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Targeting the Talent: Killing or Capturing Scientists as a Counter-proliferation Strategy

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Abstract

How does targeting scientists 'work' as a counter-proliferation strategy? How might targeting nuclear scientists delay or destroy a target state's ability to build nuclear weapons? This article addresses these questions and investigates the capturing or killing of nuclear scientists as a counter-proliferation strategy by analyzing a new dataset of the 48 known targeting attempts that occurred from 1944 to 2022. As a theory building exercise, this paper investigates the potential utility of targeting scientists and explores the logic through which targeting could delay or destroy another state's ability and desire to produce nuclear weapons. To explore the plausibility of the theoretical argument, we demonstrate the logic through brief case studies drawn from within the full case population. This article has implications not only for the academic scholarship on targeted assassination and counter-proliferation, but also for policy making in capitals around the world.

Introduction

When Iran's top nuclear scientist woke in the pre-dawn hours of November 27, 2020, intending to drive later that day with his wife from their vacation home on the Caspian Sea to their country house, he did not know that the day's events would unfold like the plot of a Bond film. Though Iranian intelligence had warned of a potential assassination plot against him, after more than a decade of such threats, Mohsen Fakhrizadeh no longer paid the warnings much heed. Yet a pick-up truck was parked along the route to the country house and concealed in its bed a machine gun with an attendant sniper waiting for the scientist's approach. Only later, following Fakhrizadeh's death, would the international community learn that the sniper was not actually prone in the back of the vehicle; instead, he was over 1,000 miles away peering into a computer terminal and firing the satellite-controlled and artificial intelligence-enabled weapon in a truck intended to self-destruct following the successful strike.[1]

How might targeting nuclear scientists, as in the above episode, "work" to delay or destroy another state's ability to build nuclear weapons? The reliance on the targeting of scientists by Israel and others suggests that there is some perceived utility to removing an adversary's nuclear scientists as a means of forestalling the state's nuclear development. Indeed, the aforementioned 2020 assassination of the father of the Iranian nuclear program, allegedly by Israel, offers a recent example of the phenomenon and one tool in the Israeli toolkit to attempt to prevent Iranian proliferation.[2] Though this example offers a particularly high-tech and sophisticated demonstration of the phenomenon, the modal example of the targeting of scientists requires far less technical sophistication and often occurs through far more rudimentary means including the use of handguns and explosives attached to private cars.

Despite the low-tech possibility, the reliance on the targeting of scientists as a counter-proliferation strategy is also a rare event. The full universe of known cases suggests that Israel and the United States are the main purveyors of this strategy even though many other states have both the capability and interest in delaying enemy nuclear weapons programs in development. Indeed, while targeting nuclear scientists might effectively delay or deter another's nuclear aspirations and

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1 Bergman, Ronen and Farnaz Fassihi. "The Scientists and the A.I.-Assisted, Remote-Control Killing Machine." *The New York Times*. Published September 18, 2021, and updated October 26, 2021 https://www.nytimes.com/2021/09/18/world/middleeast/iran-nuclear-fakhrizadeh-assassination-israel.html

2 Sanger, David E., Eric Schmitt, Farnaz Fassihi, and Ronen Bergman. "Gunmen Assassinate Iran's Top Nuclear Scientist in Ambush, Provoking New Crisis." *New York Times*. Published November 27, 2020; updated December 9, 2020. https://www.nytimes.com/2020/11/27/world/middleeast/iran-nuclear-scientist-killed.html

abilities, it might also counterproductively cause the target state to redouble efforts and pursue proliferation with more dedication. Additionally, pursuing assassination as a strategy likely runs afoul of international law, drawing international attention and censure. Setting aside such issues of morality and legality, as well as several other potential cost-based considerations, it generally remains unclear how pursuing the targeting of nuclear scientists might even theoretically function as a counter-proliferation strategy. This article attempts to fill this gap by illuminating the theoretical logics that might make scientists a useful target to attack as a counter-proliferation strategy.

Note that we leave questions of the efficacy of targeting scientists to future work, though suspect that depending on variation in vulnerabilities in key choke points as well as depth in an indigenous scientific community, some individuals may make for more effective targets than others. Indeed, some scientists may be hypothetically more "useful" to target if one's intentions are to roll-back an enemy program, depending on nuclear program type (i.e. uranium or plutonium pathway given the plutonium route is relatively more difficult), degree of hardening of facilities or individuals, and how far along a program is in development, among other characteristics.[3] We also leave for future work addressing the conditions under which states are likely to pursue this counter-proliferation option.

