Communication

Leveraging Intellectual Property to Prevent Nuclear War

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Abstract: Although international law forbids nuclear attacks, only nine states have mutually assured destruction available to prevent direct attacks against themselves, while non-nuclear states have few substantive options to deter a nuclear attack. This study analyzes the economic impacts of a theoretical international agreement that eliminates patent rights for any nuclear aggressor (i.e., free global compulsory licensing of all intellectual property (IP) for a nuclear aggressor). The results found that all but one of the nuclear states would have a significant economic disincentive to start a nuclear attack if the proposal was put into force. Payback times ranged from 1.2 to 40 years, where the entire GDP of a nuclear aggressor would be needed to offset the loss for aggression, indicate such a mechanism as a whole would be an effective nuclear deterrent. This method would not be universally effective without ensuring all nuclear states are members of the international economy and IP processes. With the growth of open-source products and reduced value of patents, this mechanism does have a limited effectiveness time. Currently it appears to be a policy trajectory worthy of future work that can enhance safety from nuclear threat without causing harm to countries of goodwill.

Keywords: nuclear war; nuclear weapons; nuclear winter; nuclear proliferation; national survival; nuclear safety; global catastrophic risk; existential risk; intellectual property; patents

1. Introduction

The predicted impact of full-scale nuclear war on the world is one of devastation [1], and possibly extinction [2]. As Ehrlich et al. summarized in the impact of large-scale nuclear war in *Science*: "The population size of Homo sapiens conceivably could be reduced to prehistoric levels or below, and extinction of the human species itself cannot be excluded." (p. 1293) [3]. This can come from what Vaughan et al. called an "extinction cascade" [4] brought on by nuclear winter, which is the potential severe multi-year global climatic cooling effect caused by widespread firestorms burning forests, crops, fossil fuels, and cities [5], following nuclear war [6]. Widespread fires throughout the world would produce a thick smoke layer in the atmosphere, which would radically reduce the solar flux on the ground and cause "nuclear twilight" [5] and subfreezing temperatures [7]. For example, several thousand megatons of TNT (Mt) of nuclear weapons would reduce land temperatures to -15 to $-25\ ^{\circ}\mathrm{C}$ based on simulations by Turco et al., in the U.S. [7] and confirmed by Aleksandrov and Stencikov in Russia [8]. Although, as Sagan pointed out, the extinction of humanity is debatable, the evidence, even 40 years ago, that full nuclear war would mean the destruction of contemporary civilization, and the deaths hundreds of millions or billions of people, is strong [9]. Thus, an inescapable policy conclusion is that the number of nuclear weapons should be reduced below such an environmentally destructive threshold (i.e., a few hundred over cities or a few thousands at missile silos for dust generation and ancillary fires) [9].

Today, humanity has more data. The earlier models have evolved and are more precise such as with the now well-established models in 3D simulations of smoke [10] and 3D climate simulations [11]. It is obvious that reduction in light and much colder temperatures

following a nuclear exchange would have a severe impact on the world's food supply [12] and thus risk mass human starvation [13]. Perhaps, more disturbing is that even in a limited regional nuclear conflict with only a limited number of nuclear weapons used a "nuclear autumn" would create about 1 °C global temperature drop and a 10 to 20% reduction in food production [14]. This would cause mass human suffering and exacerbate existing food insecurity. The environmental consequences of a small nuclear war have been confirmed [15] and would be severe even for a small number (e.g., 100) of small by current standards (i.e., Hiroshima-sized) nuclear weapons [16]. Modern nuclear weapons are 5 to 25 times larger [17] and so the effects can be expected to be severe. A substantive body of evidence now exists that shows even a small regional conflict (or a very limited single source nuclear strike) has the potential to cause mass starvation worldwide [14–22]. Interestingly, the nuclear aggressors (even in the best-case scenario for the aggressor where there was no retaliation), would suffer from food shortages under these circumstances, which has set a pragmatic limit of 100 nuclear weapons [23]. To stockpile more than this pragmatic limit does not appear to be a rational use of government funds, because investing in increased nuclear weapons above the limit does not provide additional deterrence while only endangering one's own country [23].

