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Strategic and Tactical Nuclear Weapons in Politics and Warfare

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Strategic and Tactical Nuclear Weapons in Politics and Warfare

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Abstract

After Hiroshima and Nagasaki, a nuclear weapon has not been launched for 78 years. This article presents a game-theoretic model of why a nuclear war with strategic ballistic weapons has been ruled out. However, Russia's attack on Ukraine on February 24 in 2022 has raised fears about the use of tactical nuclear weapons on the battlefield. The interpretation of the Russian military doctrine appears flexible and does not necessarily exclude the use of tactical nuclear weapons. The article shows in an analytic model why such an action is not excluded even if the United States has threatened to strike back. Then the key question is whether the US threat of a counter attack is credible.

JEL Classification: H12, H56

Key words: *strategic ballistic nuclear weapons, tactical nuclear weapons, Russian military doctrine, Russian attack in Ukraine*

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1. Introduction

Russian President Vladimir Putin's repeated threat to use tactical nuclear weapons in the Ukraine war raises the question of how credible that threat is.

In the 1990s, Russia's conventional military weakness forced its military doctrine to rely heavily on nuclear weapons, including both ballistic strategic weapons and non-strategic (tactical, theatre nuclear) weapons. Since then, Russia has carried out substantial reforms both in its military doctrine and carried out substantial reforms to its military forces. In June 2020, and for the first time, Russia publicly revealed its official nuclear deterrence policy in *On Basic Pinciples of the State Policy of the Russian Federation on Nuclear Deterrence,* published by its Ministry of Foreign Affairs.

As reported by the US Congressional Research Service CRS in its report *Russia's Nuclear Weapons: Doctrine, Forces, and Modernization* from April 21, 2022b, the Russian 2020 document outlined the threats and circumstances that could lead to Russia's use of nuclear weapons. The 2020 document specifically noted that Russia "considers nuclear weapons exclusively as a means of deterrence." It stated that Russia's nuclear deterrence policy "is defensive by nature, it is aimed at maintaining the nuclear forces potential at the level sufficient for nuclear deterrence, and guarantees protection of national sovereignty and territorial integrity of the State, and deterrence of a potential adversary from aggression against the Russian Federation and/or its allies." It emphasized that Russia maintains forces that could "inflict guaranteed unacceptable damage on a potential adversary … in any circumstances".

As stated by CRS (2022b), the nuclear parity with the United States offered the Soviet Union prestige and influence in international affairs. During the 1960s, both countries had recognized the reality of the concept of "Mutually Assured Destruction" (MAD)—a situation in which both sides had nuclear retaliatory capabilities that prevented either side from prevailing in an all-out nuclear war both sides accepting limits on their ability to protect themselves from a retaliatory nuclear attack, thus reducing incentives for either side to engage in a nuclear first strike. Although Russia had stated during the Cold War that it would not be the first to use nuclear weapons it subsequently had not retained the Soviet "no first use" policy.

Instead, fears have been expressed that Russia might threaten to use nuclear weapons if it were losing the conflict with conventional weapons. Such a strategic deterrence became known as "escalate to de-escalate" strategy.

The June 2020 document did not call for the preemptive use of nuclear weapons during conventional conflicts. However, there was some ambiguity in the use of the language. The document did not completely resolve the question of whether Russia would escalate to nuclear use if it were losing a conventional war. In the context of the Russian 2022 attack to Ukraine, this question appears relevant. Russia possesses about 1000-2000 non-strategic nuclear weapons and they are not subject to any arms control or transparency measures.[1]

Since 1997, it has been a threat to Russia's existence that has allowed the use of nuclear weapons in Russian military doctrine. Now that Russia has annexed Ukrainian territories, can this serve as a pretext for using nuclear weapons in Ukraine on the battlefield? If Russia does not succeed in its military operations in Ukraine with conventional weapons, will it return to the possibility of first use of nuclear weapons? Why did Russia decide to transfer some of its tactical nuclear weapons to Belarus? On the other hand, President Vladimir Putin's stated in his speech from October 27, 2022, that Russia has no intention of using nuclear weapons and that its use would not make sense politically or militarily.

