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Using Game Theory to Model Tripolar Deterrence and Escalation Dynamics

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USING GAME THEORY TO MODEL TRIPOLAR DETERRENCE AND ESCALATION DYNAMICS

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Abstract

The study investigated how game theory can been utilized to model multipolar escalation dynamics between Russia, China, and the United States. In addition, the study focused on analyzing various parameters that effected potential conflict outcomes to further new deterrence thought in a tripolar environment.

A preliminary game theoretic model was created to model and analyze escalation dynamics. The model was built upon framework presented by Zagare and Kilgour in their work 'Perfect Deterrence'. The model is based on assumptions and rules set prior to game play. The model was then analyzed based upon these assumptions using a form of mathematical backwards induction applicable to game theorists. Then, potential outcomes were evaluated to produce deterrence recommendations.

To accomplish this objective, a hypothesis was set and then compared to the final research results. Based upon the comparison, final conclusions and recommendations were made. The result obtained through game theory and research was according to the hypothesis set and this thesis describes the reasons and theory behind satisfying the hypothesis.

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Using Game Theory to Model Tripolar

Deterrence and Escalation Dynamics

Introduction

Russia has reached rough strategic parity with the United States. China will soon join the United States and Russia as a nuclear peer or near peer, creating a new multipolar geopolitical environment. The US' traditional nuclear deterrence policies are rooted in a bipolar context, requiring a reconsideration of deterrence strategies. Game theoretic models provide an avenue for exploration as they model strategic situations between multiple players engaged in a particular situation or game. Strategic situations involve outcomes dependent on the actions of all players and their distinct motives. Understanding and analyzing outcomes and situations is imperative for formulating new deterrence policies and strategies to stay ahead of competitors. By formally modeling games, modelers are forced to articulate any assumptions and conclusions from the model, creating opportunities for informed and new deterrence thinking. Significant work has been done to develop game theoretic models of bipolar conflict, but research in the tripolar domain is severely lacking. For instance, in 2000, Zagare and Kilgour presented an asymmetric escalation game to study the dynamics of bipolar deterrence. Their work could be broadened to apply to multi-player frameworks. This thesis aims to unpack the changing geopolitical environment by utilizing previous bipolar game theoretic models to develop tripolar models to analyze escalation and deterrence dynamics between Russia, China, and the US, and more specifically, assess key factors that affect conflict outcomes. While much of this project examines these dimensions more broadly and concretely, it is first critical to analyze previous bipolar game theoretic deterrence strategies to understand and expand upon past theories and research. I aim to find a correlation between bipolar game theoretic models and the current geopolitical environment to build new tripolar game theoretic models for analysis. The objective of this study is to **utilize game theory to analyze multipolar escalation dynamics between Russia, China, and the United States**. The analysis will be investigated in three possible scenarios. The first assumes all players are acting separately and without coordination, simulating an equilateral triangular environment. The second scenario assumes coordination between China and Russia, and the third, coordination between China and the U.S. While there is another possible case of coordination between Russia and the U.S., I have not considered it plausible. Current hostilities between the two actors in relation to tensions in Ukraine have made an alliance against a third party highly unlikely. Therefore, all scenarios assume continued antagonism between the two nations.

It is hypothesized that the risk of all-out strategic conflict will increase in a multipolar environment and the time frame for de-escalation will decrease. Before I can fully analyze and build new models, both theoretically and empirically, it is necessary to survey the existing literature on deterrence and game theory. The following section provides a brief overview of multiple scholarships to date.

Literature review

Perfect Deterrence

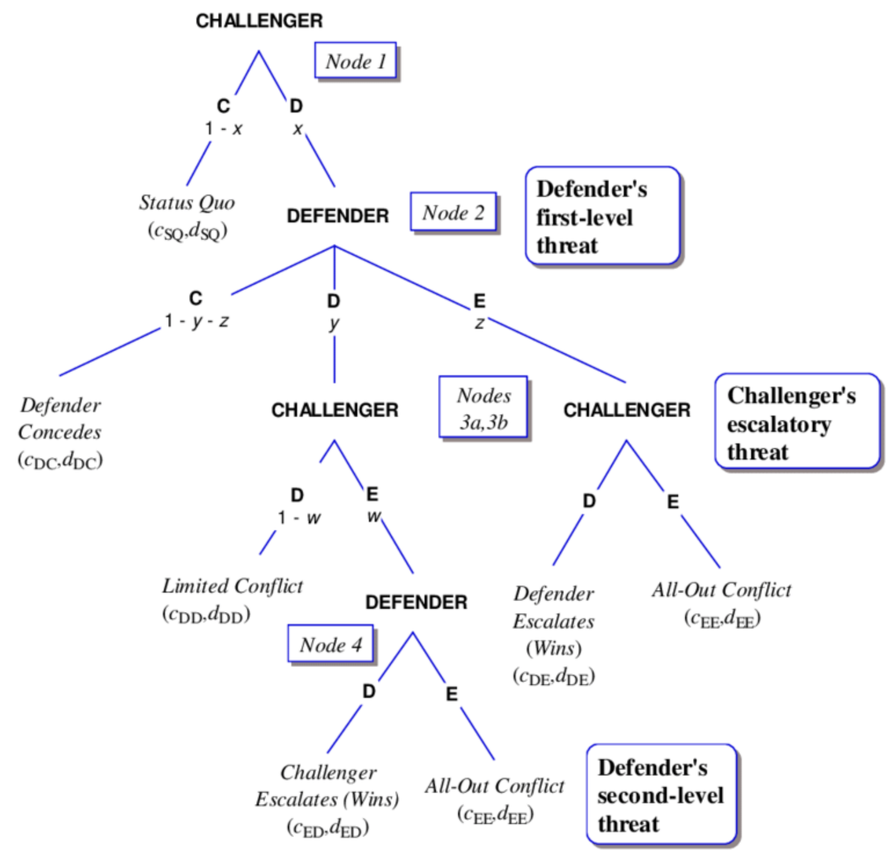
Zagare and Kilgour's research 'Perfect Deterrence' in 2000 provides a framework for understanding the conditions under which deterrence can be perfectly achieved as well as various game theoretical models to study bipolar deterrence and escalation dynamics. They define 'perfect deterrence' as a situation in which the adversary is deterred from any action that would harm the deterrent, even when the deterrent is not actively threatening the adversary. According to Zagare and Kilgour, ‘perfect deterrence’ is possible when the deterrence threat is credible, the antagonist is rational, and the target believes the deterrent has the capability and will to follow through on their threat. The authors claim perfect deterrence is the ideal outcome of any deterrence strategy and achievable under certain conditions. As deterrence is a central topic in international relations theory, it has been extensively studied by scholars. In this literature review, I will examine the concepts presented in ‘Perfect Deterrence’ and evaluate their relevance and possible contributions to tripolar deterrence theory.

