For example, the model case involves peace talks of civil wars and ethnic conflicts, including the disarming of rebel groups. To end the armed conflict and restore social order, the government must demand the disarmament of the insurgent group, even if the government caused the civil war. If both sides desire conflict termination, the government that is stronger than the rebels must compromise for trust building, and even amnesties that would increase the rebels' military power promote a peaceful solution (Dancy 2018). However, the insurgent group cannot easily choose disarmament because of the fear of the government's deception after disarming. When the weaker side chooses armament at first, the stronger side decides on war to prevent a disadvantageous war in the future. The weaker side has no incentive to move first, even if there is a high risk that the stronger side will attack because, in this situation, the weaker side always chooses an aggressive option at its turn, that is, armament or rebellion. Therefore, the first offer falls to the stronger side if the purpose is disarmament and the end of the war. There is also a first mover advantage in peace talks, including disarmament.

3-3 The Disadvantage of the First Move in an Unequal Nuclear Rivalry

The first offer is advantageous in a negotiation, and this is also true in arms control and disarmament negotiations for nuclear stability, as with the US–USSR negotiations. The two parties' negotiations centered around maintaining nuclear deterrence and that any result should never disable their nuclear deterrence. Nuclear deterrence assures their security, and their power balance remains unchanged: No country can win in a nuclear attack.

However, negotiations for denuclearization aim to disrupt one side's nuclear deterrence capability. If the result is denuclearization, the denuclearized country loses nuclear deterrence, and its national security is under nuclear threat. In such a situation, the fear of deception is as strong as in the disarmament inspection games. The country has a strong motivation to maintain nuclear deterrence and avoid such a result. Therefore, the negotiation in an unequal nuclear rivalry for denuclearization is a different situation from those of an equal rivalry.

In the negotiations of an unequal nuclear rivalry, the first offer cannot be advantageous because

gaining a peace treaty while keeping nuclear weapons is the best result for the weaker side. The role of the stronger side is more important for achieving peaceful denuclearization. However, unlike conventional disarmament, denuclearization requires the weaker side to move first because the first mover advantage is lost in the negotiation. To peacefully achieve denuclearization, the stronger side must encourage the weaker side to clearly depict their intention to disarm before the stronger side's move.

The weaker side can be regarded as a soft security type in the nuclear issue; the best outcome for the weaker side is peaceful resolution in many situations. There are two key factors in this disarmament game. The first is an imbalance of military forces. The weaker side is quite concerned about its regime collapsing, so the imbalance makes the weaker side distrustful of the stronger side. The stronger side can win a war against the weaker side, but the expected cost and damage by nuclear attacks makes the stronger side hesitant to conduct military actions.

The second is the order of the game. For example, it is better for the US that North Korea denuclearize before signing a peace treaty in the Korean peninsula, but it is impossible for the weaker side to do this without robust assurance of its own security. Nevertheless, the stronger side's moving first and selecting the peace treaty option does not always lead to a favorable result because such an offer does not guarantee the weaker side's denuclearization. The more the weaker side demands robust security, the more it needs nuclear weapons.

In a nuclear disarmament negotiation, the only substantial disadvantage of possessing nuclear weapons is sanctions. Deterioration of relations or escalation of conflicts with countries rarely manifest as direct damage if sanctions are not imposed. Therefore, the cost of keeping nuclear weapons is expressed by the amount of sanctions s^t in this game model (See Table 1 and 2).

