Decision Making with LBA Assignment

Will Russia Invade Ukraine?

Minerva Schools at KGI

CS51: Formal Analyses

Prof. B. Richard

April 11, 2021[1]

MINERVA®

[1] **#professionalism:** I used consistent font type and size throughout the paper, followed the APA guidelines to make it look presentable. I included a title to indicate what this work is about. I included all the relevant parts of the assignment as stated by Minerva faculty. I included bibliography with reliable sources. Also, I used formal speech and checked the work for grammar mistakes and typos.

Contents

Will Russia Invade Ukraine?

Location-Based Inspiration

Starting with annexing the peninsula Crimea and seizing the eastern regions of Ukraine, Russia tuned into war with Ukraine (see Figure 1 for more information). On April 2nd, 2021, Ukrainian president Volodymyr Zelenskyy had a phone call with American president Joe Biden who agreed to affirm "unwavering support for Ukraine's sovereignty and territorial integrity in the face of Russia's ongoing aggression in the Donbas and Crimea" (Statements and Releases, 2021). A few days later, on April 9th, Russia concentrated armed troops at the eastern border of Ukraine. The whole country became worried about the potential massive attack.

Figure 1. The timeline describing the main events in the Russo-Ukrainian War from the beginning of 2014 till the most recent time of 2021 (own figure).

Overwhelmed by the current situation, I visited the Consulate General of Ukraine in San Francisco to reach out to locals to learn more about the problem and empathize with other Ukrainians outside of the country (Figure 2).

Figure 2. Selfie at the Consulate General of Ukraine in San Francisco (own photo).

Game Theory

Introduction to the Game

We designed the game based on a true story according to the proposed scenario for the assignment. The US government agreed with Ukraine to save the latter's sovereignty and territorial integrity in light of Russia's interventions. In addition to Russia's attacks in Crimea and the East, the country significantly increased the number of armed troops at the border. We may guess that president Putin has intentions to seize the whole Ukrainian territory. If the US represents the side of Ukraine, then the question is whether Russia will try to invade Ukraine. Therefore, we have two players: the USA and Russia. Each model agent has the following policies to choose from when making a decision:

I. The United States:
   A. KA - keep agreement → aid Ukraine and sanction Russia;
   B. BA - break the agreement and not intervene.

II. Russia:
   A. AU - attack Ukraine;
   B. WF - withdraw the forces.

Payoff Matrix

Analyzing payoffs in the political context is complex since numerous factors affect the agents' decision-making: economic, geopolitical, historical, cultural. We will assume that the economic and geopolitical factors are the most crucial; therefore, focus our analysis on identifying payoffs within these two dimensions. Mainly, we determine how many gains the

players have in the economic and geopolitical frameworks. We measure the payoffs on a scale from 1 to 4 in terms of gains:

- 1 is the worst outcome with no gains;
- 2 is next to the worst product with little gains;
- 3 is next to the best situation with substantial gains;
- 4 is the best one with 100% gains (or the gains are so superior they override some losses so that we neglect them).

Explanation of the Payoffs for Each Possible Outcome[2]

1. BA - AU: For Russia, this is the best possible result since they have enough forces to invade Ukraine and obtain another territory with many financial growth areas. For the US, this is next to the worst outcomes. Though they do not experience economic losses, they have high geopolitical costs. The international rights are violated, and their promises proved meaningless.
2. BA - WF: If both agents withhold from the plans, then there would likely be a parliamentary reform to restore the previously damaged territories - Crimea and the East - and prepare to enter the European Union. Russia would experience both geopolitical and economic losses since Ukraine would not be under its control anymore, thus restricting access to its free trade zone, which would diminish the Russian economy. On the other hand, it is the US's best

[2] Note that the process of assigning payoffs was inspired by the paper "Ukraine Crisis 2014: A Study of Russian-Western Strategic Interaction" written by Richard E. Ericson and Lester A. Zeager. Here, they explain the payoffs on a scale from 1 to 9 by providing the same dimensions - economic and geopolitical. However, instead of the West as a player, I am considering the United States and thinking about the payoffs in terms of their position.

outcome because their economic costs are low, the international norms are satisfied, and relations with Russia are not spoiled by implementing sanctions.

