



Applying the AHP to Conflict Resolution: A Russia—NATO Case Study

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Abstract

In this paper, we apply the Analytic Hierarchy Process approach to conflict resolution in the context of the Russia–Ukraine conflict. We build models that illustrate the evaluation criteria, strategic and sub-criteria, and concessions for each party in this negotiation. Ratings are used to evaluate the degree to which concessions contribute or take away from successful resolution of the conflict. Afterwards, gain ratios are built to determine the benefit-cost scores so that concessions may be traded that result in equitable solutions. The approach presented here demonstrates for the first time why all concessions that parties to a conflict may offer might not trade all at once. A Max–Min optimization approach is used to maximize the gain to both parties of the conflict while minimizing the disparity in gain between the two.

Keywords Russia–Ukraine conflict · Conflict resolution · Analytic hierarchy process · Multi-criteria decision making · Negotiations

1 Introduction

The ongoing war between Russia and Ukraine has created reverberating consequences not only for citizens of those nations, but for people all around the world. Given these far-reaching global impacts, the global community has a responsibility to facilitate a peaceful resolution of this conflict. The possible ramifications of continued war in Ukraine are grave and diverse. Beyond the direct loss of life, Mykhnenko (2020) argues that as hostilities in Ukraine, particularly the Donbas region, persist, the human and economic costs in Ukraine will escalate to “depopulation,

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economic decline and erosion of development” (p. 528). Outside of Ukraine, researchers at the National Institute of Economic and Social Research estimate that the global GDP could reduce by 1 per cent in 2023 (Liadze et al. 2022). They go on to describe deleterious impacts that the war will have on supply chains, inflation, and other global financial challenges.

The costs of the conflict are likely to go well beyond the direct loss of life and supply chain issues. Beyond the financial and supply chain complications, the war is a humanitarian crisis. This war has displaced millions of Ukrainians, becoming the second worst refugee crisis globally in a matter of months. Such massive displacement has consequences not only for the health of displaced Ukrainians but also for the rest of the world. In particular, forced migration predictably increases the risk of infectious disease epidemics such as those due to measles, diarrheal diseases, acute respiratory infections and others. Conflict similarly disrupts local public health systems, creating new infections and increasing the global burden of chronic disease. For example, Russia’s 2014 invasion of the Donbass has contributed to outbreaks of measles in Israel and the United States in 2019 (McNeil 2019) and the annexation of Crimea has fueled one of the fastest growing epidemics of HIV and tuberculosis worldwide (Simoneau and Khan 2022).

The conflict also threatens global mental health. The trauma this war has inflicted on Ukrainians exceeds measurement, especially for children; it is likely the long-term consequences of the conflict will be intergenerational, transforming the lives of Ukrainians for the foreseeable future. However, this trauma is not limited to Ukrainians. Citizens of all nations, already traumatized by the COVID-19 pandemic, are now confronted with horrific images and stories, uncertainty surrounding nuclear weapons, food shortages and spike in gas costs, and stress on government services to due increased demand.

Wise (2022) discusses the global call to boycott Russian scientists from the research community. Bans are proposed the break research ties between Russian and all universities. Many European Union funded research projects that included Russian researchers have been cut off. The impact of this boycott of Russian researchers is that technological advancement within Russia may be stultified.

Russia has framed its invasion of Ukraine as “proxy war” with the North Atlantic Treaty Organization (NATO), considering Ukraine as an element of Russia’s “sphere of influence”. Indeed, analysts have suggested that that, in the wake of movements by former Soviet nations to distance themselves from Russian influence, an objective of the invasion was to force the “West”, represented by NATO, into concessions of security guarantees (National Public Radio 2022). Conversely, NATO recognizes Ukrainian sovereignty and seeks to preserve an international system that prevents sovereign nations from invading each other except in well- defined circumstances. To this end NATO nations have provided military technical assistance, funding, intelligence, and weapons to Ukraine and implemented punitive economic sanctions and trade restrictions on Russia. Unfortunately, although Ukraine is neither a territory of Russia nor a member of NATO, the framing of the war and the failure of peace negotiations to this point has led some analysts to conclude that the resolution of the conflict must be negotiated between these two external powers (Zakaria 2022).

However, with where the parties are at now lead Fareed Zakaria to state that the only way that we are going to get out of this [Russia's war with Ukraine] is if we find a way to rationally negotiate concessions that Putin will accept (Zakaria 2022). To this end, in this article, we explore potential peace negotiations between Russian and NATO using a *retributive* conflict resolution approach that has been applied in the context of South African apartheid (Saaty and Vargas 1982), the Cyprus “problem” between Turkish and Greek Cypriots (Ozkaya 1994), and more recently, the Israeli-Palestinian conflict (Saaty et al. 2022). In this article, we extend this body of knowledge by investigating the optimization of the tradeoffs between the two parties and bundling them in such a way that the concessions are *tradable*, identifying a case where every concession is tradable at once in theory but in practice a nonstarter. We then proceed with illustrating a step-wise process to achieve a workable solution.

We continue the paper in the next section with a brief presentation of the relevant literature on conflict resolution with the Analytical Hierarchy Process (AHP) as well as the AHP itself. In Sect. 2, we also present a summary both of the concessions Russia hopes to achieve from to the conflict and of the objectives NATO is seeking from the resolution. Following the literature review, we present the development of decision hierarchies and the prioritization of resultant models. Then we present the priorities, the *data*, derived from pairwise comparisons followed by the optimization of the tradeoffs. Finally, we present our discussion and conclusions as well as some potential next steps.

2 Literature Review

In Vargas et al. (2021), the authors state that negotiations employ two sites in the brain with competing interests: the nucleus accumbens and the amygdala. The nucleus accumbens is concerned with potential gain whereas the amygdala is concerned with potential loss. The process of negotiation helps the brain manage the tradeoffs between the risk and the reward through communications, learning, accommodation of positions and development of alternatives. The use of negotiation support systems, software designed to aid in negotiations, helps to facilitate the learning process by collecting and maintaining information as well as communications. It has been documented elsewhere that it is not sufficient that each party merely states their demands and acceptable concessions; each party must also understand the perceptions of the other party's costs and benefits (Saaty 1986). We define a *concession* as an item or activity that one party provides to the other hoping to get something in exchange.

As a simple illustration to the importance of understanding the differences in perception between the two parties, assume that party *A* concedes to make a payment of \$1,000 to party *B* for damages. While the amount of \$1,000 is the same from an accounting perspective for both parties, it is very different from in terms of perceived value. If party *A* earns \$20,000 a year, the value of the payment is much more significant than the value perceived by party *B* if party *B* earns \$100,000 per year. While the purchasing power of the payment is the same to either party, the value of the payment is not since for *A* it represents 5% of *A*'s salary and for *B* it is only 1%.

If party *B* also feels slighted by damages incurred, then party *B* may also expect additional compensation for the offense (*retribution*). Further, if both parties expect concessions from the other, it complicates the perceptions of benefits and costs.