[1] Russia thus has superiority in the number of tactical nuclear weapons, as the USA has 230 of them, with around 100 deployed with aircraft in Europe, cf. CRS (2022a).

The former commander of the Finnish Armed Forces Ari Puheloinen (2023) writes: "If Russia follows its principles, the use of nuclear weapons to promote Russia's own military actions in the territory of another state would not be in accordance with the doctrine. In an authoritarian system, the doctrine is, however, not binding in the same way as in democracies". He continues: "Official doctrines in Russia have a much more declarative nature... Therefore, it cannot be said that Russia will definitely not use nuclear weapons in its war, even though their use is extremely unlikely." "By considering the possibility of using nuclear weapons as a latent threat, Russia has tried to keep the initiative in its hands and limit Western countries' support to Ukraine"..."Russia's leadership understands that if it were to use nuclear weapons, the Russian forces in eastern Ukraine would probably be destroyed as a result. Western countries would not need to use nuclear weapons for that", Puheloinen writes.

The Russian threats have indeed been effective in creating an impression that Russia has an exceptionally low threshold for nuclear use, and that a wide range of circumstances or 'provocations' could cause that threshold to be crossed.

The vagueness of Russia's speeches regarding the use of nuclear weapons gives reason to look analytically at the incentive to use nuclear weapons instead of the interpretation of speeches and documents. This paper formulates a simple game-theoretic model of a war. The cost of a nuclear war rises to a decisive position. The magnitude of the cost of a nuclear war with ballistic weapons explains the fact of the Cold War that, despite the Berlin (1961) and Cuban (1962) crises, a nuclear war did not take place.[2] In the case of tactical nuclear weapons, the cost is lower, which is why a war with tactical nuclear weapons is possible in the equilibrium.

2. Model of armament in nuclear weapons

It is clear that a formal model significantly limits the number of questions that are related to the use of nuclear weapons and that can be analyzed within the model. Still, it is plausible that a formal model helps to understand some key mechanisms that can be accurately described in the model world.

In the model world of this paper, there are two hostile countries (players), A and B. Potentially resorting to their military power, they compete in the spirit of the contest theory for a resource with a value of $v > 0$ with imperfectly specified property rights. The 'winner takes it all' principle applies if countries end up in fighting. A complete-information war game with two stages is examined.[3]

The timeline and action space are as follows. In stage 1, both players simultaneously allocate their resources, say x and y to their military capacity in strategic ballistic, tactical and conventional arms to maximize their expected payoff.[4] In stage 2, the players decide independently whether they will fight by deploying their military strength or settle the issue peacefully. The war game with strategic weapons is a simultaneous-move game. When one player resorts to tactical nuclear weapons, the game is sequential. The model is solved in the spirit of backward induction. Depending on the perceived cost of war relative to the payoff from victory, two types of equilibria can arise.

[2] In the late 1940s, the creator of the zero-sum games John von Neumann favored a surprise nuclear assault on the Soviet Union before it was able to develop the bomb itself, writes Harford (2008). Thomas C. Schelling did not agree. For him, life is not a zero-sum game as there are common as well as conflicting interests. His book on the strategy of conflict is essentially a book on bargaining, coordination of expectations and nonuse of force, cf. Schelling (1960). In his Nobel Prize lecture in 2005, Schelling stated: "The most spectacular event of the past half century is one that did not occur. We have enjoyed sixty years without nuclear weapons exploded in anger".

[3] Earlier, Kraig (1999) studied the interactions between threat credibility, threat capability, and the dynamics of escalation showing when nuclear blackmail remains a possibility. The current model is a variant of Kanniainen (2019).

[4] The use of conventional weapons is not explicitly addressed.

To economize in notation, the investments in the military spending are discussed separately. The key distinction arises from the cost of their use. In the event of mutual deployment of ballistic nuclear weapons, the cost to the mankind is huge.[5] The cost of war when tactical nuclear weapons (or conventional weapons) are used is local and more limited.