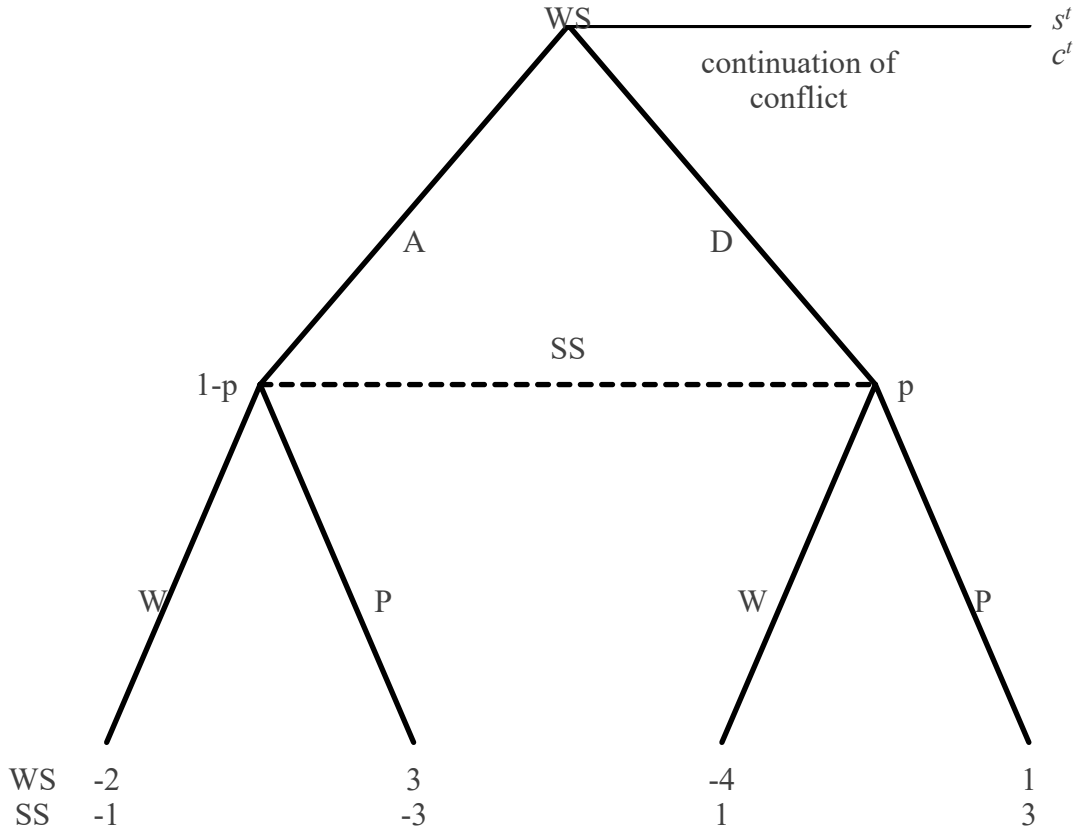

Figure 2. Nuclear disarmament games in an unequal rivalry: Weaker side moves first

Table 1 Notation in the figures

	Notation	Explanation
Player	WS	Weaker side
	SS	Stronger side
Strategy	A	Nuclear armament of WS
	D	Nuclear disarmament of WS
	P	SS offers a peace treaty
	W	SS chooses war

Table 2 Meaning of outcomes

Outcome		Explanation
WS moves first	SS moves first	
(D, P)	(P, D)	Peaceful denuclearization

(A, P)	(P, A)	Peaceful resolution
(A, W)	(W, A)	War
(D, W)	(W, D)	SS's win
(s^t, c^t)	(c^t, s^t)	Profitability of choosing the continuation of conflict (CC) to avoid the final decision at turn t. The cost of sanctions is included in the SS. The cost of the SS's sanction is included in the WS.

In these games, "continuation of conflict" means that the stronger side continues non-military sanctions and the weaker side continues provocations and escalating tensions with nuclear development. The stronger side's profit c^t includes the weaker side's continuous provocations, such as nuclear and missile launch tests. If the amount of c^t is unacceptable, the stronger side needs to decide peace or war. "Armament" means that the weaker side formally declares the possession of an important nuclear capability because the completion of development unambiguously changes the situation of nuclear rivalry, and the stronger side must take some action. If no response is given, it is taken as tacit approval: It is a kind of "peace" in the game. For example, in the current North Korean nuclear issue, the promulgation of the 2012 Constitution which stipulated the country's nuclear possession is regarded as armament. Conducting nuclear and missile tests is a continuation of conflict, not armament. If North Korea formally declared completion of long-range missiles to strike the mainland of the US, that is a form of armament. "Disarmament" means formally giving up important military development. "War" means a military sanction to coercively stop the weaker side's important military development, and "peace" means accepting its nuclear capability and ending the state of hostility. The signing of a peace treaty while keeping nuclear deterrence capability is the best result for the weaker side.

The games presented in Figures 2 and 3 are built on the assumption that the weaker side is the soft security type: (D, P) > (A, W). This is in contrast to the hard security type: (A, W) > (D, P). P and q are the second movers' information sets. However, they express that the first movers cannot expect the second mover's response.

The weaker side can have a preference order: peaceful resolution > peaceful denuclearization > war > stronger side's win. The preference order of the stronger side in Figure 2 is as follows: peaceful denuclearization > stronger side's win > war > peaceful resolution. Both players have a moderate preference. However, the game is the prisoner's dilemma. Figure 2's solution is separate equilibria.

Proof. Suppose that the profits and strategies of the WS and SS in Figure 2 are cited as follows: (α_1, β_1) in war, (α_2, β_2) in a peaceful resolution, (α_3, β_3) in SS's win, and (α_4, β_4) in peaceful denuclearization. The preference orders are $\alpha_2 > \alpha_3 > \alpha_1 > \alpha_4$ and $\beta_4 > \beta_1 > \beta_2 > \beta_3$. The

amount of p decides an equilibrium point.