In the development of concessions in the above scenario, both *A* and *B* know the respective true benefits they receive from the concession of the opposite party and the true costs of the concessions that they give up. However, neither *A* nor *B* know the true benefits that the opposite party receives from the concessions they are given nor the true costs to the opposite party for the concession that they offer; they only have a perception of the other’s benefits and costs. Each party strives to maximize their gain ratio from the resolution of the conflict, where the gain ratio is the benefits received divided by the costs incurred. In a conflict that is not *retributive*, each party is indifferent to the gains and losses to the other. Conversely, in a *retributive* conflict the parties are believed to have some utility from it. Given that the conflict defined here is *retributive* in nature, each party further benefits from the perceived inverse gain ratio of the opposite party, i.e. the perceived costs that the opposite party incurs divided by the perceived benefits that the opposite party obtains. In retributive conflicts in which the benefits and costs are not measure in a monetary scale, we use relative measurement which relative ratio scales. Hence, the concessions are evaluated using multiplication and ratios is as follows.

Following the notation used in Vargas et al. (2021), let T_A and T_B be the sets of concessions (trade-offs) of parties *A* and *B*, respectively. Let $w_A(C_A|T_A)$ and $w_B(C_B|T_B)$ be the relative costs of the trade-offs for each party; let $w_A(PB_B|T_A)$ and $w_B(PB_A|T_B)$ be the relative perceived benefits of a party from a concession by the other party. For example, $w_A(PB_B|T_A)$ represents *A*’s relative perceived benefits of *B* from *A*’s concessions. Let $w_A(B_A|T_B)$ and $w_B(B_B|T_A)$ be the relative benefits from the concessions of the other party; and let $w_B(PC_A|T_A)$ and $w_A(PC_B|T_B)$ a party’s relative perceived costs of the other party from its own concessions. The gain/loss ratios of the two parties *A* and *B* may be expressed as follows:

$$A's \text{ ratio} = \frac{\left[\frac{w_A(B_A|T_B)}{w_A(C_A|T_A)} \right]}{\left[\frac{w_A(PB_B|T_A)}{w_A(PC_B|T_B)} \right]} = \frac{w_A(B_A|T_B) * w_A(PC_B|T_B)}{w_A(C_A|T_A) * w_A(PB_B|T_A)} \tag{1}$$

$$B's \text{ ratio} = \frac{\left[\frac{w_B(B_B|T_A)}{w_B(C_B|T_B)} \right]}{\left[\frac{w_B(PB_A|T_B)}{w_B(PC_A|T_A)} \right]} = \frac{w_B(B_B|T_A) * w_B(PC_A|T_A)}{w_B(C_B|T_B) * w_B(PB_A|T_B)} \tag{2}$$

Equations 1 and 2 were first developed in Saaty (1986) and later applied in other cases (e.g., Saaty 1988; Ozkaya 1994; Vargas et al. 2021; and Saaty et al. 2022). In the case of more complex conflicts, such as proxy conflicts or those with global impacts, each party may need to offer multiple concessions and the problem space can become quite large. In the simple example provided above, the parties were merely trying to negotiate a payment for damages. In Eqs. 1 and 2, we note that the gain/loss ratio is the sum of all actual and perceived benefits and

costs to the two parties. When a party's gain/loss ratio is below parity, less than 1, then the party is said to be *losing* with the proposed tradeoff. When a party's gain/loss ratio is above parity, greater than 1, then the party is said to have *benefited* from the tradeoff. In any case, an *equitable* resolution is one where both parties' gain/loss ratios are above parity for all the tradeoffs. Figure 1 shows the four quadrants in which the gain/loss ratios for both parties would appear. The *equitable resolution space* is the upper right quadrant of Fig. 1. The *losing resolution* space consists of the gain/loss ratios for which both parties are below parity (lower left quadrant in Fig. 1). In all other cases, the resolution is *inequitable*.

The tradeoff model is based on following seven steps:

1. Each party identifies a set of concessions;
2. Each concession that a party gives up incurs a set of costs (not necessarily monetary) for the yielding party and a perceived set of benefits for the opposite party receiving the concession;
3. Each concession that a party receives generates a set of benefits and a perceived set of losses for the yielding party;
4. The benefits, costs, perceived benefits and perceived costs are prioritized using the AHP;
5. The trade-offs (i.e., pairs of sets of concessions from each party) are evaluated according to the sum of benefits to self times the perceived costs imposed upon the opposite party divided by the sum of perceived benefits for the opposite party times the known costs to self (see Fig. 2) resulting in the gain/loss ratio;
6. The trade-offs of the parties are paired to decide which pairs are acceptable. Acceptable means both parties benefit from the trade-off and that they receive more than they lose from the concession they yielded. Acceptability of a pair of trade-offs is implemented using the gain–loss ratio. Retributive conflicts are not a zero-sum game, meaning that gain–loss ratios are not symmetric for the parties.

Fig. 1 Concession resolution space

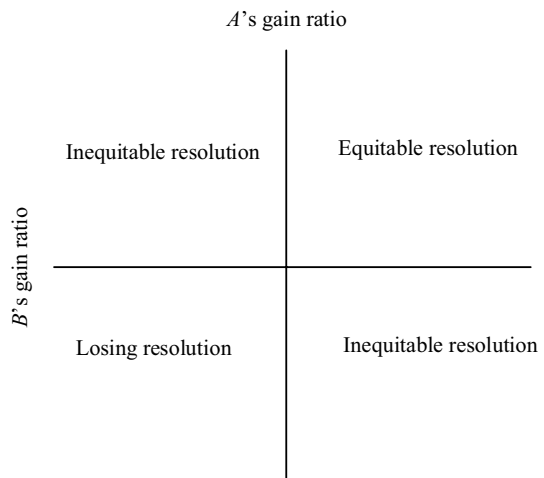




Fig. 2 Gain to loss ratio

- Acceptable pairs of trade-offs are identified with the additional condition that the gain–loss ratio of a pair of concessions is as close as possible to each other for the parties such that no party gains or loses disproportionately.

This approach has been used with some success in retributive conflict negotiations in South Africa before Apartheid was abolished (Saaty 1988), and with Israelis and Palestinians (see for instance, Saaty and Zoffer 2012; Vargas et al. 2021; and Saaty et al. 2022).

Within the bundle of concessions that either party may offer, there may be some instances that are unattractive but when combined with other concessions become more attractive. Hence, the goal in selecting a bundle of concession options is to

optimize the gain/loss ratios of each party such that they are in the equitable resolution space. Further, obtaining a solution in the equitable resolution space alone is not sufficient; rather, one must identify the unique space with the least difference between the two parties' gain/loss ratios. If A 's perception of Eq. 3 is greater than or equal to zero, A will be satisfied with the outcome, else not. Likewise, if B 's perception of Eq. 4 is greater than or equal to zero, B will be satisfied with the outcome, else not. The best solution brings the two ratios as close together as possible. Either party may be willing to accept a small negative value in Eqs. 3 or 4, but as that number increases in disparity, willingness to accept the solution decreases.

$$A's \text{ perception of equity} = \sum A's \text{ gain/ loss ratios} - \sum B's \text{ gain/ loss ratios} \quad (3)$$

$$B's \text{ perception of equity} = \sum B's \text{ gain/ loss ratios} - \sum A's \text{ gain/ loss ratios} \quad (4)$$

The bundled solutions represent a max–min problem (Vargas et al. 2021). The problem consists of finding pairs of concessions such that:

1. Both parties have gain ratios above parity;
2. The gain ratios of both parties are as close as possible; and
3. The smallest gain of each party is as large as possible, i.e., minimum gain of each party is maximized.

