

Collaborative Strategy Game Between ROK and USA as Means for Denuclearization in DPRK by Seung Hyun Steven Kwon

Abstract: This paper is a continuation on Dr. Zuyu Ye and Dr. Jun Zhuang's work, "*Denuclearization or Not? A Multiple-Player Sequential Game Model*", in which a "*multi-attribute (politics, economy, military) utility model*" is used for each player to determine a sequence of decisions between the strategic players South Korea, United States, Japan, Russia, China and North Korea. An essential component of the result was that North Korea chooses to denuclearize. In this project, we consider a collaboration subgame between allies South Korea and the United States that could in fact, incentivize North Korea to denuclearize. We will contextualize conflicting interests between the two allies, namely military spending, as well as see how their joint efforts could apply pressure on North Korea without entirely isolating them.

1. Introduction

The alliance between the Republic of Korea (ROK) and the United States (USA) has existed since the Korean War (1950-1953). As allies joining forces to denuclearize the Democratic People's Republic of Korea (DPRK), their joint efforts across all fronts are essential. The objective in this paper is to find a *strategic collaboration between ROK and USA to make denuclearization a more viable option for DPRK*. We first provide some context to their alliance as well as conflicting interests.

The US-ROK Mutual Defense Treaty enacted in 1953 provides a partnership as the US supplies troops to defend against DPRK in exchange for promoting its interests in the East Asia region. As of April 2020, approximately 28,500 US troops are spread out across South Korea in addition to provisions of advanced military technology and joint training. Currently, the US is ROK's 2nd largest economic partner while ROK is US's 7th. Regardless, some notable tensions and problems have come about between the two nations.

The Special Measures Agreement (SMA) negotiations, which began in the 1980s, requests that ROK steadily pay a bigger portion for stationing US troops in South Korea as the nation industrializes. Fast forward to the modern day and ROK has become a major economic presence. The US government has expressed skepticism in supplying troops implying that South Korea does not pay their fair share for deploying US troops. While former President Trump's demands to increase ROK's payments twofold is an extreme measure, a new administration is still likely to prefer increasing payments (Chungku Kang, James Kim, Yumi Ko, Scott A. Snyder, Ellen Swicord, 2019). We want to research whether *it is in the US's interest to have ROK pay more each year (the amount of increase is a point of contention) and if it is ROK's best interest is to keep the current incrementally increasing payments*. To do this, we will take a look at defense spending data for both nations as well as opinions of experts on matter of nuclear security.

We also want to consider whether US should keep troops deployed, regardless of payment conflicts (e.g., promoting interests in East Asia, urgency of DPRK nuclear crisis upon US, maintaining it military powerhouse presence in the world) and assess if it outweighs the *preference* for increased payment. Having US troops is obviously beneficial for ROK with access to more advanced technology as well as sheer military power in fending off DPRK threats. The large increase in payment for the troops is not in their best interest, however. What is the threshold for payment? On the other hand, if US troops were to withdraw, could they fend off

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a potential DPRK attack? Korea's military is in fact very advanced and they have the tools to manufacture their own nuclear arsenal if need be in a matter of few months.

It is also important to consider what factors that DPRK sees as a threat in the ROK/USA alliance. North Korea has seen USA's provision of advanced military technology to ROK and the joint training efforts between the USA and ROK military as reason to develop their own nuclear arsenal. Additionally, the sanctions placed upon them by both the USA and ROK governments has left them expressing no other option. Would adhering to both these demands lead to denuclearization?

These are the various decisions we will use to build our strategic game.

2. Model

The format of our model is a dynamic two player game between USA and ROK, with a series of decisions made in the following order: USA → ROK → USA → ROK. We will determine the preference of all outcomes (ending nodes) for both players. We then apply linear utility functions to their respective preference relations and determine payoffs.

The first decision for the United States is:

1. Should USA keep its troops in ROK region?

Following that decision is ROK's next decision 2a (if USA keeps troops in region) and 2b (if USA reduces troops in region). Note: the decision tree, if goes to 2b will end after 2b.

- 2. a. Should ROK pay a higher contribution for US troops or pay its current rate?*
- b. Should ROK develop their own nuclear weapons as defense? (ending decision on this side of decision tree)*

Regardless of the decision for 2a., the next decision for USA is:

3. Should USA arm ROK with weapons (ex. Anti-missile system in Camp Humphreys)?

The last decision then is whether ROK should sanction DPRK:

4. Should ROK keep sanctioning DPRK?

At the end, we will consider each string of decisions and their utilities to determine the best collaboration strategy between USA and ROK. The extensive form decision tree is shown in Figure 1 on the next page. Note that O_1 represents the current situation where USA is keeping soldiers deployed, ROK is paying the agreed amount from the special measures agreement, USA is arming ROK with an anti-missile defense system and ROK is sanctioning North Korea. The payoffs for this outcome will be 0 for both as it is the current scenario.

In the sections 3 and 4, we will gather the necessary information to determine the outcomes preferences for each player and then calculate the payoffs.