If the payoff is $s^t > a > d$, the sequential equilibrium is (CC, W). The WS can choose CC for the largest payoff at the first move. The SS chooses W because $a > d$ means $p < \omega_1$. If the payoff is $s^t > d > a$, the sequential equilibrium is (CC, D). The SS chooses P because $d > a$ means $p > \omega_1$. If the payoff is $a > s^t > d$, the sequential equilibrium is (A, W). The SS chooses W because $a > d$ means $p < \omega_1$. If the payoff is $d > s^t > a$, the sequential equilibrium is (P, D). The SS chooses P because $d > a$ means $p > \omega_1$. If the payoff is $a > d > s^t$, the sequential equilibrium is (A, W). The SS chooses W because $a > d$ means $p < \omega_1$. If the payoff is $d > a > s^t$, the sequential equilibrium is (P, D). The SS chooses P because $d > a$ means $p > \omega_1$. A chance exists to achieve peaceful denuclearization.

In the game of Figure 2, "the first mover" weaker side chooses continuation of conflict if the expected utility of armament, a, is less than s^t and the expected utility of disarmament, d. It carries out armament if $a > s^t$ and $a > d$. It chooses disarmament if $d > s^t$ and $d > a$. Peaceful denuclearization is only possible if not only $d > s^t$ and $d > a$ but also $a > s^t$ occur because the weaker side can choose continuation of conflict if $a < s^t$. This shows that the stronger side must not only exhaust the weaker side with sanctions but also convince the weaker side that offering nuclear disarmament voluntarily will spare it from the worst consequences. The (D, P) is an equilibrium point if $p > 1/2$ and $s^t < a < d$ in Figure 2.

In summary, the condition required (D, P) to actualize the Nash equilibrium point in the game of Figure 2 is as follows: $d > a > s^t$. Only when the damage from sanctions in turn t is significant enough to make an armament or disarmament decision and the subjective probability distribution is such that the weaker side can trust the stronger side is peaceful denuclearization achieved.

An example of Figure 2 is West Germany. German chancellor Adenauer was strongly looking to the US to appease the USSR (Dülffer 2007). However, the post-Adenauer government believed that the US would defend Europe due to reforming the NATO Nuclear Planning Group (Shibai 2015, 2019). In this case, the US appeasement heightened the danger of attack by the Soviet Union. The fear caused West Germany to keep the option of nuclear armament open. Thus, West Germany could choose A if p was insufficient.

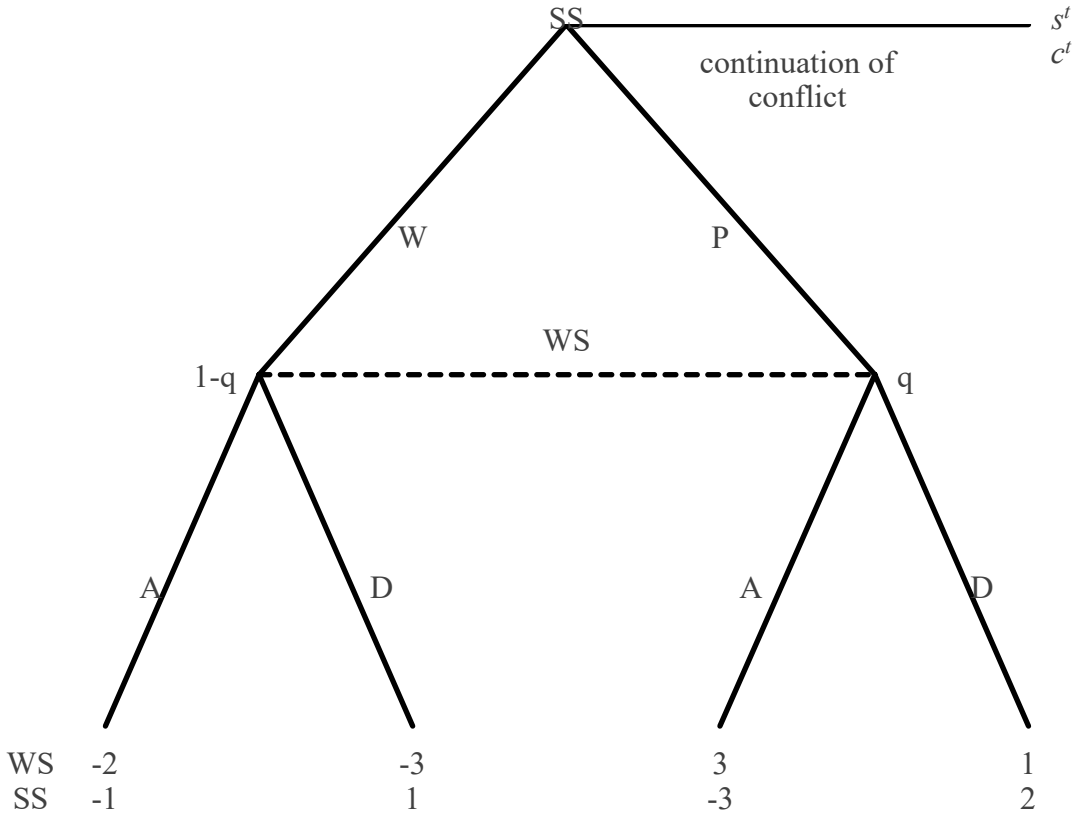

Figure 3. Nuclear disarmament games in an unequal rivalry: Stronger side moves first