Acceptable pairs of tradeoffs are identified with the additional condition that the gain/loss ratio of a pair of concessions is as close as possible to each other for the parties (i.e., within a small percentage of each other) yielding a balanced agreement. The proximity of the gain score of the two parties captures the concept of equity as suggested by Brams and Taylor (1996) and Klamer (2010). The result of this model is a set of all pairs of concessions (or bundles of concessions) that are at most within a defined percentage of each other.

2.1 What Russia Wants

The first step of the tradeoff model is to identify which concessions each of the parties wants in order to resolve the conflict. As described above, although Russia has made various statements about the objectives of the war in Ukraine, its disregard for Ukraine's sovereignty means that objectives of the conflict transcend Ukraine's actions to focus largely on concessions from NATO. After reading newspapers and media sources we compiled the following list of concessions Russia is demanding from NATO (NATO 2022a, 2022b):

1. NATO should refrain from expansion of membership to other Ukraine and other states.
2. NATO must cease "involvement in Ukrainians affairs", i.e., autonomy for eastern Ukraine.

3. NATO should not consider Russia an adversary and maintain dialogue.
4. NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia.
5. NATO should not deploy military forces and weaponry on the territory of any other states in Europe in excess to any forces that were deployed as of May 27, 1997.
6. NATO should not conduct any military activity on the territory of Ukraine, the South Caucasus, or Central Asia.
7. NATO should employ multilateral consultations with Russia to address points of conflict.
8. NATO members should remove economic sanctions on Russia:
 - The EU, US, UK, Japan and Canada have expelled key Russian banks from the international Swift payment network, which facilitates the smooth and rapid transfer of money across borders
 - The EU, UK and Canada have shut off their airspace to Russian airlines
 - Individual/personal sanctions are being imposed on President Putin and Foreign Minister Sergei Lavrov by the US, EU and UK, while 351 Russian MPs are being targeted by the EU
 - Germany has halted approval on Russia's Nord Stream 2 gas pipeline, a major investment by both Russia and European companies
 - Russia's state-run media Sputnik and Russia Today (RT), seen as a Kremlin mouthpiece, are being banned across the EU
 - The Russian city of St Petersburg will not host this year's Champions League final and the Russian Grand Prix will not take place in Sochi.
9. The UN Security Council's primary objective of maintaining peace and security should not be affected by any agreement between NATO and Russia.
10. NATO should not strengthen its security at the expense of Russia's perceived security.

2.2 What NATO Wants

While NATO recognizes the sovereignty of Ukraine and as such has provided Ukraine many forms of support in the war, its interests transcend preservation of Ukrainian lives, territory, and to focus on maintaining the current international order, bolstering its own territorial and existential security, and protection of international treaty structures (Ukraine TNP 1994). Analysts Rennack and Welt (2021) posit that the sanctions put in place by NATO members are the result of the following: transgression of Ukraine's borders; cyber activities and influence operations; corruption and human rights abuses; chemical weapons and proliferation; coercive use of exports; and facilitation of sanctions evasion by North Korea, Syria, and Venezuela. These violations form the core of what NATO's demands for Russian. The following items are the 'concessions' that NATO wants from Russia in exchange for the concessions that will be yielded by NATO for the purpose of stopping the conflict (Maynes 2022):

1. Russia must cease the illegal annexation of Crimea.
2. Russia should not threaten to cut oil and gas supplies to the NATO member nations.
3. Russia should remove all troops from Ukraine sovereign territory (with the possible exception of Eastern Ukraine).
4. Russia should cease all illicit trade with North Korea.
5. Russia must cease human right abuses of its citizens, foreigners, and Ukrainians.
6. Russia should pay reparations to Ukraine.
7. Russia should commit not to use chemical weapons in current and future conflicts.
8. Russian should cease military, political, and financial support of Syria and Venezuela.
9. Russia must end its expansionistic activities and policies.
10. Russia should cease cyberattacks on NATO countries.

While both parties in this case have ten concessions that they want from each other, it is not necessary that the number of concessions must be the same. It is possible that one party wants less than the other in terms of number of concessions. What is important, as noted above, is not the number of items that one wants from the other but that the gain/loss ratios scores are as close to each other as possible.

3 Methods

The next step in this approach requires development of the necessary models required to assess the value of the concessions. A mediator, the party or parties selected to lead the negotiation, needs to elicit a goal, strategic criteria, and evaluation sub-criteria from each of the parties as illustrated in Figs. 3 and 4. The goal and

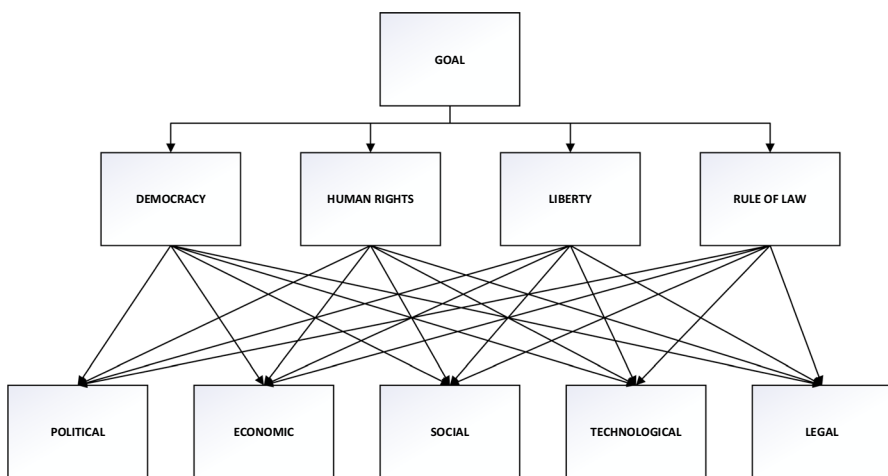


Fig. 3 NATO's criteria hierarchy

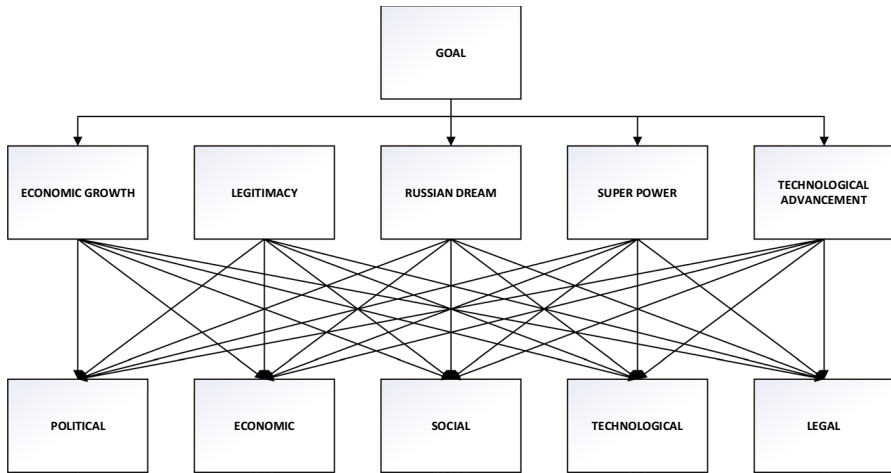


Fig. 4 Russia's criteria model

strategic criteria remain consistent for each of the party's models though the sub-criteria under the evaluation criteria vary. To build each of the eight models necessary to develop the gain ratios, we start in the next section with NATO's model and then in the following with Russia's.