To deploy a formal presentation, the expected ex ante payoffs of the war game to the players involved are

$$E[\pi_A] = P(A)v - x - C(y) \tag{1}$$

$$E[\pi_B] = P(B)v - y - C(x). \tag{2}$$

The probabilities of winning a war in the last stage of the war game are denoted by $P(A)$ and $P(B)$. The well-known Tullock (1967) model predicts that the probabilities of winning a war are dictated by their relative military investments x and y, yielding the contest success functions

$$P(A) = \frac{x}{x+y};\ \ P(B) = \frac{y}{x+y}. \tag{3}$$

The cost functions are assumed to be increasing, $C'(x) = C'(y) > 0$ and in the case of strategic ballistic weapons identical across the counties. It should be noticed that the above formulation provides an important qualification for the existing literature on how to model the cost of war: the damage caused by the war depends on the military strength of the enemy.

Settling the issue peacefully with zero investment in military and sharing the resource would be Pareto efficient but cannot be an equilibrium if peace is not contractible and the commitment to it is not credible. Therefore, both invest. In the two-stage war game, the solution of the last game must be found first in the spirit of backward induction. In order to highlight the effect of the cost of war on the results, assume for a moment that the cost of war is zero. In stage 2, the investments are sunk and as the cost of war is zero, the countries definitively fight. The post-investment expected payoffs from investments and from the subsequent warfare are

$$E_2[\pi_A] = \frac{x}{x+y}v - x \tag{4}$$

$$E_2[\pi_B] = \frac{y}{x+y}v - y. \tag{5}$$

Carrying out the maximization of the expected returns with respect to investments in stage 0 and subject to $C(x) = C(y) = 0$, the reaction functions are

$$x = -y + \sqrt{yv},\ \ y = -x + \sqrt{xv}. \tag{6}$$

Then, the Nash equilibrium in investments in conventional weapons is given by a pair (x^0, y^0) satisfying[6]

$$x^0 = y^0 = \frac{v}{4}. \tag{7}$$

Natural as it is, the optimal investment is less than the available prize. It follows that both countries have the same probability of winning the war, $P(A) = P(B) = 1/2$. In the absence of a cost of war, the countries

[5] Ellsberg's titled his 2017 book *The Doomsday Machine*.
[6] The second-order conditions are satisfied as $P(A)$ is strictly concave in x and $P(B)$ in y.

fight, having access to an expected payoff which is solved to be $v/4$. As the winner takes it all, the *ex post* payoff to the winner, however, is $3v/4$ while it is $-v/4$ for the loser.

The existence of a Nash equilibrium in investments is no issue. By continuity, a Nash equilibrium in investments also exists when a war is costly. Introducing the cost of war into the model, the expected ex ante returns are

$$E_1[\pi_A] = \frac{x^N}{x^N+y^N} v - x^N - C(y^N) \quad (8)$$

$$E_1[\pi_B] = \frac{y^N}{x^N+y^N} v - y^N - C(x^N). \quad (9)$$

It is the cost of war that results in mutual externalities in the war game. As one is looking for a Nash equilibrium of the war game, we have denoted these investments by x^N and y^N. It turns out that the investments in equilibrium are independent of the cost of war, $x^N = x^0, y^N = y^0$.

Abstracting from the investment costs that are sunk in stage 2, we notice that for any positive cost of war, the *ex post* payoffs would be greater under peaceful contracting with sharing the prize than the expected payoffs from fighting,

$$\frac{v}{2} > \frac{v}{2} - C(y^N),\ \frac{v}{2} > \frac{v}{2} - C(x^N). \quad (10)$$

We now complete the characterization of the equilibria. It turns out that one is subject to fighting while only the other is a no-fight equilibrium. The amounts of investments in those equilibria are, however, independent of whether the countries expect to fight.