It is impossible to trace the path of (P, D) in Figure 3, in which the stronger side is the first mover, because the optimal strategy of the weaker side remains the same at armament, irrespective of the value of q. The preference order of the stronger side in Figure 3 is as follows: peaceful denuclearization > peaceful resolution > stronger side's win > war. In this situation, the stronger side is not incentivized to start a war. Figure 3's solution is pooling equilibria.

Proof. Suppose that the profits and strategies of the SS and WS in Figure 3 are cited as follows: (β_1, α_1) in war, (β_2, α_2) in SS's win, (β_3, α_3) in a peaceful resolution, and (β_4, α_4) in peaceful denuclearization. The preference orders are $\alpha_3 > \alpha_4 > \alpha_1 > \alpha_2$ and $\beta_4 > \beta_2 > \beta_1 > \beta_3$. The amount of q decides an equilibrium point.

If the payoff is $c^t > w > pe$ or $c^t > pe > w$, the sequential equilibrium is (CC, A). The SS can choose CC for the largest payoff at the first move. The WS chooses A. If the payoff is $w > c^t > pe$, the sequential equilibrium is (W, A). If the payoff is $pe > c^t > w$, the sequential equilibrium is (P, A). If the payoff is $w > pe > c^t$, the sequential equilibrium is (W, A). If the payoff is $pe > w > c^t$, the sequential equilibrium is (P, A). The WS always chooses A in this game. Therefore, peaceful denuclearization is never realized.

Figure 3 shows that peaceful denuclearization is never realized by the first move of the stronger

side because the weaker side knows that it has no incentive to denuclearize a non-enemy nuclear power by paying sanction costs.

The discussion has proceeded on the assumption that the weaker side has a firm security desire. However, the weaker side can have a more moderate preference order, as follows: peaceful resolution > peaceful denuclearization > war > stronger side's win. This is the preference order of the soft security type. The hard security type pursues nuclear possession for the military advantage in every conflict, but the soft security type hopes for security and survival, so it is necessarily obsessed with nuclear weapons.

In addition, $q = 1$ makes the weaker side choose disarmament if the values of peaceful denuclearization and nuclear resolution are the same (Figure 4).

