

Game-Theoretic Analysis of the North Korean Missile Crisis

by

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A Senior Honors Project Presented to the

Honors College

East Carolina University

In Partial Fulfillment of the

Requirements for

Graduation with Honors

by

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Greenville, NC

May 2020

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## **Abstract**

This paper will provide a game-theoretic analysis of the ongoing North Korean missile crisis. It begins by discerning from the available literature the options available to each party involved in the game and determining a rank ordering (best to worst) for each party of the possible combinations of options. I will use the Theory of Moves (ToM) to predict the ultimate outcome of the crisis. This requires, in addition, the initial “state of play” when negotiations begin, and the first mover in the game, both given by the history of the crisis. ToM allows the parties strictly alternating turns to move from the initial state. At each turn to move, a player can either move (back to the previous state or ahead to another state), or pass (remain in the current state). Equilibrium is achieved when the players choose not to move on consecutive turns, i.e., accept the current state as the ultimate outcome.

The preference orderings of each player are difficult to determine with certainty, so we consider a variety of possibilities. A reading of the existing literature on the history of the crisis and the expressed interests of the countries involved suggests a set of plausible possibilities worth considering in this analysis. I use ToM to sort this set of possibilities into three subsets that each yield a different ultimate outcome. Comparisons are drawn between the predictions of the ToM and the Nash Equilibrium (NE), a popular game-theoretic approach. Thus, the analysis narrows the likely outcomes of the crisis from nine to three and indicates how the preference orderings of the two countries influence which of these three outcomes actually occurs.

## **Introduction**

In this paper, the geopolitical conflict between the United States and North Korea will be discussed from the perspective of game theory. Game theory was used in the Cold War by President John F. Kennedy, who led the U.S. through the nuclear conflict with the Soviet Union with the help of game theorists such as Nobel Prize winner Thomas Schelling (Basu, 2017). Game theory uses mathematical models and reasoning to predict the outcome of a “game” (strategic conflict) between two rational decision-makers. It allows for logical thinking about who is involved in a conflict, what their options are, and what will result from each choice made (Winkler, 2017). Kilgour and Hipel (2005, 442) provide a great description for the analysis of a strategic conflict, stating that “A strategic conflict is an interaction of two or more independent decision-makers, each of whom makes choices that together determine how the state of the conflict evolves, and each of whom has preferences over these possible states (as eventual resolutions)”. For the analysis in this paper, the United States and North Korea are independent decision-makers making policy decisions that will together determine the state of their conflict.

This conflict will be examined by implementing ToM, which is an application of game theory that simulates two parties negotiating an agreement, perhaps implicitly with moves and countermoves. The final state of the game is referred to as the ultimate outcome (UO). This application will be compared against the more traditional NE analysis to show the sequence of moves toward an agreement between these two countries. The analysis begins once each country’s policy decisions are outlined and the possible outcomes (combinations of policies by each country) are ranked in order of preference. This paper will examine three potential policy

options for each country, thus creating nine potential policy combinations, known as “states,” of the conflict.

Due to incomplete information regarding North Korea’s preferences, this model makes credible assumptions based on sources. The leader of North Korea, Kim Jong Un, is young and not much has been revealed about his desires beyond the common knowledge that he wants to maintain his family’s dictatorial regime through the development and threat of nuclear weapons (Winkler, 2017). In addition to this uncomfortable lack of familiarity with North Korea’s leader, the United States is also unaware of the status and location of most nuclear development facilities and warheads in North Korea (Sagan, 2017). Even United States preferences cannot be entirely pinned down, as President Donald Trump has made incorrect statements regarding North Korea in the past, for example claiming that North Korea would never develop a nuclear weapon able to reach the United States (Basu, 2017). To account for this incomplete information, multiple preference rankings are considered, resulting in eight games being modeled. Each game has a slightly different preference ordering, and this slight change can impact both the Nash equilibrium and the ultimate outcome from ToM.

## **Review of Literature**

This conflict between the United States and North Korea has been ongoing since the 1980s. Given this large timespan, there is a lot of literature to be found regarding negotiations, policy decisions, and actions taken by either country. To narrow my research and simultaneously provide an initial state for my models, I researched primarily scholarly articles and books that have been published since President Donald Trump took office for the United States. This decision allowed me to also focus specifically on the negotiations between one U.S. leader

(Trump) and one North Korean leader (Kim Jong Un). Aside from researching the conflict itself, literature detailing game theory and the theory of moves was also necessary for providing understanding on the perspective from which this analysis is done.

There is an abundance of scholarly articles from the U.S. perspective on this conflict. Articles regarding the past, present, and future policy decisions were most useful for this paper, as they provided historical evidence of the policies mentioned in my models. Some sources were useful in providing timestamps for policy decisions made by either country, while others, such as *The Korean Missile Crisis: Why Deterrence Is Still the Best Option*, by Dr. Scott Sagan, provided detail on specific U.S. policy options. In this article, Sagan explains how the U.S. has enacted economic sanctions and avoided any sort of military action with North Korea for the entirety of this conflict and he believes that maintaining this course of action is best for the U.S. to avoid war. Sagan further cites Cold War efforts made by President Kennedy and parallels those negotiations to current negotiations between the U.S. and North Korea. Sagan's insight on the consequences and rationale of United States policy decisions allowed me to establish a stronger preference ranking of United States policy alternatives in my models.

