

When Will It End? Assessing the Duration of Putin's War with Ukraine

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Abstract

The war in Ukraine has continued for more than a year without an end in sight. Estimating the duration of such a conflict that is a combination of attrition and manoeuvre is difficult. In a general sense both sides are drawing resources from their respective pools of manpower, (artillery) ammunition and other supplies to slowly wear down their opponent. It is likely that the war will end once one of both parties runs out of their resources. In this chapter we use mathematical models and open source data to estimate when the war will end and how, within given bounds of uncertainty.

Keywords: Russia-Ukraine war, Conflict prediction, War of attrition, Mathematical model

1. Introduction

The war in Ukraine has been going on for more than one and a half years at the time of writing. Vladimir Putin's evident plan of a short war with a quick victory has run into the quagmire of trench warfare and continuing military escalation. When will this conflict end, and how?

Most interstate wars do not last that long (median duration one year).¹ We are witnessing a war-of-attrition² in which the opponents wear each other out by destroying military capability and economic resources. Eventually, in the absence of a decisive battle, one side (or both) will collapse because of lack of resources or because of a regime change. The likely outcome of a long war is a frozen conflict,³ but how long will it take before it reaches this state? We evaluate which resources are crucial and estimate when they run out, and consider the likelihood of a regime change, to predict the duration of this war.

¹ Bennett and Stam, "The duration of interstate wars, 1865-1985," 239-257.

² Maynard Smith, "The Theory of Games and the Evolution of Animal Conflicts," 209-221; Malkasian, "A History of Modern Wars of Attrition."

³ Wolford et al., "Information, Commitment, and War," 556-579.

The standard mathematical model for the duration of a war is a hazard model.⁴ Such models often involve dozens of finely tuned input parameters.⁵ We base our analysis on the simple and robust model of Vuchinich and Teachman, which has one parameter only. Its value depends on possible future events such as: success or failure of Russian mobilisation, the outcome of the American elections, the amount of EU financial support, etc. We estimate their effect based on data of recent conflicts, such as the Yugoslav Wars and the Arab Spring.

Historically, wars last long if the nations are large, the armies are matched, the domestic support is strong, and if only two states are involved.⁶ All these conditions are in place. Decision makers need to realise that this war is likely to last for years. The World Bank anticipates that rebuilding Ukraine will cost 349 billion dollars over the next ten years.⁷ Will the war even be over by then?

2. Current state of the war

The point of a war-of-attrition is to make the opponent run out of resources.⁸ We divide resources into (a) human capital, (b) financial costs and military equipment, (c) public support for the war and eagerness to fight. In other words: men, money, and morale. We quantify these parameters from open-source data. Some care is required. The amount of data is limited and biased: even before the start of the war, Russia and Ukraine have been involved in a disinformation war.⁹

2.1 Resources: Men, money, and morale

Manpower. Russia has one of the largest armies in the world at about 800,000 active soldiers. Ukraine has about 200,000 (see Fig 1). Both countries can tap from significant numbers. On 21st September 2022 Russia announced the first mass mobilisation since WWII¹⁰ and an estimated 700,000 men fled the country to avoid being drafted.¹¹ Most have come back and now are facing strict rules to avoid

⁴ Allison, *Event Historical Analysis, Quantitative Applications in the Social Sciences*; Horvath, "A statistical model for the duration of wars and strikes," 18-28.

⁵ Bennett and Stam, "The duration of interstate wars, 1865-1985," 239-257; Collier, Hoeffler, and Söderbom, "On the duration of civil war," 253-273.

⁶ Idem.

⁷ The World Bank, "Ukraine recovery and reconstruction needs estimated \$349 billion."

⁸ Malkasian, "A History of Modern Wars of Attrition."

⁹ Meijas and Vokuev, "Disinformation and the media: The case of Russia and Ukraine," 1027-1042.

¹⁰ Shuster and Bergengruen, "Inside the Ukrainian counterstrike."