Here we are interested in one important question: how might targeting scientists as a counter-proliferation strategy delay or destroy adversarial nuclear programs? To explore the potential mechanisms through which such a strategy might "work," we conduct a comprehensive analysis of all 48 known instances of targeting nuclear scientists that have occurred between 1944 and 2022. We include both instances of capturing scientists as well as attacks that both "successfully" killed their target as well as those attempted attacks that did not succeed. We show

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[3] We discuss how we plan to assess efficacy in future work in the conclusion.

that the logic of targeted assassination as a counter-proliferation strategy derives from international relations theories of balancing and centrally offers a story of coercion as states seek to forestall shifts in the balance of power.

Targeting nuclear scientists is a form of preventive military force to prevent unfavorable shifts in the balance of power through compelling or deterring another state away from nuclear weapons acquisition. Using strategies of denial or punishment, targeting can thus help a state either maintain the existing balance of power or stave off some future decline, relative to a rising adversary. The theory on offer suggests why a state might be inclined to target an adversary's nuclear scientists. While we do not test effectiveness specifically, our findings speak to the possibility thereof; we hope future work will continue in this direction. Nevertheless, through the current article and the presentation of the new dataset of all known targeting instances between 1945 and 2022, we shed light on this important international political phenomenon. In doing so, this theory building effort improves scholarly understanding of existing strategies of counter-proliferation, assassination as a tool of coercion in international politics, and the logics of deterrence and compellence via both denial and punishment.

The remainder of the article proceeds as follows. The next section describes why states might pursue a counter-proliferation strategy of targeting nuclear scientists and defines the scope conditions for our analysis. We then unpack the logic for how the strategy might conceivably "work" to delay or forestall adversarial proliferation. Third, we introduce the new dataset of targeting episodes, describe the case universe and the procedures we deployed in order to build it, and explore a representative set of examples to illustrate the operative mechanisms. A last section discusses conclusions, implications, and areas for future research.

Why Target Nuclear Scientists?

Building nuclear weapons is difficult. In the political science lexicon, doing so relies on states having both the willingness and the opportunity to do so.[4] Opportunity rests critically on a state's technical, intellectual, and material capacity to execute a significant feat of science and engineering. Willingness is centrally about a state's desire or demand for possessing nuclear weapons and may rest on security, domestic political, normative, and/or leader-specific justifications.[5] Political science has spilled a significant amount of ink on both the supply (opportunity) and demand (willingness) sides of this critical equation thinking both about why and how states attempt to build or acquire nuclear weapons and if and how the international community can try and stop them.

Arguably the most significant and most technically difficult step in the scientific process affecting a state's opportunity to build nuclear weapons is the ability to produce sufficient quantities of fissile material, the material required to fuel a nuclear weapon's core (or power nuclear reactors for civilian nuclear energy). What does that process look like?

Nuclear 101: The Science and the Scientists[6]

How does one build a nuclear bomb? Even though details for doing so have long been publicly available, successfully detonating a nuclear weapon is not open access science. Unlike making a back-yard bomb with nails, ball-bearings, and TNT, generating a nuclear explosion relies on advanced scientific knowledge and technical skill. Moreover, the production of nuclear weapons relies on a significant and organized scientific and industrial infrastructure an individual or small

[4] Jo, Dong-Joon, and Erik Gartzke. "Determinants of nuclear weapons proliferation." *Journal of Conflict Resolution* 51, no. 1 (2007): 167-194.
[5] Sagan, Scott D. "Why do states build nuclear weapons?: Three models in search of a bomb." *International Security* 21, no. 3 (1996): 54-86; Solingen, Etel. Nuclear logics. Princeton University Press, 2009; Rublee, Maria Rost. Nonproliferation norms: Why states choose nuclear restraint. University of Georgia Press, 2009; Fuhrmann, Matthew, and Michael C. Horowitz. "When leaders matter: Rebel experience and nuclear proliferation." *The Journal of Politics* 77, no. 1 (2015): 72-87; Way, Christopher, and Jessica LP Weeks. "Making It Personal: Regime Type and Nuclear Proliferation." *American Journal of Political Science* 58, no. 3 (2014): 705-719; among many others.
[6] Tremendous thanks are due to our colleagues in nuclear and radiological engineering for letting us learn with and alongside them over the past few years.

group is unlikely to possess. Instead, building nuclear weapons has been the historical purview of states reliant on a skilled national scientific capacity. The process requires significant and specific labor and capital resources: sensitive materials, advanced scientists and engineers, complex technologies, and experimentation and testing are generally required for building nuclear weapons.