This is well-known, yet even as nuclear weapons inventories are in slow decline in the two nuclear states most severely above the rational limit (Russia (5977) and the United States of America (5428)), eight of the nine nuclear states continue to produce new nuclear weapons [24] (with about 225 in the UK, 20 in North Korea, 350 in China, 160 in India, 165 in Pakistan, 90 in Israel, and 290 in France). While there are "first strike" national nuclear weapons policies [25,26], there is a legitimate concern that one of the nuclear states will break the "nuclear taboo" [27]. Many authors have argued to limit nuclear weapons inventories because of the risks of accidents [28,29], full-scale nuclear war, or threats of retaliation for first strikes [30–34]. These concerns have recently been brought to a head by the return of military conquest with the 2022 Russian invasion of Ukraine [35]. Although the military actions of Russia have been widely condemned, including a 2 March 2022, UN General Assembly resolution ES-11/1 that "deplores in the strongest terms the aggression by the Russian Federation" (p. 1) [36], the war has been allowed to continue. This is in a large part because "President Putin's administration is again on record as asserting the right to use nuclear weapons in Ukraine. Putin was widely reported as establishing the nuclear threat at the very start of the war, warning that western intervention would reap 'consequences you have never seen'." (p. 1) [37]. In addition to threating full scale nuclear war [38], Russia has made the unprecedented attacks on energy generation-based nuclear facilities [39]. Such attacks have long been a concern and are already codified in the substantive nuclear insurance subsidy [40–42]. These nuclear insurance subsidies ensure nuclear power plant owners/operators are not responsible for full damages regardless of the cause of a nuclear release [43] as they are not insurable on the free market [44] because of the magnitude of the potential damages and thus are not sustainable [45]. Despite the protocols of the Geneva Conventions, the rules of International Humanitarian Law, and Russia's military regulations that prohibit the kinds of attacks that Russia made on the Zaporizhzhia nuclear power plant, how to deal with them and prevent them legally is complicated [46]. Who would hold Russia accountable for violations of international norms of attacking nuclear power plants and risking a meltdown or using nuclear weapons? How? Moore concluded that while international law provides norms that arguably forbid such attacks, the international system needs to consider putting in place stronger measures that can be enforced [46]. Only a few nuclear states (9) have mutually assured destruction (MAD) as a means to prevent direct attacks against themselves from other nuclear nations [47], but non-nuclear states have little in the way of leverage to stop a nuclear attack. Smaller nations such as Ukraine are limited in their ability to respond if a nuclear state invades with conventional weapons and the fear of nuclear weapons is used to dissuade other nations (e.g., members of the North Atlantic Treaty Organization (NATO)) from joining the war [48]. **Until nuclear weapons are eliminated, a means is needed to make the use of**

them painful enough to the aggressor that they become unusable. The purpose of this study is to provide such a point.

This paper evaluates a new method to prevent the efficacy of nuclear weapons by eliminating how a nuclear state can use the threat of global annihilation to threaten the entire world not to interfere with their aggression against another state. **Specifically, as a means to dissuade the nine nuclear states from ever using their weapons, a global pact can be made preemptively to nullify all intellectual property (IP) from the aggressor nation**. This short communication analyzes the impact of such an agreement. First, the literature was reviewed on precedence for the approach. Second, a means of quantifying the economic impact for the nuclear nations was provided and the results of this analysis for each of the nuclear nations were compared. Finally, the limitations of this approach and results are discussed in the context of preventing nuclear weapon use that threatens the entire world.