3.1 NATO's Model

At the top of the model for NATO is the overall goal "to safeguard the Allies' freedom and security by political and military means. NATO remains the principal security instrument of the transatlantic community and expression of its common democratic values" (NATO 2022a). This represents the "goal" in each of the benefits and costs models that are used to prioritize NATO's strategic criteria as illustrated in the sample benefits model represented in Fig. 3.

The second level of the hierarchy represents the *strategic criteria* against which the *evaluation criteria* are made. The strategic criteria are those criteria against which NATO prioritizes its long-term goal. The evaluation criteria are those against which the country evaluates the degree to which a concession contributes or takes away from their ability to achieve their goal. NATO's 2010 Strategic Concept "Active Engagement, Modern Defense" outlines its strategic objectives: democracy, human rights, liberty, and rule of law (NATO 2022b). For the evaluation criteria, we used the often applied political, economic, social, technological, and legal (PESTL) framework (e.g. Guiora et al. 2021b). The PESTL framework is commonly used to capture the macro-environment when making strategic decisions (see for example Guiora et al. 2020b; and, Guiora et al. 2021a; Saaty & Vargas 1994).

We built NATO's costs model in a similar fashion. The goal, strategic criteria, and evaluation criteria are the same for both the benefits and costs models, but the sub-criteria of the evaluation differ. To assess the perceived benefits and costs to the other party, NATO uses Russia's models but applies its own perception of how

Russia would prioritize the judgements. As we will discuss in latter in the manuscript, this allows us to capture the difference in perceptions between what each party thinks that the other party is getting and giving up.

3.2 Russia's Model

As with the NATO models, we follow a similar process for the Russian models. Unlike NATO, Russia is much less explicit publicly about its intentions, objectives, and process to evaluates or prioritizes decision making. Therefore, we used reporting on the matter to form the models (see for example, Aris 2021; Crowley and Sanger 2022; and, Maynes 2022). From the reports, we defined Russia's strategic goals as: economic growth, legitimacy, the "Russian dream", super power, and technological advancement.

By *Legitimacy* we mean that all Russian actions are recognized as having a legitimate claim and that Russia is within its rights to attack and occupy any territories in their "sphere of influence." "*Russian Dream*" reflects an extreme, nostalgic view of Soviet structures that is famously espoused by Vladimir Putin and recognizes Russia's desire to reinstate the perceived 'glory' that preceded the independence and establishment of democracy in former Soviet nations. *Super Power* captures Russia's need to maintain its position as one of the worlds super power countries alongside the United States and China. The rest of the strategic criteria are self-explanatory.

3.3 Ratings

Finally, all the concessions are put into a ratings sheet to evaluate the degree to which each concession contributes to or subtracts from the overall gain of the party. Once all pairwise comparisons are complete for each level of the hierarchy, the priorities are carried over and the concessions rated with respect to each of the criteria. Each of the concessions is rated with respect to the degree to which it contributes to each of the criteria, either benefiting the outcome (benefits) or detracting (costs).

A rating scale for each of the strategic criteria is developed to evaluate the concessions. An example of a ratings scale within the benefits model is illustrated in Fig. 5: Example ratings scale in benefits. If a particular concession contributes greatly to the criteria in the Economic cluster, then "Lot of economic gain" is selected and the concession gets a score of 1. If, on the other hand, there is no economic gain, then a score of 0.0786 is assigned. In this case, we assessed that every concession will have



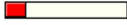

Scaletem	Value	Graphic
Lot of economic gain	1.0000	
Much economic gain	0.4714	
Some economic gain	0.1667	
No economic gain	0.0786	

Fig. 5 Example ratings scale in benefits

some marginal contribution beyond ‘nothing’ so even ‘no economic gain’ has a non-zero score.

Each of the strategic criteria went through a similar process to develop the ratings scales. For instance, under *Social* the ratings scale items evaluated the degree to which each concession contributes or detracts from the social good.

4 Data

The data in this approach come from the judgements of the participants in the negotiation. The mediator in the process solicits pairwise judgements from the participants which reflect the intensity of the preferences with respect to the criteria. If this exercise had been conducted with actual representatives of both parties, the participants would be NATO and Russian representatives designated by each party. In this case, for the purpose of illustration, the authors are the participants. One of us adopted one party’s position and another the other party’s. Additional details of the outcome of the pairwise comparisons, the weights, can be found in Appendix 1.

4.1 Russia’s Results

The result of NATO’s concessions to Russia are presented in Table 1. From NATO’s perspective in this case, NATO incurs the greatest loss from concession 9 (The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia) followed by concession 5 (NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27, 1997). However, the Russian actor’s perception is that he gains the most from 9 followed by 4 (NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia).

4.2 NATO’s Results

As with the Russian results, we present NATO’s perceived scores in Table 2. These results emphasize the fact that though NATO is a strong supporter of Ukraine, but Ukraine is not a member and that NATO’s interests, values, and priorities do not represent those of Ukraine. Of particular note, the NATO actor perceived that Russia loses the most from 9 (stopping expansionist policies) followed by 4 (stopping illicit trade with North Korea). NATO gains the most from 9 followed by 4.

4.3 Trading Ratios

The gain/loss ratios are calculated for each party from Tables 1 and 2. For example, if NATO trades N3 and Russia trades R6, the gain/loss ratios are computed as follows:

Table 1 Benefits, costs, perceived benefits, and perceived costs from NATO concessions

NATO's concessions	NATO's costs	NATO's perception of Russia's benefits	NATO's total loss	Russia's benefits	Russia's Perception of NATO's Costs	Russia's Total Gain
N1 NATO should refrain from enlargement by including other States and Ukraine	0.740838	0.680271	0.503970607	0.586606	0.406855	0.238663584
N2 NATO must stop interfering in Ukrainian's affairs, i.e., autonomy for Eastern Ukraine	0.151675	0.383507	0.058168424	0.18062	0.370022	0.066833374
N3 NATO should not consider Russia an adversary and maintain dialogue	0.393745	0.593643	0.233743963	0.624511	0.333113	0.208032733
N4 NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	1	0.496493	0.496493	0.504056	0.900698	0.454002231
N5 NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27, 1997	1	0.541717	0.541717	0.480249	0.935647	0.449343536
N6 NATO should not conduct any military activity on the territory of Ukraine, in South Caucasus and in Central Asia	0.910749	0.588285	0.535779975	0.509621	0.501409	0.255528556
N7 Use of multilateral consultations to address points of conflict	0.916311	0.475549	0.43575078	0.156814	1	0.156814
N8 NATO to remove economic sanctions	0.129233	0.365203	0.047196279	0.118724	0.327289	0.038857059
N9 The UN security council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia	0.671944	1	0.671944	1	0.590765	0.590765
N10 NATO should not strengthen its security at the expense of Russia	0.118638	0.616349	0.073122413	0.520594	0.453336	0.236004002

There are levels of significance to note since significance is not measured in this application

Table 2 Benefits, costs, perceived benefits, and perceived costs from russian concessions