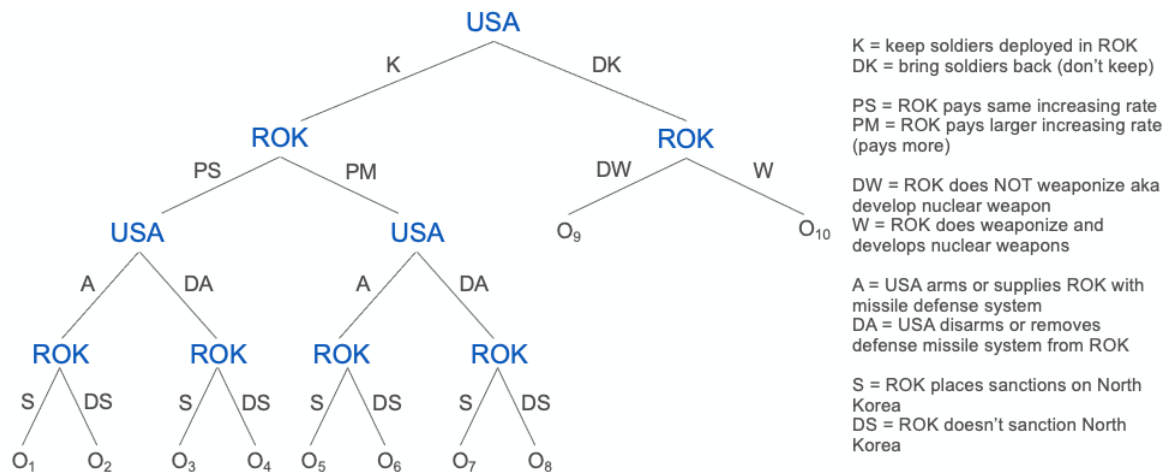


Figure 1: Decision Tree Model for USA/ROK alliance game. The ending nodes, $O_1, O_2 \dots O_{10}$, represent all outcomes and paths for our dynamic game.

3. Gathering Data for Decision Preferences

3.1 Should USA keep troops deployed in ROK region?

We first analyze the initial decision node of USA to keep (*K*) or not keep (*DK for don't keep*) soldiers deployed in the ROK region. Robert E. Kelly is an International Relations professor in *Pusan International University* in South Korea. As a consultant and expert on Northeast Asian affairs, Dr. Kelly underscores key reasons why it's in the US's best interest to keep troops stationed in ROK region. Historically, South Korea has been a reliable ally making payments as promised in addition to supplying the US with their own armed forces in foreign conflicts. South Korea isn't "abusing a patron's goodwill to pursue parochial interests that entrap the US in unnecessary conflicts. U.S. clients in the Middle East – Saudi Arabia, Israel, Egypt, Turkey – have long done this, in contrast to docile South Korea". Additionally, the long-term rise of Asian economies is of global importance. As "wealth and growth flow to Asia", it is beneficial for the US to maintain its historically stable relationship with ROK for economic and trade related benefits. (Robert E Kelly, 2019).

Michael E. O'Hanlon is a director of Research in Foreign Policy at the Brookings Institution and a specialized expert on U.S. defense strategy. In an article in the *Brookings* titled "Is the US Defense Spending too High, too Low, or Just Right?", O'Hanlon highlights that one of the reasons for the US defense budget being so large is, as outlined in the 2018 National Defense Strategy, to "maintain a strong nuclear deterrent; protect the homeland from attack by missiles, aircraft, terrorists, and others... and deter North Korea while doing so; and sustain momentum in the "war on terror" (Michael E. O'Hanlon, 2019). North Korean nuclear deterrent is a major objective for US Defense strategy and therefore, it makes sense to keep US troops deployed in the Korean peninsula. US defense as percentage of GDP is historically lower at 3% when compared to the 1960s to the last decade where it declined from 8-9% to 4.5%.

The Asan Institute for Policy Studies is a research institute in South Korea devoting research in matters pertaining to national security and foreign policy. In February 2019, Asan published an

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article “*South Korean Attitudes Toward the U.S.-ROK Alliance*” where they surveyed people of various ages about their sentiments towards US forces in Korea. The survey showed “*strong support across every cohort within Korean society for USFK as a reliable partner in assuring South Korean security*”. The survey revealed that 62.5 percent of South Koreans “*view USFK as trustworthy*” (Chungku Kang, James Kim, Yumi Ko, Scott A. Snyder, Ellen Swicord, 2019). South Korea’s general sentiment towards US troop presence is one of support.

Ultimately, it is in both players’ interests to keep soldiers in ROK region. While the US would prefer to be receive larger incremental payments from Seoul, the repercussions of withdrawing troops outweighs the cost of not receiving larger payments along with the fact that ROK is already contributing increasing payments each year. Hence $K > DK$ for both players.

3.2 Should ROK pay more for the deployment of US soldiers in its peninsula?

We want to assess if increase in annual payments from ROK has an effect on the players. *Stockholm International Peace Research Institute* is a research institute that provides defense spending data for various nations. You can find the site link to the data in the appendix. We use Python to display line plots for annual USA military spending amounts (for years 2012-2019) along with spending as a percentage of government spending (see Figure 2). We observe a sharp decrease from 2012-2015, gradual decrease from 2015-2017 and then a significant increase in spending from 2017 onwards. We contrast it to its percentage of total government spending which decreased significantly from 2012 and has floated little under 9.5% for the last three years. Due to annual military costs trended upwards in recent years, USA would prefer to be paid more if ROK offers to $\rightarrow PM > PS$ for USA.