2. Materials and Methods

2.1. Literature Background on Eliminating Patent Rights for the Aggressor (Compulsory Licensing)

The idea of nationalizing enemy patents is not new [49] and was practiced in World War (WW) I and II [50]. Such compulsory licensing allows governments to license patented inventions without the consent of patent owners. In WWI, the U.S. Trading with the Enemy Act made all German-owned patents available for licensing to U.S. firms [51] (most notably chemical patents) [52]. After WWII, because Germany surrendered unconditionally, the Allies confiscated all the German patents (including secret patents) and used them freely [53]. The U.S. government seized tens of thousands of foreign-owned patents and other forms of intellectual property through the Office of the Alien Property Custodian [54]. Similarly, the Australians took over the Japanese Patent Office and handled IP-related issues, as foreign-owned patent owners wanted reparations for Japanese infringement [55]. More recently, as the West is levying sanctions [56] and pulling away from Russia's huge oil and gas industry [57] because of the Russian invasion of Ukraine, Russia ironically provides a model to be copied that can help prevent nuclear war. In a decree [58], Russia has effectively legalized patent theft from anyone affiliated with countries "unfriendly" to it, declaring that unauthorized use will not be compensated [59]. The short-term gains for Russian industry come at the already substantial risk that lifting IP protections can eliminate Western investment in Russia well-beyond any de-escalation of the war in Ukraine [59]. The economic damage from doing so seems much greater than the potential gains for what can be being forced into an ostracized internal national market. The same would not be said if the roles are reversed (i.e., if the whole world took advantage of a single nation's IP), which brings up the core concept of this investigation: What are the impacts of theoretical international agreement that eliminates patent rights for any nuclear aggressor (i.e., allows for free compulsory licensing of all IP for a nuclear aggressor)?

2.2. Quantification of Deterrence

In order to determine the deterrence that such an agreement would have, three approaches are used with 2020 data, which was selected as it is available for all approaches. First, the number of U.S. patents issued by each nuclear state is quantified using data from the U.S. Patent Office [60], because the U.S. is the largest market [61]. These values are used to gauge the U.S. unilateral ability to discourage the use of nuclear weapons without relying on military-related threats. Next, the World Intellectual Property Organizational data is used to quantify the patents in force globally, and patent applications abroad (e.g., filings going out to other countries) [62]. These values provide insight into the financial exposure each nuclear state has to the agreement and how much each nuclear state prioritizes gaining IP monopolies in external markets. Finally, the estimated total value, V (USD), of all IP from each country is needed, but more challenging to determine. The number of patents in force is used with a sensitivity over the range of values. On the optimistically high end of value of a patent is from a study in the U.S. that found each patent for a new firm was worth USD

10.6 million in additional sales over the 5 years after winning the patent "lottery" [63]. This extraordinary value is derived primarily from new firms' abilities to leverage patents for startup funds. On the more conservative side an analysis of the patent literature completed earlier estimates of a patent and converted to 2020 values to reach USD 156,000 [64]. The estimated payback time (*t*) is then determined by:

$$t_c = \frac{V_c}{G_c} \text{ [years]} \tag{1}$$

where *G* is the gross domestic product (GDP) in current USD from the World Bank [65] (with the exception of an estimate for North Korea [66]). The analysis is run for nuclear state, c, independently. The total nuclear state value of the sensitivities on patents were checked against detailed PatentVector estimates for the U.S. and China, which found total IP values of USD 3 trillion and USD 488 billion, respectively [67]. The analysis was applied to the nine nuclear states as determined by the Federation of American Scientists [68].