Although numerous sources are cited throughout this paper, *The North Korean Nuclear Weapons Crisis the Nuclear Taboo Revisited?* by Jina Kim provided perhaps the most substantial contribution to this thesis, specifically to my understanding of the North Korean perspective of the negotiations within this conflict. In her book, Dr. Kim looks back to the establishment of the Democratic People's Republic of Korea and provides deep insight into the nation's cultural ideals and beliefs. She shows how these influenced the development of the country and its negotiation habits. Kim displays timetables of all previous major negotiations North Korea has been a part of

and explains how cultural identity impacted the results of these past negotiations. A significant aspect of North Korean ideology that Dr. Kim discusses is *Juche*. Juche philosophy is a part of North Korea's cultural identity, and it consists of the belief in self-sufficiency, self-respect, and self-defense for a nation. Considering this North Korean philosophy helps bring a better understanding of decisions the nation has made in the past. The country negotiates with little regard for the benefit of other nations. Self-preservation and progression are their primary concerns. This philosophy led Dr. Kim to describe North Korean negotiation tactics with the phrase "minimal compliance" to best describe many of North Korea's past decisions. Minimal compliance means that North Korea acts in a way that is viewed as compliant to the U.N., U.S., and other nations from afar, but in reality, North Korea is still acting solely in their best interest, specifically with their nuclear development. Dr. Kim provides evidence of this with North Korea's decisions regarding IAEA inspection and the Nonproliferation Treaty. North Korea initially appeared to fully accept both the inspections and the treaty, but their later actions revealed that they were still developing their nuclear capabilities in secret, not in compliance with the NPT or the IAEA. Due to the historical presence of this tactic in North Korean negotiations, I include minimal compliance as one of the three policy options for North Korea in this paper.

## **Policy Options**

This model looks at three policy options for each country. Upon first glance at the conflict, a strong military response is something both countries have hinted at or in the case of North Korea, displayed in the form of missile tests (Revere, 2018). In this model, however, regardless of how aggressive North Korea or even some Americans appear, strong military

action is not considered by the U.S. due to the strongly undesirable consequences of an actual war.

### **United States Policy Options**

The United States' three policy alternatives are to normalize relations (NR), place economic sanctions (ES), or resort to a limited military action (MA). Normalize relations would mean that the United States would develop better communication such as opening an embassy in North Korea. Sanctions would be lifted, and international trade would be available for North Korea. This policy has never truly been put into place, but President Trump did offer hopes of normalized relations with North Korea in June of 2018 (Samuels, 2018). This was offered on the grounds that North Korea begin the route to denuclearization, however, which did not occur.

The policy option of ES would mean that the United States would continue doing what's been done throughout the majority of this conflict since the 1980s. The U.S. and U.N. have been sanctioning North Korea since the beginning of its nuclear development program. Selecting this policy option would mean the U.S. is either maintaining or worsening the sanctions applied to North Korea (Albert, 2019). These sanctions include any variety of ways that the United States can restrict financial services for North Korea, forcing them to produce for themselves or trade with a select few countries for necessities, primarily China. An example of the U.S. recently enacting this policy option was in August of 2019 when Taiwan and Hong Kong based firms were caught attempting to smuggle fuel into North Korea illegally. This resulted in the U.S. tightening sanctions on North Korea and applying sanctions to the firms responsible in Taiwan and Hong Kong (Talley, 2019).

The final option for the United States would be limited to MA. This includes the potential for a blockade, shooting down test missiles, or bombing missile launch sites. Boots on the ground or nuclear attacks are off the table for this option as they would be acts of war (Sagan, 2017). This limited MA would be in response to continued and increasingly dangerous missile testing and hostility from North Korea. Since the Korean War, the U.S. has not performed many military actions towards North Korea. Almost all actions involving the military stemmed from sending or removing troops in South Korea and pulling nuclear capabilities out of South Korea in a failed effort to denuclearize the peninsula (Kim 2014).

### **North Korea Policy Options**

The policy options for North Korea are to go nuclear (GN), minimal compliance (MC), and denuclearization (DN). Going nuclear would mean for North Korea to maintain a fully tested nuclear arsenal consisting of missiles and weapons such as IRBMs and ICBMs. This move would be with the intent of being accepted as a nation with recognized nuclear capabilities such as the U.S., Russia, China, India, and Pakistan. This policy option has been considered by North Korea since the beginning of their nuclear development program and North Korea has gone for periods with this being their chosen policy, as seen with their increasing number of missile tests over the years (Masterson, 2020).

Minimal compliance means halting nuclear development as far as the outside world is aware of and allowing outside observers like the International Atomic Energy Agency to check known nuclear sites, which slows the development of nuclear weapon capabilities. “Minimal compliance” is a phrase used by Dr. Jina Kim in her book, *The North Korean Nuclear Weapons Crisis the Nuclear Taboo Revisited*. She explains how North Korea has acted rationally and

consistently throughout this conflict. Even though North Korea has seemed to make irrational decisions, such as allowing IAEA inspections and ratifying the Nonproliferation Treaty and abruptly withdrawing from each organization, Kim argues that these actions are consistent with the strategy of MC. Under the leadership of Kim Il Sung and Kim Jong Il, North Korea consistently operated under the policy of minimal compliance, meaning that every decision made was intended to prolong the regime by slowly advancing nuclear capabilities while seeming to cooperate with the United States and United Nations. This strategy has been used significantly less by Kim Jong Un, who took leadership of the country in 2011, but he seemed to apply it in 2018 when North Korea did not fire any missile tests (Masterson, 2020) under what appeared to be good standing with the United States after the 2018 Singapore Summit (Fisher, 2018).