The scientists who form the backbone of this sophisticated undertaking, described briefly below, are the "special sauce" required to combine specific materials in particular forms – themselves often radioactive, flammable, and difficult to procure or manufacture – into a useable and reliable explosive device. These individuals are necessary for successfully building nuclear weapons: without them, a nuclear program is highly unlikely to succeed. This scientific knowledge is also highly specialized: nuclear scientists are not easily substitutable within a nuclear program or as individuals.[7] They are also in relatively limited supply both within any given state and internationally.[8] Consequently, they are also important in the context of countering nuclear proliferation; empirically, they have been targeted repeatedly over time, again indicating their valuable nature.

To show how nuclear scientists fit into the sophisticated process of constructing a nuclear weapon, below we offer a simplified sketch of the nuclear production pathway. Note that there are many additional techniques for each of the steps described,[9] so our sketch is not intended as a scientifically exhaustive exploration of the various existing pathways. It is merely meant to highlight

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[7] To paraphrase, one such scientist said that despite a PhD in one relevant scientific field, they could not easily be asked to facilitate another part of the process.

[8] In 2006, Lawrence Livermore National Laboratory described that the United States, a historical leader in nuclear development, was on track to produce less than 50 nuclear scientists annually by 2010. https://www.llnl.gov/news/numbers-decline-more-nuclear-physicists-are-needed-homeland-security-and-other-work

[9] For example, uranium is conventionally mined out of the ground at the first stage of the fuel cycle and milled to chemically remove the uranium and make it into concentrated yellowcake. Alternatively, one may use in-situ recovery to bring the ore to the surface (NRC, "Uranium Recovery (Extraction) Methods," https://www.nrc.gov/materials/uranium-recovery/extraction-methods.html).

the basic arc of the nuclear fuel cycle for the purpose of producing fuel for a nuclear bomb and to demonstrate the scientific skill required.[10]

The Nuclear Fuel Cycle

Thankfully, the preferred material for producing nuclear energy or nuclear bombs is not readily available. Instead, uranium-235 is rare, and plutonium-239 is human made through the process of running a nuclear reactor. Some 99.3% of the uranium mined in the Earth's crust is uranium-238, an isotope less useful for nuclear production. Only about 0.7% is the specific isotope of interest, U^{235}.[11] What the two isotopes (U^{235} and Pu^{239}) have in common is that they are fissile, meaning that they can more easily sustain the critical reactions key to producing a nuclear explosion or power a nuclear reactor. Separating the desired uranium from the more abundant other isotopes and building and sustaining a nuclear reactor or explosion requires the complex technical production described below.

Geologists and chemists often begin the nuclear fuel cycle at a mine, where uranium ore is extracted from the Earth by geologists and chemists. Next, the ore is conveyed to a nearby mill, where it is crushed and chemically processed to extract the uranium, forming a concentration known as yellowcake. This yellowcake is then converted to a gas, uranium hexafluoride or UF_6.[12]

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[10] For detailed scientific explorations of the nuclear fuel cycle and many of its permutations see the World Nuclear Association (https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx) and the U.S. Nuclear Regulatory Commission (https://www.nrc.gov/materials/fuel-cycle-fac/stages-fuel-cycle.html).

[11] For example, uranium is conventionally mined out of the ground at the first stage of the fuel cycle and milled to chemically remove the uranium and make it into concentrated yellowcake. Alternatively, one may use in-situ recovery to bring the ore to the surface (NRC, "Uranium Recovery (Extraction) Methods," https://www.nrc.gov/materials/uranium-recovery/extraction-methods.html).

[12] Highlighting the complexity of the fuel cycle as a whole, UF_6 – just one relevant material – is highly corrosive and can react easily with other materials and explode when mixed with water.