To utilize game theory to model deterrence scenarios, understanding the various factors that contribute to deterrence is necessary. Zagare and Kilgour begin by discussing the factors that contribute to the credibility of a deterrent threat. They propose the most important factor is the credibility of the deterrent’s capabilities, which can be demonstrated through past actions, public statements, a willingness to undertake costly actions or the possession of military and economic resources.

Another important deterrence factor is rationality. Zagare and Kilgour argue a rational target can only be deterred if the cost of the action to the target is greater than the expected benefit. In other words, the adversary must perceive the cost of taking an action as higher than the benefit it would receive from the action. On the other hand, deterrence becomes increasingly more difficult, if not impossible, when working with non-rational actors. Therefore, any game theoretic model presented assumes actors must be rational. Also note, actors’ perceptions of the costs and benefits of various actions may differ, lending to the importance of effective communication and information sharing to align perceptions.

Lastly, the authors consider the impact of uncertainty on perfect deterrence. They argue uncertainty can potentially undermine the credibility of a deterrent threat, as the target may not be able to accurately predict the deterrent's response. To reduce uncertainty, communication and transparency between actors is essential. Overall, Zagare and Kilgour provide valuable research for understanding the conditions under which deterrence can be perfectly achieved. Credibility, rationality, and communication are imperative for achieving perfect deterrence. Understanding these factors can inform policy makers in designing more effective deterrence strategies. However, the authors acknowledge that perfect deterrence may be difficult to achieve in practice, and some levels of uncertainty and risk may present different deterrence situations. Later in the novel, Zagare and Kilgour provide important frameworks for understanding bipolar deterrence using game theoretic models. To create tripolar game theoretic models, it is first important to analyze and update bipolar models.

Zagare and Kilgour present multiple models, one being the 'Asymmetric Escalation Game under Flexible Response'. This model provides a theoretical framework for analyzing conflicts between two players with different levels of military power. Like other models, the game is played in rounds, with each player choosing to respond-in-kind or escalate based on the move of the previous player. The key feature of this game is the ability for players to have flexible response. Flexible response allows players to choose a range of possible responses to their opponent's move, rather than being limited to a predetermined set of options. Below is a depiction of the model.



Key:

Challenger: C = Cooperate
D = Demand
E = Escalate

Defender: C = Concede
D = Defy
E = Escalate

x = probability Challenger initiates at node 1
w = probability Challenger escalates at node 3a
y = probability Defender responds-in-kind at node 2
z = probability Defender escalates at node 2

This model depicts a game between two players, call one ‘Challenger’ and the other ‘Defender’. Challenger begins play at node 1 by either cooperating (C) and accepting the status quo (Outcome SQ), or by defecting (D) and demanding a change in the existing order (Zagare, Kilgour 176). In this model, defection is defined as precipitating a crisis, launching a limited military attack, or taking aggressive action other than strategic assault (Zagare, Kilgour 221). Thus, the Challenger’s initial demands are restricted to a level short of an all-out assault against the defender. If the challenger cooperates at node 1, the game ends in the status quo, if they defect, the defender must choose how to respond. At node 2, the defender has the option to either respond-in-kind or escalate, assuming a response-in-kind is commensurate with the challenger's initial decision. Therefore, at node 2 or the second round of the game, a defender can either match, in scope and intensity, the actions of the previous player to contest the status quo, or they may escalate by choosing an unconstrained action, such as one associated with all-out war.

To further analyze the model, Zagare and Kilgour defined fundamental assumptions and definitions that were made to play through the model. First, we assume Challenger prefers defender concedes to the status quo. Therefore, Challenger has an immediate incentive to defect. Second, we assume Defender prefers the status quo to all other outcomes, making deterrence Defender's primary objective. Next, to ensure Defender has a capable threat, we assume Challenger prefers the status quo to conflict. "To reflect the costs of conflict, we assume players prefer to win, or, if it comes to it, lose at the lowest levels on conflict" (Zagare, Kilgour 182). In other words, players prefer their opponent concedes to themselves winning, merely because this means they win at the lowest possible level of conflict. Lastly, we assume Challengers can be one of two types: hard or soft. 'Hard' meaning Challenger prefers conflict to the opponent winning and 'soft' meaning Challenger prefers the opponent wins to conflict. On the other hand, Defender may be one of four types. These being:

1. Type HS (Hard at the first level, but soft at the second)
2. Type SH (Soft at the first level, but hard at the second)
3. Type HH (Hard at both levels)
4. Type SS (Soft at both levels)

We also assume incomplete information, meaning each player only has probabilistic knowledge of its opponent's type's (Hard or Soft). Various game assumptions produce biases that need addressed. For instance, assuming all payoffs from the all-out conflict outcome are the same no matter which player escalates first creates an overreporting problem. However, Zagare and Kilgour go on to explain that even with this bias, the conditions under which overreporting exists is quite restricted.