	Russia's concessions	Russia's costs	Russia's perception of NATO's benefits	Russia's total loss	NATO's benefits	NATO's perception of Russia's costs	NATO's total gain
R1	Stop the illegal annexation of Crimea	0.939706	0.894289	0.840368739	0.648847	0.939968	<i>0.609895417</i>
R2	Stop the threat of cutting gas and oil supplies to the West	0.535965	0.557065	0.298567343	0.501065	0.938145	<i>0.470071624</i>
R3	Exit of all troops from Ukrain with the exception of Eastern Ukraine	0.45631	0.69496	0.317117198	0.450345	0.771459	<i>0.347422703</i>
R4	Stop illicit trade with North Korea	1	0.942339	0.942339	0.746599	0.958282	<i>0.715452383</i>
R5	Stop human right abuses	0.353595	0.382221	0.135151434	0.756349	0.378238	<i>0.286079933</i>
R6	Reparations for Ukraine	0.346309	0.402347	0.139336387	0.756349	0.478928	<i>0.362236714</i>
R7	Stop the use of chemical weapons	0.425144	0.407153	0.173098655	0.501702	0.573504	<i>0.287728104</i>
R8	Stop the support of Siria and Venezuela	0.576584	0.387933	0.223675961	0.65657	0.746568	<i>0.490174152</i>
R9	Stop expansionistic policies	0.970855	1	0.970855	1	1	<i>1</i>
R10	Stop cyberattacks to NATO countries	0.63758	0.664715	0.42380899	0.70143	0.937398	<i>0.657519079</i>

There are levels of significance to note since significance is not measured in this application

NATO G/L (R6 vs. N3) = Gains from R6/Losses from
 $N3 = 0.3622/0.2337 = 1.5497$.
 Russia G/L (N3 vs. R6) = Gains from N3/Losses from
 $R6 = 0.2080/0.1393 = 1.4930$.

The entire trading space consist of 100 possible combinations where we have (R_i, N_j) for i and j from 1 to 10. To solve for the pairing, we set up a linear programming model to search through the decision space to determine if the trade would be acceptable, where acceptable tradeoffs means that both parties benefit from the tradeoff and that they receive more than they lose from the tradeoff they give away. As stated in Vargas et al. (2021), the problem consists of finding pairs of concessions $(i, j) \in T_A \times T_B$ such that:

1. $R_A(i, j) \geq 1$ and $R_B(i, j) \geq 1$;
2. They are as close as possible, that is, $\left| \frac{R_A(i,j) - R_B(i,j)}{R_A(i,j)} \right| < \epsilon$; and
3. The smallest gain of each party is as large as possible, of each party.

This is accomplished by solving a MaxMin problem given by:

$$\begin{matrix} \text{Max} \\ (i,j) \in T_A T_N \end{matrix} \quad \begin{matrix} \text{Min} \\ \left\{ \begin{matrix} x_{ij} \in \{0,1\} \\ R_A(i, j) \geq 1, R_B(i, j) \geq 1 \\ \left| \frac{R_A(i,j) - R_B(i,j)}{R_A(i,j)} \right| < \epsilon \end{matrix} \right\} \end{matrix} \quad \{R_A(i, j)x_{ij}, R_B(i, j)x_{ij}\} \tag{5}$$

Acceptable pairs of tradeoffs are identified with the additional condition that the gain/loss ratio of a pair of concessions is as close as possible to each other for the parties (i.e., within a small percentage of each other) yielding the desired balanced agreement. Incidentally, the idea of fairness has been applied in conflict resolution as, for example, by Brams and Taylor (1996) and illustrated in their well-known book, and by Klamer (2010). The result of this model is a set of all pairs of concessions that are at most within ϵ percent of each other.

Those gain ratios are then paired with each other, the result of which is a 10×10 matrix (see Table 3). If we allow for the trading of concessions all at once, all 10 concessions from each party, we get the results shown in Table 4. We see in Table 4 that there are five concessions that NATO give for which Russia perceives no positive gain whereas there are three Russian concessions for which NATO does not perceive any positive gain. Note that the order in which the concessions appear is the result of the optimization algorithm; for instance, N1 pairs with R8, N2 pairs with R3, etc. These results do not appear realistic since in the first three trades of concessions, NATO will perceive that Russia is gaining disproportionately and is unlikely to continue with the trading. More on why this approach is unlikely to work is presented in the results section.

However, if we start the trading using one pair at a time and then increase the number of items traded until no further trade results in concessions traded, we get the results shown in Table 5. We fixed the difference threshold between the two parties' gains to be small at first (1%). When no more trades could take place with the

Table 3 Gain/loss ratios for paired concessions

NATO Ratios	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
N1	1.2102	0.0000	0.0000	1.4196	0.0000	0.0000	0.0000	0.0000	1.9842	1.3047
N2	10.4850	8.0812	5.9727	12.2997	4.9181	6.2274	4.9465	8.4268	17.1915	11.3037
N3	2.6092	2.0111	1.4863	3.0608	1.2239	1.5497	1.2310	2.0971	4.2782	2.8130
N4	1.2284	0.0000	0.0000	1.4410	0.0000	0.0000	0.0000	0.0000	2.0141	1.3243
N5	1.1259	0.0000	0.0000	1.3207	0.0000	0.0000	0.0000	0.0000	1.8460	1.2138
N6	1.1383	0.0000	0.0000	1.3353	0.0000	0.0000	0.0000	0.0000	1.8664	1.2272
N7	1.3996	1.0788	0.0000	1.6419	0.0000	0.0000	0.0000	1.1249	2.2949	1.5089
N8	12.9225	9.9599	7.3612	15.1591	6.0615	7.6751	6.0964	10.3859	21.1881	13.9316
N9	0.0000	0.0000	0.0000	1.0648	0.0000	0.0000	0.0000	0.0000	1.4882	0.0000
N10	8.3407	6.4286	4.7512	9.7843	3.9123	4.9538	3.9349	6.7035	13.6757	8.9920
Russia Ratios	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
N1	0.0000	0.0000	0.0000	0.0000	1.7659	1.7129	1.3788	1.0670	0.0000	0.0000
N2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N3	0.0000	0.0000	0.0000	0.0000	1.5393	1.4930	1.2018	0.0000	0.0000	0.0000
N4	0.0000	1.5206	1.4317	0.0000	3.3592	3.2583	2.6228	2.0297	0.0000	1.0712
N5	0.0000	1.5050	1.4170	0.0000	3.3247	3.2249	2.5959	2.0089	0.0000	1.0603
N6	0.0000	0.0000	0.0000	0.0000	1.8907	1.8339	1.4762	1.1424	0.0000	0.0000
N7	0.0000	0.0000	0.0000	0.0000	1.1603	1.1254	0.0000	0.0000	0.0000	0.0000
N8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N9	0.0000	1.9787	1.8629	0.0000	4.3711	4.2398	3.4129	2.6412	0.0000	1.3939
N10	0.0000	0.0000	0.0000	0.0000	1.7462	1.6938	1.3634	1.0551	0.0000	0.0000

Table 4 Gain ratios trading all concessions at once

NATO's Concessions		Russia's Concessions	
	G/L	G/L	
N1	NATO should not strengthen its security at the expense of Russia	0.00	R8
N2	Use of multilateral consultations to address points of conflict	5.97	R3
N3	NATO should not consider Russia an adversary and maintain dialogue	4.28	R9
N4	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27, 1997	0.00	R6
N5	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	0.00	R2
N6	NATO should refrain from enlargement by including other States and Ukraine	0.00	R7
N7	NATO should not conduct any military activity on the territory of Ukraine, in South Caucasus and in Central Asia	1.51	R10
N9	NATO to remove economic sanctions	0.00	R5
Totals		11.76	11.68

Table 5 Gain ratios when combined first singly than paired. Bundles with boxes are paired bundles. All concession pairs are listed in order of precedence