The nuclear fuel used in many nuclear reactors or in an explosive core requires a more concentrated presence of U^{235} than naturally occurs in the ore first extracted.[13] Chemists, physicists, mathematicians, and engineers, are therefore required to produce these enriched concentrations, using sensitive and complex technical equipment. Again, the U^{235} isotope is desirable as it is relatively more stable during the fission process, when the nucleus of the atom splits apart, producing both heat and extra neutrons. These fission products are then harnessed to produce energy[14] or an explosion.[15] Getting to this end stage, however, requires the uranium to be enriched to higher concentrations, commonly done through either gaseous diffusion or centrifuge enrichment.[16]

Next, scientists at fuel fabrication facilities convert the enriched material into useable fuel by modifying the uranium first into a gaseous solution and subsequently into powder form. The powder is then re-manufactured into a fuel form appropriate for the power plant into which it will be fed. Uranium fuel thus follows a circuitous path beginning the cycle as a solid, being converted to a gas, and ultimately returning to a different solid or liquid form.[17]

Finally, in an open fuel cycle, the waste produced in the above processes must be safely stored and disposed of in perpetuity, and environmental scientists, various engineers, and materials scientists work together to develop the necessary storage facilities. As the materials are chemically hazardous and radioactive, the effort required for safe storage, environmental protection, and security against lost or theft is substantial. Alternatively, a closed fuel cycle continues when spent nuclear fuel is "reprocessed" or recycled to produce new fuel, in addition to waste. Regardless of the

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[13] CANDU reactors, by contrast, operate using natural uranium.
[14] Between 5 and 20% enrichment is typically necessary for energy production, depending on the reactor type.
[15] Bomb grade material needs 80% enrichment, though 93% is desirable.
[16] Both processes rely on differences in isotopic mass to complete. Gaseous diffusion involves moving the UF_6 through an extensive pipe complex fitted with molecular barriers to separate the lighter molecules with the valuable U^{235} from the heavier molecules. A now more popular process of centrifuge enrichment requires spinning thousands of cylinders, which use centrifugal forces to separate the U^{235} into higher concentrations over time.
[17] From this point, states can use the fuel to produce energy for their power grid or material for a bomb's core.

system type, open or closed, used nuclear fuel that emerges from the process contains approximately 1% plutonium, which is valuable both for advanced reactor fuel sources, deep space missions, and potentially for weapons.

Bomb Design

There are two basic types of nuclear weapons designs built by theoretical physicists, chemists, and chemical engineers over time. First, a gun type device generally uses uranium for its core, and as its name suggests, involves causing a conventional explosive to rapidly condense a uranium "bullet" into a cylindrical target. The second more sophisticated design, or implosion device, uses spherical compression of a plutonium core to cause a chain reaction. The weapons dropped on Hiroshima and Nagasaki, were a gun-type and implosion device, respectively. More sophisticated and modern weapons rely on nuclear fusion, fusing together hydrogen atoms, to yield a more significant nuclear explosion. Known as hydrogen, h-bombs, or boosted weapons, these designs rely on not one but two explosions – marrying first a primary implosion bomb with a secondary fuel source for the fusion reaction. Modern arsenals are primarily comprised of these more powerful weapons.

Thus, there are numerous types of scientific expertise required at every stage of the nuclear fuel cycle, from the geologists who help locate the uranium ore to the through to seismologists and engineers who figure out a safe and secure way to store nuclear waste in perpetuity. Additional chemical, physical, electrical, and aerospace engineering expertise is necessary for building the explosive devices and their means of delivery.[18] This knowledge is required to successfully build and

[18] States that build nuclear weapons will also seek means of delivery. Generally, this process involves marrying a nuclear explosive device on some sort of warhead. In the contemporary landscape, we often think of bombs to be dropped from airplanes or missiles to be launched from silos or submarines. Marrying a warhead to a means of delivery is also a sophisticated process and an important part of standing up a national deterrent or war-fighting capability. We do not

manage the complex nuclear weapons infrastructure. Of course, this information is not the only kind of knowledge necessary: to sustain a functioning nuclear program, you also need military expertise to manage and deploy a weapons capability within a national arsenal, as well as other aspects of an industrial complex. Nevertheless, given both scientists' critical expertise and the empirical record, it is useful to explore the scientists as a critical choke point for counter-proliferation behavior.