The third and final policy alternative for North Korea is DN. This means dismantling nuclear weapon capabilities, although scientific and research infrastructure would remain, subject to international observation, and North Korea would be allowed to develop nuclear capabilities for exclusively peaceful purposes. Although the United States along with the rest of the world strongly desires this outcome, it is highly unlikely to ever happen. In the past, North Korea has offered denuclearization in exchange for U.S. removal of troops and nuclear capabilities from South Korea, but this was actually minimal compliance, as the U.S. upheld their end of the deal, but North Korea did not (Kim, 2014).

### **Priorities and Preferences**

The United States' priorities are to reduce the threat of nuclear warfare in the world and to issue a warning to any other nations that may attempt to follow in the footsteps of North Korea. North Korea's priorities are to deter the U.S. and other international aggression, maintain

power for the ruling family and regime by strengthening nuclear capabilities, and to force other nations to take them seriously as a world power. These priorities are expressed in the preference orderings for the different states of play within the games in this model. We do not know these preferences with certainty, so we consider several variations as possibilities.

For the United States, preference rankings for each state are as follows:

<b>NR/GN: 4</b>	<b>NR/MC: 7 or 8</b>	<b>NR/DN: 9</b>
<b>ES/GN: 5 or 6</b>	<b>ES/MC: 7 or 8</b>	<b>ES/DN: 3</b>
<b>MA/GN: 5 or 6</b>	<b>MA/MC: 2</b>	<b>MA/DN: 1</b>

For North Korea, preference rankings for each state are as follows:

<b>NR/GN: 9</b>	<b>NR/MC: 7</b>	<b>NR/DN: 5</b>
<b>ES/GN: 8</b>	<b>ES/MC: 6</b>	<b>ES/DN: 4</b>
<b>MA/GN: 2 or 3</b>	<b>MA/MC: 2 or 3</b>	<b>MA/DN: 1</b>

### **Rationale for the Preference Rankings of each State**

**NR/GN:** The United States lifts sanctions and opens international trade for North Korea, North Korea establishes itself as a nuclear power in the world.

Normalize Relations/Go Nuclear is ranked as a 4 for the U.S. and a 9 for North Korea. For the U.S., this ranking is preferred over punishing a denuclearized North Korea with sanctions or military action as well as applying military action to a minimally complying North Korea. The

reasoning behind these rankings is that the U.S. does not by any means want a nuclear North Korea, but the U.S. is a rational decision-maker, and punishing North Korea for denuclearizing is irrational and illegal. The same can be said for applying military action when North Korea is in minimal compliance, it is not prudent and therefore is ranked lower than NR/GN. That being said, this is not a desirable state for the U.S., as shown by the rankings for responding to a nuclear North Korea with either sanctions or limited military action in the model. As for North Korea, this is the dream scenario. North Korea has a strong preference for going nuclear, and to go nuclear and normalize relations would be the ultimate achievement for Kim Jong-un(Kim, 2014).

**ES/GN:** The United States tightens financial burdens on North Korea such as restricting trade partners and goods available for trade, North Korea establishes itself as a nuclear power in the world.

Economic Sanctions/Go Nuclear is ranked as a 5 or 6 for the United States and an 8 for North Korea. This state of play has occurred before and will likely occur again, as the United States has and will continue to tighten economic sanctions in response to continued nuclear development by North Korea (Min, 2017). This is consistent in scenarios where the ranking is 6 because that is the United States' highest preference in response to North Korea going nuclear in the model. The reason for the potential ranking of 5 is in scenarios where North Korea acts with nuclear capabilities in an extreme way, such as testing missiles extremely close to the United States or another nation and putting people in danger. This would force the U.S.'s hand towards limited military action, similar to Kennedy's enacting of a naval blockade of Cuba during the Cold War (Basu, 2017). As for North Korea, this state is ranked as an 8 because it is consistent

with their desire to become a fully nuclear state and a decreasing incentive to stop nuclear development (Min, 2017). In this scenario, they are countered with economic sanctions, which are undesirable, but not as much as U.S. military action.

**MA/GN:** The United States applies limited military force e.g., a blockade, bombing missile launch sites, and shooting down missile tests, North Korea establishes itself as a nuclear power in the world.

Military Action/Go Nuclear is ranked as a 5 or 6 for the United States and a 2 or 3 for North Korea. The ranking of 5 or 6 for the United States was explained above when explaining the ranking for ES/GN, which has the same possible rankings. For North Korea, this option is ranked a 2 or 3 because military action is the least desirable policy it would like to face. North Korea does not want United States military involvement in the Korean peninsula at all, as shown with their strong desire to remove U.S. troops and nuclear capabilities from South Korea (Kim, 2014). Beyond this, the ranking of 3 is for scenarios where the United States shoots down test missiles, as the 3 would be the most preferred way to combat that military action in this scenario, and North Korea has stated it will retaliate against said military action (Min, 2017). The ranking of 2 is for scenarios where North Korea feels that it is more in their interest to respond to military action with minimal compliance, as they did in the 1990s when trying to achieve the removal of U.S. nuclear capabilities and troops from South Korea (Kim, 2014).