¹¹ Reuters, "Kremlin rejects reports that 700,000 have fled Russia."

another evasion.¹² Ukraine has imposed martial law and can potentially draft 10 million soldiers.¹³ Men aged 18 to 60 are not allowed to leave the country.¹⁴

Soldiers suffer from fatigue and can only continue combat for a limited time.¹⁵ Twenty percent of soldiers in Afghanistan or Iraq experienced PTSD¹⁶ and forty percent suffered from anger and hostility issues.¹⁷ The actual war in Ukraine will create a higher stress than combat in Afghanistan or Iraq. The leaked Pentagon papers estimate that in the first year of the war 190-220,000 Russian soldiers had been killed or wounded, versus 125-131,000 Ukrainians.¹⁸ At this rate both countries need to enlist at least 200,000 new active soldiers per year. Another round of Russian mobilisation is expected¹⁹ while the West is expanding its military support and training of Ukrainian forces. Russia is a larger country and has a much larger resource of manpower. However, the Ukrainian army is significant and can continue to match Russian forces for many years to come.

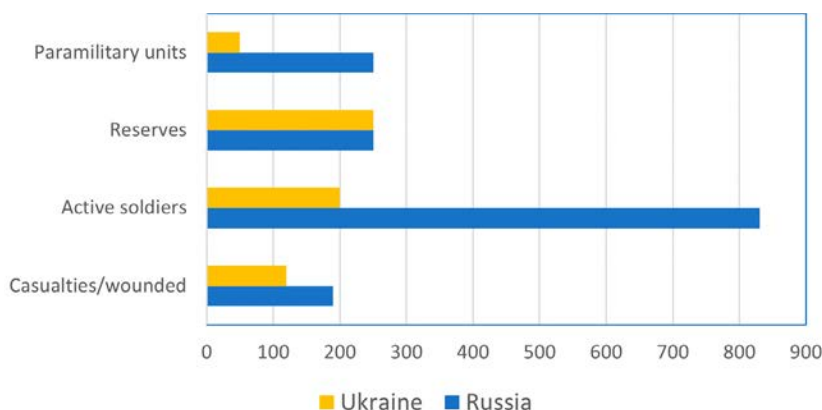


Figure 28.1: A comparison of the armed forces (numbers in thousands) illustrates that Russia has strength in numbers. Source: Statista, comparison of the military capabilities as of 2023

¹² Picheta, "Russians fear a second wave of mobilization, as Putin prepares to make it harder to avoid a military call-up."

¹³ The Defense Post, "Ukraine could draft all men under 60 to fight Russia."

¹⁴ The number of Ukrainian men avoiding the draft runs into tens of thousands, BBC: Deserters risk death fleeing to Romania, 8 Jun 2023.

¹⁵ The author Robert Graves noted in the first world war that after "a year or fifteen months" officers were often worse than useless: Graves, *Goodbye to All That*.

¹⁶ Hoge et al., "Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care," 13-22.

¹⁷ Jakupcak et al., "Anger, hostility, and aggression among Iraq and Afghanistan War veterans reporting PTSD and subthreshold PTSD," 945-954.

¹⁸ BBC, "Who leaked top secret US documents."

¹⁹ ABC News, "Russian military announces plan to expand, create new units."

Economic power. At a GDP of 200 billion dollars Ukraine's economy is much smaller than Russia's GDP of 1780 billion dollars. The main trade partner of both Russia and Ukraine is Russia's ally China (14.5% share of exports for both countries). Other main trade partners of Ukraine are Poland (6.7%), and Russia (5.5%). For Russia, the other main trade partners are the Netherlands (7.4%), and the United Kingdom (6.9%).²⁰



Figure 28.2 Growth percentage of GDP between 1990 and 2022. Source: World Bank. The economies were in sync until 2021, but Ukraine's economy shrunk sharply in 2022