Following similar work by Fuhrmann and Kreps (2010) and Reiter (2006),[19] we define attacks as the state-sanctioned threat or use of force to capture or kill scientific individuals related to another state's nuclear weapons program that has the intention of interrupting that state's acquisition of nuclear weapons. Such individuals could span a wide range of academic disciplines including but not limited to metallurgists, aerospace, electrical, mechanical, and nuclear engineers, materials scientists, chemists, physicists, and other relevant experts. They could be experts specifically working on fissile material production or those working to build the core of a functional nuclear explosive device. Regardless of their specialty, these are individuals with highly specialized scientific expertise germane to the ability to produce nuclear weapons. Whether recruited from outside, or cultivated and trained indigenously, such experts are necessary to achieve the technical processes inherent to weapons production. They are often employed by national universities or associated with private corporations affiliated with the state itself. They are department heads as well as more junior scientists working toward the project's development.

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detail the technical means necessary here, as it only further underlines the requisite technical expertise with a national nuclear program. Moreover, we expect the logic described in our theory of targeted assassination of nuclear scientists to carry over from a nuclear physicist working on enrichment to an aerospace engineer working on warhead delivery systems.

[19] Fuhrmann, Matthew, and Sarah E. Kreps. "Targeting nuclear programs in war and peace: A quantitative empirical analysis, 1941-2000." *Journal of Conflict Resolution* 54, no. 6 (2010): 831-859; Reiter, Dan. Preventive war and its alternatives: the lessons of history. *Strategic Studies Institute*, US Army War College, 2006.

By contrast, we do not include attacks against non-state actors such as terrorist groups.[20] We also set aside attacks targeting infrastructure, including but not limited to centrifuge facilities or nuclear reactors. Both types of attack are excluded from our universe of exploration, a topic we return to in a later discussion of the construction process used to build our dataset.

Attacks on scientists could ostensibly have a variety of goals as their purpose from the perspective of the state doing the targeting. As the present analysis is not constructed to assess those goals, nor is it necessarily knowable from the outside which if any of various goals might be operative, here we limit our analysis to attacks on scientists that are affiliated with state nuclear programs.

It is worth noting that targeting attempts also fail. Failure might occur if the target is missed, the person is merely injured, or the target was not where expected. A botched assassination would not only fail to delay the program, but it could also accelerate the program, should the target redouble effort with particular zeal. Finally, targeting efforts can cause states to harden their program and to ensure that their nuclear scientists are well protected and out of the public eye, making future attacks more difficult to execute.

Understanding Targeting as a Counter-proliferation Strategy

Scholarship concerning counterproliferation, the nature and utility of targeting, and counterterrorism offer relevant insights for understanding targeting as a counterproliferation strategy. To begin, there is a robust literature on counter-proliferation writ large, including but not

[20] Though we do not consider them here, there is a related category of individuals of strategic consequence, such as General Qassim Suleimani, head of the Iranian Quds force. Though his assassination may have been related to countering Iran broadly, the attack likely operated through a distinct mechanism more akin to counterterrorism targeting. On such targeting, see Jordan 2019.

limited to analysis of alternative strategies that states might deploy including preventive war,[21] economic sanctions,[22] and cyber operations.[23] Within this niche, few scholars have explored the use of targeting scientists to rollback or delay another state's nuclear development. As most of the work on targeting that does exist explores single case episodes, the larger question of the broader strategic logics that might be at work is left in the background. Examining the effect of Israel's preventive military attack on Iraq's Osirak nuclear facility, for example, Sadot asserts that the attack was due in part to the failure of previous efforts, which included assassinations.[24] Elsewhere, Tobey has argued that states may see the threat from nuclear proliferation as "infinite" such that doing nothing is a worse option than doing something, thus the turn to targeting as a strategy.[25] At the same time, this work highlights the potential for counterproductive consequences, such as legitimizing the killing of one's own scientists and making diplomatic solutions harder to achieve,[26] eroding norms against assassination,[27] provoking nationalist sentiment,[28] increasing both the security of a target's nuclear program and the possibility of retaliation.[29]

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21 Whitlark, Rachel Elizabeth. All Options on the Table: Leaders, Preventive War, and Nuclear Proliferation. Cornell University Press, 2021; Whitlark, Rachel Elizabeth. "Nuclear beliefs: A leader-focused theory of counter-proliferation." Security Studies 26, no. 4 (2017): 545-574.