This model can be interpreted for a variety of scenarios. The first level of the game may be associated with conventional conflict and the second with nuclear war, but other distinctions can also be made. For instance, you could associate the first level of game play with tactical (or theater) nuclear weapons and the second with strategic nuclear weapons. Or the two levels could represent conventional and chemical weapons or conventional and biological weapons and so on. In other words, two level escalation games provide frameworks to model any conflict in which players share a common belief that saliency exists and crossing that threshold is irrevocable (Zagare, Kilgour 184). Zagare and Kilgour's models were influenced from a variety of scholarly works. Their extended deterrence and escalation process was influenced by Kahn's 1965 escalation ladder. The sequence of moves in the model was influenced by an informal escalation model developed by Snyder and Diesing in 1977 in their classic study of interstate crisis. The model is also compatible with Smoke's 1977 characterization of escalation as a choice that involves crossing a plateau, and with Huth and Russett's 1988 conceptualities of escalation as a two-phase process (Zagare, Kilgour 186). Many scholars criticize game theoretic models for their lack of realism, but flexible response provides a level of complexity to better reflect real-world conflicts. Overall, the asymmetric escalation game under flexible response provides a useful framework for understanding how conflicts escalate and de-escalate over time, and how military power and strategic decision-making affect escalation patterns.

In conclusion of their research, Zagare and Kilgour argue that the concept of perfect deterrence, where a state can deter all potential adversaries from any type of aggression, is unrealistic, and all deterrence strategies involve risks and uncertainties. Specifically, adversaries have potentially different perceptions of the costs and benefits of aggression, and these perceptions are influenced by factors like ideology, culture, and history. Deterrence is also a dynamic process involving continuous adjustments which are influenced by internal and external factors. For instance, leadership changes, technological innovations, and changes in the international environment all affect deterrence policies and processes. Rather than aiming for perfect deterrence, Zagare and Kilgour suggest states focus on achieving effective deterrence. Effective deterrence involves using threats that are credible, clearly communicated, and capable of imposing costs on adversaries. Achieving effective deterrence requires a deep understanding of adversaries' interests, capabilities, vulnerabilities, and limitations of one's own deterrent capabilities.

The survey of literature raises some important questions for analyses. First, do current geopolitical trends match patterns consistent with Zagare and Kilgour's models of escalation? Second, if there are differences between today's deterrence scenarios and the scenarios analyzed by Zagare and Kilgour, how can we create new, updated models for analysis and decision-making? What do the differences in environments mean when it comes to countering and deterring the use of nuclear weapons? Lastly, how can we use the data and logistics presented in existing literature to predict or counter future adversary's and conflicts?

In the broader project, I seek to engage and contribute to the ongoing discussion in academic, policy, and military communities on what strategies can be best applied to mitigate nuclear conflict and ultimately create a tripolar model to inform future conflicts. Lastly, I seek to understand how tri-polarity effects the probability of nuclear warfare as well as different tripolar mitigation tactics. By using existing patterns, I hope to provide intel that can be useful to understand future nuclear conflicts and adversaries.

Preliminary Model

The preliminary model depicts a tripolar theoretical game in which all players act separately. In other words, no player in the game is coordinating with another player against an antagonist. This model was built based upon Zagare and Kilgour's 'Asymmetric Escalation Game under Flexible Response' in Perfect Deterrence. The idea was to transform previous bipolar game theoretic models to build a new tripolar model to analyze potential nuclear conflict between China, Russia, and the United States. The United States has never had to defend against two nuclear near peer competitors, therefore game theoretic models provide insight to analyze possible tripolar conflict. Because this model is based upon Zagare and Kilgour's bipolar game, many assumptions and game rules remain the same. Before we can backwards induce results from the model, we need to specify important assumptions, rules, and definitions. Below, I will describe each of these elements to understand the conditions under which the game is played.

Assumptions

Below is a list of assumptions that enable game theorists to backwards induce results from various models. These assumptions are imperative to ensure results are both realistic and correct according to the model.

- Players execute a response-in-kind or escalatory attack based on their perceived type (hard/soft).
- Each player has probabilistic knowledge of opponents' type and knows its own type.

- Assume that a response-in-kind is commensurate with the first antagonist's initial decision.
- Players are taking steps to optimize and achieve their goal (Players are rational)
- Players always prefer winning to losing but, if it comes to it, players prefer to lose at the lowest level of conflict.
- Players have incomplete information about each other's preferences between backing down after an escalatory choice or counter-escalating.

Game Rules

Game rules lay out the conditions each player is held to in the game. For instance, players can make one of three choices at any node in the game, and they must act to optimize their own interests without coordination between players. These rules allow us to evaluate a game between three players when all players are acting separately and in their best interests. Below is a simplification of the game rules specific to this model:

- Each player acts to optimize their own interests, as determined by preferences, and does not coordinate actions with another player.
- Players have up to three choice options depending on the node: concede, defy, or escalate.
- Players that move without prior knowledge of the move of the previous player are said to be in an information set.