USA DEFENSE SPENDING

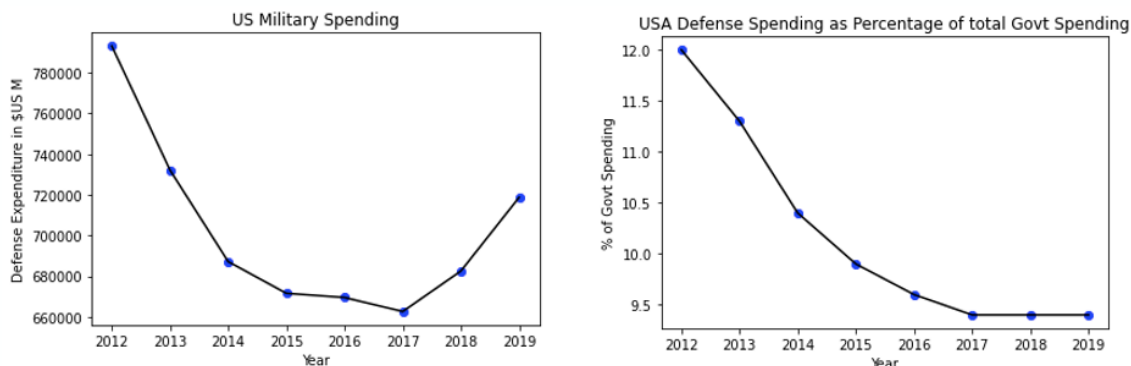


Figure 2: USA annual defense spending in millions of dollars and as percentage of total government expenditure from 2012 to 2019. Link to python code is provided in references.

We then evaluate the defense spending data for ROK. There is a steady annual increase in payments as shown in the left table in Figure 3. This makes sense since they agreed to the Special Measures Agreement and in general are supportive of US military presence. As a percentage of total government spending, the percentage has floated between 12 and 13% for the last 15 years. Understandably, ROK would prefer to stick to the current payment plan and have the US troops remain. Recently this year, current South Korean president offered a 5-year increased payment plan as response to former President Trump’s demand. Trump rejected the

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offer, and an agreement was not made. While ROK prefers the current cost burden, they are willing to negotiate and pay marginally higher. We will consider this option in the section 6. For now, we set ROK's preference to $PS > PM$.

ROK DEFENSE SPENDING

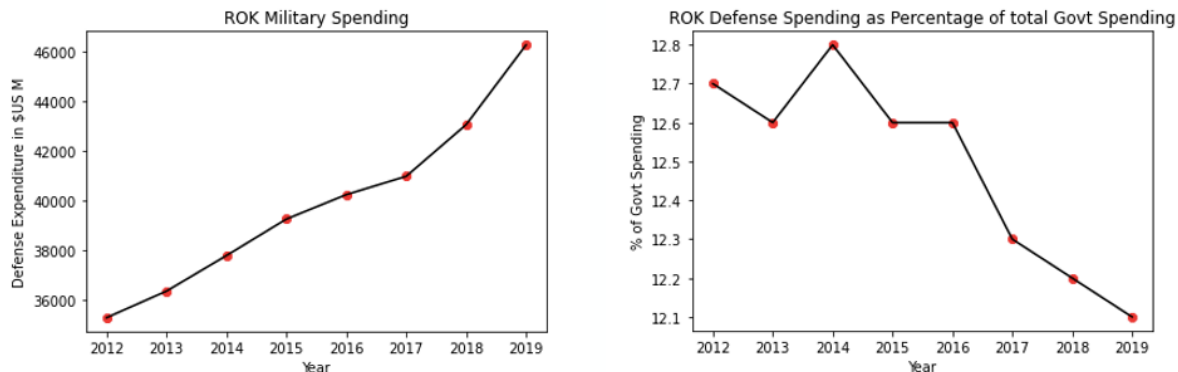


Figure 3: ROK annual defense spending in millions of dollars and as percentage of total government expenditure from 2012 to 2019. Link to python code is provided in references.

3.3 Should USA arm ROK with an anti-missile defense system?

We now look at whether USA should supply ROK with the anti-missile defense system to combat any incoming threats. To reiterate, the objective is to reach a chain of decisions that could potentially lead to North Korea denuclearization. From their perspective, US's provision of weapons can be viewed as a major threat. The epitome of advanced military provision is in fact the anti-missile defense system placed in Camp Humphreys, a US base about forty miles south of Seoul. We also want to consider whether North Korea would denuclearize in the case that the US were to halt provision of military weapons.

Colonel Scott W. Mueller is a US garrison commander at Camp Humphreys. Regarding the location of the base as a warfare strategy, he says, *"Down here we're a little bit further from the action, and that helps buy us some strategic decision space should anything happen ... We've been able to create the facilities needed to keep up with the pace of modern warfare and modern communications technology."* (Anna Fifield, 2017) This sentiment along with the National Defense Strategy's mission to *"maintain a strong nuclear deterrent"* (Michael E. O'Hanlon, 2019) implies the belief that strong military arms provision is a necessary step in North Korea denuclearization. There is little evidence to suggest that the USA is inclined to disarm Korean armies as a strategy to deter North Korean threat.

ROK and USA are in agreement on this matter as the missile defense decision was deemed by both parties as necessary strategies in the rise of nuclear tests by North Korea. This is outlined in the United States Forces Korea official page.

As a result, the preference is $A > DA$ for both parties.

3.4 Should ROK sanction North Korea? (30 min)

In terms of maintaining peace in the Korean peninsula, sanctions are a big topic as to whether

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North Korea could consider denuclearization. Kim Song, the UN ambassador for North Korea mentioned in a summit that for denuclearization to be on table “*punishing sanctions*” must be relieved (Michelle Nichols and David Brunnstrom 2019).

In this section, we consider whether ROK should sanction North Korea. A peace treaty between the two nations would not occur if ROK were not to even consider lifting sanctions. Additionally, current president Moon Jae In has often times expressed his hope for Korean Reunification and improving inter-Korea relations. In the wake of COVID, the Moon administration has expressed opportunity in assisting North Korea and to “*open the door to inter-Korean relations by transferring its quarantine system... to the North.*” (Sean Lee, 2020). Earlier this year the president even hinted at lifting sanctions: “*If exceptions from U.N. sanctions are necessary for South-North cooperation, I think we can make efforts for that...I think there is a heightened need for South and North Korea to dial up their cooperation a little bit and promote North Korean-U.S. talks*” (Hyung-Jin Kim, 2020).