**NR/MC:** The United States lifts sanctions and opens international trade for North Korea, North Korea acts in minimal compliance with U.S. and U.N. requests, pausing nuclear development and allowing for outside inspection of known nuclear facilities.

Normalize Relations/Minimal Compliance is ranked as a 7 or 8 for the United States and a 7 for North Korea. This state is ranked as a 7 or 8 for the United States because it is one of the best and most likely outcomes given that North Korea will not denuclearize. The ranking of 7 is for scenarios when North Korea's minimal compliance leans more towards going nuclear and the ranking of 8 is for scenarios when the minimal compliance leans more towards genuine compliance. If North Korea's minimal compliance is getting noticeably closer to nuclearization, the U.S. would rather apply economic sanctions to slow this movement. For North Korea, this state is ranked as a 7 because it is the most favorable option aside from their preference of going nuclear. Minimally complying allows for them to continue slowly enhancing nuclear capabilities in secret while normalized relations allows for the advancement of their economy.

**ES/MC:** The United States tightens financial constraints on North Korea such as restricting trade partners and goods available for trade, North Korea acts in minimal compliance with U.S. and U.N. requests, pausing nuclear development and allowing for outside inspection of known nuclear facilities.

Economic Sanctions/Minimal Compliance is ranked as a 7 or 8 for the United States and a 6 for North Korea. The ranking of 7 or 8 for the United States was explained above, under NR/MC. As for North Korea, this state is ranked a 6 because NR/GN, ES/GN, and NR/MC are all more beneficial to North Korea's agenda of going nuclear and advancing as a nation of power, but all other states either include military action or denuclearization, both of which North Korea aims to avoid.

**MA/MC:** The United States applies limited military force e.g., a blockade, bombing missile launch sites, and shooting down missile tests, North Korea acts in minimal compliance with U.S.

and U.N. requests, pausing nuclear development and allowing for outside inspection of known nuclear facilities.

Military Action/Minimal Compliance is ranked as a 2 for the United States and a 2 or 3 for North Korea. This state is ranked a 2 for the U.S. because there is little to no incentive to apply military action to a minimally complying North Korea and the only worse state of play is to apply military action to a denuclearized North Korea. Historically, the United States has valued sanctions over military action when both options were available. This is partially how Truman avoided disaster when faced against a newly nuclear Russia and China in the 1960s. (Sagan, 2017). For North Korea, this state is ranked a 2 or 3 because of previously mentioned reasons listed under MA/GN.

**NR/DN:** The United States lifts sanctions and opens international trade for North Korea, North Korea dismantles all nuclear weapons capabilities, leaving only peaceful nuclear capabilities.

Normalize Relations/Denuclearize is ranked as a 9 for the United States and a 5 for North Korea. This is the ideal state for the United States. The United States would gladly welcome North Korea to the world stage if they denuclearized. For North Korea, this state is ranked as a 5 because it avoids U.S. military action and is the best outcome provided they denuclearize, but it is not preferred compared to minimal compliance and going nuclear.

**ES/DN:** The United States tightens financial constraints on North Korea such as restricting trade partners and goods available for trade, North Korea dismantles all nuclear weapons capabilities, leaving only peaceful nuclear capabilities.

Economic Sanctions/Denuclearize is ranked as a 3 for the United States and a 4 for North Korea. This is ranked as a 3 for the United States because they would not apply economic sanctions to a denuclearized North Korea. This state is ranked a 3 because ranks 2 and 1 for the U.S. are less realistic. For North Korea, this state is ranked a 4 because they have no incentive to denuclearize, but rankings 1, 2, and 3 are placed on less ideal states that involve either denuclearization, U.S. military action, or both.

**MA/DN:** The United States applies limited military force such as a blockade, North Korea dismantles all nuclear weapons capabilities, leaving only peaceful nuclear capabilities.

Military Action/Denuclearize is ranked as a 1 for the United States and a 1 for North Korea. This state of play is simply unthinkable for both sides and would never happen. The United States would not enact military action on a denuclearized North Korea and North Korea would not denuclearize to combat military action.

### **Nash Equilibrium vs Theory of Moves and Ultimate Outcome**

Eight scenarios are examined in this model. These eight scenarios resulted in two different Nash Equilibria and three different ultimate outcomes. To discover the Nash Equilibrium of a game, we do a best-response analysis of each payoff configuration for each country. For example, in Game 1, the United States' best policy choice to combat North Korea choosing to go nuclear is economic sanctions. This is because the U.S. prefers economic sanctions (preference rank 6) over normalized relations (preference rank 4) and military action (preference rank 5) in response to North Korea going nuclear. After selecting each country's best response to the other country's policy decisions, the Nash Equilibrium reveals itself as any state

that is the best policy alternative for each country, given the policy decision of the other. Again, looking at Game 1, the Nash Equilibrium is the state ES/GN. This is because economic sanctions are the U.S. preference to combat North Korea going nuclear and going nuclear is the North Korean preference to combat U.S. sanctions.