Definitions

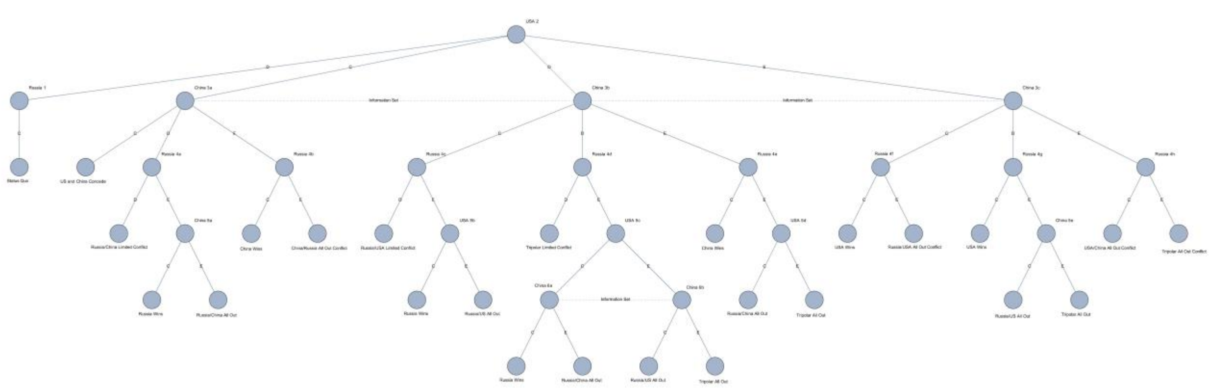
I have defined each player based on credibility and capability. As China does not yet have a credible nuclear second-strike capability, I have chosen the first antagonist as Russia. The first antagonist is the player who decides whether to challenge the other antagonists or the status quo dependent on its evaluation of the status quo. Therefore, in this scenario, Russia has chosen to upset the current world order. The other two players are defined as either the second antagonist or third antagonist. Both the second and third antagonists are players who opt to defend the status quo from the first antagonist's initial challenge, concede to the first antagonist, or make an escalatory move. In this scenario, I have defined the second antagonist as the United States, and the third antagonist as China. Overall, the players are defined as follows:

- First Antagonist (Russia)- Player who decides whether to challenge other antagonists/the status quo dependent on its evaluation of the status quo.
- Second Antagonist (United States)- Player who opts to defend the status quo from the first antagonist's initial challenge, concede to the first antagonist, or make an escalatory move.
- Third Antagonist (China)- Player who opts to defend the status quo from the first antagonist's initial challenge, concede to the first antagonist, or make an escalatory move.

Next, specific definitions of each option or choice in the game is important for later analysis. In this model, players can choose one of three choices at each node or step in the game. A player can either 'concede', 'defy', or 'match'. If a player chooses to concede, they admit they are not capable or willing to continue playing the game. A player defies by opting not to concede, but rather choosing to respond-in-kind or equivalently to the move of the previous player. A response-in-kind is commensurate with antagonist one's initial decision and subsequently equivalent to the move of the previous player. Action can include the expansion of military effort, such as the degree, type, and location of force applied. Lastly, a player can escalate in which case they respond to the previous move with an attack that surpasses the threshold set by the move of the previous player. Escalatory action can include the expansion of military effort, such as the degree, type, and location of force applied.

Lastly, defining possible outcomes is both relevant and important to decision-makers and analysts. This model contains four main outcomes; concede, win, limited conflict, or all-out conflict. A game ending with the outcome ‘concede’ means all additional players have met the demands of the first antagonist without any conflict occurring. Win, although intuitive, is the outcome in which some degree of conflict was involved but the demands of a player have been met and that player no longer faces resistance from any other player(s). Limited conflict is an outcome in which military engagement between players is short of all-out warfare, meaning the objectives and targets are restricted or constrained. This outcome includes but is not limited to conventional conflict and tactical or theater level nuclear engagement on a limited set of targets, such as the military or industrial assets of another player(s). Lastly, all-out conflict is the outcome in which large-scale military engagement between players involves all readily available forces, including strategic, or high yield weaponry. In this outcome, targets include the military, industrial, economic, or civilian populations of another player(s).

Model Outline



The model above begins on the left-hand side with Russia choosing between defecting from the status quo or maintaining the status quo. There are 25 variations of the four possible outcomes, concede, win, limited conflict, and all-out conflict. To further specify these outcomes, the game could end in bipolar limited conflict between two players or in tripolar limited conflict, in which China, Russia, and the United States are all fighting at the conventional level. Similarly, the game could end with two players involved in bipolar all-out conflict or tripolar all-out conflict. There are outcomes where no conflict occurs, meaning a variation of two players concede. Furthermore, there are outcomes involving conflict but ultimately one player wins. Before analyzing each node in the game, it's important to set player preferences and types (Hard/Soft).

Player Preferences

To build player preference sets, I used 'Perfect Deterrence' as a model and guide. Based upon the set rules and definitions, players prefer to lose and win at the lowest levels of conflict. Therefore, players prefer the other antagonists concede over themselves winning. Antagonists 1 and 2 defend the status quo, meaning they prefer to win with no conflict and want an outcome that ends in maintaining the status quo. Limited conflict is always preferred to all out conflict. This allows players to perform credible signaling against antagonists while also preferring to lose at the lowest level of conflict possible. To simplify, I have rank ordered each antagonist's preferences below. It is important to note the outcomes in the bracket. Based on the specific players, environment, and technology involved in a particular conflict, the order of the bracketed outcomes can change.