It was expected that the economic sanctions imposed by the EU and the USA would cause significant harm to Russia. However, this appears not to be the case. A recent analysis found no negative economic effect at all, while some companies even benefitted from the sanctions.²¹ Energy exports transferred from the EU to China and India. Direct imports from the EU dropped sharply, but seem to have found a roundabout way through Armenia, Kazakhstan, and Kyrgyzia.²²

Ukraine's economy took a hit. It shrank by 30 percent in 2022, or 60 billion dollars²³ mainly because of reduced grain exports, which continue to be threatened by a possible Russian blockade. The destruction of the Nova Kakhovka dam may turn its richest farmland into a desert within a year.²⁴ For the time being, Ukraine

²⁰ In terms of exports according to the World Bank.

²¹ Gaur, Settles, and Väättänen, "Do economic sanctions work? Evidence from the Russia-Ukraine conflict," 1391-1414.

²² Chupilkin, Javorcik, and Plekhanov, "The Eurasian roundabout: trade flows into Russia through the Caucasus and Central Asia."

²³ CNN, "Ukraine's economy shrank by more than 30% in 2022."

²⁴ BBC, "Ukraine dam: Floods devastate tracts of rich farmland."

receives substantial economic support.²⁵ The total allocated support over 2022, including weaponry, financial, and humanitarian aid is between 50 and 100 billion dollars.²⁶ The total support from the West that has been allocated or rewarded up to June 2023 is 200 billion euros and counting.²⁷ This money flow, which is roughly 0.1 percent of GDP per country, will be necessary for the duration of the conflict. As of now, three quarters of Americans and Europeans support continuing economic and military aid to Ukraine.²⁸ Will the support remain that high when inflation and national deficits continue to rise?

Public support. Initially, Vladimir Putin's support within Russia seemed to be strong. The initial protests against the war were suppressed by mass arrests.²⁹ The Levada center, an independent poller, reports that a solid majority supports the war (70 percent support and 40 percent strong support), but that an increasing number of people think it is time to start peace negotiations (55 percent in June 2023). Of course, any estimate on public support has a large margin of error as Russia is a totalitarian state without tolerance for even the slightest criticism.³⁰ Sentiment analysis of open-source data³¹ does show that public sentiment has become more negative due to the large number of Russian casualties.³² Public support in totalitarian states can suddenly crumble without prior warning.³³ Prigozhin's rebellion in June 2023 did not attract the anticipated public support, but it was a sign that Putin's hold on power is not absolute. Regime change is a possibility.

Volodymyr Zelensky's approval rating jumped from 38 to 94 percent.³⁴ Support of the war remains strong with 85 percent of Ukrainians not open to any territorial concession to stop the war.³⁵ Russia's relentless bombing of civilian targets is likely to strengthen public support rather than weaken it, as civilian morale only hardens under aerial bombing.³⁶ Zelensky is popular in the EU and the USA, where he tops

²⁵ European Commission, "Commission proposes stable and predictable support package for Ukraine for 2023 of up to €18 billion."

²⁶ Tian et al., "Developments in military expenditure and the effects of the war in Ukraine," 547–562; Antezza et al., "The Ukraine support tracker: Which countries help Ukraine and how?" 1–65.

²⁷ Kiel Institute for World Economy, Ukraine Support Tracker.

²⁸ Brookings Institute, "23 Feb 2023 – Eurobarometer, 12 Jan 2023."

²⁹ The Guardian, "More than 4,300 people arrested at anti-war protests across Russia."

³⁰ New York Times, "A child's drawing, a dad's antiwar posts, and Russia's latest orphan."

³¹ Filterlabs.ai provides real time analysis of Russian attitudes towards the war in Ukraine, <https://www.filter-russia.com>.

³² Politico, "AI can tell us how Russians feel about the war. Putin won't like the results."

³³ Koster et al., "Mass-mobilization with noisy conditional beliefs." 55–77.

³⁴ Statista opinion poll.

³⁵ Kyiv International Institute of Sociology.