3. KA - AU: This is the state of WW3. Russia is invading Ukraine but suffers more losses than in BA - AU since the US give military aid to Ukraine and significantly sanction Russia. By helping Ukraine, the US also gains the West's support since Ukraine serves as a bridge for Russia's attacking the EU.
4. KA - WF: This outcome is one of the worst for Russia. After withdrawing their forces, they suffer economic losses because of the US' sanctions and do not gain anything geopolitically (as outlined in BA - WF). The US suffer severe economic losses because they sponsor Ukrainian growth. However, they gain from sanctioning Russia and winning trust of other countries by keeping the promise.

The payoffs for each outcome are shown in Table 1.

USA	**Russia**		
		Attack Ukraine	**Withdraw the forces**
	Keep agreement	**(3, 2)**	**(2, 1)**
	Break Agreement	**(2, 4)**	**(4, 1)**

Table 1. The payoff matrix between the USA and Russia. The payoffs for the USA are bolded in red; the payoffs for Russia are bolded in blue. The range of payoffs is from 1 to 4 in terms of gains, where 1 is the worst outcome with no gains, 2 is next to the worst outcome with little gains, 3 is next to the best situation with substantial gains, and 4 is the best one with no losses (or the gains override some loses so that we neglect them).

Players' Strategies

We will first look at the US' strategy. If Russia attacks Ukraine, then the US' best approach is to keep the agreement because the payoff of 3 is greater than 2; however, if Russia is to withdraw the forces, then the US' best strategy is to break the promise because the payoff of 4 is greater than 2 (Table 2). So, given what Russia is doing, the US has a different best response. Therefore, instead of looking at the US, we will look at Russia's strategies.

USA	Russia	
	Attack Ukraine	Withdraw the forces
Keep agreement	(3, 2)	(2, 1)
Break Agreement	(2, 4)	(4, 1)

Table 2. The best strategies for the USA (highlighted in yellow). The arrows show which payoff is greater. We see that there are no strictly dominant strategies; thus, we have to base our choice on Russia's actions.

Russia would never want to withdraw the forces because attacking Ukraine always produces a greater payoff: 2 > 1 if the US keeps agreement, and 4 > 1 if the US breaks agreement (Table 3). So, AU strictly dominates the WF.

USA	Russia	
	Attack Ukraine	Withdraw the forces
Keep agreement	(3, 2)	(2, 1)
Break Agreement	(2, 4)	(4, 1)

Table 3. The best strategies for Russia (highlighted in purple). The arrows show which payoff is greater. The result indicated that attacking Ukraine is a strictly dominant strategy. Thus, we can eliminate the choice of withdrawing the forces to simplify the game.

Thus, regardless of what the US does, Russia would always want to attack. If the US knows that Russia acts rationally, then the US can infer that Russia would never withdraw its forces. Therefore, the US should choose the strategy that gives them a better payoff - keep agreement because it strictly dominates the 'break agreement' strategy (3 > 2). This leaves us with the solution: KA - AU (Table 4).

USA	**Russia**	
		Attack Ukraine
	Keep agreement	(3, 2)
	Break Agreement	2

Table 4. The final result of the iterated elimination of strictly dominated strategies (highlighted in blue). The arrow shows the last step in eliminating the breaking agreement strategy since the payoff of 3 is greater than 2 for the US.

Nash Equilibria

To find the Nash equilibrium, we check each state and find the one where none of the players have an incentive to change their strategy. After comparing payoffs at each outcome in this asymmetric game, we find only one pure Nash equilibrium at KA - AU (see Table 5). This proves that any dominant strategy equilibrium is always a Nash equilibrium. However, since there is an odd number of Nash Equilibrium - precisely one, we do not have any mixed strategy Nash Equilibrium.