Antagonist 1: Antagonist 2 & Antagonist 3 Concedes >*a1* Status Quo >*a1* Antagonist 1 Wins >*a1* Limited Conflict >*a1* [Antagonist 2 Wins, Antagonist 3 Wins, All Out Conflict]

Antagonist 2: Status Quo >*a2* Antagonist 2 Wins >*a2* Limited Conflict >*a2* [Antagonist 1 Wins, Antagonist 3 Wins, All Out Conflict]

Antagonist 3: Status Quo >*a3* Antagonist 3 Wins >*a3* Limited Conflict >*a3* [Antagonist 1 Wins, Antagonist 2 Wins, All Out Conflict]

To reiterate, players in this model can be one of two types at various stages in the game. Similar to 'Perfect Deterrence', players are either defined as hard or soft. Below are the possible types players can be defined as throughout the game. These types directly correlate to each players preference sets. For instance, a player who is soft or prefers the opponent wins to conflict would prefer the other antagonists win to all-out conflict. If a player is hard and prefers conflict to the opponent winning, they may rank all-out conflict higher than the other antagonist's winning. For this model specifically, I have rank ordered all possible outcomes according to current literature and research. By creating multiple preference orderings, I was able to backwards induce results for a variety of orders, analyzing possible trends and deviations. Below is an example preference set for a three-player game between Russia, China, and the United States, where Russia and the U.S. are hard, and China is soft.

- Antagonist 1 (Russia) - Hard
  - US/C concede > Status quo > Russia wins > R/US Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > R/US All-Out > Tripolar All-Out > US/C All-Out > China wins > US wins
- Antagonist 2 (United States) - Hard

    - Status quo > US wins > R/US Limited Conflict > Tripolar Limited Conflict > R/C Limited Conflict > R/US All-Out > US/China All-Out > Tripolar All-Out > R/C All-Out > US/C concedes > China wins > Russia wins

- Antagonist 3 (China) - Soft
    - Status quo > China wins > US/R Limited Conflict > R/US Limited Conflict > Tripolar Limited Conflict > US/C concedes > US wins > Russia wins > R/US All-Out > R/C All-Out > C/US All-Out > Tripolar All-Out

Before using backwards induction to analyze potential results and trends, understanding each node in the game is imperative. There are varying possibility outcomes for each node based on the players previous choices. Below is a compilation of all the possible steps in the game.

Game Play

- At **Node 1,** Russia, acting as the first antagonist, makes a demand to change the status quo, through threat or deployment of military force, or opts to cooperate with the status quo.
- At **Node 2**, the United States, acting as the second antagonist, can concede to Russian demands (removing themselves from the conflict), defy/respond in-kind to Russian aggression, or escalate past the previous Russian move.
- At **Node 3** there are three possibilities
    - **A)** China, acting as the third antagonist, without prior knowledge of the United States' previous action, opts to concede, defy, or escalate. If China concedes at this move, both China and the United States have conceded and met Russian demands without any conflict.

- **B)** China, without prior knowledge of the United States' previous action, opts to concedes, defy, or escalate.
- **C)** China, without prior knowledge of the United States' previous action, opts to concede, defy, or escalate.

- At **Node 4** there are eight possibilities
  - **A)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to defy or escalate. If Russia defies, Russia and China engage in limited conflict.
  - **B)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to concede or escalate. If Russia concedes, China wins. If Russia escalates, Russia and China engage in all out conflict.
  - **C)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to defy or escalate. If Russia defies, the United States and Russia engage in limited conflict.
  - **D)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to defy or escalate. If Russia defies, all states engage in tripolar limited conflict.
  - **E)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to concede or escalate. If Russia concedes, China wins.
  - **F)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to concede or escalate. If Russia concedes, the United States wins. If Russia escalates, the United States and Russia engage in all out conflict.

    - **G)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to concede or escalate. If Russia concedes, the United States wins.
    - **H)** Russia, with prior knowledge of the United States and China's decisions at Nodes 2 and 3, opts to concede or escalate. If Russia concedes, the United States and China engage in all out conflict. If Russia escalates, all states engage in tripolar all-out conflict.
- At **Node 5** there are five possibilities
    - **A)** Based on Russia's escalation, China can concede or escalate. If China concedes, Russia wins. If China escalates, China and Russia engage in all out conflict.
    - **B)** Based on Russia's escalation, the United States can concede or escalate. If the United States concedes, Russia wins. If the United States escalates, the United States and Russia engage in all out conflict.
    - **C)** Based on Russia's escalation, the United States can concede or escalate.
    - **D)** Based on Russia's escalation, the United States can concede or escalate. If the United States concedes, Russia and China engage in all out conflict. If the United States escalates, all states engage in tripolar all-out conflict.
    - **E)** Based on Russia's escalation, China can concede or escalate. If China concedes, the United States and Russia engage in all out conflict. If China escalates, all states engage in tripolar all-out conflict.
- At **Node 6** there are two possibilities

- **A)** China, without prior knowledge of the United States' move at Node 5c, decides to concede, or escalate. If China concedes and if the United States concedes at 5c, Russia wins the game. If China chooses to escalate at this node, Russia and China engage in all-out conflict as the United States conceded at 5c.
- **B)** China, without prior knowledge of the United States' move at Node 5c, decides to concede, or escalate. If China concedes and the United States escalates at Node 5c, Russia and the United States engage in all-out conflict, as China's move of concession would result in its removal from the game. If, at Node 6b, China escalates, the resulting interaction is a tripolar, all-out conflict.