In contrast, the ToM provides a sequential-move analysis, displaying a chain of decisions that reaches an ultimate outcome rather than simultaneous decisions. Sequential-move analysis is appropriate for this conflict, as this is not an issue that will be resolved with each country simply making one decision (Basu, 2017). To apply ToM, we first begin with an initial state of play. We will begin in 2018, where the state of this conflict was economic sanctions by the U.S. and minimal compliance by North Korea. This is consistent with the U.S. and North Korean actions at the time, as the U.S. had been continuing its policy of economic sanctions and North Korea had halted nuclear tests in 2018. In June 2018, at the Singapore Summit, President Trump made the first move by offering to change U.S. policy from economic sanctions to normalize relations, providing that North Korea would take the next step by choosing to denuclearize. This proposal was brought up during the Singapore Summit that year (Fisher, 2018).

Following this initial state of play, the game has strictly alternating turns to move, so North Korea has the next turn to either move (change its policy to denuclearize or go nuclear) or pass (maintain its minimal compliance policy). If it chooses to denuclearize, the U.S. reaches its most preferred state. If it passes or chooses to go nuclear, the U.S. can switch back to economic sanctions or pass on the next turn to move. Play continues with the players alternating turns to move. The game ends at its ultimate outcome after (1) consecutive passes (the players both agree to remain at the current state), or (2) a maximum number of moves (not counting passes)

have been made by the players (Willson, 1998). The ultimate outcome for this game does not depend on the maximum number of moves, but a finite number of moves is necessary to solve the game by backward induction.

The players receive the payoffs associated with the ultimate outcome. Analysis of the ultimate outcome is done by reviewing the route taken to achieve the said outcome, referred to as the equilibrium path. Another reason ToM is a better tool for analyzing this conflict is that the strategy required for either side of this conflict is not immediately visible, but upon viewing the equilibrium path and seeing the necessary responses either country needs to make to achieve their most mutually beneficial outcome, it becomes more clear (Carpanini, 2017).

The next section presents all eight scenarios, grouped by their similarities concerning Nash Equilibrium and the ultimate outcome.

## Scenario Matrices

**Table 1: Games That Share a Nash Equilibrium and an Ultimate Outcome**

		Game 1 North Korea					Game 2 North Korea		
		GN	MC	DN			GN	MC	DN
United States	NR	4, 9	8, 7	9, 5	United States	NR	4, 9	7, 7	9, 5
	ES	<u>6, 8</u> ★	7, 6	3, 4		ES	<u>6, 8</u> ★	8, 6	3, 4
	MA	5, 3	2, 2	1, 1		MA	5, 3	2, 2	1, 1

		Game 3 North Korea					Game 4 North Korea		
		GN	MC	DN			GN	MC	DN
United States	NR	4, 9	8, 7	9, 5	United States	NR	4, 9	7, 7	9, 5
	ES	<u>6, 8</u> ★	7, 6	3, 4		ES	<u>6, 8</u> ★	8, 6	3, 4
	MA	5, 2	2, 3	1, 1		MA	5, 2	2, 3	1, 1

In the four scenario payoff configurations in Table 1, the Nash Equilibrium and the ultimate outcome are the same, Economic Sanctions/Go/Nuclear. The difference between each of these games is the shifting of the U.S. 7 and 8 preference rankings between NR/MC and ES/MC alongside the shifting of North Korea's 2 and 3 preference rankings between MA/GN and MA/MC. The preference orderings for the United States in these games prioritizes sanctions in response to a nuclear North Korea and normalized relations in response to denuclearization. The games are split, however, in their response to minimal compliance. Games 1 and 3 value normalized relations over economic sanctions to combat minimal compliance, implying that in these scenarios the U.S. believes normalizing relations can either bring North Korea from minimal compliance to denuclearization or at least prevent the transition to going nuclear. For Games 2 and 4, the opposite can be said. These scenarios display interactions where the U.S.

feels economic sanctions are a better policy response to prevent nuclearization or persuade denuclearization. The significance of a shared Nash Equilibrium and ToM ultimate outcome is that regardless of simultaneous moves or sequential moves, the result is the same. In a single-turn game with both countries acting simultaneously, they will each find ES/GN to be their best policy decision. In a sequential-move game with each country alternating turns from the initial state, the countries will eventually move to and agree on the ES/GN state as well.

North Korea's preference ordering in these games primarily signifies a strong desire to both pursue going nuclear and avoid U.S. military action. The difference between Games 1 and 2 compared to Games 3 and 4 concerning North Korea is the preference to go nuclear or show minimal compliance in response to U.S. military action. Games 1 and 2 present situations where North Korea feels full nuclear capabilities are the necessary response to actions such as a blockade or shooting down test missiles by the U.S. Games 3 and 4, however, show scenarios where North Korea feels that minimal compliance is the better response to such limited military action, due to either a lacking nuclear program or a struggling economy. Regardless, the Nash Equilibrium and ultimate outcome among these four games show that these specific preference changes do not change the result of the game. This is not true for all games however, as we will see in games 5-8.