Because the investments x^N, y^N are sunk in stage 2, the post-investment incentives for a no-fight equilibrium, adjusted for the costs of war, are

$$E_2[\pi_A] = \frac{x^N}{x^N+y^N} v - C(y^N) \leq 0 \quad (11)$$

$$E_2[\pi_B] = \frac{y^N}{x^N+y^N} v - C(x^N) \leq 0. \quad (12)$$

The expected payoffs from fighting in stage 2 have to be negative, or at most zero, for a no-fight equilibrium to arise. A large cost of war relative to the available payoff then makes the players pay attention to the mutual externalities. With symmetric military strengths, surrendering is no option. For peaceful sharing of the prize, the benefit/cost ratio of fighting has to be sufficiently low,

$$\frac{v}{C(x^N)} \leq 2,\ \frac{v}{C(y^N)} \leq 2. \quad (13)$$

The cost of a war with strategic ballistic missiles is insanely high.[7] The conditions above explain the fact that the great powers developed a significant number of nuclear weapons during the Cold War but

[7] As Albert Einstein taught us, matter is concentrated energy that is released when an atom splits. Finnish astronomy professor Heikki Oja has calculated that if all the energy hidden in him could be put to useful use, he alone would be able to satisfy the entire energy consumption of Finland for more than four years.

avoided war with each other. A nuclear war will not be fought with ballistic weapons if the benefit-cost ratio is too low. The world lives in a balance of terror.[8]

Instead, the destruction caused by the launch of a tactical nuclear weapon would remain *local*. Therefore, their use cannot be ruled out with certainty. The condition derived above may therefore be violated in the case of tactical nuclear weapons, let alone in the case of conventional weapons. One concludes:

Proposition 1. In the war game where hostile countries have access to nuclear weapons, there can be two Nash equilibria. In both equilibria, $x^N = y^N = v/4$ qualifies as a Nash equilibrium in armaments. If the above conditions (11) and (12) hold at the solution $x^N = y^N = v/4$, a Nash equilibrium exists with no fighting (balance of terror). If these conditions do not hold, there will be fighting in equilibrium.

3. Resorting to tactical nuclear weapons

A game involving the use of a tactical nuclear weapon cannot be a simultaneous game. Combat operations are initiated by one side using a nuclear weapon first, while the other side either counterstrikes or fails to do so.

The conditions for the use of tactical nuclear weapons are more complicated than in the case of ballistic missiles, because players can have different interests and different views on valuing the consequences of using nuclear weapons. It is no longer about total destruction but about limited destruction. Equally important, the user of the nuclear weapon must assess whether or not the opponent will retaliate and use a nuclear weapon or whether it will refrain from retaliating.[9] The problem of credibility emerges.

Russia annexed the Crimean peninsula belonging to Ukraine in 2014. On the last day of September 2022, Russian President Vladimir Putin illegally annexed four Ukrainian territories occupied by Russia into Russia. The territorial annexations, which have no basis in international law, concern the regions of Donetsk, Luhansk, Zaporizhia and Kherson in the eastern and southern parts of Ukraine. In Russia's military strategy, the use of nuclear weapons is possible if the country faces an existential threat. If Russia is threatened with the loss of these areas, is this a valid reason to rely on tactical nuclear weapons?

It is worth mentioning that when the Soviet Union collapsed on December 25, 1991, Ukraine possessed 176 intercontinental missiles, 1,500-1,700 nuclear warheads and 33 bombers. In 2005 Ukraine destroyed its last Tu-22M heavy bomber & 423 cruise missiles as part of voluntary disarmament. In 1994, Russia, Great Britain and the United States had signed the so-called "Budapest memorandum", in which the countries committed themselves to respect the sovereignty of Ukraine. Russia violated the agreement in 2014 by annexing the Crimean peninsula.

[8] Despite several arms limitation treaties on the number of ballistic missiles, the total number of nuclear weapons in the United States and Russia is more than 5,000 (US 5,244, Russia 5,889). According to CRS data, the US has 230 tactical nuclear warheads. 100 of them are located in Europe. The estimates of the number of Russian tactical nuclear warheads vary between 1,000 and 2,000. The number of nuclear weapon states has increased. In total, there are approximately 12,500 nuclear weapons in the world as follows: United Kingdom 225, France 290, China 410, India 164, Pakistan 170, North Korea 30 and Israel 90. Source: SIPRI 2023.