While the preference for sanctioning is tough to decide, lifting sanctions could be a viable option for ROK in working towards inter-Korea relations if prior decisions were to work in their favor. That is, US keeps forces deployed and continues to arm ROK with the anti-missile defense system. The rationale is to maintain a formidable armed force to have an upper hand and explore further peace dialogue as North Korea is unlikely to denuclearize if US were to withdraw its presence from South Korea. Hence the decision to sanction depends on the prior decisions.

From US’s perspective, it seems the preference is to keep placing sanctions on North Korea to maintain a dominant force. In the exchange of intense rhetoric between former President Trump and North Korea Leader Kim Jung Eun, it is unlikely as of now for USA to prefer lifting sanctions. It would therefore desire ROK to sanction: $S > DS$ for USA.

3.5 Should ROK develop their own nuclear weapons in chance of USA troop withdrawal?

We look at this decision if USA withdraws troops altogether from the ROK (DK). Historically, ROK has desired some form of security whether in trying to develop their own nuclear weapons or having US supply some of their own in the region. Studies conducted by South Korean historians in the 1970s hinted that then Korean president Park Chung Hee was “*motivated to pursue a nuclear bomb capability due to fear of US abandonment*” (Toby Dalton and Ain Han, 2019). With nonproliferation agreements being important, US would not want to sever ties with ROK which could lead to ROK weapons development. While North Korea could see US presence in the ROK as a threat, who’s to say ROK’s independent development of weapons wouldn’t be if US troops were to leave. Therefore, we infer that both players prefer that ROK doesn’t develop their own nuclear weapons: $DW > W$ for both players.

4. Establishing Outcome Preferences (30 min)

4.1 USA Outcome Preferences

Now that we’ve established preference relations for the individual decisions, we want to establish the preference relations of all outcomes. We will not explicate every single preference but will review some to give a general idea. We first denote X as the set of all outcomes (or ending nodes).

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$$X = \{O_1, O_2, O_3, O_4, O_5, O_6, O_7, O_8, O_9, O_{10}\}$$

$$\rightarrow X = \{(K, PS, A, S), (K, PS, A, DS), (K, PS, DA, S), (K, PS, DA, DS), (K, PM, A, S), (K, PM, A, DS), (K, PM, DA, S), (K, PM, DA, DS), (DK, DW), (DK, W)\}$$

The preference relation ordering for USA is the following:

$$\text{USA's preferences} = \{O_{10} < O_4 < O_9 < O_3 < O_2 < O_8 < O_1 < O_7 < O_6 < O_5\}$$

Outcome 10 is the least preferred in the context of North Korea denuclearization due to the fact that the US would not want ROK to nuclearize due to nonproliferation agreements. It would create tension on the Korean peninsula and possibly make matters worse. The US also prefers to keep troops deployed in ROK as outlined in the previous section. Outcome 4 is also bad for the US because it would require disarming South Korea with the anti-missile defense system as well as Korea deciding not to sanction North Korea which leaves ROK vulnerable to threat. As we can see, a major component for outcomes with higher preference is that ROK decides to increase its payment for US troops. The best possible outcome is Outcome 5 where USA keeps troops \rightarrow ROK pays more \rightarrow USA arms ROK \rightarrow ROK sanctions North Korea.

4.2 ROK Outcome Preferences

We also have a set of outcome preferences for ROK.

$$\text{ROK's preferences} = \{O_{10} < O_9 < O_8 < O_4 < O_7 < O_3 < O_5 < O_1 < O_6 < O_2\}$$

Similar to US's set, Outcome 10 is the worst scenario due to the fact that they prefer to have US troops in the region for security and would not prefer to develop their own nuclear weapons. The preference to sanction or not depends on the prior USA decision to arm ROK with the anti-missile defense system. If ROK is armed, then they are in a place to continue further peace talks and possibly lift sanctions. If they are not armed, they would want to keep sanctioning to maintain some legitimate threat. The outcomes with highest preferences tend to involve ROK choosing to pay the same cost burden they are currently paying (opposite to US). The best possible outcome then is outcome 2 where USA keeps troops \rightarrow ROK pays same cost burden \rightarrow USA arms ROK \rightarrow ROK lifts sanctions on North Korea.

We will explore the possibility of ROK possibly agreeing to pay more under peaceful negotiations.

5. Utility Functions (45 min)

We now discuss the utility functions for each of the players. We reiterate that outcome 1 is the current scenario where USA keeps troops \rightarrow ROK pays same cost burden \rightarrow USA arms ROK \rightarrow ROK sanctions North Korea. We will base our utility functions so that the payoff for outcome 1 is 0 for both players.

We also note that for both players, outcome 1 (current scenario) is very high on their respective set of preferences. While I considered using a risk averse utility function like a logarithmic one, I

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decided to use a linear function with a small slope as the payoffs would be easier to differentiate. Since there are only approximately 2 or 3 outcomes better than the O_1 for both players, having a utility that is 1 or 1.5 more is not extreme.

5.1 USA Utility Function

We first assign number 1-10 to the outcome preferences we obtained for USA in the previous section.

$$\begin{aligned} \{O_{10} < O_4 < O_9 < O_3 < O_2 < O_8 < O_1 < O_7 < O_6 < O_5\} \\ \rightarrow \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\} \end{aligned}$$

Where $O_{10} \rightarrow 1, \dots O_5 \rightarrow 10$.