**Table 2: Games with Ultimate Outcomes That Differ from Nash Equilibria**

		Game 5					Game 6		
		North Korea					North Korea		
		GN	MC	DN			GN	MC	DN
United States	NR	4, 9	8, 7 <sup>★</sup>	9, 5	United States	NR	4, 9	7, 7	9, 5
	ES	5, 8	7, 6	3, 4		ES	5, 8	★ 8, 6	3, 4
	MA	<u>6, 3</u>	2, 2	1, 1		MA	<u>6, 3</u>	2, 2	1, 1

In these two games, the Nash Equilibrium is Military Action/Go Nuclear, however, the ultimate outcome is Normalize Relations/Minimal Compliance. This split comes from swapping the U.S. preference rankings of 5 and 6 so that MA/GN is ranked higher than ES/GN. This small change moves the Nash Equilibrium from ES/GN to MA/GN and the ultimate outcome from ES/GN to either NR/MC or ES/MC. This Nash Equilibrium shift follows the U.S. preference ranking 6. The ultimate outcome shift, however, follows the U.S. preference ranking of 8 and is Pareto superior to the Nash Equilibrium in these games. This provides evidence that the Theory of Moves will discover a Pareto superior outcome if one is available (Willson, 1998). Such an outcome means that neither country cannot improve its state without reducing the other country's state.

Performing a sequential turn analysis (ToM) rather than a simultaneous turn analysis (Nash) allows for this Pareto superior ultimate outcome to emerge. This is due to the reactionary element of ToM. ToM provides each country with the knowledge of the current state as well as the routes available to reach other states. Each country then makes sequential decisions in an effort to reach their desired state, and these decisions will eventually lead to a Pareto superior outcome when one is present. A ToM analysis of Table 2 shows that, based on these preference

rankings, if the United States prioritizes military action as their response to a nuclear North Korea then North Korea will avoid going nuclear in the ultimate outcome. The Nash equilibrium analysis of Table 2, however, shows that when forced to act simultaneously, The U.S. will engage in limited military action to combat North Korea going nuclear.

**Table 3: Games with no Nash Equilibria in Pure Strategies**

		<b>Game 7</b>					<b>Game 8</b>		
		North Korea					North Korea		
		GN	MC	DN			GN	MC	DN
United States	NR	4, 9	8, 7 <sup>★</sup>	9, 5	United States	NR	4, 9	7, 7	9, 5
	ES	5, 8	7, 6	3, 4		ES	5, 8	★ 8, 6	3, 4
	MA	6, 2	2, 3	1, 1		MA	6, 2	2, 3	1, 1

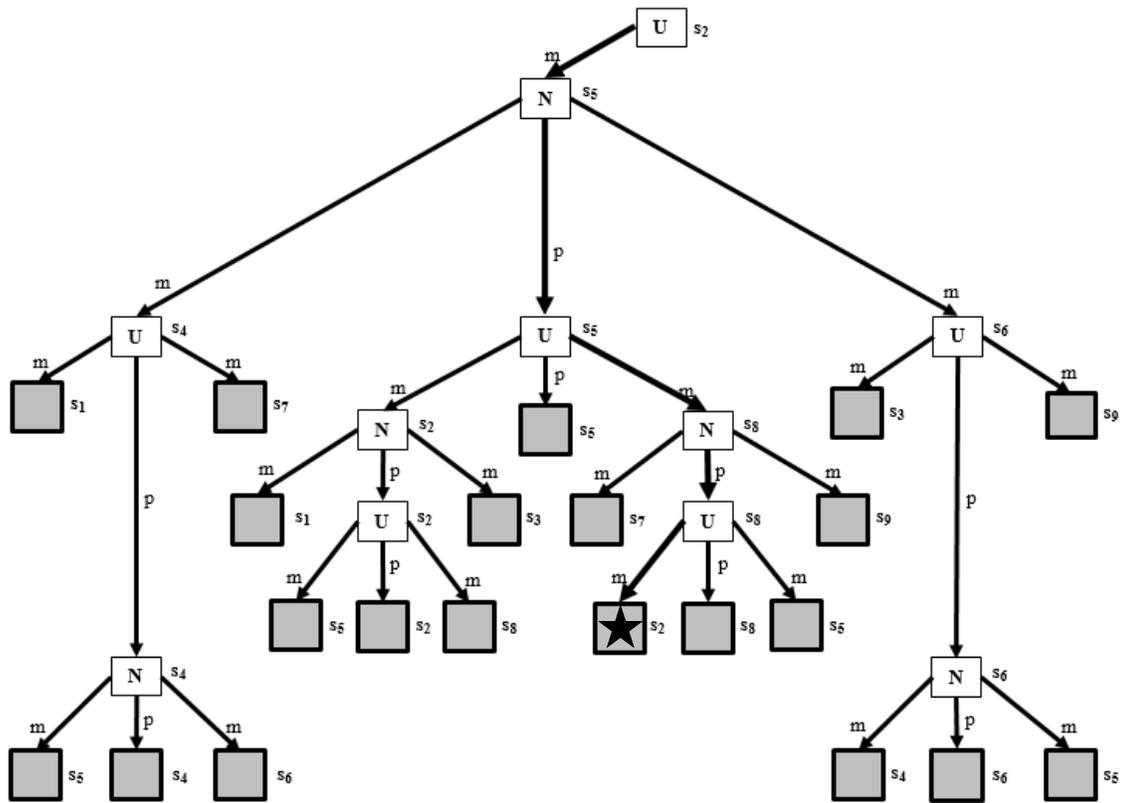
In these two games, the ultimate outcomes are Normalize Relations/Minimal Compliance and Economic Sanctions/Minimal Compliance. These ultimate outcomes follow the U.S. preference ranking 8. What makes these games interesting is there is no Nash Equilibrium in pure strategies for either game. This is the result of switching the North Korean preference rankings 2 and 3 from MA/GN to MA/MC. This switch implies that in this scenario, North Korea would rather respond to U.S. limited military action with minimal compliance than going nuclear. This would be a situation where the U.S. limited military action, whether it be shooting down test missiles, bombing missile launch sites, or putting in place a naval blockade, would put North Korea at too much of a deficit in terms of finances or resources or both. Thus, minimal compliance would be more beneficial than going nuclear.

