Game Theory in Cold War

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ABSTRACT

This paper provides a context of game theory in the cold war that lasted for four decades. The paper models the game and provides a solution to the game. It defines the players, the action spaces, and the path chosen by each player in real-life leading to a stalemate between the two superpowers. The paper models and solves the Cuban Missile Crisis as well.

KEYWORDS

Cold War, USA, Soviet Union

ACM Reference Format:
Usman Malik, Amna Shafiq, and Musa Ishaq. 2023. Game Theory in Cold War. In *Proc. of the 22nd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2023), London, United Kingdom, May 29 – June 2, 2023*, IFAAMAS, 5 pages.

1 INTRODUCTION

1945 marked the beginning of a time period filled with proxy wars, spy-craft, espionage, and the struggle toward world dominance between two superpowers. The United States of America (USA) and the Soviet Union (USSR). The three major players on the allies' front during WW2 met in Postdam in 1945 to agree on terms to conclude WW2 and decide on post-war Europe. Britain, USA, and USSR met in Postdam in 1945 which kick-started the cold war. Within 18 months of this meeting, the cold war officially began lasting almost four decades finally coming to an end in 1991 with the fall of the Soviet Union.

But how did it begin in Postdam? During the meeting, US President Harry Truman took Joseph Stalin, the leader of the Soviets, aside and told him about the recent development of the nuclear arsenal of the US capable of destroying cities with just one blow. This little piece of information kick-started the race to arms and the cold war itself. Soon after this, the US used two bombs in Japan totally destroying the two cities of Hiroshima and Nagasaki.

Proc. of the 22nd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2023), U. Malik, A. Shafiq, M. Ishaq, May 29 – June 2, 2023, London, United Kingdom.

This showed the world that the US was the superpower dominating the world. USSR didn't like the US getting the upper hand and started to build its own arsenal of weapons of mass destruction. The cold war was filled with espionage, spy-craft, proxy wars all over the globe, and the race to dominate the world. The major highlight of the cold war era is the Cuban missile crisis in 1962 when the world almost saw a full-out nuclear war between the US and the USSR.

It started with the USSR installing weapons of mass destruction in communist Cuba just 90 miles south of Florida. US president John F. Kennedy warned USSR to dismantle the weapons and withdraw. If the US was attacked then a nuclear strike on USSR would be the immediate response from the US. Eventually, after a tense standoff and negotiations, USSR agreed to dismantle and withdraw the weapons from Cuba. The US agreed to not invade Cuba and to dismantle its nuclear weapons in Turkey. This was the closest the world came to a nuclear war between the two superpowers at the time.

2 MAJOR EVENTS

On Saturday, October 27, 1962, as the world was on the verge of a nuclear war, John F. Kennedy proposed a deal to Nikita Khrushchev. If the Soviets withdraw their missiles, the United States would publicly promise not to invade Cuba while privately promising to remove Jupiter missiles from Turkey. He didn't want people to know about the latter concession because it would make him look weak. Khrushchev concurred. The world was spared.

In late October 1969, Richard Nixon and Henry Kissinger ordered a squadron of nuclear-armed B-52 Strato fortresses to race toward the Soviet Union's border. They zigzagged along the edge of Soviet airspace for three days, taunting Moscow. This was part of a deliberate White House strategy to persuade the USSR that Nixon and Kissinger were just a little crazy. The prevailing side in many negotiations is the one most willing to take the fatal step.

If the Soviets believed Nixon and Kissinger were capable of unleashing Armageddon, they might be more willing to give ground in talks over.

During a particularly tense period in the Cold War, Soviet observers observed planes carrying what appeared to be taxiing out of their hangars in November 1983. Shortly after, NATO command centers exchanged a flurry of communication, and, after receiving reports that their Soviet adversaries had used chemical weapons, the United States decided to increase readiness to DEFCON 1. Concerned about a preemptive strike, Soviet forces prepared to launch nuclear weapons.

A variant of an annual military training exercise began with a change in Soviet leadership and culminated in the Soviet invasion of several European countries. It lasted five days and culminated in NATO using nuclear weapons. The event piqued the interest of Soviet intelligence, which suspected the US of carrying out a nuclear strike under the guise of a drill. Able Archer's realism was ironically effective: it was designed to simulate the start of a nuclear war, and it nearly succeeded.

3 GAME MODEL

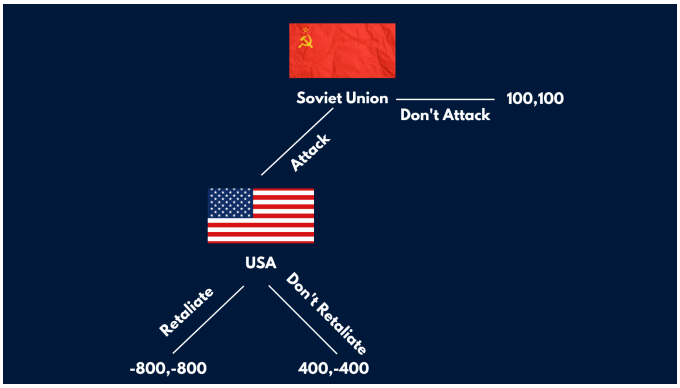

Figure 1: The game model

In this game, the Soviet Union makes the first move (doesn't matter who goes first). Now the Soviet Union has two options:

(1) ***Attack***
(2) ***Don't Attack***

If the Soviet Union chooses Don't Attack then the game ends in a stalemate where no nuclear weapons are used. If the Soviet Union chooses Attack then the US gets two options:

(1) ***Retaliate***
(2) ***Don't Retaliate***

The game has the following players and action spaces:

(1) Players = [***"SOVIET UNION", "USA"***]
(2) Action Space **SOVIET UNION** = [***"Attack", "Don't Attack"***]
(3) Action Space **USA** = [***"Retaliate", "Don't Retaliate"***]

The game is represented in a Normal Form below.

Soviet Union	USA	
	Retaliate	*Don't Retaliate*
Attack	*-800, -800*	*400, -400*
Don't Attack	*100, 100*	*100, 100*

Figure 2: The game in normal form

The payoffs are as below:

(1) If the Soviet Union chooses to ***Don't Attack*** the game ends in a stalemate and both players get a payoff of ***100***.

(2) If the Soviet Union chooses to ***Attack*** and the US chooses to ***Don't Retaliate*** then the Soviet Union gets a payoff of ***400*** whereas the US gets a payoff of ***-400***.

(3) If the Soviet Union chooses to ***Attack*** and the US chooses to ***Retaliate*** then the game results in a nuclear war destroying everything with both the nation getting a payoff of ***-800***.

4 SOLVING THE GAME

The Soviet Union beings the game. It has the option to choose ***Don't Attack*** and get a payoff of ***100*** or choose ***Attack*** and get a payoff of ***X*** as it needs to know what will the US pick so it can get a payoff of ***400*** or ***-800*** depending on what the US chooses.

Now for the turn of the US, it can choose to ***Retaliate*** and get a payoff of ***-800*** or choose ***Don't Retaliate***

and get a payoff of ***-400***. Since ***-400*** is better than ***-800*** it will choose to ***Don't Retaliate*** if the Soviet Union chooses to ***Attack*** the US.

So the solution here is; the Soviet Union will choose to ***Attack*** since the US will choose ***Don't Retaliate*** meaning the Soviet Union will get a payoff of ***400*** and since ***400*** is better than ***100*** it will choose ***Attack***. So the final solution of the game is the Soviet Union attacking the USA and the USA choosing to not retaliate.

But this solution doesn't really make sense. What if the US can make the Soviets believe that if the Soviets attack the US then the US will choose to Retaliate? No rational player will pick -800 over -400 but if the US can make the Soviets believe that it is using the madman strategy or the doomsday device then the game changes totally.

Now the Soviets believe the US will choose to ***Retaliate*** if the Soviets choose to ***Attack***. If this is the scenario then the Soviets will receive a payoff of ***-800***. It can now choose to ***Attack*** and get a payoff of ***-800*** or it can choose to ***Don't Attack*** and get a payoff of ***100***. Since ***100*** is better than ***-800***, it will choose to ***Don't Attack***. The game will end in a stalemate with both players getting a payoff of ***100***.

5 MODELING THE CUBAN MISSILE CRISIS

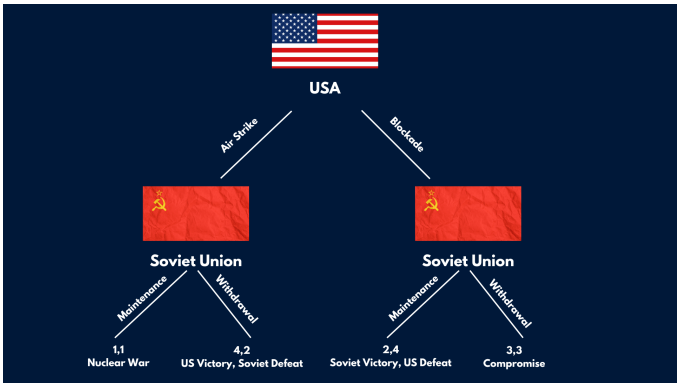

Figure 3: The game model

In this game, the US makes the first move. Now the US has two options:

(1) ***Air Strike***
(2) ***Blockade***

Whatever the US chooses the Soviets get two options:

(1) ***Withdrawal***
(2) ***Maintenance***

The game has the following players and action spaces:

(1) Players = [***"SOVIET UNION", "USA"***]
(2) Action Space **SOVIET UNION** = [***"Withdrawal", "Maintenance"***]
(3) Action Space **USA** = [***"Air Strike", "Blockade"***]

The game is represented in a Normal Form below.

Soviet Union	USA	
	Blockade	*Air Strike*
Withdrawal	*(3,3) Compromise*	*(4,2) US Victory, Soviet Defeat*
Maintenance	*(2,4) Soviet Victory, US Defeat*	*(1,1) Nuclear War*

Figure 4: The game in normal form

The payoffs are as below:

(1) If the US chooses ***Air Strike*** and the Soviet Union chooses ***Maintenance*** then it results in a nuclear war.