3. Results

The total nuclear weapons inventory in 2022 [68] for each of the nine nuclear states is illustrated on a world map in Figure 1. Russia and the U.S. have the most nuclear weapons, roughly 60 and 54 times the pragmatic limit and both are slowly reducing these values in part because of the cost of upkeep with no strategic advantage for the additional marginal nuclear weapons [23]. It should be noted that all the nuclear states are above the pragmatic limit (i.e., 100), with the exception of Israel and North Korea.
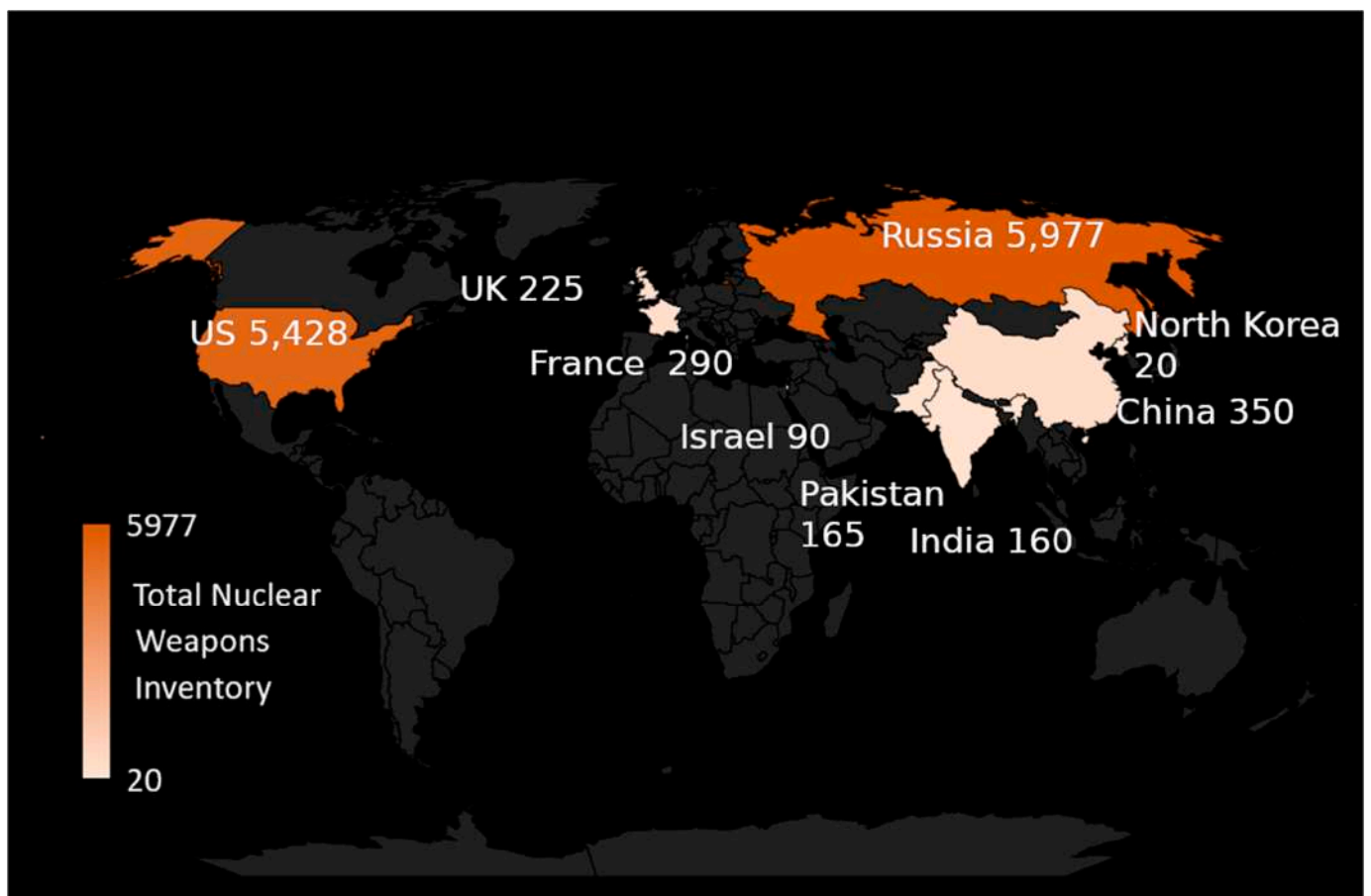

Figure 1. The total nuclear inventory for each of the nine nuclear states [68].

For each of the nuclear states shown in Figure 1, the input data are summarized in Table 1, including the U.S. patents, patents in force, patent applications abroad, the

value of IP (high and low estimates), and GDP for each of the nuclear states. PatentVector values showed that the high and low estimates were within reason. For the U.S. case, the value per patent in force was found to be USD 895,915.25. This is about one tenth of the value estimated on the high end for the value of patents to startups as shown in Table 1 (where most of the value comes from leveraging funding from venture capitalists). The PatentVector value for China was estimated at USD 159,589.57 per patent, which is just above the low patent value sensitivity estimate as shown in Table 1. It should be pointed out that North Korea has neither U.S. patents nor any patents in force.

Table 1. The U.S. patents, patents in force, patent applications abroad, the value of IP (high and low estimates), and GDP for each of the nuclear states.