22 Miller, Nicholas L. "The secret success of nonproliferation sanctions." International Organization 68, no. 4 (2014): 913-944; Early, Bryan R. and Keith Preble. "Going Fishing versus Hunting Whales: Explaining Changes in How the US Enforces Economic Sanctions," *Security Studies* 29:2 (2020); Early, Bryan R. *Busted Sanctions: Explaining Why Economic Sanctions Fail*, Stanford University Press, 2015.

23 Lindsay, Jon R. "Stuxnet and the limits of cyber warfare." *Security Studies* 22, no. 3 (2013): 365-404.

24 Sadot, Uri. "Osirak and the counter-proliferation puzzle." *Security Studies* 25, no. 4 (2016): 646-676.

25 Tobey, William. "Nuclear Scientists as Assassination Targets." *Bulletin of the Atomic Scientists* 68, no. 1 (2012): 61-69.

26 Meisels, Tamar. "Assassination: Targeting Nuclear Scientists." *Law and Philosophy* 33, no. 2 (March 2014): 207-234. In the aftermath of the assassination of Mohsen Fakhrizadeh, allegedly by Israel, the Israeli government warned ex-nuclear scientists who had previously worked as Israel's own Dimona nuclear facility to take extra safety precautions. https://www.timesofisrael.com/israel-warns-ex-nuclear-scientists-they-could-be-targets-of-iran-revenge-attack/ Likewise, following the 2012 assassination of Mostafa Ahmadi Roshan, a supervisor at the Natanz Enrichment plant, attacks occurred targeting a number of Israeli officials and diplomats in India and Georgia. Michael Davis, "Between Peace and War: The Moral Justification of State-Sanctioned Killing of Another State's Civilian Officials," 790, citing 'Car bombs 'target Israeli envoys' in India and Georgia, *BBC News India,* 13 February 2012, https://www.bbc.com/news/av/world-17018187, accessed 2 February 2022.

27 Meisels 2014.

28 Hymans, Jacques E. C. *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation.* United Kingdom: Cambridge University Press, 2012.

29 Tobey 2012.

There are also facets of targeting that might make it an appealing strategy to pursue. For example, as a covert operation, targeting scientists can provide states with plausible deniability, which could appeal to states that are also attempting to employ other more observable counterproliferation efforts, such as negotiations with the target state to reach a diplomatic solution.[30] Targeting may also present a lower cost option, at least relative to other possible counter-proliferation strategies, making it such that the barrier to entry to use this strategy is likely relatively low at least comparatively. For example, the Stuxnet cyber attack on Iranian nuclear centrifuges required years of investment between both the United States and Israel, as well as significant technological skill.[31] Likewise, the 1981 Israeli preventive attack against Iraq's Osirak nuclear reactor entailed the use of Israel's sophisticated air force, including F15 and F16 fighter jets to carry out a dangerous and complicated mission across enemy territory.[32] This is not to say that assassinating specific individuals in hostile territory does not require skill and sophistication, however, at least conceptually, blowing up a single car with TNT, presents a lower-cost option likely with a smaller destructive footprint. Consequently, the likely risk of retaliation following a targeted assassination should be smaller, relative to a more significant counterproliferation operation. Last, targeting the talent might be an appealing option as the precise scientific skills required to build a new program are relatively difficult to replace.

By contrast, there are three reasons why states might be disinclined to target scientists as a means of counter-proliferation. First, as described previously, moral and legal arguments call into question the legitimacy of killing scientists, in as much as it is unclear whether individuals working

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[30] Much of the literature has focused on broader phenomenon of covert intervention and regime change (O'Rourke 2020, Poznansky 2019 and 2020, Downes and Lilley 2010) or covert involvement in foreign wars (Carson 2018). These studies, which examine a variety of empirical phenomena, highlight the strategic utility of plausible deniability and secrecy, particularly when states are limited by international legal obligations.
[31] Lindsay 2013.
[32] Bar-Joseph, Uri, Michael Handel, and Amos Perlmutter. Two minutes over Baghdad. Routledge, 2004.

on nuclear programs are civilians or combatants. Indeed, there is a large amalgamation of customary international, treaty, and domestic law that governs the use of force broadly in international politics and concerning killing civilians in particular. Under Article 2.4 of the UN Charter for example, *jus ad bellum*, regulates the decision to initiate the use of force between states not engaged in armed conflict. While the rules of *jus in bello* address the moral and legal prohibitions against extra-judicial killing and targeting non-combatants. Further, the Law of Armed Conflict established at the Geneva Convention of 1949 codified an important distinction between combatants and civilians, the latter of which cannot be targeted through military operations. Additionally, there are also domestic prohibitions against targeting civilians, such as the U.S.'s Executive Order 11905 and the 2001 Authorization for the Use of Military Force.[33] Though we return to these considerations in our concluding section, here we raise them simply to highlight that there are potential moral and legal costs associated with targeting.