	NATO's Concessions	G/L	G/L	Russia's Concessions
N3	NATO should not consider Russia an adversary and maintain dialogue	1.55	1.49	R6 Reparations for Ukraine
N5	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27, 1997	1.21	1.06	R10 Stop cyberattacks to NATO countries
N1	NATO should refrain from enlargement by including other States and Ukraine	1.98	1.98	R2 Stop the threat of cutting gas and oil supplies to the West
N9	The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia			R9 Stop expansionistic policies
N4	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	3.91	3.78	R5 Stop human right abuses
N10	NATO should not strengthen its security at the expense of Russia			R8 Stop the support of Syria and Venezuela
N6	NATO should not conduct any military activity on the territory of Ukraine, in South Caucasus and in Central Asia	1.4	1.48	R1 Stop the illegal annexation of Crimea
N7	Use of multilateral consultations to address points of conflict			R7 Stop the use of chemical weapons
		Total	Total	
		10.06	9.78	

small difference, we increased the score till the difference appear to be too large for the parties to accept it. This resulted in N3 trading with R6 and then N5 with R10 in the next round. No further trades could happen at the individual level so the difference weight was lowered again and then the optimization took place in pairs. The result of the next round of two concessions trades resulted in N1 and N9 with R2 and R9, etc.

Of particular note, the total gain is greatest in the case when all concessions are allowed to be traded at one time and the total gain/loss ratio differ by less than 3 percent. However, as noted earlier, this is not likely to result in a final agreement. While the total scores are lower in the second instance, the gain is still equitable between the two parties and an acceptable resolution is obtained.

5 Analysis

The results of the gain/loss ratios are illustrated in Fig. 4. The blues plots represent each of the 100 possible pairs of concessions with the gain ratio of each party plotted with respect to the potential gain. We forced the model to zero out all trades that did not result in a gain for ease of interpretation; hence, there are no lose-lose results. All the scores that fall along the axis, 0's on either the X or Y axis, represent an "inequitable" trade as illustrated in Fig. 1. Of particular note, the scale of gains between the two parties is not equal. The best gain for NATO is 21.19, the concession combination (N8, R9), whereas the best gain for Russia is only 4.37, the concession combination (N9, R5). The large difference between the two scales suggest that NATO has a lot to gain but Russia only perceives a small gain in resolving the conflict.

The equitable resolution space are all those points in the plot illustrated in Fig. 6 that are positive for both parties. However, not all tradeoffs represent *optimal* pairs of tradeoffs. The optimal solution might be represented by a 45-degree line splitting the optimal space equally.

The five sets of concessions (1-to-1 or 2-to-2 pairs) along the 45-degree line, colored yellow, are the eight pairs of traded concessions in Table 5. When normalizing the scales for both parties, roughly 4 and 4, the line fits an approximate 45-degree angle and the eight points most closely along the line trade as 'equitable'.

There are concessions that do not trade. For NATO, N2 (NATO must stop interfering in Ukrainian's affairs, i.e., autonomy for Eastern Ukraine) and N8 (NATO to remove economic sanctions) and for Russia, R3 (Exit of all troops from Ukraine with the exception of Eastern Ukraine) and R4 (Stop illicit trade with North Korea). These concessions are at the heart of the problem.

The reader may ask how stable the results given here are. A complete stability and sensitivity analysis would be worthwhile if we applied this analysis with real actors representing the parties. We have not done this here to keep the paper simple. However, one could study this problem by developing scenarios in which priorities would emphasize some extreme positions in the hope that the

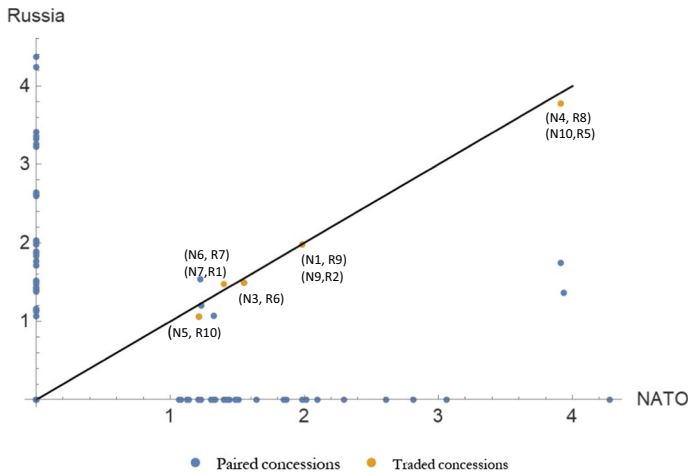


Fig. 6 NATO and Russia's gain ratio for each pair of tradeoffs. Bundled concessions that paired off are illustrated in yellow

real future would be somewhere in the convex hull of the extreme results. We learned from a different project involving real representatives (Saaty et al., 2022) that the actors were set on their priorities and never requested perturbations on their judgments. After almost 10 years developing that project clearly the priorities of the representatives may have changed but we have learned through experience that individual judgments do not change by a lot over time (See for example Saaty & Vargas, 1980, 1985). Sensitivity and stability analysis may be worth it in preparing for negotiations. So, in this case yes, we could have done them but as we mention above to keep the paper simple we opted for keeping the analyses for another paper.

The actual use of this approach in a negotiation requires:

1. The parties are willing to develop concession lists. A party asks from concessions from the other party. Thus, the list of concessions from a party are subject the requests from the other party. The parties can ask for anything from the other party, this does not mean that they will get it in the final agreement if there is one.
2. The parties must be willing to prioritize goals and strategic criteria which in turn are used to prioritize benefits, costs, perceived benefits, and perceived costs.
3. The parties do not need to know the priorities of the other party. Only if an agreement is possible the parties may come together to write up a document detailing the agreement.

Moreno-Jiménez & Vargas (2018) listed a set of reasons why the use of the AHP in negotiation is useful:

“The use of AHP as the methodological support is because of its: (1) intuitive and realistic character in scientific decision making; (2) ability to integrate through hierarchies and clustering the large and the small; (3) capability of combining tangible and intangible aspects of problems by means of absolute pairwise comparisons that yield relative ratio scales of priorities; (4) flexibility to consider dependencies between levels in a hierarchy with the extension of the AHP known as ANP (Analytic Network Process); (5) power in group decision making by allowing decision makers the construction of group welfare functions that do not violate Arrow’s conditions; and (7) strength in negotiations and learning / cognition (discussion, extraction and dissemination of knowledge). (p. 71)

6 Conclusions

In the time that the authors have been using and refining this approach, we have found that one of the greatest benefits is not in the optimization of the concessions themselves but in the discussions that happen around the process. The reason why the concessions are able to *trade* the way that they are is because we are capturing more than just the tangibles in this approach; we are also capturing the intangibles. For instance, while both parties might use the PESTL (Political, Economic, Social, Technological, Legal) framework to evaluate options, they likely do not prioritize them in the same way. Likewise, when evaluating alternatives, each party to the negotiation is likely to weight them differently with respect to the degree to which they contribute / hinder the resolution.

There is more to the process than just the optimization that results in a resolution. In going through this process, each party has the opportunity to understand more precisely the intensity of preferences of the other. In the example discussed earlier in the paper, money is not valued in the same way by two parties. Likewise, the perception of starting or stopping an action is not considered as valuable or costly by both parties to a negotiation. Hence, in having a negotiation using this approach, one of the gains is that each party to the conflict is able to understand the degree to which the other party quantifies an action; something that may be missed in ‘traditional’ negotiations.