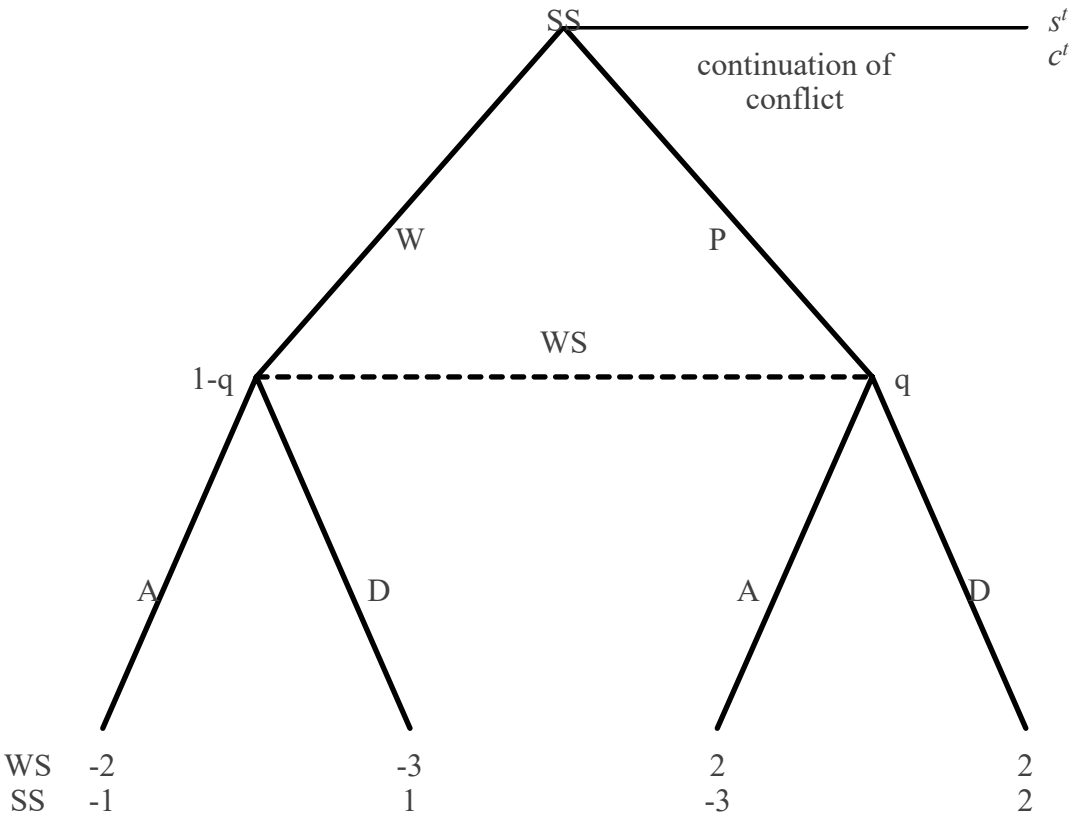

Figure 4. Game of $a = d$

However, in nuclear disarmament negotiations between unequal nuclear rivalries, the benefits of (P, A) and (P, D) are never equal; such a situation is not realistic unless nuclear deterrence has no security advantage. The greater the effectiveness of nuclear deterrence, the less benefit there is for the weaker side to denuclearize. The expected utilities of the weaker side are never u_{WS}(P,

D) > u_{WS}(P, A) because the utility of nuclear deterrence is more than 0, and another type of profit, signing of a peace treaty, is the same.

Figure 3's game model shows why negotiations between the US and China resulted in a peaceful resolution. The cases described above show that the weaker side can select maintaining nuclear weapons after the stronger side chooses peace. Furthermore, the stronger side can also accept a peaceful resolution if the weaker side is not hostile at that time. These precedents predict North Korea will choose a peaceful resolution if the US chooses a peace treaty as the first move. This proposal is impossible unless the US puts peace before denuclearization, as they did not include it in the articles.

In these situations, there is no path to lead to peaceful denuclearization when the stronger side moves first. Therefore, to achieve peaceful denuclearization, it is necessary for the weaker side to make the first move. Peaceful denuclearization will more easily be achieved if the effect of nuclear deterrence has been decreased and extinguished; however, it is impossible to expect this. To achieve a peaceful denuclearization in a situation where nuclear deterrence works, making the weaker side move first and offer nuclear disarmament voluntarily is a necessary condition. Therefore, the following methods should be analyzed.

4 Methods to Reduce Uncertainty

To summarize the analyses, the conditions for peaceful denuclearization are as follows:

(1) There is no expectation created that the stronger side will make the first move.
(2) The stronger side implements sanctions to force the weaker side into a decision of armament or disarmament.
(3) It is necessary to maintain confidence that the stronger side is willing to respond to disarmament with peace when the weaker side is pushed to the brink by sanctions.

It is difficult to reconcile conditions (2) and (3) because it means achieving an increase in the likelihood that strengthening sanctions will provoke radical behavior while simultaneously maintaining trust.

Figure 2 shows that the weaker side's moving first is necessary to reach peaceful denuclearization. This section analyzes strategies wherein the stronger side induces the weaker side to make the first move.

Suppose that nuclear deterrence does not lose its positive security effect: in this case, it is difficult or impossible to change the payoffs of the weaker side's armament in Figures 2 and 3. The payoff (including the nuclear deterrence effect) is never less than the payoff of disarmament because u_{WS}(P, A) > u_{WS}(P, D) and u_{WS}(W, A) > u_{WS}(W, D) is fixed in the game, and the relationships of expected utilities also do not depend on the subjective probabilities p and q. In the game of Figure 2, u_{WS}(A, W) > u_{WS}(D, W) is fixed because of the effect of nuclear deterrence

and nuclear retaliation. The nuclear threat of the weaker side is effective because it has a strong motivation to use nuclear weapons in a war against the stronger side for its survival when the former is backed into a corner by the stronger side. The u_{WS}(A, W) > u_{WS}(D, W) and incentive to choose armament is the same even if the weaker side is a soft security type, which prefers peaceful denuclearization to peaceful resolution. There is no method to decrease the payoff of armament unless nuclear deterrence is useless. Therefore, changing the payoff of the stronger side in the case of disarmament is a method to increase the likelihood of peaceful denuclearization.