Overall, there are various pros and cons to this model. For instance, the simplicity of the model creates opportunities for easier analysis of escalation patterns in a tripolar conflict. On the other hand, simplicity poses issues when trying to simulate realistic and complex scenarios in today's environment. This model has the potential to devolve into all-out conflict in two moves, increasing the risk of nuclear warfare in short timeframes. This model also does not implement levels of limited conflict or options for de-escalation or de-mobilization. Therefore, players are restricted to escalatory options without the opportunity for a de-mobilization of forces. All these elements pose potential problems for analysis. Without limited conflict or options for de-escalation, this model increases the potential for escalatory trends and nuclear engagement. Regardless, tripolar game theoretic models provide an avenue for exploration due to their foundations in modeling strategic situations between multiple "players" engaged in a particular situation or "game". Formal modelling of games forces researchers to articulate any assumptions and conclusions from the model, stimulating unconventional thought in academia and professional environments.

Model Analysis

Understanding the definitions, assumptions, and game play of the preliminary tripolar model is essential for formulating possible outcomes through preference orderings. In this section, I aim to create various preference orderings for Russia, China and the United States based upon indicated types (Hard/Soft). From there, I will use the preference orderings and a form of mathematical backwards induction to produce possible results. I used two different sets of soft and hard preference orderings for each player based on current literature and research. There are 12 specific outcomes to a conflict between Russia, China, and the United States. The outcomes are then ranked to create the preference orderings for each player. The outcomes and associated preference orderings are as follows:

Outcomes:

1. Status quo (Russia concedes at node 1)
2. United States / China Concede (No conflict occurs)
3. Russia / China Limited Conflict
4. Russia wins
5. Russia / China All-Out Conflict
6. China wins
7. Russia / United States Limited Conflict
8. United States wins
9. Russia / United States All-Out Conflict
10. Tripolar Limited Conflict
11. Tripolar All-Out Conflict
12. United States / China All-Out Conflict

Preference Orderings:

Russia

Hard-

- US/C concede > Status quo > Russia wins > R/US Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > R/US All-Out > Tripolar All-Out > US/C All-Out > China wins > US wins

Soft-

- US/C concede > Status quo > Russia wins > R/US Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > China wins > US wins > US/C All-Out > R/US All-Out > R/C All-Out > Tripolar All-Out

United States

Hard-

- Status quo > US wins > R/US Limited Conflict > Tripolar Limited Conflict > R/C Limited Conflict > R/US All-Out > US/China All-Out > Tripolar All-Out > R/C All-Out > US/C concedes > China wins > Russia wins

Soft-

- Status quo > US wins > R/C Limited Conflict > R/US Limited Conflict > Tripolar Limited Conflict > US/C concedes > China wins > Russia wins > C/R All-Out > R/US All-Out > C/US All-Out > Tripolar All-Out

China

Hard-

- Status quo > China wins > R/C Limited Conflict > Tripolar Limited Conflict > R/US Limited Conflict > C/R All-Out > C/US All-Out > Tripolar All-Out > R/US All-Out > US/C concedes > US wins > Russia wins

Soft-

- Status quo > China wins > US/R Limited Conflict > R/US Limited Conflict > Tripolar Limited Conflict > US/C concedes > US wins > Russia wins > R/US All-Out > R/C All-Out > C/US All-Out > Tripolar All-Out

These orderings are based upon the preference set from ‘Perfect Deterrence’ without considering international treaties, tensions, alliances, or current geopolitical environments. To reiterate, when a player is hard, they prefer conflict to the opponent winning and when a player is soft, they prefer the opponent winning to conflict. These differences are depicted in the above preference orderings by placing the outcomes of opponents winning above all-out conflict for soft players and vice versa for hard players. It is important to note, the model is not limited to a specific preference set per player. The next set of preferences is based upon a combination of research from ‘Perfect Deterrence’ and existing literature. Those preferences are as follows:

Russia

Hard-

- US/C concedes > Russia wins > R/US Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > Status quo > R/US All-Out > R/C All-Out > Tripolar All-Out > US/C All-Out > China wins > US wins

Soft-

- US/C concede > Russia wins > R/US Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > Status quo > China wins > US wins > US/C All-Out > R/US All-Out > R/C All-Out > Tripolar All-Out

United States

Hard-

- Status quo > US wins > R/US Limited Conflict > Tripolar Limited Conflict > R/C Limited Conflict > R/US All-Out > US/C All-Out > Tripolar All-Out > US/C concedes > R/C All-Out > China wins > Russia wins

Soft-

- Status quo > US wins > R/C Limited Conflict > R/US Limited Conflict > Tripolar Limited Conflict > US/C concede > China wins > Russia wins > C/R All-Out > R/US All-Out > C/US All-Out > Tripolar All-Out

China

Hard-

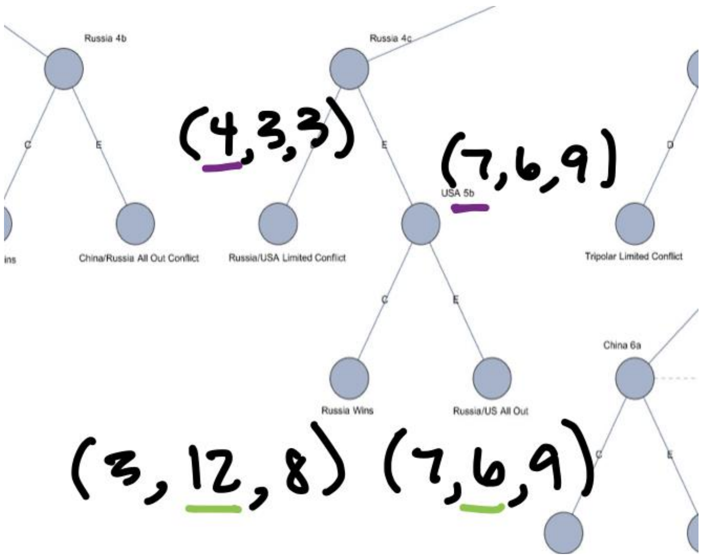
- Status quo > China wins > R/C Limited Conflict > Tripolar Limited Conflict > R/US Limited Conflict > C/R All-Out > C/US All-Out > Tripolar All-Out > US/C concedes > R/US All-Out > US wins > Russia wins