For a variety of reasons, negotiations between Russia and Ukraine seem less and less likely to achieve a peaceful resolution of war between Russia and Ukraine. The political economy of recent events suggests that given Russia’s framing of the conflict and the power and resource availability of NATO, an approach to negotiation that bypasses Ukraine may end up being an avenue to peace. This paper explores that scenario. However, while we were able to simulate the conflict and a potential solution space, we also do not represent decision-making authority. We have captured the multi-criteria decision-making environment, but these proxy judgements may not represent the true judgements of the

parties. Therefore, it is necessary to have actual decision-makers involved for future work to make judgements and implement a resolution that may come from this approach. Having used similar models in other contexts, we are confident that this approach may yield positive results. Having learned in this simulation about the difficulty in trading all concessions at once, we hope that future work will build on this approach to facilitate early consensus and thereby minimize the loss of life, massive displacement, and global trauma and disruption that we have witnessed in the Russia-Ukraine war.

Appendix 1: Results Tables

See Tables 6, 7, 8, 9, 10, 11, 12 and 13.

Table 6 NATO's benefits from Russian concessions

	Description	Ideals	Normals	Raw
R1	Stop expansionistic policies	0.648847	0.096565	0.096565
R2	Stop cyberattacks to NATO countries	0.501065	0.074572	0.074572
R3	Stop the threat of cutting gas and oil supplies to the West	0.450345	0.067023	0.067023
R4	Stop the illegal annexation of Crimea	0.746599	0.111113	0.111113
R5	Stop human right abuses	0.756349	0.112564	0.112564
R6	Stop the use of chemical weapons	0.756349	0.112564	0.112564
R7	Stop illicit trade with North Korea	0.501702	0.074666	0.074666
R8	Stop the support of Siria and Venezuela	0.65657	0.097715	0.097715
R9	Exit of all troops from Ukrain with the exception of Eastern Ukraine	1	0.148826	0.148826
R10	Reparations for Ukraine	0.70143	0.104391	0.104391

Table 7 NATO's costs from NATO's concessions

	Description	Ideals	Normals	Raw
N1	NATO should not strengthen its security at the expense of Russia	0.740838	0.122795	0.122795
N2	Use of multilateral consultations to address points of conflict	0.151675	0.02514	0.02514
N3	NATO should not consider Russia an adversary and maintain dialogue	0.393745	0.065264	0.065264
N4	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27	1	0.165751	0.165751
N5	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	1	0.165751	0.165751
N6	NATO should refrain from enlargement by including other States and Ukraine	0.910749	0.150958	0.150958
N7	NATO should not conduct any military activity on the territory of Ukraine	0.916311	0.15188	0.15188
N8	The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia	0.129233	0.02142	0.02142
N9	NATO to remove economic sanctions	0.671944	0.111376	0.111376
N10	NATO must stop interfering in Ukrainian's affairs	0.118638	0.019664	0.019664

Table 8 NATO's perception of Russia's costs from Russian concessions

	Description	Ideals	Normals	Raw
R1	Stop expansionistic policies	0.939968	0.121718	0.121718
R2	Stop cyberattacks to NATO countries	0.938145	0.121482	0.121482
R3	Stop the threat of cutting gas and oil supplies to the West	0.771459	0.099898	0.099898
R4	Stop the illegal annexation of Crimea	0.958282	0.12409	0.12409
R5	Stop human right abuses	0.378238	0.048979	0.048979
R6	Stop the use of chemical weapons	0.478928	0.062017	0.062017
R7	Stop illicit trade with North Korea	0.573504	0.074264	0.074264
R8	Stop the support of Siria and Venezuela	0.746568	0.096674	0.096674
R9	Exit of all troops from Ukrain with the exception of Eastern Ukraine	1	0.129492	0.129492
R10	Reparations for Ukraine	0.937398	0.121386	0.121385

Table 9 NATO's perception of Russia's benefits from NATO's concessions

	Description	Ideals	Normals	Raw
N1	NATO should not strengthen its security at the expense of Russia	0.680271	0.118493	0.118493
N2	Use of multilateral consultations to address points of conflict	0.383507	0.066801	0.066801
N3	NATO should not consider Russia an adversary and maintain dialogue	0.593643	0.103404	0.103404
N4	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27	0.496493	0.086482	0.086482
N5	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	0.541717	0.094359	0.094359
N6	NATO should refrain from enlargement by including other States and Ukraine	0.588285	0.10247	0.102471
N7	NATO should not conduct any military activity on the territory of Ukraine	0.475549	0.082834	0.082834
N8	The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia	0.365203	0.063613	0.063613
N9	NATO to remove economic sanctions	1	0.174185	0.174185
N10	NATO must stop interfering in Ukrainian's affairs	0.616349	0.107359	0.107359

Table 10 Russia's benefits from NATO concessions

Name	Ideals	Normals	Raw
N1	Description	0.125295	0.125295
N2	Use of multilateral consultations to address points of conflict	0.038579	0.038579
N3	NATO should not consider Russia an adversary and maintain dialogue	0.133391	0.133391
N4	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27	0.107663	0.107663
N5	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	0.102578	0.102578
N6	NATO should refrain from enlargement by including other States and Ukraine	0.108852	0.108852
N7	NATO should not conduct any military activity on the territory of Ukraine	0.033494	0.033494
N8	The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia	0.025359	0.025359
N9	NATO to remove economic sanctions	0.213593	0.213593
N10	NATO must stop interfering in Ukrainian's affairs	0.111195	0.111195

Table 11 Russia's costs from Russia's concessions

	Description	Ideals	Normals	Raw
R1	Stop expansionistic policies	0.939706	0.150544	0.150545
R2	Stop cyberattacks to NATO countries	0.535965	0.085864	0.085864
R3	Stop the threat of cutting gas and oil supplies to the West	0.45631	0.073103	0.073103
R4	Stop the illegal annexation of Crimea	1	0.160204	0.160204
R5	Stop human right abuses	0.353595	0.056647	0.056647
R6	Stop the use of chemical weapons	0.346309	0.05548	0.05548
R7	Stop illicit trade with North Korea	0.425144	0.06811	0.06811
R8	Stop the support of Siria and Venezuela	0.576584	0.092371	0.092371
R9	Exit of all troops from Ukrain with the exception of Eastern Ukraine	0.970855	0.155535	0.155535
R10	Reparations for Ukraine	0.63758	0.102143	0.102143

Table 12 Russia's perception of NATO's benefits from Russian concessions

	Description	Ideals	Normals	Raw
R1	Stop expansionistic policies	0.894289	0.14121	0.14121
R2	Stop cyberattacks to NATO countries	0.557065	0.087962	0.087962
R3	Stop the threat of cutting gas and oil supplies to the West	0.69496	0.109736	0.109736
R4	Stop the illegal annexation of Crimea	0.942339	0.148798	0.148798
R5	Stop human right abuses	0.382221	0.060354	0.060354
R6	Stop the use of chemical weapons	0.402347	0.063532	0.063532
R7	Stop illicit trade with North Korea	0.407153	0.06429	0.06429
R8	Stop the support of Siria and Venezuela	0.387933	0.061256	0.061256
R9	Exit of all troops from Ukrain with the exception of Eastern Ukraine	1	0.157902	0.157903
R10	Reparations for Ukraine	0.664715	0.10496	0.10496