We then apply a linear utility function $U_{USA}(x) = \frac{1}{2}x - \frac{7}{2}$. By applying this function, we obtain utility of 0 for O_1 which we have assigned a preference number of 7. All outcomes less preferred will hence be < 0 and all more preferred outcomes will be > 0 . We then obtain the respective utilities:

$$\begin{aligned} \{O_{10} < O_4 < O_9 < O_3 < O_2 < O_8 < O_1 < O_7 < O_6 < O_5\} \\ \rightarrow \{-3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5\} \end{aligned}$$

Where $U(O_{10}) = -3, \dots U(O_5) = 1.5$

5.2 ROK Utility Function

Likewise, we assign numbers 1-10 to each of the outcome preference for ROK.

$$\begin{aligned} \{O_{10} < O_9 < O_8 < O_4 < O_7 < O_3 < O_5 < O_1 < O_6 < O_2\} \\ \rightarrow \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\} \end{aligned}$$

Where $O_{10} \rightarrow 1, \dots O_2 \rightarrow 10$.

We then apply a linear utility function $U_{ROK}(x) = \frac{1}{2}x - 4$. By applying this function, we obtain utility of 0 for O_1 which we have assigned a preference number of 8. All outcomes less preferred will hence be < 0 and all more preferred outcomes will be > 0 .

$$\begin{aligned} \{O_{10} < O_9 < O_8 < O_4 < O_7 < O_3 < O_5 < O_1 < O_6 < O_2\} \\ \rightarrow \{-3.5, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1\} \end{aligned}$$

Where $U(O_{10}) = -3.5, \dots U(O_2) = 1$.

5.3 Updated Model with Payoff Values

Now that we have our payoff values, we can add them to our decision tree as shown in Figure 4. We can see that O_{10} is the worst scenario and O_5 and O_2 are the best scenarios for USA and ROK respectively.

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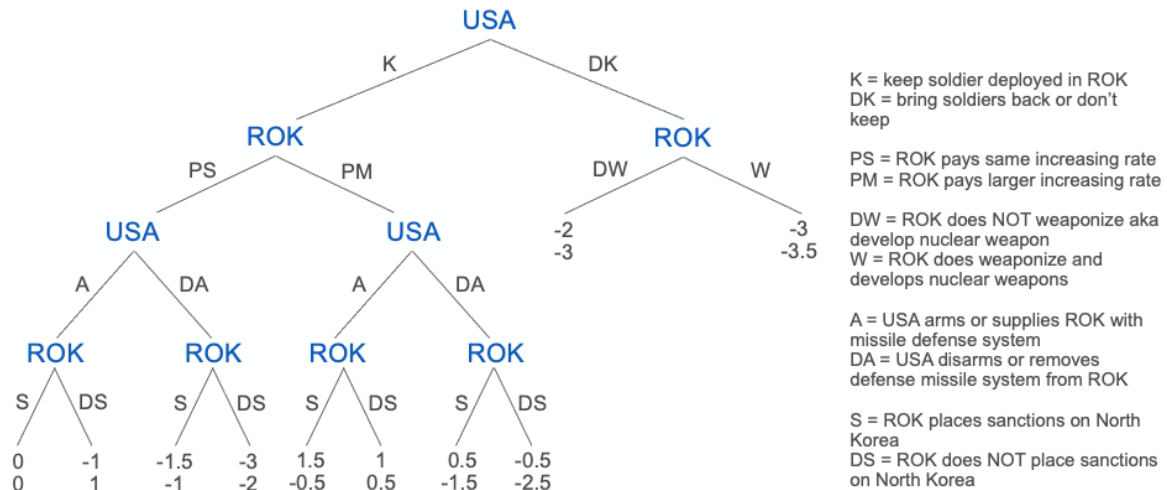


Figure 4: Updated dynamic decision tree with newly obtain payoff values for each player.

6. Results and Analysis

6.1 Utilizing Computer Program to Solve Model

To save time for larger dynamic games, we built a program in Python that asks for possible equilibrium paths and payoffs from the user and outputs the subgame Perfect Nash Equilibrium.

Figure 5 shows the output after entering in the paths and payoffs of our game.

```

Here are your paths: [['K', 'PS', 'A', 'S'], ['K', 'PS', 'A', 'DS'], ['K', 'PS', 'DA', 'S'],
['K', 'PS', 'DA', 'DS'], ['K', 'PM', 'A', 'S'], ['K', 'PM', 'A', 'DS'], ['K', 'PM', 'DA',
'S'], ['K', 'PM', 'DA', 'DS'], ['DK', 'DW'], ['DK', 'W']]
What is the payoff for player 1 for path 1?0
What is the payoff for player 2 for path 1?0
What is the payoff for player 1 for path 2?-1
What is the payoff for player 2 for path 2?1
What is the payoff for player 1 for path 3?-1.5
What is the payoff for player 2 for path 3?-1
What is the payoff for player 1 for path 4?-3
What is the payoff for player 2 for path 4?-2
What is the payoff for player 1 for path 5?1.5
What is the payoff for player 2 for path 5?-0.5
What is the payoff for player 1 for path 6?1
What is the payoff for player 2 for path 6?0.5
What is the payoff for player 1 for path 7?0.5
What is the payoff for player 2 for path 7?-1.5
What is the payoff for player 1 for path 8?-0.5
What is the payoff for player 2 for path 8?-2.5
What is the payoff for player 1 for path 9?-2
What is the payoff for player 2 for path 9?-3
What is the payoff for player 1 for path 10?-3
What is the payoff for player 2 for path 10?-3.5
Your subgame Nash Equilibrium path is ['K', 'PS', 'A', 'DS'] with payoffs -1.0 1.0 for P1 a
nd P2 respectively.
  
```

Figure 5: After asking for input data from user (potential equilibrium paths and payoffs), the SPNE will displayed to the user as shown in the last line.