³⁶ Horowitz and Reiter. "When does aerial bombing work?" 147–173.

the list of most trustworthy world leaders.³⁷ His position is secure and Ukraine's morale is likely to remain high.

2.2 *War of attrition*

The front line more or less stabilised two months after the failed Russian invasion and stretches over roughly one thousand kilometres, from Kherson along the Dnepr River to Zaporizhzhia to Donetsk and along the border of Luhansk province to the Russian border.³⁸ Russia now controls a major part of the Ukrainian provinces Donetsk, Kherson, Luhansk, and Zaporizhzhia, which it claimed as its own on 30th September 2022. It has established a land bridge to Crimea, which was one of its strategic objectives,³⁹ and has fortified the front line with trenches and mine fields.⁴⁰ The provinces under Russian control are devastated. Before 2014, the income level was higher than average in Ukraine, but the proxy war that has been going on for a decade devastated the area. Already during 2014-2017 more than 3 million civilians had fled and tens of thousands died.⁴¹ The war rages in a no-man's land.

The military losses on both sides are steadily increasing at a constant rate. According to the warfare analysis website Oryx, Russia has lost total equipment of over 12,000 (tanks, aircraft, vehicles, missile carrier) while Ukraine has lost over 4,000. These numbers are based on verified open data and are likely to be an underestimate of the actual losses. The losses are starting to make a dent. Russia has lost 2,000 out of 3,000 active tanks and has re-opened factories for production.⁴² The war is also taking a toll on its aircraft, which by the summer of 2024 may have reduced to 75 percent of its prewar strength.⁴³ Ukraine's losses are less significant, but its recent counter offensive has already taken a toll of roughly ten percent of its equipment.⁴⁴

In almost every major war, armies run out of ammunition.⁴⁵ Indeed, artillery fire has gone down significantly due to shortages on both sides.⁴⁶ The leaked

³⁷ Pew Research Center, 17 Apr 2023.

³⁸ Institute for the Study of War.

³⁹ The Guardian, "Mission accomplished?"

⁴⁰ Reuters, "Digging in."

⁴¹ Mykhnenko, "Causes and consequences of the war in Eastern Ukraine: An economic geography perspective," 528-560.

⁴² Forbes, "Russia might restart production of the T-80 Tank. Don't expect it to happen soon."

⁴³ Bohnert, TheRandBlog, "The uncounted losses to Russia's air force."

⁴⁴ Peck, Center of European Policy Analysis, "Surprised That Ukraine is taking combat losses? You shouldn't be."

⁴⁵ Bruce, "To the last limits of their strength the French army and the logistics of attrition at the Battle of Verdun 21 February – 18 December 1916," 9–21.

⁴⁶ CNN, "Russian artillery fire down nearly 75%."

Pentagon papers predicted that Ukraine would run out of ammunition in May 2023 and that Kyiv would no longer have air-defence cover.⁴⁷ That did not happen. Ukraine receives ammunition from the EU and the US, which are both increasing production of shells and ammunition.^{48;49} Russia increased its production and receives ammunition from North Korea.⁵⁰ As a stopgap both Russia and Ukraine use ammunition that dates back to WWII.⁵¹

Both sides extensively use drones. Within half a year, one thousand Russian drone strikes had been recorded, mostly targeting civilians⁵² but also critical infrastructure.⁵³ Ukraine in return targets Russian military infrastructure. Kamikaze drones are not an immediate game-changer on the battlefield⁵⁴ but they do drain the air defence systems. The surface-to-air missiles that take out drones cost 100,000 dollars a piece.⁵⁵ Defensive MANPADs are less expensive at 30,000 dollars a piece⁵⁶ but still more expensive than drones. The use of drones is a punishment strategy⁵⁷ to inflict such high costs on the opponent that war becomes unaffordable in the long run.