	Russia		
		Attack Ukraine	Withdraw the forces
USA	Keep agreement	(3, 2)	(2, 1)
	Break Agreement	(2, 4)	(4, 2)

Table 5. The Nashville Equilibrium in the game between the USA and Russia. The Nashville Equilibrium, highlighted in green, happens at the state KA ('keep agreement') and AU ('attack Ukraine'). The yellow arrow with a black cross shows that the USA has no incentive to move from KA to BA. The purple arrow with a black cross shows that Russia has no incentive to move from AU to WF, respectively.[3]

[3] **#gametheory:** I modeled the game involving two players based on the real situation and justifying the scenario by providing relevant context. I precisely explained the assigned payoffs on a scale from 1 to 4 and created a payoff matrix. I identified the best strategies for each player and showed the process of the iterated elimination of strictly dominated strategies in detail. I found the Nash equilibrium and explained what it means for the players' decision-making - no of them has an incentive to move from that point.

Decision Trees and Probabilities

Decision Tree Demonstration

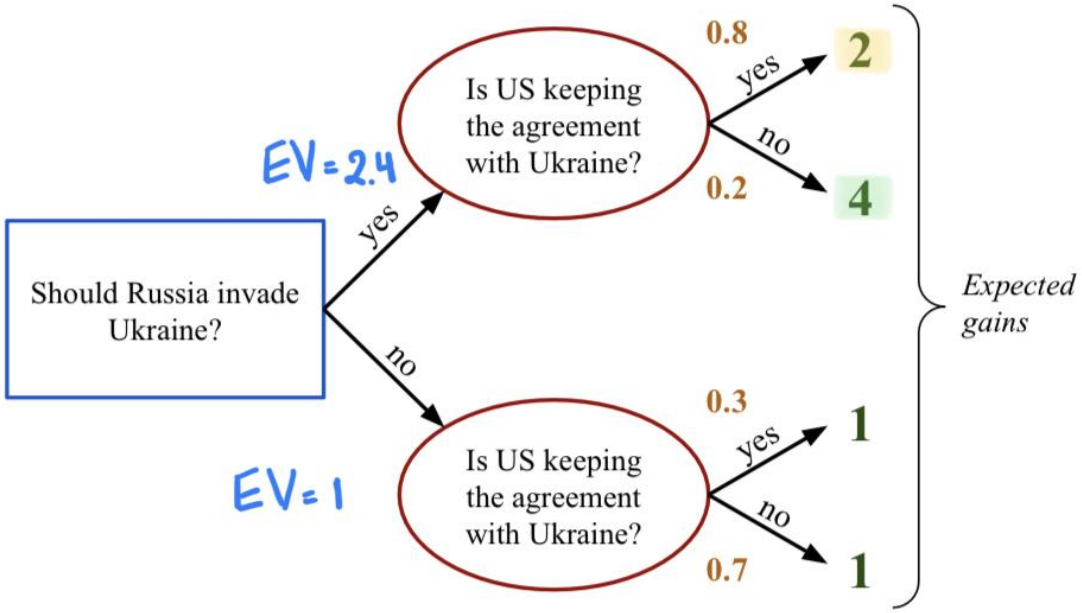

Figure 3. This is a binary decision tree on whether Russia should invade Ukraine. The tree provides two choices: attack Ukraine or withdraw the forces. The choice can be made based on two more binary decisions - is the US keeping the agreement with Ukraine? The values of the expected gains were taken from the payoff matrix and displayed at the endpoints.Using different strategies (explained) later, we can make a choice. The maximax result is highlighted in green, the maximin result is highlighted in yellow. The expected values are written on the left in blue.

Explaining the Probabilities

Russia acts as a rational agent; thus, the country understands that there is little incentive for the US to keep the agreement and help Ukraine if Russia is withdrawing the forces. The only gains would come from sanctioning Russia and saving authority. We would not assign much

weight to these; thus, the US's probability of keeping the agreement when Russia withdraws is 0.3. However, there is motivation to aid Ukraine if Russia decides to attack. The only loss would be from helping Ukraine, but sanctioning Russia would repay the part of it. Therefore, the probability of the US keeping the agreement when Russia attacks is 0.8. We calculate the remaining probabilities by subtracting these from one.

Strategies Interpretation

Maximax

Maximax is the optimistic strategy where Russia, acting as a risk-seeking player, will choose the decision that maximizes its gains. The maximum payoff at 4 occurs when Russia decides to invade Ukraine and the US breaks the agreement. Although there is a slight probability of an event happening, we ignore this value at making the decision.