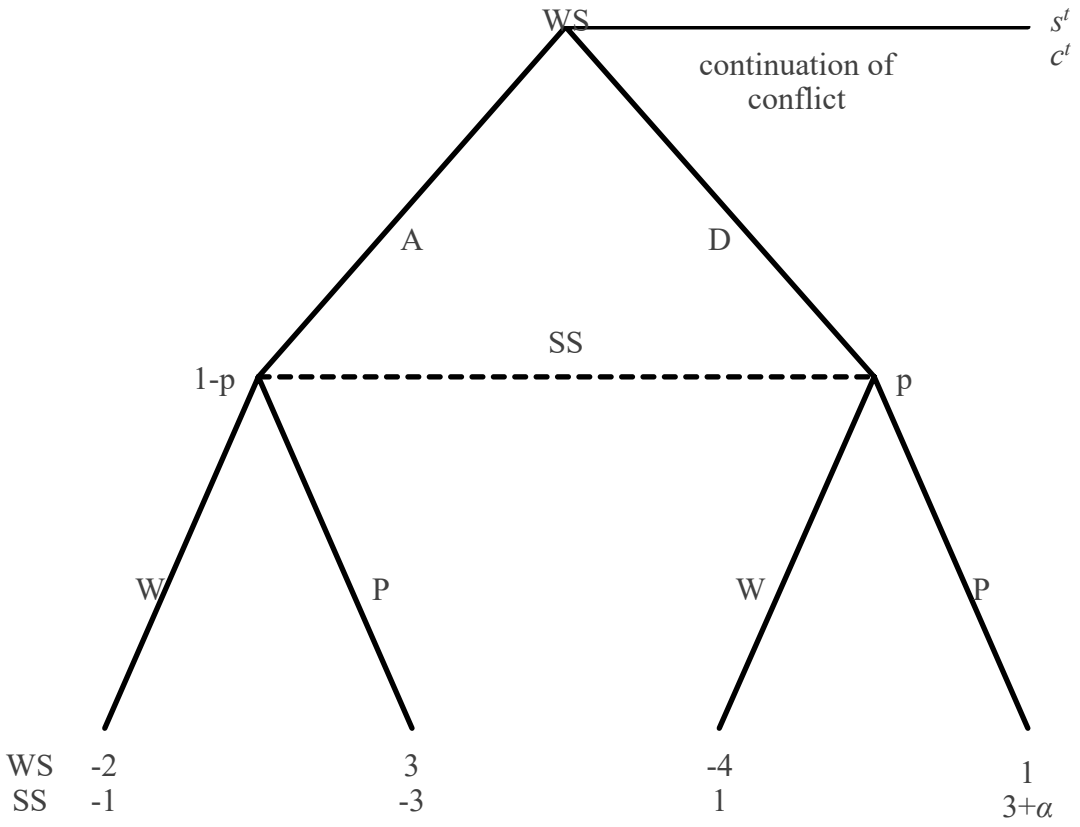

Figure 5. Effect of changing the stronger side's payoff

As shown in Figure 5, a corrected game—that is, increasing the payoff of the stronger side of (D, P)—increases the likelihood of peaceful denuclearization and makes it easier for the weaker side to opt for disarmament.

Variables to increase α should have an immediate effect on negotiations and must be something that the weaker side can trust to be feasible. What changes the payoffs of the stronger side and reduces uncertainty of the weaker side in the real world? Of course, there are variables that not only decrease uncertainty but also increase it. The causal variables are listed, and the effects are

analyzed.

Allies of the stronger side (*al*). The allies' interest regarding the nuclear disarmament issue influences the payoffs α. If they desire peaceful denuclearization, their policies increase α. In the case of North Korea, allies located near North Korea are more vulnerable to nuclear threats than the US. If the US, as the stronger side, chooses a military action after disarmament, South Korea, Japan, and the US military bases within them are attacked by North Korea with conventional weapons. The allies do not hope for an additional cost of war after freedom from nuclear threats. They also have absolutely no desire for the US to compromise with North Korea and allow it to possess nuclear weapons after armament. Therefore, the effect of the allies must include not only the lower limit but also the upper limit. If α changes the dominant strategy of the stronger side to peace, peaceful denuclearization is never achieved. Therefore, the allies must not be free riders and must express the belief to share some cost to achieve peaceful denuclearization with the US. The player must manage not only the expected utility of the rival but also that of the third party if denuclearization is needed.

Public opinion of the stronger side (*pos*). Public opinion of the stronger side and allies has an influence on this process. It is difficult but not impossible for public opinion to change a security policy (Baum and Groeling 2010; Foyle 1999; McDonald 2009). In democratic states, the political leader can decide on an undesired war to maintain support from nations (Fearon 1994; Tomz 2007). Even in communist countries, the government compromises with the demand of nations when the authority is weak, as in the "Wir sind das Volk" and Pan-European Picnic in 1989.

In nuclear disarmament negotiations, the public opinion of the stronger side can increase α if it supports peace. The more Americans do not support a military sanction, the more North Korea believes that the US will not choose one after its disarmament. Decreasing the support of US public opinion has a strong effect on the policy of the U.S. government.

Public opinion of an ally (*poa*). An ally's public opinion has less influence on the nuclear disarmament negotiations than the stronger side's public opinion. However, it is also difficult for allies to ignore its people's peace request if the vital interest of the ally's citizens is at stake in the issue and the ally more actively urges the stronger side to make peace. Therefore, the public opinion of the stronger side's allies can also increase α if it supports peace.