2.3 Summary

The current rate of attrition can be compensated by both parties. They can continue the war for years and there is no sign that they will start peace talks anytime soon.⁵⁸ The countries do experience the strain of the war. Ukraine's population is under constant attack and its economy is getting increasingly worse. Russia's morale is vulnerable. For now, public support seems to be sufficiently strong to supply the necessary manpower, but this may suddenly change. The main question of course is: when exactly will the strain of the war become too much?

⁴⁷ Time, "4 major takeaways from the Pentagon leaked files."

⁴⁸ European Council, Press Release, 5 May 2023.

⁴⁹ US DoD, "Large quantity of defensive munitions earmarked for Ukraine."

⁵⁰ Reuters, "Russia seeking munitions from North Korea."

⁵¹ Forbes, "Desperate for artillery."

⁵² Irish Times, "8006 recorded deaths."

⁵³ @vonderleyen, "I strongly condemn the Russian drone attack on the port of Izmail in Ukraine. These and other attacks against civilians are war crimes Russia will be held accountable for, 23 Aug 2023

⁵⁴ Deveraux, "Loitering munitions in Ukraine and beyond"; Kunertova, "The war in Ukraine shows the game-changing effect of drones depends on the game," 95-102.

⁵⁵ Defense Express, "How much GLMRS missiles for HIMARS cost."

⁵⁶ Withington, "Terrorism: Stung by stingers," 16-17.

⁵⁷ Bennett and Stam, "The duration of interstate wars, 1865-1985," 239-257.

⁵⁸ Al Jazeera: "Experts have said the prospect of meaningful talks remains distant."

3. Forecasted timelines under various scenarios

War is the continuation of politics by other means, and therefore it is driven by a rational weighing of costs and benefits. A war ends once its goal has been reached or when the costs have run up too high. However tragic, the decision to end a war is rational and open to a mathematical analysis. The simplest and most robust model for war duration is Vuchinech and Teachman's. It essentially has one parameter that has been calibrated on a data set of 110 wars between 1810 and 1980.

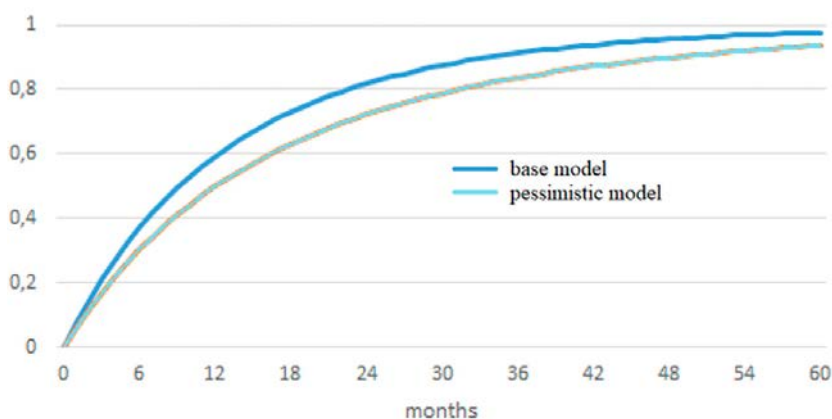


Figure 28.3: Probability that the war ends according to Vuchinech and Teachman. It is a Weibull hazard rate model with shape parameter 0.74 (95% conf interval (0.64,0.84)) and base rate of 0.07 (after 18 months of war). The pessimistic model has a shape parameter of 0.64. The longer the war lasts, the less likely it is to end soon.

Bennett and Stam refined the Vuchinech-Teachman model, by adding parameters and by distinguishing different types of wars.⁵⁹ In the Bennett-Stam classification, the war can best be described as type OPDP, punishment strategies by both sides with minimal tactical battles. These wars last longer, which is why the pessimistic model of Vuchinech and Teachman seems most appropriate. According to this model, the probability that the war between Russia and Ukraine will be over within a year is fifty percent, see Figure 28.3. The probability that it will last for another three years or more is twenty percent. We emphasise that the Vuchinech-Teachman model averages the timelines of many wars. As of now, with no bilateral talks in sight, the fifty percent probability of the war lasting more than one year is likely to be an underprediction.