Maximin

Maximin is the pessimistic strategy where Russia, acting as a risk-averse player, will choose the decision that maximizes its minimum gains; thus, selecting the best worst-case scenario. The minimum payoffs for each decision are 1 and 2. Since 2 is greater than 1, we choose the strategy to invade Ukraine.

Expected Value

Expected value is the only strategy that uses the probabilities to find the optimal solution. We calculate it by multiplying each possible outcome of the uncertain alternative by its probability and summing the results:

I. If Russia decides to invade:

   A. EV1 = 0.8 * 2 + 0.2 * 4 = 2.4

II. If Russia withdraws:

A. EV2 = 0.3 * 1 + 0.7 * 1 = 1

Since the expected value of attacking Ukraine is higher (2.4 > 1), Russia will choose this option.

Final Decision

Russia would gain the most when invading Ukraine since this choice gives it the greatest expected value and satisfies both the maximal and the maximin strategies.

Hiring a Spy

To ensure the chosen strategy is correct, Russia might decide to hire a spy and send them to the US to acquire additional information about the outcomes. Now, we have a further decision to make: should we hire a spy? If we do not hire him, we will follow the original decision to attack Ukraine. If we decide to hire him, we have to consider how successful they have been in the past situations and how much it would cost to hire them. We suppose the spy could give two reports: a positive one with maximizing the payoffs - attack, or a negative one - withdrawal. We could assign probabilities to acquire each outcome and then paste chance nodes as an original decision tree with the posterior probabilities after performing the tree fleeping. We calculate the posterior using the Bayes theorem and updating the prior beliefs by using the conditional probabilities:

$$P(Event \mid Effect) = \frac{P(Event \,\&\, Effects)}{P(Effect)}$$

Using path probability, we can then calculate the expected value of both the positive and the negative reports the spy can produce. If the expected value of the additional information and the cost of hiring the spy is higher than our expected value of 2.4, we can hire a spy. If the value

is the same or less, then there is no point in getting him since the value of imperfect information cannot be worth more than perfect information.[4]

Cognitive Biases

One of the biases that may arise and skew the agents' decision-making is the probability distortion when we tend to either misperceive probabilities - the certainty effect - or assign too much weight to them - the possibility effect (see Figure 4). Since we are thinking about payoffs in terms of gains, agents could experience the certainty effect when acting as risk-averse because they diminish the marginal returns. If the agents are risk-seeking, they fall under the influence of the possibility effect. In our case, Russia and the US will likely act as risk-averse players since the scenario involves human lives and international relations, thus, experience the certainty effect. Therefore, they will assign higher probabilities to their unfavorable events (Russia - to the US keeping the agreement and the US - to Russia attacking Ukraine) to avoid the risks even if they know the probabilities are lower than they assume. [5]

[4] **#decisiontrees:** I created a clear decision tree to break down Russia's complex decision of whether attacking or withdrawing into smaller steps. I applied three strategies to find the best solution: maximin, maximax, and expected value. I justified the use of each and explained what it means for an agent to use each. Then, I added information to the scenario to consider - whether Russia should hire a spy. I explained how we can calculate the expected value of the sample information and use it to decide whether the cost of hiring the spy and the EV of the imperfect information will outweigh the value of the perfect information. If not, then there is no value in hiring them.

[5] **#expectedutility:** I explained what the probability distortion is and how it can affect the players' decision. I acknowledge the players' behaviors under thinking in terms of gains: they are acting as risk-averse with the certainty effect and as risk-seeking with the possibility effect. I show the graph that visualizes the effects compared to the true probabilities. Since the probabilities are affected, our expected utilities would change as well since the utility function calculation includes the probability weights.