The program built in Python will ask for number of outcomes and number of decisions for each outcome. After inputting each decision, it will create a list of possible equilibrium paths. You then enter the respective payoffs for each player and the SPNE will displayed to the user as shown in the last line. Check the GitHub link in references if you would like to see the Python program in depth.

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The program tells us that the path associated with (K, PS, A, DS) is our subgame perfect Nash Equilibrium. We now delve into how this is solved through backward induction.

6.2 Results

We can now solve the problem and find the subgame Perfect Nash Equilibrium for this dynamic game by using backward induction. We start at the bottom nodes where ROK decides to sanction or not sanction North Korea as shown in Figure 6. ROK will look at the highest payoff for each scenario.

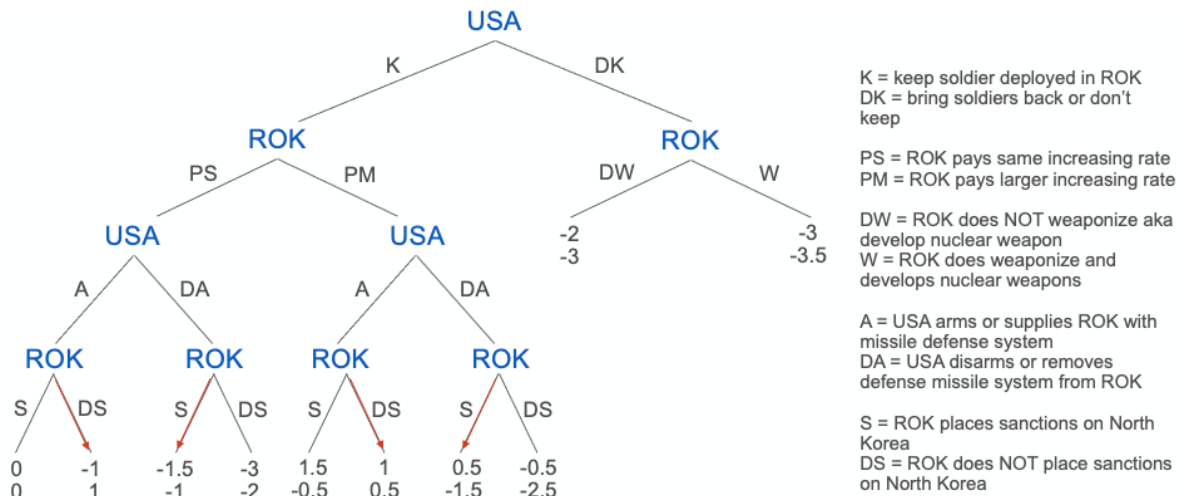
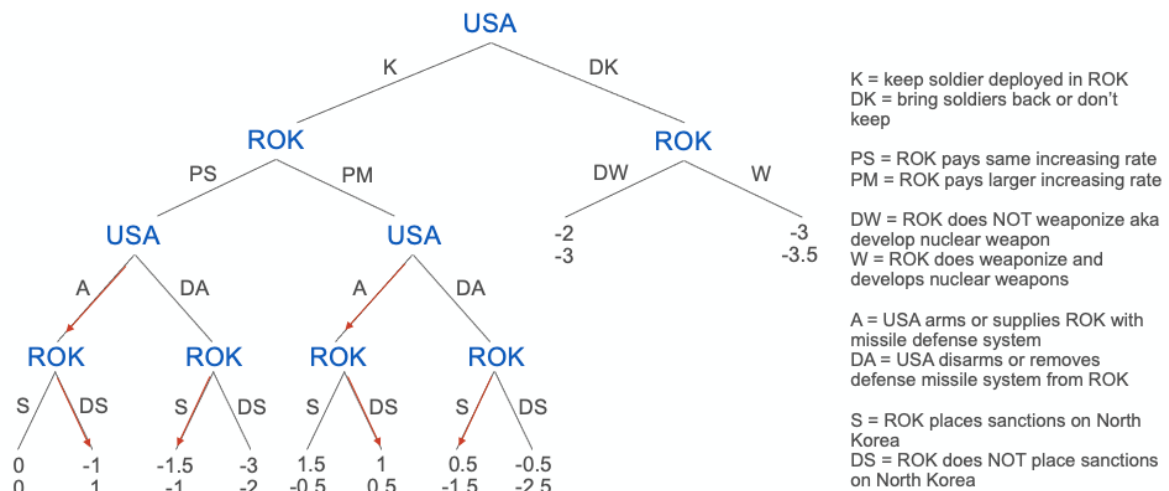


Figure 6: Results of first stage of the backward induction.

We see that ROK's preference to sanction or not sanction North Korea depends on whether USA decides to arm or disarm ROK with the anti-missile defense system. In the case of A , ROK will choose DS . In the case of DA , ROK will choose S .

Next, we look at the second stage of the backward induction where, based off the given results from stage 1, USA chooses A or DA that will provide maximum payoff as shown in Figure 7.



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Figure 7: Results of the second stage of backward induction.

The subgames where USA must choose to arm or disarm ROK is shown here. Note that USA chooses to arm in both cases.

Next we look at the subgame where ROK must determine maximum payoff at nodes 2. If USA keeps troops deployed, should ROK pay the same cost burdens or pay more of the cost burdens? If USA were to withdraw troops, does ROK have a higher payoff if they choose to weaponize their own nuclear arsenal or not. Figure 8 shows the decision based on the current path determined from previous stages.