Soft-

- Status quo > China wins > US/R Limited Conflict > R/C Limited Conflict > Tripolar Limited Conflict > US/C concedes > US wins > Russia wins > R/US All-Out > C/R All-Out > C/US All-Out > Tripolar All-Out

There are distinct differences between the two preferences orderings. First, when Russia is hard or soft, I moved the outcome 'Status quo' from their second preferred outcome to their sixth preferred outcome. By definition of antagonist one, Russia's goal is to defect from the status quo. Therefore, 'Status quo' was ranked too high in the last round. I placed it before China or the US wins because we know from our assumptions that players prefer to lose at the lowest level of conflict. The position of outcome 'R/C All-Out' for the U.S., 'US/C All-Out' for Russia, and 'R/US All-Out for China also differs from the original set. Although the player technically loses at a higher level of conflict, a possible new deterrent caused the rankings to shift. For example, if the United States lost to the outcome 'R/C All-Out' conflict, they could become the next world superpower if Russia and China destroy each other in all-out strategic warfare. Therefore, a new deterrent arises for players exiting conflict hoping their adversaries destroy each other to a point of no economic or industrial return. After compiling these different sets of preference orderings, backwards induction was used to yield possible patterns and results.

To preform mathematical backwards induction, I gave each outcome a number based on the preference sets above. I then created ordered triples for each outcome on the model of the form (Russia, United States, China). For instance, from the first set of hard/soft preferences, the ordered pair for an outcome of 'Tripolar Limited Conflict' when Russia and the United States are hard, and China is soft would be (6, 4, 5) as tripolar limited conflict is Russia's sixth preferred outcome, U.S.'s forth, and China's fifth. I then started at the bottom of the model and analyzed preferred outcomes for the players at each node. Below is a visual of this process.



To further explain the above image, I started by finding the ordered triples for the outcomes 'Russia Wins' and 'Russia/US All-Out Conflict'. Based on the first set of preference orderings I provided, I found (3, 12, 8) for 'Russia Wins' and (7, 6, 9) for 'Russia/US All-Out Conflict'. I Then looked to see which player was deciding the outcome of that node and found the U.S. was deciding between conceding (Russia wins) and escalating (Russia/US All-Out) at node 5b. To figure out which outcome was more favorable, I looked at the U.S. preferences underlined in green. Six is lower than twelve so the U.S. ranked the outcome 'Russia/US All-Out' more favorable than 'Russia Wins'. Therefore, (7, 6, 9) moved up the 'ladder' to the next node. Russia is moving at node 4, so similarly, I ranked each outcome based on the preferences and looked at Russia's move favorable option underlined in purple. Four is lower than seven so the set (4, 3, 3) moves up to the next node and so on and so forth. Backwards induction allows game theorists to yield results for each specific game. Using this technique with a variety of ‘types’ and ‘preferences sets’ I was able to find probable results and analyze escalation patterns for a tripolar conflict involving Russia, China, and the U.S.

For each of the preference sets provided above, I analyzed results dependent on type. Below is a compilation of the types of games I played on the preliminary model.

	Russia	United States	China
Game 1	Hard	Hard	Soft
Game 2	Hard	Hard	Hard
Game 3	Soft	Hard	Hard
Game 4	Soft	Soft	Soft
Game 5	Soft	Hard	Soft
Game 6	Soft	Soft	Hard

Overall, I ran through twelve variations of the model. Six utilized the preference sets updated from ‘Perfect Deterrence,’ and six utilized the preference sets from ‘Perfect Deterrence’ and existing literature. There are distinct similarities and differences between both orderings.

Results

	Player Types (Russia, U.S., China)	Resulting Outcome
Preference Sets 1	(Hard, Hard, Hard)	Status quo
Preference Sets 1	(Hard, Hard, Soft)	US/C concede
Preference Sets 1	(Soft, Hard, Hard)	Status quo
Preference Sets 1	(Soft, Soft, Hard)	Status quo
Preference Sets 1	(Soft, Hard, Soft)	Status quo
Preference Sets 1	(Soft, Soft, Soft)	Status quo
Preference Sets 2	(Hard, Hard, Hard)	Tripolar Limited Conflict

Preference Sets 2	(Hard, Hard, Soft)	R/US Limited Conflict
Preference Sets 2	(Soft, Hard, Hard)	Status quo
Preference Sets 2	(Soft, Soft, Hard)	Status quo
Preference Sets 2	(Soft, Hard, Soft)	Status quo
Preference Sets 2	(Soft, Soft, Soft)	Status quo