Nuclear State	US Patents	Patents in Force	Patent Applications Abroad	Value of IP High (USD 1 Million)	Value of IP Low (USD 1 Million)	GDP (USD 1 Million)
Russia	709	266,189	3799	2,821,603	41,525	1,483,498
United States	183,147	3,348,531	141,875	35,494,429	522,371	20,953,030
France	7614	674,334	40,903	7,147,940	105,196	2,630,318
China	26,845	3,057,844	96,268	32,413,146	477,024	14,722,731
United Kingdom	8470	682,245	35,355	7,231,797	106,430	2,759,804
Israel	4844	35,096	14,577	372,018	5475	407,101
Pakistan	18	1973	21	20,914	308	262,610
India	5984	92,897	14,739	984,708	14,492	2,660,245
North Korea	0	0	20	0	0	27,400

To gauge the impacts of a theoretical international agreement that eliminates patent rights for any nuclear aggressor, the payback time based on the assumption that a nuclear state's entire GDP would be used to recoup the lost value of IP is summarized in Table 2. As can be seen by Table 2, the high estimates, which are almost certainly overestimates by a factor of ten, would appear to provide an enormous disincentive to using nuclear weapons for all nuclear states. Even, with more realistic valuations of patents, the low estimated payback time ranges from 40.0 years for France to 1.2 years for Pakistan. This indicates such a mechanism as a whole would be an effective deterrent to using nuclear weapons in an act of aggression. The notable exception for both the high and low estimates of payback time is North Korea, which has no patents in force. Thus, this method would not appear to be universally effective.

Table 2. The payback time in years based on the high and low value estimates of IP.

Nuclear State	Payback Time (Years)	
	T-High	T-Low
Russia	1902.0	28.0
United States	1694.0	24.9
France	2717.5	40.0
China	2201.6	32.4
United Kingdom	2620.4	38.6
Israel	913.8	13.4
Pakistan	79.6	1.2
India	370.2	5.4
North Korea	-	-

4. Discussion

The results provide substantial insight into the potential efficacy of a preemptive pact to freely license all IP from nuclear aggressors. First, as can be seen in Column 1 of Table 1, it is clear that the U.S., as the largest market, has some leverage to reduce the threat of nuclear aggression. The substantial economic loss from nullified U.S. patents from all nuclear states would be thought to be an effective deterrent with the exception of Pakistan,

Russia, and North Korea, all of which have little IP exposure from U.S. patents. Second, if a pact was made by all nations to nullify a nuclear aggressor nation, the two nations with the most to lose would be the U.S. and China as seen in Columns 2 and 3 of Table 1 as they have the most patents in force and are the most aggressive about patenting in foreign markets. The potential losses for all the nuclear nations if they used nuclear weapons to attack another state can be seen in Columns 4 and 5 of Table 1.

The effectiveness of a theoretical international agreement that eliminates patent rights for any nuclear aggressor is best illustrated by Table 2, which shows the payback times. If only the low estimates for a patent's value are used, the payback times for a nuclear state to earn back the value of the lost IP would be more than ten years if the entire GDP were used for all nuclear states other than India, Pakistan, and North Korea. Even India with a 5.4-year payback and Pakistan with a 1.2-year payback would lose so much value, the agreement can be considered a substantive disincentive. Realistically, if such an agreement is put into force, not only would a nuclear aggressor state immediately lose all monopoly protection in the world markets, but also both an anti-purchasing preference and perhaps even sanctions would be expected to reduce the GDP. For example, the sanctions leveraged against Russia for the invasion of Ukraine is expected to shrink the Russia GDP by 12% [69]. This expectation indicates that the low estimates shown in Table 2 are exceptionally conservative. As seen in Tables 1 and 2, the only nuclear state for which this approach appears to be ineffective is North Korea, which is already largely excluded from global markets because of UN sanctions for their nuclear weapons program. This, however, is slowly changing as direct investment is rising (largely from China), but the county remains significantly dependent on aid to finance imports (largely from South Korea) [70].