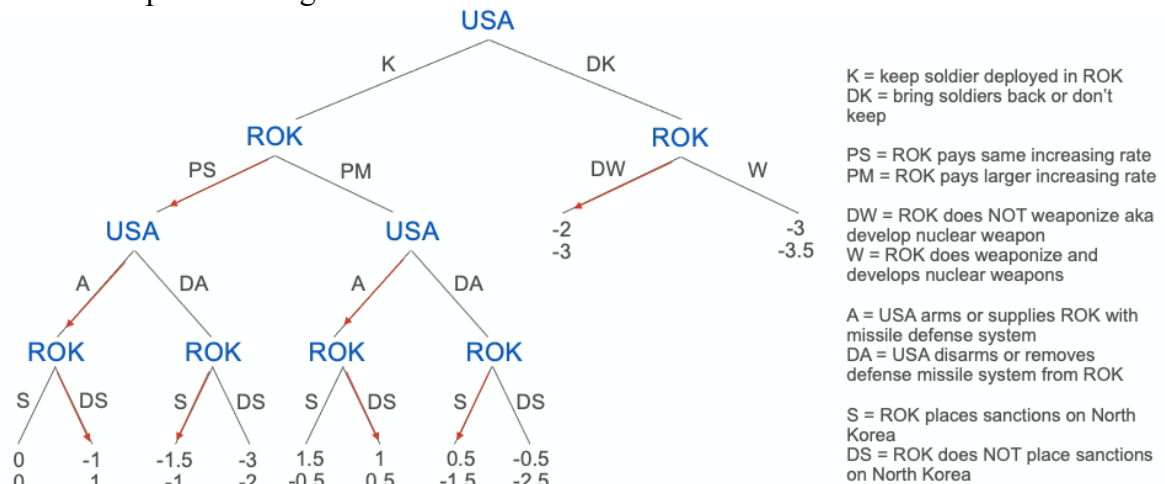
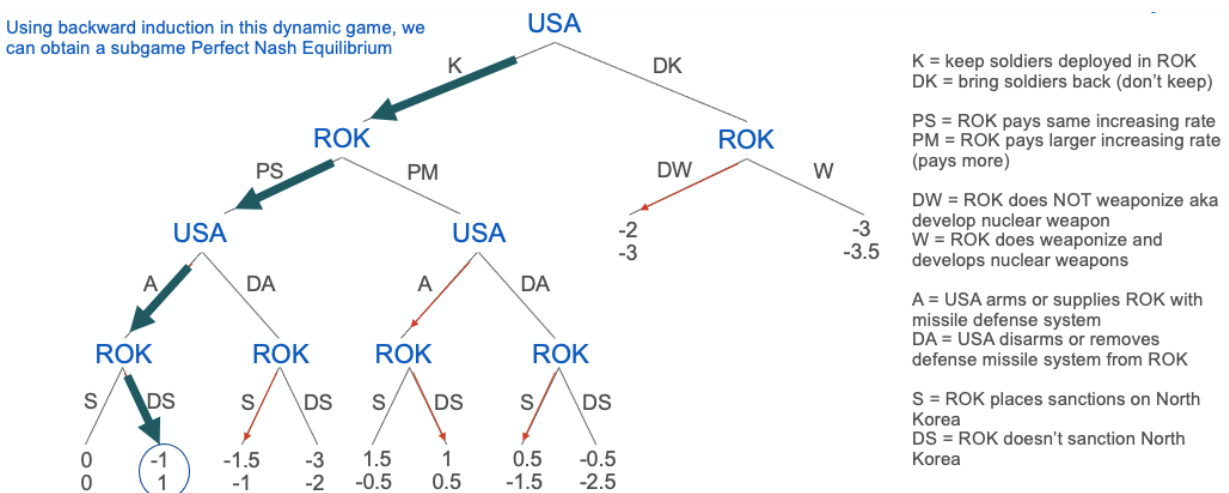


Figure 8: Results of the third stage of backward induction.

If USA were to keep troops deployed, ROK obtains highest payoff if they choose to pay the same cost burdens they've been paying. If US were to withdraw, ROK obtains the highest payoff by not weaponizing.

Finally, we look at the final subgame where USA chooses maximum payoff by choosing between keeping and withdrawing US forces. The results are shown in Figure 9.



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Figure 9: Final results of backward induction. The subgame Perfect Nash Equilibrium is therefore: USA keeps troops → ROK pays the same cost burdens → USA arms ROK with anti-missile defense system → ROK does not sanction North Korea.

Therefore, the subgame Nash equilibrium path is the following path (K, PS, A, DS) .

6.3 Analysis and What if

We observe that ROK obtains all their preferences in this dynamic game. Moving after USA gives them a big advantage in thinking considering their strategies. Additionally, in a game where optimal decisions aren't far off from the current scenario of O_1 , most decisions are already in ROK's favor. USA is currently keeping soldiers deployed in South Korea and USA is arming ROK and they aren't likely to deter from those decisions. The only decisions in contention are whether ROK agrees to a larger cost burden payment and whether they sanction North Korea, both of which are ROK's to make.

It is worth noting that the current path is not ideal for the US. We observe that O_6 is only one preference tier lower for ROK from the current equilibrium path. Additionally, O_6 is four preference tiers better for USA. The only difference between the two decisions is that ROK would choose (PM) and agree to higher cost burden. While not preferable, ROK has suggested higher payment negotiations when former president Trump had been drilling the administration to pay more. It seems ROK is willing to negotiate if given understandable demands. The suggestion then is to consider if $O_6 \succcurlyeq O_2 \Rightarrow U(O_6) = U(O_2) = 1$. Hence our new subgame Perfect Nash Equilibrium could be as shown in Figure 10.