⁵⁹ Bennett and Stam, "The duration of interstate wars, 1865-1985," 239-257.

3.1. Possible future developments

Scenario A – The West withdraws its economic and military support. The western financial and military support of Ukraine keeps its economy going and enables its current military offensive. This support may reduce because of economic or political reasons. The Eurozone faces a stubbornly high inflation that could push its economy into recession. The American presidential elections next year may be won by a pro-Russian candidate.⁶⁰ One year from now, western support may decrease significantly. How will this affect the war?

A loss of financial aid is likely to cause an economic meltdown of Ukraine's economy, which is severely weakened already. This does not mean that the country loses its ability to fight. Serbia and Montenegro faced severe hyperinflation after the outbreak of the Yugoslav War.⁶¹ Economic sanctions wrecked its economy⁶² but the war lasted for another seven years. Collier et al.⁶³ estimate that an economic meltdown increases the hazard rate by 0.015. The hazard rate at a certain time encapsulates the probability that the war will not last any longer given that it lasted until that time. Compared to the current hazard rate of 0.07 after 1.5 years into the war, the expected increase of 0.015 is within the uncertainty range of the parameter and henceforth the effect of an economic meltdown on the length of the war is negligible.

A loss of military aid will force Ukraine to stop its offensive actions and diminish its air defence against drones and missiles. It may even force Ukraine to end the war with an unfavorable peace agreement. Right now, military supplies for Ukraine will be delivered for the coming year and it is unlikely that this will stop before the end of the next year.

Scenario B – Public support breaks down in Russia. Russia's main weakness is a possible loss of public support for the war. Knowledge about collective action under oppressive regimes is limited.⁶⁴ Once a dictator is ousted there are three possible outcomes: replacement by another autocracy, regime survival with leadership replacement, or democratisation. In the last 75 years, less than a quarter of ousted

⁶⁰ Politico, "I like that he said that": Trump revels in praise from Putin."

⁶¹ Inflation peaked at 313,563,558 percent in 1994, the second highest level ever recorded and lasted for two years, the second longest period recorded in history.

⁶² Petrovic and Zorica Vujošević, "The monetary dynamics in the Yugoslav hyperinflation of 1991-1993," 467-483.

⁶³ Collier, Hoeffler, and Söderbom, "On the duration of civil war," 253-273.

⁶⁴ Teorell, *Determinants of Democratization: Explaining Regime Change in the World, 1972-2006*.

dictators were replaced by a democratic leader.⁶⁵ The recent popular uprisings during the Arab Spring showed an even more dismal result for democracy:

Country	Days	Outcome
Egypt	18	Government overthrown
Borders of Israel	22	No regime change
Tunisia	28	Government overthrown
Bahrain	33	Governmental changes
Djibouti	43	Minor protests
Libya	190	Government overthrown
Lebanon	292	Governmental changes
Iraq	315	Start of war on terrorism
Algeria	378	Lifting state of emergency after 19 years
Yemen	397	Government overthrown
Morocco	407	Governmental changes
PLA	604	Resignation of prime minister
Jordan	629	Governmental changes
Oman	630	Governmental changes
United Arab Emirates	653	Protests quelled
Kuwait	661	Governmental changes
Saudi Arabia	704	No regime change
Mauritania	797	Minor protests
Egypt	874	Government overthrown
Sudan	1001	No regime change
Yemen	1061	Government overthrown

Table 28.1: Time-scale (avg=464, stddev=325) of Arab spring mobilisation dynamics. Number of days is counted between the protest start date and the final outcome. Most protests had no effect. Some resulted in minor governmental changes. Only 6 out of 22 protests caused a regime change, none of which resulted in a lasting democracy, see https://en.wikipedia.org/wiki/Arab_Spring

Information (repression) plays another important role in protests, political mobilisation and eventual regime survival.⁶⁶ Initial protests may reveal information about the lack of regime support, leading to more people joining the protest, which

⁶⁵ Geddes, Wright, and Frantz. "Autocratic breakdown and regime transitions: A new data set," 313-331.