Using backwards induction and comparing results, I found three-player escalation games appear to increase the potential for all-out conflict and the rate of escalation when there is no option for de-escalation or de-mobilization. Further, when all players are soft, tripolar all-out conflict is the least probable outcome. Since soft players prefer the opponent winning to conflict, it is not surprising that the probability of using of all readily available strategic forces on an adversary is low. Similarly, analysis found when all players are hard, tripolar all-out conflict is the least probable outcome no matter what route is taken. Although, other forms of all-out conflict are still possible. Originally, I hypothesized the risk of all-out strategic conflict will increase in a tripolar environment and the timeframe for de-escalation will decrease. While bipolar all-out strategic conflict continues to become plausible in a tripolar environment, surprisingly, tripolar all-out conflict decreased in probability. To further analyze this outcome, there may be a deterrent to having three near-peer nuclear competitors. For instance, one player can ‘step back’ and watch as the other two players ‘kill’ each other. With depleted resources and the need for rebuilding economically and militarily, the player who didn’t enter conflict has the potential to become the next superpower. Therefore, a deterrent arises for initiating all-out conflict in a tripolar environment. It is important to note, tripolar all-out conflict was probabilistically higher using the first set of preference ordering than the second. Therefore, international treaties, arms agreements, and deterrence have decreased the likelihood of tripolar nuclear warfare according to my model. The first set of preference orderings found a high probability in maintaining the status quo. I believe this correlation is due to Russia ranking the status quo higher themselves winning. While this ranking does not line up with our definition of antagonist one defecting from the status quo I believe it produces valuable insight. Simply using the preference orderings from the bipolar models in ‘Perfect Deterrence’ does not produce reliable results. Therefore, it is imperative to extend previous research efforts to create new analytic techniques for evaluating tripolar deterrence and escalation dynamics. Lastly, analysis revealed, a player who moves first out of a state of conflict has an advantage as well as a higher probability of ending the game with one of their preferred outcomes. In other words, a player who initiated conflict was more likely to ‘win’ the conflict over the other players. Understanding various advantages through game theoretic models can assist policy analysts in creating new strategies for both deterrence and offensive mobilization. While this model lacks elements of levels of limited conflict, de-mobilization, and extended time frames, I believe this research provides an avenue for decision makers to further unconventional thought and analyze possible strategies and deterrence failures. Moving forward, a possible hypothesis is tripolar deterrence will act as a chaotic system that is continually changing and sensitive to initial conditions.

Future Avenues

In the future, this research can be extended for further analysis. New models can be built to implement levels of limited conflict, de-escalation measures, and extended time frames for more realistic tripolar scenarios. The drawback of increasing complications and adding new elements is complexity, which makes analysis difficult. For instance, analytical techniques like backwards induction may become impossible with increased complexity. Therefore, finding new analytic techniques is imperative. Programming languages and agent-based modeling techniques could provide new avenues for analysis. Another future research pathway is building a model for coordinated players. Coordination between players is entirely possible during tripolar conflict. For instance, Russia and China may coordinate their interests and goals against the U.S. Building a model to analyze the impacts of this scenario could provide insightful new analysis for deterrence strategies. Lastly, my analysis was confined to set preference orderings and players maintaining a certain type throughout the game. Changing player types throughout the game as well as their preference orderings would provide a holistic review of possible outcomes. Comparing all possible scenario outcomes would reduce ambiguity and uncertainty as well as provide insight to tripolar escalation patterns.

Policy Implications

The bottom line is results prove a need for new deterrence strategies and thought. Possible solutions include creating nuclear arms treaties between Russia, China, and the U.S. This option is of high risk as China historically has been reluctant to form or join arms treaties. Further, NewSTART has recently been suspended by Russia. Russia's suspension of NewSTART jeopardizes the last remaining pact that regulates the world's two largest nuclear arsenals. Not only could this suspension increase the possibility of proliferation but also may rekindle a Cold War and force other nuclear armed states to pick a side, further complicating deterrence. Another possible option is to foster the enforcement of international treaties. Again, this option contains risk as China has been reluctant to enter agreements in the past and Russia has just suspended the last remaining nuclear arms treaty between the two superpowers. Lastly, western powers could increase cooperation through economical and industrial investment. Interconnected economies provide a deterrent from conflict as well as decrease credibility of strategic attack. If economies are intertwined, the cost of warfare increases for all states involved. Overall, game theoretic models provide a framework for analyzing and spurring unconventional thought to study changing deterrence strategies and tripolar escalation dynamics.

Conclusion

The People's Republic of China will soon join the United States and the Russian Federation as a nuclear peer or nuclear near-peer. Traditional deterrence policies are rooted in bipolarity necessitating a need for new analysis and strategies. Game theoretic models provide an avenue for tripolar exploration due to their foundations in modeling the actions and motives of players engaged in a particular situation or 'game'. Researchers are forced to articulate assumptions and conclusions through modeling therefore forcing new insight and analysis. Previously, game theorists have applied theory to bipolar deterrence. Specifically, Zagare and Kilgour in 2000 presented an asymmetric escalation game to study the dynamics of bipolar deterrence. Their research could be broadened to apply to multi-player frameworks, specifically possible tripolar scenarios between Russia, China, and the United States. This research was designed to broaden previous models to encapsulate three-players in an asymmetric escalation game. I hypothesized the risk of all-out strategic conflict will increase in a multipolar environment and the time frame for de-escalation will decrease. While the model presented didn't implement extended time frames, future research and analysis can be built from my preliminary model to incorporate these elements. Through mathematical backwards induction, results proved a need for new deterrence strategies. Without de-escalatory option, tripolar models increase the potential for all-out conflict and the rate of escalation. If all players prefer the opponent wins to conflict, tripolar all-out conflict is the least probable outcome no matter what route is taken. If all players prefer conflict to the opponent winning, the potential for nuclear escalation increases but the probability of tripolar all-out conflict decreases. Lastly, a player who moved first out of a state of conflict has a higher probability of ending the game with one of their preferred outcomes. Overall, results indicate a need for focus on tripolar deterrence and escalation dynamics in both academia and industry. Game theoretic models of multipolar deterrence interactions provide tools to diagram strategic situations and analyze tripolar conflict in the lens of deterrence and escalation.

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