(2) If the US chooses ***Air Strike*** and the Soviet Union chooses ***Withdrawal*** then the Soviet Union gets a payoff of ***2*** whereas the US gets a payoff of ***4*** resulting in a US victory and a defeat for the Soviets.

(3) If the US chooses ***Blockade*** and the Soviet Union chooses ***Maintenance*** then the Soviet Union gets a payoff of ***4*** whereas the US gets a payoff of ***2*** resulting in a Soviet victory and a defeat for the US.

(4) If the US chooses ***Blockade*** and the Soviet Union chooses ***Withdrawal*** then both nations get a payoff of ***3*** resulting in a compromise.

6 SOLVING THE CUBAN MISSILE CRISIS

The US beings the game. It has the option to choose ***Air Strike*** and get a payoff of X as it needs to know

what will the Soviets pick so it can get a payoff of ***4*** or ***1*** depending on what the Soviets choose. Or the US can pick ***Blockade*** and get a payoff of ***2*** or ***3*** depending on what the Soviet Union chooses.

Now for the turn of the Soviet Union, it can choose ***Maintenance*** and get a payoff of ***4*** or ***1*** depending on what the US picked. Or it can choose ***Withdrawal*** and get a payoff of ***2*** or ***3***.

Now let's assume the US picks ***Blockade***. The Soviets can now choose ***Withdrawal*** and get a payoff of ***3*** or they can choose ***Maintenance*** to get a payoff of ***4*** and win the game. Since 4 is better than 3 the Soviets will choose ***Maintenance*** if the US chooses ***Blockade***.

Now let's assume the US picks ***Air Strike***. The Soviets can now choose ***Withdrawal*** and get a payoff of ***2*** or they can choose ***Maintenance*** to get a payoff of ***1***. Since 2 is better than 1 the Soviets will choose ***Withdrawal*** if the US chooses ***Air Strike***.

So what will the US pick? The US can choose ***Air Strike*** and get a payoff of ***4*** since the Soviet Union will pick ***Withdrawal***. Or it can choose ***Blockade*** and get a payoff of ***2*** as the Soviet Union will pick ***Maintenance***. Since 4 is better than 2 the US will choose ***Air Strike***.

So the solution here is; the US will choose ***Air Strike*** and the Soviet Union will choose ***Withdrawal*** resulting in a US victory and a soviet defeat. But this didn't happen in real events. There was a compromise between the nations. The US implemented a madman strategy and convinced the Soviets that it will attack the Soviets if they don't withdraw.

This led to a compromise between the nations as the Soviets made the US believe the Air Strike will end up in a nuclear war. So the threat of a nuclear war acted as a deterrent and led to a compromise between the nations where the US agreed not to invade Cuba and the Soviet Union dismantled its nuclear weapons in Cuba.

7 IMPLEMENTATION

The game has been modeled in python. The Soviet Union gets to make the first move. The US is given a turn to choose if the Soviet Union chooses to Attack. The game lets the players know about the results, the payoffs, and the consequences of their choices. The game also outputs the nash equilibrium for the game which is:

(1) ***100,100 (Don't Attack)***
(2) ***400, -400 (Attack, Don't Retaliate)***

8 LIMITATIONS

Game theory cannot account for the fact that in some situations we may fall into a Nash equilibrium, and other times not, depending on the social context and who the players are. Game theory assumes that each firm has knowledge of the strategies of the other as against its own strategies and is able to construct the pay-off matrix for a possible solution. This is a highly unrealistic assumption and has little practicability.

In the case of the cold war, both nations didn't know what the other nation will pick but they both played the game in their head. Speculating and anticipating the moves of the opponent in the head enabled both nations to construct a possible roadmap of the game and strategize accordingly. But what if the anticipation is incorrect? For example what if the Soviet Union anticipated the US conducted an airstrike during the Cuban missile crisis and actually move ahead with the initial threat instead of a naval blockade as the first line of offense? This could have led to a quicker withdrawal of the Soviets or maybe a possible nuclear war.

9 NO NUCLEAR WEAPONS

Nuclear weapons acted as a deterrent during the four decades of the cold war preventing both sides from attacking each other. What if we take nuclear weapons out of the equation? How would have the players acted then? Well, let's assume there are no nuclear weapons. The Soviet Union makes the first move and can choose to ***Attack*** the US and the US will choose ***Don't Retaliate*** since according to the game model shown in Figure 2, the payoff of -400 is better than -800 for the US. The Soviet Union will choose to ***Attack*** as it knows the US will not retaliate and for the Soviet Union, 400 is better than 100 hence it will choose to ***Attack*** the US.

Now there is no madman strategy at play here. There is no nuclear deterrent preventing war as a conventional war may or may not be beneficial for either nation. Yes, war is costly and bad for the economy but either nation can profit at the expense of the other if

the US acts irrationally and enters into a war with the Soviet Union instead of the rational choice of not retaliating. But since there is no nuclear deterrent or the doomsday device at play here war is possible.

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