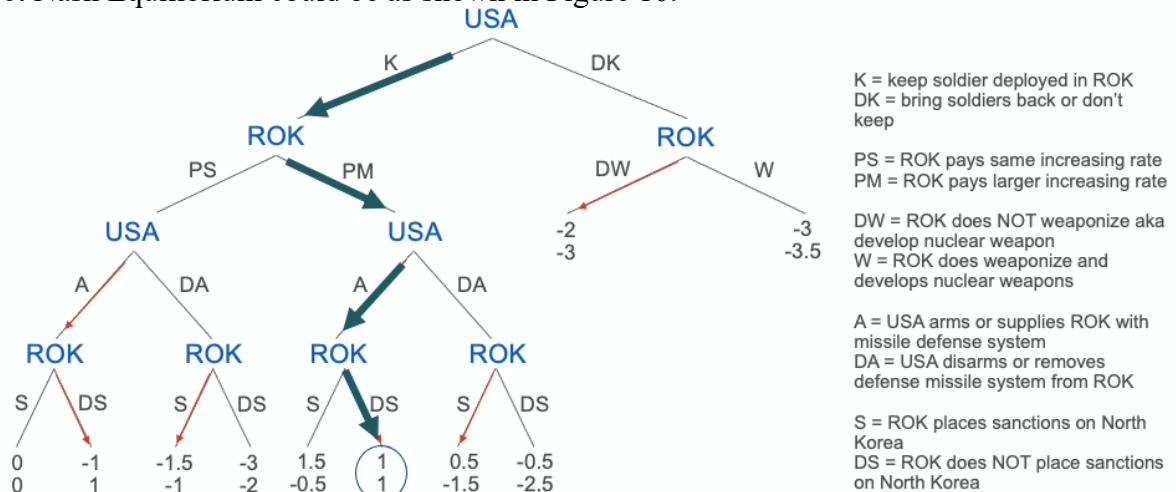


Figure 10: Editing of preferences where ROK is okay with paying a higher cost burden. While there are two subgame Perfect Nash Equilibrium, we see one outcome is clearly better for the US, O_6 : USA keeps troops → ROK pays higher cost burdens → USA arms ROK with anti-missile defense system → ROK does not sanction North Korea.

While there might be two equilibrium paths in Figure 9, if ROK obtains the same payoff from O_2 and O_6 , there is no reason to not choose the path that benefits the US more. As allies in combatting North Korean threats, it would make sense for ROK to consider O_6 to maintain the relatively good relations it has with the United States.

7. Conclusion

In this dynamic game model, we researched the preferences of a set of decisions that impact both the US and ROK. We devoted considerable research into whether it is in the United States best interests to keep US soldiers deployed in ROK regardless of higher ROK cost burdening payments. We established that because of the long-term rise of East Asian economies and the half century long relationship that it would serve the US well to deploy its troops.

We analyzed defense spending data and observed rising costs for both nations and hence their conflicting interest in payment contribution. Due to their relationship being vital, both parties seem to be willing to negotiate, which lead us to the potential modified equilibrium path in section 6.

We also utilized expert opinions and surveys to determine preference relations for supplying of weapons and the matter of sanctions. Overall, the strategic outlook across both nations is to establish a formidable defense system and then perhaps make steps towards inter-Korea peace talks and even have ROK offer lifting sanctions if matters play out right.

8. Future Research Directions

Provided below are some suggestions to further research directions.

8.1 In Depth Study of ROK's Preference for Cost Burden Payments

As we saw in section 6, a good outcome for both players could be if the utility of paying more for US troops was at least as good as paying the current cost burden. The current Moon Administration in ROK is willing to negotiate conditions of payment it seems. This could be done through a thorough defense budget analysis for ROK and as well as considering the benefits that could come about (utility) that could come about if they were to agree to higher cost burdens.

8.2 Subgame including Japan or China

Considering South Korea and Japan's long history of ill-will towards each other, how could the US mediate the centuries worth of tension to work together in combatting the nuclear threats? Could they ease up pricing wars and trade conflicts with each other and establish a stable partnership?

Given Korea's economic relationship with China, what are the next steps towards North Korean denuclearization given China's and North Korea's past relationship? What is in China's interests as the nuclear conflict rages on?

8.3 Sanctioning Game

Some experts believe that sanctions aren't effective solutions to nuclear determent. What decisions should we consider in deciding whether or not to place sanctions on North Korea? Should all U.N. nations reach a consensus, or should each consider the issue on their own terms? Is there a clear step by step procedure after sanctions are lifted?

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Defense Spending Data

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10. Appendix

<i>Decision notations</i>	<i>Decision</i>
K	US keeps its soldiers deployed in ROK
DK	US doesn't keep its troops deployed in ROK
PS	ROK pays same incremental cost burden for troop deployment
PM	ROK pays more, a larger incremental cost burden for troop deployment
DW	ROK doesn't weaponize (nuclearize)
W	ROK weaponizes and develops own nuclear weapons
A	US arms ROK with the anti-missile defense system
DA	US doesn't arm ROK with anti-missile defense system
S	ROK sanctions North Korea
DS	ROK doesn't sanction North Korea

<i>Outcomes</i>	<i>Outcome Decision Chain</i>
O_1	(K, PS, A, S)
O_2	(K, PS, A, DS)
O_3	(K, PS, DA, S)
O_4	(K, PS, DA, DS)
O_5	(K, PM, A, S)
O_6	(K, PM, A, DS)
O_7	(K, PM, DA, S)
O_8	(K, PM, DA, DS)
O_9	(DK, DW)
O_{10}	(DK, W)

<i>Utility Functions</i>	<i>Meaning</i>
$U_{USA}(x) = \frac{1}{2}x - \frac{7}{2}$	Utility function for USA where x is a numerical assignment for the outcomes in order of US preference
$U_{ROK}(x) = \frac{1}{2}x - 4$	Utility function for ROK where x is a numerical assignment for the outcomes in order of ROK preference