Critics of the UN sanctions against North Korea such as Smith point out that the UN policy of placing sanctions on North Korea's civilian economy with no consideration provided to their impact on the safety and survival of millions of innocents does not meet ethical criteria of effectiveness, necessity, and proportionality [71]. The proposed theoretical international agreement that eliminates patent rights for any nuclear aggressor overcomes this challenge in three ways. First, it is only applied to aggressors, not for countries having nuclear weapons. Thus, they must be used for it to take effect, thus meeting the proportionality arguments. Second, the results show that they have the potential to be effective because of the substantive economic loss a nuclear aggressor would face as shown in Tables 1 and 2. Finally, because patents are largely owned by large companies, controlled by the wealthy, and most influential in society, the agreement would be a necessary leverage point to ensuring that the ramifications of a nuclear attack would go to the decisionmakers rather than the common people. This effect is magnified by unequal societies. For example, in the U.S. 89% of all stocks are owned by the top 10% wealthiest and the top 1% own about a third of stock [72]. The financial and business elite of the U.S. who are highly exposed to the proposed agreement because they have over 3 million patents in force and have applied for over 140,000 patents abroad in 2020 alone, would be expected to apply substantial pressure to the U.S. government to avoid the risk of losing 25 years of value. This wealthy leverage effect can be estimated using the Gini index, which is a measure of statistical dispersion intended to represent the income (or wealth) inequality within a nation [73]. The World Bank lists the nuclear states in decreasing order of Gini index (higher number, worse inequality) [74]: U.S. (41.5), Israel (38.6), China (38.2), Russia (36.0), India (35.7), UK (35.1), France (32.4), and Pakistan (29.6). No data were available for North Korea. Thus, this list also shows the order at which it can be expected for the wealthy and business elites to apply the most pressure to prevent their loss of IP value if the proposed pact went into force.

4.1. Limitations of the Study and Approach

There are several limitations to both this study and the approach. First, in the case of the study, it is clear that this study is incomplete by observing the results, primarily because of lack of data access for North Korea. In addition, although the values used for the sensitivity for the value of IP for all the nuclear states were found to bracket the realistic values indicated by comparing the detailed results for China and the U.S., more accurate

results for the payback table would be possible if the full IP analysis were available for the other nuclear states. With the data available, the low values appear to be more realistic and should be used until full IP valuations are available.

Second, it is clear from the analysis that one of the primary limitations of this approach to nuclear deterrence is that it only works for countries actively participating in the global economy and IP regime. Again, the results show that this method is unlikely to deter states such as North Korea that do not have a large program to attempt to gain IP outside of their own territories. This may be changing for North Korea. Although it remains a global pariah [75,76], it does have 20 patents pending, and if some of those begin to be granted and the numbers increase, those investments can represent a growing potential deterrence. This problem for the proposal is a similar problem to that of sanctions. By excluding North Korea from the global markets, sanctions have been ineffective [77]. This is concerning as currently the nuclear state with the most weapons, Russia, appears to be headed down the path of becoming a pariah state [78–80] and thus this method may become ineffective on it as well. Kleine-Ahlbrandt and Small argue that China's diplomacy and policies to legitimize pariah states and bring them back to the global community may be helpful on this front [81]. This challenge underlies the primary limitation of the approach, it can only work if the nuclear state is an active participant in the global economy and uses conventional IP practices and those practices remain intact.

4.2. Longevity of Approach in the Context of Open-Source Innovation and Positive Blowback

This approach is dependent on nuclear states using conventional IP. Intellectual monopoly based business models [81–83] rely on patents [84]. A substantial body of research now exists that challenges the long-held belief that intellectual monopoly is an overall good for the economy [85–88]. Paradoxically there is evidence that IP and patents even slow innovation [89–93]. Evidence is mounting that shows this to be the case as the software industry has embraced the concept of liberating otherwise restrictive IP using free and open-source software (FOSS) because it has distinct benefits particularly with respect to innovation [94–101]. FOSS is now the dominant form of technical development in the software industry as 90% of cloud servers [102] run open-source operating systems (e.g., major internet companies such as Amazon, Facebook, Google, and Twitter). Overall FOSS is used in 90% of the Fortune Global 500 (e.g., Wal-Mart and McDonalds) [103], 100% of supercomputers [104], over 84% smartphones [105], and more than 80% of internet of things (IOT) devices [106]. The same open-source paradigm [107,108] is democratizing [109] the manufacturing of physical products [110] as free and open-source hardware (FOSH). FOSH is demonstrating rapid innovation [111–113] and is only approximately 15 years behind FOSS in academic investigation [114]. FOSH is already established as a superior [115–117], higher value [118,119], and lower cost [120–122] method of making scientific tools. Digital fabrication of FOSH helps even economically disadvantaged countries access high value state-of-the-art equipment [122–124]. In general, researchers can expect to save about 87% on FOSH compared with proprietary products [125]. There is evidence this FOSH distributed manufacturing paradigm [126] is going mainstream, with millions of free consumer product designs [127] providing a high return on investment for consumers on a wide range of products [128,129]. If this trend continues, the value of patents to firms as well as by proxy to nations and nuclear nations would decrease. With the reduced value of patents, the mechanisms laid out in this study would lose effectiveness. Thus, the exponential rate of growth of open-source products may limit the time over which the proposed nuclear deterrence mechanism is effective.