⁶⁶ Magaloni and Wallace, "Citizen loyalty, mass protest and authoritarian survival."

can cascade into a sudden uprising.⁶⁷ An overthrow of a government by public uprising typically goes through a back and forth between protests, repression, more protest and repression until in the end protest is no longer controllable.⁶⁸ So far, we have not witnessed such a process in Russia, which has seen far fewer public protests than its neighbour Belarus.⁶⁹ The time-scale on which such protests escalate from initial micro-mobilisation to eventual regime change, can be long and ranges between 1 month and 1-2 years (see Table 28.1). Regime change is a possibility, but it is unlikely to happen soon.

Scenario C – Ukraine's offensive succeeds. Ukraine began its counter-offensive in June, three months ago. It has not made any noticeable progress. Russia's defence line of trenches and mine fields is formidable⁷⁰ and a breakthrough seems unlikely. However, there are reports that Russian troops are worn out and on the brink of abandoning their positions.⁷¹ In the most optimistic scenario, Ukraine pushes through and is able to sever Russia's supply lines to its troops in Crimea. This will not immediately end the war, but it will put Ukraine in a stronger position and may induce both parties to start negotiating.⁷² According to the convergence principle,⁷³ negotiations are only likely to begin if both parties are sufficiently close to their military objectives. At the moment, Russia is much closer to that state.

Scenario D – A multilateral intervention forces a ceasefire. The principal role of the United Nations is to maintain international peace and deliver humanitarian aid. It has overwhelmingly passed a resolution that calls on Russia to leave Ukraine and it has called for a sustainable peace.⁷⁴ Any UN initiative can be vetoed by Russia, as a permanent member of the Security Council. However, if the war lasts for many more years, as it may very well do, a multilateral solution through mediation by the UN or other states will get more likely. UN interventions were relatively successful after the end of the cold war, but less so in more recent years because of the diminishing dominance of the USA (Kreps). World leaders of major countries are calling for peace talks.⁷⁵ These calls will become louder in the coming year.

⁶⁷ Koster et al., "Mass-mobilization with noisy conditional beliefs." 55-77.

⁶⁸ Carey, "The dynamic relationship between protest and repression," 1-11.

⁶⁹ Weidmann, Nils B., and Espen Geelmuyden Rød. "Making uncertainty explicit: Separating reports and events in the coding of violence and contention." *Journal of Peace Research* 52, no. 1 (2015): 125-128.

⁷⁰ BBC, Ukraine war: Satellite images reveal Russian defences before major assault, 22 May 2023

⁷¹ The Defense Post, Russian troops to abandon frontlines due to 'collapsing' morale, 24 Aug 2023

⁷² Financial Times, Ukraine 'ready' to talk to Russia on Crimea if counteroffensive succeeds, 5 Apr 2023

⁷³ Slantchev, "The principle of convergence in wartime negotiations," 621-632.

⁷⁴ António Guterres, UN Security Council 9421st meeting, 20 Sep 2023

⁷⁵ Reuters, "Brazil's Lula condemns invasion of Ukraine, touts peace initiative," 19 Apr 2023; "China Ministry of Foreign Affairs: China to continue contributing to political settlement of Ukraine crisis," 9 Aug 2023; CBS News, "Macron pushes Ukraine peace talks in meeting with Xi," 7 Apr 2023.

4. Conclusion

The war in Ukraine has been going on for 18 months at the time of writing. The course of the war is unclear and dependent on future developments that are hard to predict. The war is likely to last one more year, and has a relatively high chance of lasting more than three years. The most likely outcome of the war, which seems to have reached a stalemate, is a frozen conflict. A more desirable outcome would be a multilateral solution and restoration of Ukraine under the guidance of an international peacekeeping force. As of now, this is not within sight.

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