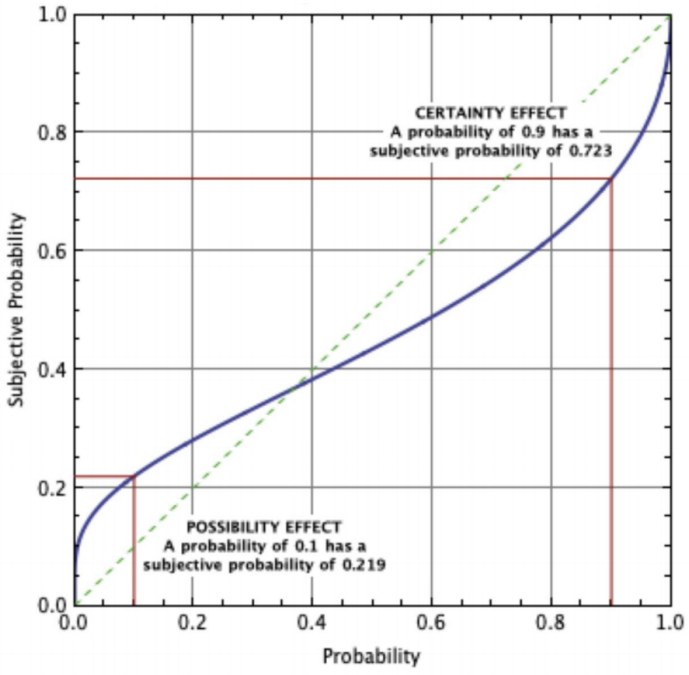

Figure 4. The probability weighting function graph: $w(p) = e^{-(-\ln p)^{0.5}}$. *The green dashed line indicates the true probability. The solid blue curved line indicates the subjective probability as a function of the true probability. At low probability values the values of subjective probability are greater than of the true one which shows the possibility effect of assigning more weights to lower probabilities. At high probability values the curve is below the true probability which illustrates the certainty effect, when we misperceive the probabilities (Terrana and Wilkins, 2020).* [6]

[6] **#probability:** First, I assigned relevant to the scenario probabilities when constructing a decision tree and justified my choices. I then used them to calculate the expected values of both Russia's decisions. WHen considering whether to hire a spy, I implemented the Bayes' theorem and explained how it is helpful to use to update our prior beliefs and get the posterior probabilities when using the conditional ones. Also, when considering the probability distortion, I explain how our biases influence how we assign the weights to the probabilities of the event occurring.

Reflection

This paper analyzed the rational decision-making process of the players Russia and the US representing the interests of Ukraine. After assigning the payoffs, we found the best strategy for each player when operating the iterated elimination of strictly dominated strategies. We confirmed the choice when computing the decision tree strategies: maximax, maximin, and expected value. We analyzed how acquiring additional information could help and what biases could affect the decision-making process. Finally, we obtained the 'best' decision to maximize the gains of agents. However, we acknowledge that in reality, this process would be more complicated and potentially include third parties as the European Union.

While completing this assignment, I gained more understanding of the material in practice. Creating a game helped to deepen my knowledge of how rational agents think. Furthermore, applying the scenario to a real topic of the current interest and researching more about the problem, I understood better why it is beneficial to Russia to continue the attack, unfortunately. The benefit of applying all the learned strategies was to practice making decisions with the information presented. The limitation, though, is that more agents are usually involved in real life; the payoffs and the probabilities I found reasonable may not be applicable in reality.

Word count: 1820 words.

References

Eriscon R. and Zeager L. (March 27, 2015). Ukraine Crisis 2014: A Study of Russian-Western Strategic Interaction. *De Gruyter*. https://www.degruyter.com/document/doi/10.1515/peps-2015-0006/html

Terrana, A. and Wilkins, J. (February, 2020). Utility, Expected Utility, and Risk. *Minerva Schools at KGI*. https://course-resources.minerva.kgi.edu/uploaded_files/mke/00217516-2225/utility--expected-utility--and-risk.pdf

The United States, Statements and Releases (April 2, 2021). Readout of President Joseph R. Biden, Jr. Call with President Volodymyr Zelenskyy of Ukraine. *The White House*. https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/02/readout-of-president-joseph-r-biden-jr-call-with-president-volodymyr-zelenskyy-of-ukraine/

Ukraine profile - Timeline (March 5, 2020). *BBC News*. https://www.bbc.com/news/world-europe-18010123

Walsh N. (April 9, 2021). Russian forces are massing on Ukraine's border. Bluff or not, Putin is playing with fire. *CNN*. https://www.cnn.com/2021/04/09/europe/russian-forces-ukraine-border-analysis-intl/index.html