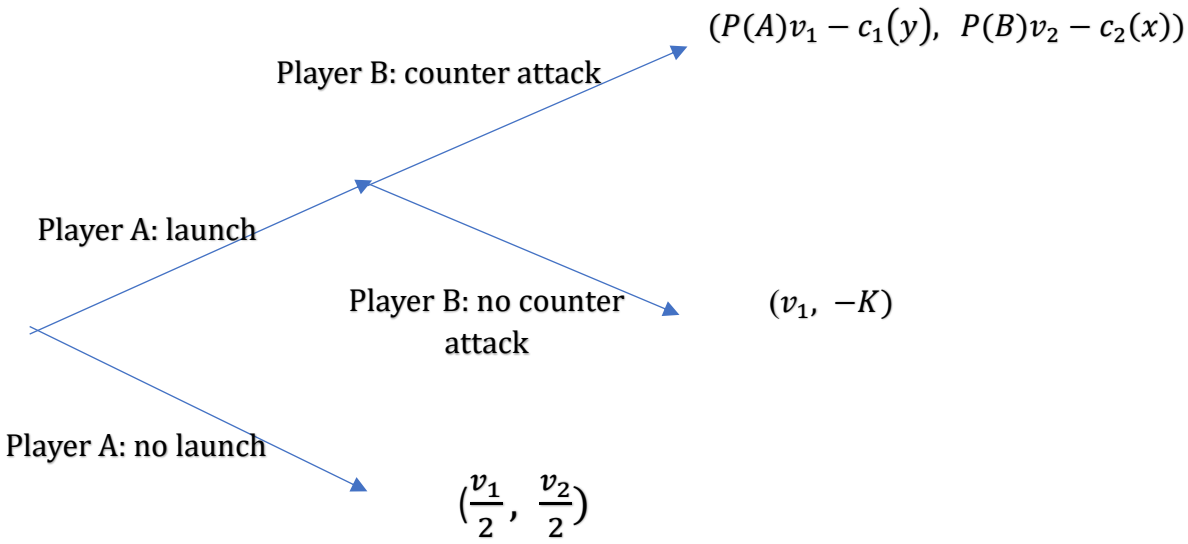
[9] Citing the statement of General von Clausewitz: "Theory demands, therefore, that at the commencement of every war its character and main outline shall be defined according to what the political conditions and relations lead us to anticipate as probable. The more, that according to this probability its character approaches the form of absolute war, the more its outline embraces the mass of the belligerent states and draws them into the vortex, so much the more complete will be the relation of events to one another and the whole, but so much the more necessary it will also be not to take the first step without thinking what may be the last", von Clausewitz (1832) Book 8, Ch 3. His statement is consistent with the modern dynamic game theory.

It is unthinkable that the United States would hand over nuclear weapons to Ukraine, even if Russia were to use a nuclear weapon. The US leaders have publicly stated that the use of a nuclear weapon in Ukraine would be completely unacceptable and that this would lead to serious consequences.[10]

We now return to the model world. It is assumed that the values of the rewards for players *A* and *B* as a winner are v_1 and v_2. Mutual use of tactical nukes incurs costs c_1 and c_2 to the players.[11] Investments in tactical nuclear weapons in phase 1 of the game are again denoted by *x* and *y*. In stage 2a of the game, player *A* decides whether to launch a nuclear weapon or not, given its assessment of player *B*'s counter attack. In stage 2b of the game, player *B* decides its counter attack. If player *B* was bluffing about whether to strike back, the bluff is revealed in step 2b of the game. Revealing the bluff is not free for player *B*, but incurs a cost $K > 0$. This cost is not trivial.[12]

The game tree is shown in the attached graph.

Figure. The game tree in a war with tactical nuclear weapons



Obviously, player *B*'s threat to respond with a counter attack is not credible if

$$P(B)v_2 - c_2(x) < -K. \qquad (14)$$

Instead, it is credible if

$$P(B)v_2 - c_2(x) > -K. \qquad (15)$$

[10] In connection with the Berlin crisis, President John F. Kennedy gave a statement on July 25, 1961: "We have given our word that an attack upon that city will be regarded as an attack upon us all". Soviet leader Nikita Khrushchev had demanded the withdrawal of American troops from their bases in West Berlin. Khrushchev 's bluff had been exposed. As a result, the construction of the Berlin Wall began in August 1961.