International Organization (*io*). A mediator can decrease uncertainty in a negotiation and increase the likelihood of an agreement. However, the necessary condition to decrease uncertainty is for a mediator to have enough power to prevent a player's deception and to punish them for it (Kydd 2003, 2006; Rauchhaus 2006). In the disarmament negotiation of an unequal nuclear rivalry, the stronger side is a great power, and an international organization has insufficient assurance power. US–USSR nuclear arms control and disarmament cooperation were achieved by bilateral negotiations. Mutual assurance measures were conducted by the two great powers

only; no international organizations, including the UN and IAEA, played an important role.

However, in the negotiation model, an international organization can play a role to increase the likelihood of peaceful denuclearization because it can increase α by other methods, except by power. An IAEA inspection has a special effect on nuclear disarmament negotiations because the IAEA is the only organization that can certify nuclear disarmament of the weaker side. A serious problem in the nuclear disarmament process is false declarations and the inability to eliminate the suspicion of concealing nuclear weapons by lying about having implemented disarmament. This can cause uncertainty and mutual distrust. An IAEA inspection can eliminate such suspicions. Assuming the inspection is not obstructed and is completed, the weaker side's acceptance of the inspection increases α. In addition, this has a negative effect on the stronger side's payoff of war. Acceptance of inspections means that war loses its legitimacy, which makes it impossible to wage war on a false accusation of concealing weapons of mass destruction, such as the Iraq War of 2003.

In the Iraqi crisis, the US and UN inspected nuclear facilities in Iraq from 2002 to 2004. The US government argued that Iraq had weapons of mass destruction and justified the war with a lie, as there were no weapons of mass destruction. Even if the stronger side has the capability, nuclear inspections by the stronger side never increase α or build mutual confidence because they increase the stronger side's payoff of war. The IAEA has no power, but its inspection places constraints on the stronger side's strategy. Only a neutral international organization that has no interest in the parties or in the negotiations and has special capabilities regarding nuclear weapons can be a mediator.

Finally, the negotiation process is constructed and includes the exogenous variables (Figure 6).

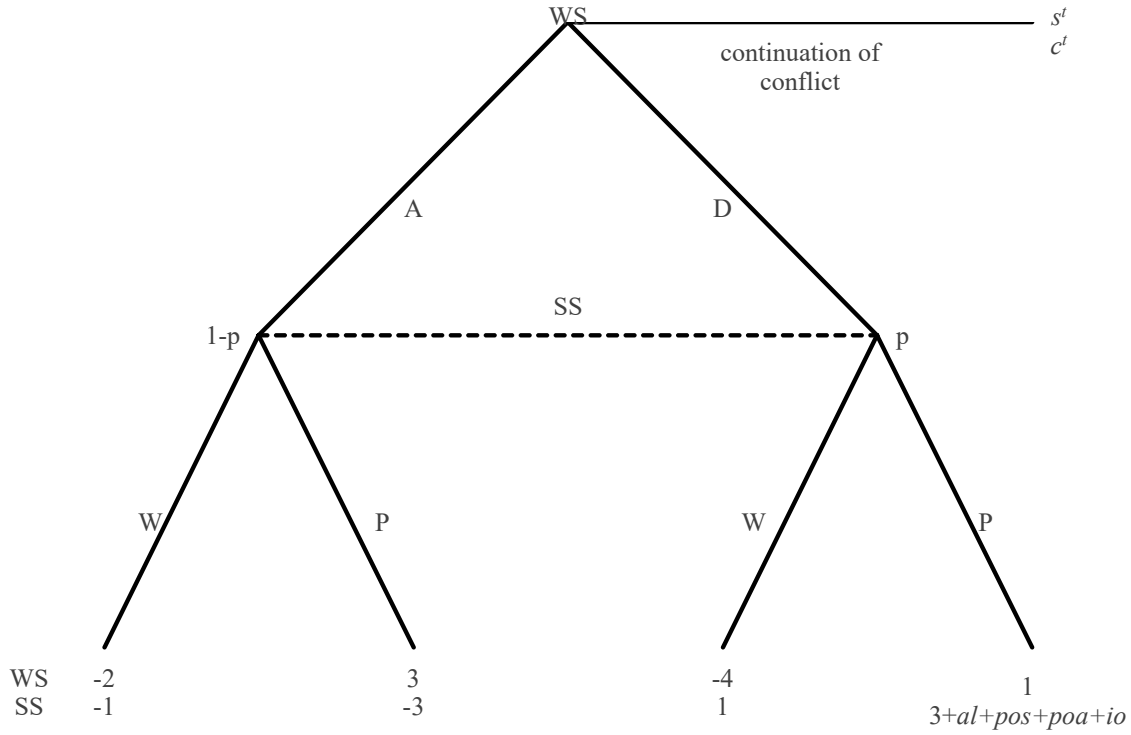

Figure 6. Disarmament game with exogenous variables

If the corrected expected utility of peace is more than *w*, the weaker side can choose disarmament. They thus reduce the uncertainty of the negotiation. What the disarmament game needs is exogenous variables that elevate the gains of peace without elevating the gains of war. Such variables are by no means numerous, and the effect of each one is never large. It is therefore important to collect as many exogenous variables as possible. They are not decisive, independent factors. However, as mentioned above, the path to peaceful denuclearization is extremely narrow. Therefore, even small influential variables must be collected and leveraged.