These games present further support towards a Theory of Moves analysis rather than Nash Equilibrium analysis, showing that an ultimate outcome through ToM can still be found

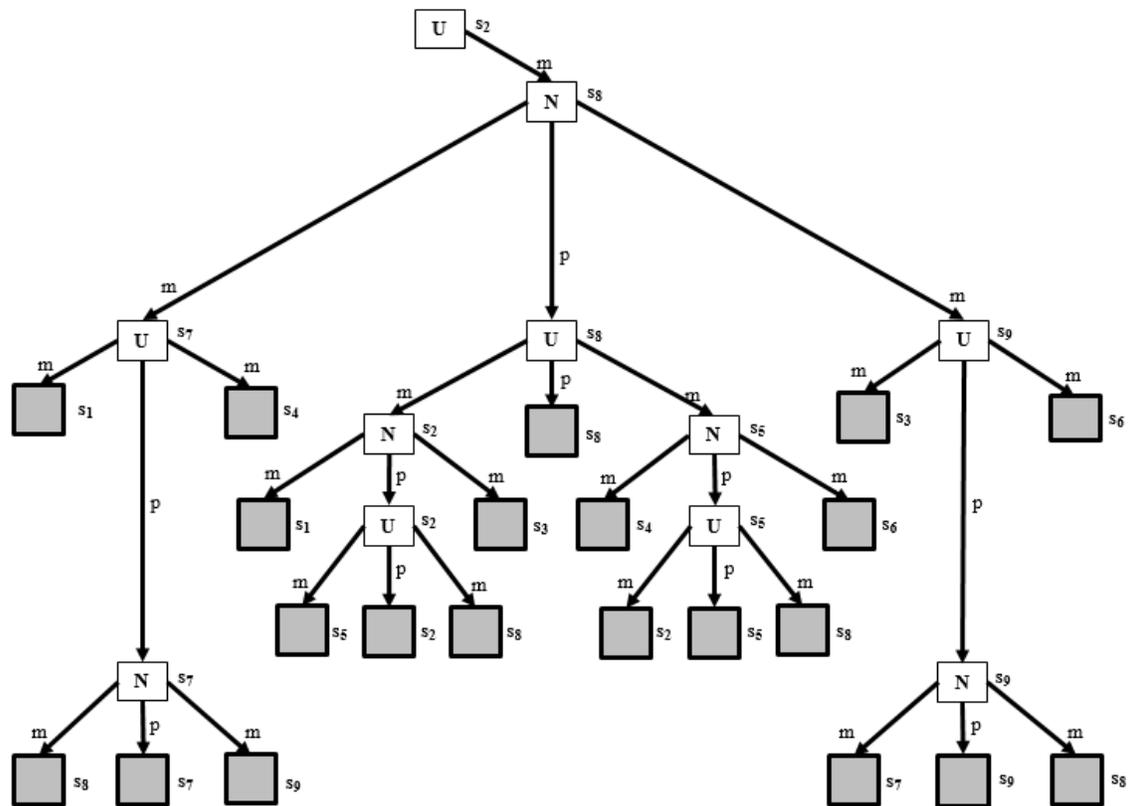
when the Nash Equilibrium does not exist. To provide a visual for this application of the ToM below is a game tree illustrating the different moves for each country in Game 7. The equilibrium path is marked with bold arrows and the ultimate outcome can be seen at the end of this path, in terminal nodes containing a star in Figures 1.1 and 1.2. The template for this game tree is from *Ukraine Crisis 2014: A Study of Russian-Western Strategic Interaction* (Ericson & Zeager, 2015).



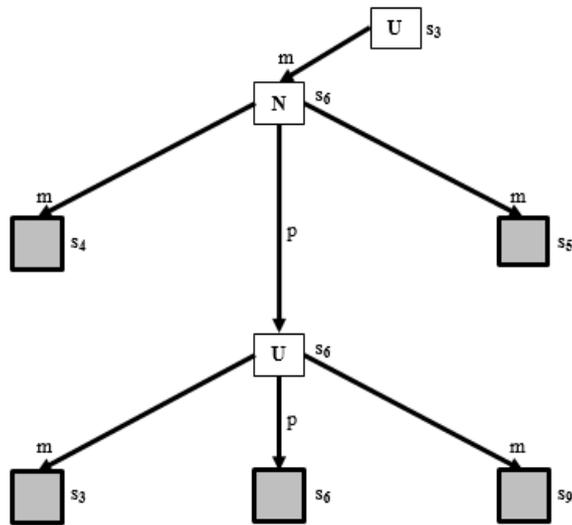
North Korea will pass, staying at state 5, ES/MC. The U.S. will then respond to this continued minimal compliance with limited military action, putting the game in state 8, MA/MC. North Korea again chooses to pass in this state, to which the U.S. responds with falling back to normalized relations, effectively ending the game.