[11] The costs are indicated in lowercase letters to distinguish them from the costs caused by long-range nuclear missiles.

[12] Europe's security architecture may be shaken if faith in the commitment of the USA or, more broadly, in NATO's ability to carry out a counterattack disappears, even though Ukraine does not have the protection provided by Article 5 of NATO.

In the latter case, player *A* has two options. If it considers *B*'s counterattack credible, it will not carry out its threat to strike, but only if

$$P(A)v_1 - c_1(y) < 0. \tag{16}$$

In the opposite case with

$$P(A)v_1 - c_1(y) > 0, \tag{17}$$

player *A* carries out the strike despite knowing that *B* will respond with a counter attack. *A* then estimates that the cost caused by *B* is *tolerable* compared to the benefit of the strike.

The obtained results highlight the difference in incentives for the use of strategic ballistic nuclear missiles and tactical nuclear missiles.

Additional insight is available when the investments *x* and *y* are solved for stage 1. The reaction functions are $x = -y + \sqrt{yv_1}, y = -x + \sqrt{xv_2}$ and the investments are

$$x = v_2\left[\frac{v_1}{v_1+v_2}\right]^2, \quad y = v_1\left[\frac{v_2}{v_1+v_2}\right]^2. \tag{18}$$

The desired number of tactical nuclear weapons positively depends on the benefit to be obtained from them,

$$\frac{\partial x}{\partial v_1} > 0, \quad \frac{\partial y}{\partial v_2} > 0. \tag{19}$$

And not only this. Their number also positively depends on the usefulness of the nuclear weapon to the enemy,

$$\frac{\partial x}{\partial v_2} > 0, \quad \frac{\partial y}{\partial v_1} > 0 \tag{20}$$

but on condition that one's benefit exceeds that of the enemy, is. $v_1 > v_2$ for player *A* and $v_2 > v_1$ for player *B*.

By evaluating further,

$$\frac{x}{y} = \frac{v_1}{v_2}. \tag{21}$$

Investments in tactical nuclear weapons are determined by their utility value on the battlefield. As is natural, the Tullock success is shown to be determined by investments,

$$P(A) = \frac{v_1}{v_1+v_2}, \quad P(B) = \frac{v_2}{v_1+v_2}. \tag{22}$$

Proposition 2. In the war equilibrium of tactical nuclear weapons with successive moves, the desired number of nuclear weapons depends on their utility to the player and to the *perceived* utility to the enemy in achieving military objectives relative to the costs. Fighting with tactical nuclear weapons is not ruled out in equilibrium, even if the other player credibly announces that it will carry out a counterstrike.

4. Final remarks

The potential use of tactical nuclear weapons in the war in Ukraine has also raised concerns about the conflict subsequently expanding to the use of strategic ballistic nuclear weapons. This concern therefore leads to the idea of a two-stage war with nuclear weapons. If the players are rational, they will follow General Carl von Clausewitz's instruction and see total destruction in the second stage of the game. Rational players stop the game before that stage and settle for the outcome of the previous game stage. As a criticism of this idea, it is worth raising Schelling's objection to the idea of a limited war: "The danger of all-out war is almost certainly increased by the occurrence of a limited war; it is almost certainly increased by an enlargement of limited war", cf. Schelling (1960).

Are players rational? This question leads to a deep reflection on humanity and its limitations. Whatever our thinking about the limits of humanity means, it is another possibility that world leaders consider whether it would be worthwhile to act in a way that would make the other side see the leader as an unpredictable decision-maker. This led to the so-called Madman theory. It would be about behavior interpreted as irrational making the other party more cautious and reserved.

The Madman theory has not been formulated in a game theoretic framework though the idea of randomization might be a feasible approach. Then, in the spirit of game theory, one should find out the probabilities at which it is optimal for the players to play each available strategy.

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