Lastly, because the evidence in the literature suggests open source drives innovation faster than the IP system, there may be an unintended consequence of rewarding a nuclear aggressor state in the long term. As Baten et al. [51] noted, due to compulsory licensing as a result of World War I when the U.S. made all German-owned patents available for licensing to U.S. firms, German innovation increased by 30%. This surprising result is perhaps predicted by the evidence in the open-source technology literature. Thus, if the

proposed agreement is in place and a nuclear state is an aggressor, in the short term it risks losing the IP value to an extent that it can take years to recover as quantified in the results; however, losing IP forces innovation and in the long term the state can actually create more value. At this point, this counterintuitive mechanism does not appear to weaken the disincentive to use nuclear weapons in the proposed context in the short term. Again, however, as open-source development becomes more widespread it would be expected to decrease the efficacy of the proposed approach.

4.3. Implementation

All the nuclear nations are members of the United Nations (U.N.). It is also in the best interests of all countries to avoid nuclear aggression against themselves, so it appears that the U.N. is well-positioned to implement an international agreement that eliminates patent rights for any nuclear aggressor by legalizing free compulsory licensing of all IP for a nuclear aggressor. There are two fundamental challenges: First, the Security Council of the U.N. is charged with ensuring international peace and security [130], which would make it the arbitrator of such an agreement. All the members of the Security Council are nuclear states, arguably all the permanent members of the Security Council (China, France, Russia, the U.K., and the U.S.) have been aggressors during their histories. One of the permanent members of the security council (all made up of nuclear states), Russia, is currently in a war of aggression and might be expected to veto the proposal if they mean to use nuclear weapons. If, however, Russia has no intention of unilaterally attacking any nation with a nuclear weapon, then they may see a strategic advantage in the proposal. As can be seen by the results of this study, Russia is exposed less than the other large nuclear states (e.g., U.S. and China are set to lose more than 10X the value that Russia risks on such a proposition). Second, North Korea is not impacted currently by this proposed rule, and as they are considered a pariah state, they may also be unwilling to ratify it. In the North Korean case, however, they are at a strategic advantage; the risk to their interests is minimal, while the nuclear states that they feel threatened by would be less likely to use a nuclear attack on them. So, the proposal would be in their best interest. The effectiveness of the approach may diminish in time with the proliferation of open-source business models. Substantial future work is needed to determine the viability of implementing the proposed agreement and how to prolong the effective insurance against nuclear aggression.

5. Conclusions

This study successfully analyzed the impacts of a theoretical international agreement that eliminates patent rights for any nuclear aggressor and allows for free compulsory licensing of all IP for a nuclear aggressor. The results of the study found that all but one of the nuclear states (North Korea) would have a significant economic disincentive to start a nuclear attack if the proposal was put into force. The long (yet extremely conservative) payback times where an entire GDP of a nuclear aggressor would be needed over many years to offset the IP loss for aggression indicates that such a mechanism would be an effective deterrent to using nuclear weapons in an act of aggression. The notable exception is North Korea, which has no patents in force, but whose strategic best interests would be served by ratifying the treaty. This method can be universally effective by ensuring all nuclear states are members of the international economy and IP processes. With the reduced value of patents, this mechanism would lose effectiveness, which with the exponential rate of growth of open-source products does appear to limit the time the proposed nuclear deterrence mechanism will be effective. For now, it appears to be a policy trajectory worthy of future work that can help improve global safety and reduce the nuclear threat without causing any significant harm to any country of goodwill.

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Conflicts of Interest: The author declares no conflict of interest.

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