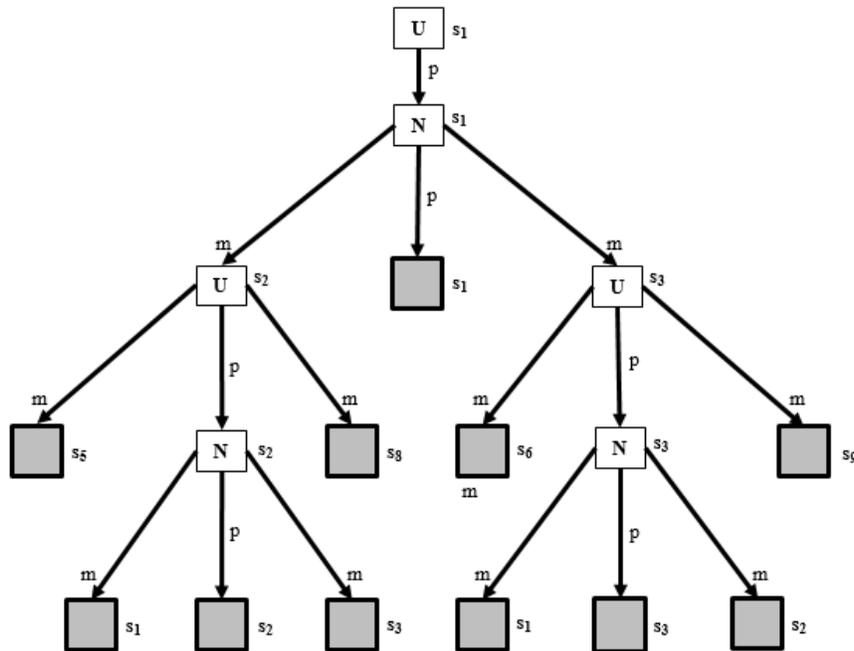
[Figure 1.2] This module begins with the United States making the second move, and extends the game tree shown in Figure 1.1. The game ends after two consecutive passes (agreement) or after four total moves (time expires). The decision nodes have player labels and the terminal nodes are shaded.



[Figure 1.3] This module begins with the United States making the second move, and extends the game tree shown in Figure 1.1. The game ends after two consecutive passes (agreement) or after four total moves (time expires). The decision nodes have player labels and the terminal nodes are shaded.



[Figure 1.4] This module begins with the United States making the third move, and extends the game tree shown in Figure 1.1. The game ends after two consecutive passes (agreement) or after four total moves (time expires). The decision nodes have player labels and the terminal nodes are shaded.



[Figure 1.5] This module begins with the United States passing after two prior moves were made. The game ends after two consecutive passes (agreement) or after four total moves (time expires). The decision nodes have player labels and the terminal nodes are shaded.

## Conclusion

This paper has presented an analysis of the North Korean Missile Crisis through the lens of game theory and in particular, the theory of moves. Upon applying preference rank orderings to all available policy options for the United States and North Korea in this conflict, priorities are clear. The United States aims to push North Korea to denuclearize while avoiding the use of military force (however limited) if possible, and North Korea desires to become a fully nuclear state while also avoiding triggering U.S. military action. Aside from these priorities, the United States and North Korea both have moderate to high preference for three particular states, ES/GN, NR/MC, and ES/MC. The high preference rankings that both countries place on these states lead to all eight scenarios producing ultimate outcomes in these three states. Incomplete information prevents a firmer grasp on the ultimate outcome of this conflict, and slight adjustments to the combination of preference orderings, as seen in the eight models simulated, can significantly alter the result, and especially alter the Nash Equilibrium, which in comparison is not as insightful as the ToM ultimate outcome for this analysis.

The first of the ultimate outcomes derived from these games is Economic Sanctions/Go Nuclear, as seen in Games 1-4. This outcome is consistent with much of what has occurred since Kim Jong Un took leadership of North Korea in 2011, as North Korea has drastically increased its missile testing and the U.S. has responded with tighter sanctions. The second ultimate outcome is Normalize Relations/Minimal Compliance, found in Games 5 and 7. This has not yet occurred for an extended period, although the state was proposed by Donald Trump at the Singapore Summit in 2018, under the understanding that North Korea would make efforts to denuclearize, which did not occur. (Fisher, 2018). The third and final ultimate outcome derived

from these games is Economic Sanctions/Minimal Compliance, found in Games 6 and 8. This state was relatively consistent before the reign of Kim Jong Un, as the United States alongside the United Nations has sanctioned North Korea since the beginning of its nuclear program. North Korea has responded to these sanctions with minimal compliance throughout this conflict, allowing for partial inspections of nuclear facilities and temporarily halting nuclear testing and development for periods. This minimal compliance was a calculated decision with North Korea aiming to remove U.S. forces and nuclear capabilities from South Korea while slowly continuing nuclear development unknown to the rest of the world (Kim, 2014). Among these three ultimate outcomes, two have occurred multiple times throughout history and one has been considered a few times. Regardless of which scenario most accurately captures the actual preference rankings of the two nations, application of the theory of moves to this crisis reveals conditions under which the most plausible outcomes could come to pass.

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