5 Conclusion

Peaceful denuclearization is a difficult task. Similar to the failure of China's case, bilateral and multilateral negotiations and lobbying from the international community have failed to denuclearize North Korea. Moreover, even if China and Russia offer a nuclear umbrella, North Korea will have no incentive to denuclearize because extended deterrence is more unstable than nuclear possession. Therefore, it is worthwhile to clarify the theoretical conditions for peaceful denuclearization, no matter how narrow the path is.

The order of strategies and the methods to reduce the uncertainty of the stronger side's strategy is needed to solve the security dilemma in unequal nuclear rivalries. The equilibrium path to peaceful denuclearization helps solve the North Korean and future nuclear issues.

The methods for peaceful denuclearization are discussed on the assumption that the weaker side is the soft security type and makes rational decisions. The weaker side will take a harder stance, even to the point of war, if it is the hard security type and has strong backing from its allies. If the theoretical models are analyzed in more detail, the possibility of the hard security type needs to be included to construct the perfect Bayesian equilibrium points to draw the path to peaceful denuclearization.

In addition, if any method to decrease the effect of nuclear deterrence is developed, this denuclearization strategy should be radically modified because its effect is based on my models. However, no invention can yet nullify nuclear deterrence. Neither National Missile Defense nor Terminal High Altitude Area Defense has yet been put to practical use. Nuclear denuclearization needs to be based on the premise of nuclear deterrence.

If a new nuclear issue arises in the future, it will be an unequal military and/or nuclear rivalry, and the primary objective of the international community will be peaceful denuclearization in accordance with the terms of the NPT and IAEA additional protocol. This study can be a basis of research on various forms of unequal nuclear rivalry and can offer some ideas on how to solve this issue.

An unequal nuclear rivalry makes it more difficult to solve nuclear disarmament and stabilize nuclear deterrence than equal rivalry. A weak nuclear power who is in conflict with a strong

nuclear power has a much stronger incentive to maintain nuclear deterrence than a non-nuclear power protected by the nuclear umbrella. Many states have tried to develop nuclear weapons; the main reason for this has been nuclear or military threats. A weak or potential nuclear power never loses its incentive as long as the threat exists because nuclear deterrence prevents many military attacks from the stronger side. In addition, maintaining nuclear deterrence is useful in preparing for future threats and is an incentive for denying denuclearization, even if the conflict with the stronger nuclear power is resolved.[1] If other methods to achieve peaceful denuclearization are to be created, nuclear deterrence must be nullified. Such a task is considerably more difficult than stabilizing mutual nuclear deterrence. This study is based solely on the premise of nuclear deterrence; research beyond this framework will be the subject of a future work. Extinction of nuclear deterrence is a necessary condition to completely free the world from nuclear threat.

Both the assurance not to be attacked after denuclearization and the coercive power not to allow the final decision to be postponed are necessary in denuclearization negotiations. The stronger side's military power and sanctions are useful in making the weaker side relinquish nuclear weapons. However, the weaker side must be left with the hope that it can resolve the issue peacefully if it compromises first. The stronger side must establish the game situation but must never move first. The most difficult task of the stronger side is building trust and not defecting in the second move after denuclearization of the weaker side.

Interactions among allies, public opinion, and international organizations are also important for trust building. The IAEA specifically has a unique role in unequal nuclear rivalries. However, public opinion has positive and negative effects on nuclear disarmament issues. It is difficult for the Japanese government to cooperate with US denuclearization in the Korean peninsula if the public opinion disagrees on US policy,[2] even though Japanese cooperation is one of the necessary conditions to make North Korea move first. The more that exogenous variables cooperate with the US, the greater the likelihood of getting North Korea to make the first move.

As long as a nuclear power has no incentive to demand denuclearization from a non-hostile nuclear power, the first offer of peace inevitably leads to a peaceful resolution without denuclearization. Establishing the second mover advantage is a key factor for denuclearization.

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[1] In surveys on nuclear issues in 2022, 25.5% of Americans agreed that "[t]o prepare for future threats" is an appropriate reason to possess nuclear weapons, but only 11% of Japanese people agreed (Shibai 2022).

[2] According to surveys on nuclear issues, 21.6% of Japanese people think that Japan contributes and 48.4% of Americans think the US contributes to nuclear disarmament. However, only 7.4% of Japanese people think that the US contributes to nuclear disarmament, and 10% of Americans think Japan contributes to nuclear disarmament (Shibai 2022).

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