Table 13 Russia's perception of NATO's costs from NATO's concessions

	Name	Ideals	Normals	Raw
N1	NATO should not strengthen its security at the expense of Russia	0.406855	0.069917	0.069917
N2	Use of multilateral consultations to address points of conflict	0.370022	0.063587	0.063587
N3	NATO should not consider Russia an adversary and maintain dialogue	0.333113	0.057245	0.057245
N4	NATO should not deploy military forces and weaponry on the territory of any other states in Europe in addition to any forces that were deployed as of May 27	0.900698	0.154782	0.154782
N5	NATO should not deploy land-based intermediate and short-range missiles in territories adjacent to Russia	0.935647	0.160788	0.160788
N6	NATO should refrain from enlargement by including other States and Ukraine	0.501409	0.086166	0.086166
N7	NATO should not conduct any military activity on the territory of Ukraine	1	0.171847	0.171847
N8	The UN Security Council primary responsibility for maintaining peace and security should not be affected by any agreement between NATO and Russia	0.327289	0.056244	0.056244
N9	NATO to remove economic sanctions	0.590765	0.101521	0.101521
N10	NATO must stop interfering in Ukrainian's affairs	0.453336	0.077904	0.077904

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References

- Aris B (2021) Russia issues a eight-point list of demands. Bne IntelliNews. Accessed 28 Jan 2022. <https://www.intellinews.com/russia-issues-a-eight-point-list-of-demands-229829/>
- Brams SJ, Taylor AD (1996) Fair division: from cake-cutting to dispute resolution. Cambridge University Press, Cambridge
- Crowley, Sanger (2022) U.S. and NATO respond to Putin’s demands as Ukraine tensions mount. The New York Times. Accessed 26 Jan 2022. <https://www.nytimes.com/2022/01/26/us/politics/russia-demands-us-ukraine.html>
- Guiora AN, Minutolo MC, Vargas LG (2020) Measuring U.S. foreign policy effectiveness. *J Behav Appl Manag* 21(1):18–31
- Guiora AN, Minutolo MC, Vargas LG (2021) Report on an analytic network process (ANP) model to estimate the benefits, opportunities, costs, and risks (BOCR) that gun policies and violence prevention interventions have on legal users of firearms. *Int J Anal Hierarchy Process* 13(2):355–394. <https://doi.org/10.13033/ijahp.v13i2.909>
- Guiora AN, Minutolo MC, Vargas LG (2021) Measuring U.S. influence in the world. *J Multi Criteria Decis Anal* 28(1–2):68–84. <https://doi.org/10.1002/mcda.1728>
- Jiménez JMM, Vargas LG (2018) Cognitive multiple criteria decision making and the legacy of the analytic hierarchy process. *Stud Appl Econ* 36(1):67–80
- Júnior JG, de Amorim LM, Neto MLR, Uchida RR, de Moura ATMS, Lima NNR (2022) The impact of “the war that drags on” in Ukraine for the health of children and adolescents: Old problems in a new conflict? *Child Abus Negl* 128:105602
- Klamer C (2010) Fair division. In: Kilgour SM, Eden C (eds) *Handbook of Group Decision and Negotiation*. Springer, Berlin, pp 183–202
- Liadze I, Macchiarelli C, Mortimer-Lee P, Juanino PS (2022) The economic costs of the Russia-Ukraine conflict. NIESR Policy Paper, 32.
- Maynes C (2022) 4 things Russia wants now. National Public Radio. Last Accessed 30 May 2022. <https://www.npr.org/2022/01/12/1072413634/russia-nato-ukraine>.
- McNeil DG (2019). Scientists thought they had measles cornered. They were wrong. The New York Times. Accessed online 8 Mar 2022 <https://www.nytimes.com/2019/04/03/health/measles-outbreaks-ukraine-israel.html>
- Moreno-Jimenez JM, Vargas LG (2018) Cognitive multiple criteria decision making and the legacy of the analytic hierarchy process. *Estud De Econ Apl* 36:67–80. <https://doi.org/10.25115/eea.v36i1.2516>
- Mykhnenko V (2020) Causes and consequences of the war in Eastern Ukraine: an economic geography perspective. *Eur Asia Stud* 72(3):528–560
- National Public Radio (2022) Four things Russia wants right now
- NATO (2022a) <https://nato.usmission.gov/about-nato/#:~:text=NATO's%20fundamental%20goal%20is%20to,of%20its%20common%20democratic%20values>. Accessed May 13, 2022a.
- NATO, b. https://www.nato.int/cps/en/natohq/topics_56626.htm. Accessed May 13, 2022b.
- Ozkaya M (1994) Conflict resolution in Cyprus. In: *Proceedings of the 3rd annual symposium of the analytic hierarchy process*, Washington, DC 491–502
- Rennack D.E. Welt C (2021) U.S. sanctions on Russia: an overview. In: *Focus, congressional research service*. <https://crsreports.congress.gov>
- Saaty TL (1986) Resolution of retributive conflicts. *IFAC Proc Vol* 19(8):91–94
- Saaty TL (1988) The negotiation and resolution of the conflict in South Africa: the AHP. *ORION* 4(1):3–25

- Saaty TL, Vargas LG (1980) Hierarchical analysis of behavior in competition: prediction in chess. *Behav Sci* 25:180–191
- Saaty TL, Vargas LG (1982) The conflict in South Africa. In: Saaty T.L. Vargas L.G. (eds.) *The logic of priorities: applications of business, energy, health and transportation* (International series in management science operations research), pp. 118–138.
- Saaty TL, Vargas LG (1985) Modeling behavior in competition: the analytic hierarchy process. *Appl Math Comput* 16:49–92
- Saaty TL, Vargas LG (1994) Decision making in economic, political, social, and technological environments with the analytic hierarchy process (Vol. 7). RWS publications.
- Saaty TL, Zoffer HJ (2012) A new approach to the Middle East conflict: the analytic hierarchy process. *J Multi Criteria Decis Anal* 19(5–6):201–225. <https://doi.org/10.1002/mcda.1470>
- Saaty, T. L., Zoffer, H. J., Vargas, L. G. & Guiora, A. (2022). *Retributive Conflicts and the AHP: The Trading Mechanism. In Overcoming the Retributive Nature of the Israeli-Palestinian Conflict* (pp. 31–45). Springer, Cham.
- Simoneau, M. & Khan, H. (April 22, 2022). War amid a pandemic: The public health consequences of Russia's invasion of Ukraine. *Center for Strategic & International Studies*. Accessed online 8/3/2022 <https://www.csis.org/analysis/war-amid-pandemic-public-health-consequences-russias-invasion-ukraine>
- Ukraine TNP (1994) Memorandum on security assurances in connection with Ukraine's accession to the treaty on the non-proliferation of nuclear weapons. Wikipedia, Accessed 1 Aug 2022. https://en.wikisource.org/wiki/Ukraine_Memorandum_on_Security_Assurances.
- Vargas LG, Moreno-Loscertales C, Moreno-Jiménez JM (2021) Conflict resolution in the era of cognitive multicriteria decision-making: an AHP-retributive approach. *Int Trans Oper Res*. <https://doi.org/10.1111/itor.13088>
- Wise J (2022) Ukraine conflict: Global research community reviews links with Russia. *BMJ*. <https://doi.org/10.1136/bmj.o637>
- Zakaria F (2022). Inside the mind of Putin. CNN

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