Second, there is a potential for targeting to result in blowback. For example, targeting may legitimize the killing of one's own scientists as well as invite retaliatory attacks as a means of retribution. Further, there are potentially other casualties that might occur during a specific assassination or attempted assassination, which can result in a public backlash. Third, successful assassination attempts might cause the target state to redouble their efforts and provide further confirmation that possessing a nuclear capability to challenge their adversaries is even more critical.

These possible blowback effects echo findings within terrorism research on the leadership targeting of militant organizations. Studies on the arrest and killing of the leaders of terrorist organizations have empirically evaluated the ability of leadership decapitation to result in

[33] Jaeger, David A., and M. Daniele Paserman. "The shape of things to come? On the dynamics of suicide attacks and targeted killings." Quarterly Journal of Political Science 4, no. 4 (2009): 315-342; See also, https://www.cfr.org/backgrounder/targeted-killings

organizational weakening or demise and have come to a variety of different conclusions. Jordan, for example, has argued that targeting leaders has the potential to increase a terrorist organization's resolve, result in retaliatory attacks, bolster sympathy and foster recruitment for the cause.[34] By contrast, Johnston and Price have found that leadership targeting can result in a decline in terrorist activity.[35]

Taken collectively, while the above scholarship is relevant, it is also narrow. In particular, it fails to provide a complete and theoretically specified understanding of the logic through which targeting scientists would even conceptually offer an effective means to delay another state's proliferation effort. It also fails to capture the full empirical universe of relevance. These are the discussions to which we now turn.

The Coercive Logic of Targeting the Talent

The balance of power is one of the most fundamental concepts in the field of international relations. According to the neorealist school of thought, due to the anarchic structure of the international system, states are forced to ensure their own survival. In order to survive states will seek to prevent others from upsetting the status quo balance through the accumulation of power,

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[34] Jordan, Jenna "Attacking the Leader, Missing the Mark: Why Terrorist Groups Survive Decapitation Strikes" *International Security,* Spring 2014: 7-38; Jordan, Jenna. *Leadership Decapitation: The Strategic Targeting of Terrorist Organizations* (Stanford*:* Stanford University Press) 2019

[35] Price, Bryan. "Targeting Top Terrorists: How Leadership Decapitation Contributes to Counterterrorism." *International Security* 34, no. 6 (Spring 2012); Price, Bryan. *Targeting Top Terrorists: Understanding Leadership Removal in Counterterrorism Strategy* (New York: Columbia University Press) 2019; Johnston, Patrick. "Does Decapitation Work? Assessing the Effectiveness of Leadership Targeting in Counterinsurgency Campaigns." International Security 34, no. 6 (Spring 2012). See also Tominaga, Yasutaka. "Killing Two Birds with One Stone? Examining the Diffusion Effect of Militant Leadership Decapitation." International Studies Quarterly 62, no. 1 (March 2018): 54–68.

both militarily and materially.[36] This condition results in states balancing against rivals and working to improve their relative power in the international system. States can attempt to rectify these imbalances and new concentrations of power, internally through building up military capabilities, and externally forming counterbalancing alliances. In short, states seek to rectify changes to the balance of power in order to survive. There are a number of different ways by which states can seek to redress these unfavorable shifts in the balance of power, and preventive military action is one option available to states.[37] The motivation for preventive military action is driven by the fear of a decline in power and prestige.

Nuclear proliferation has significant implications for the balance of power. Gaining a nuclear capability provides states with a meaningful advantage and allows states to inflict considerably more damage to their adversaries. Because it is easier to forestall or destroy a nuclear capability in its nascent stages rather than fight a nuclear armed adversary in the future, states should thus seek way to counter efforts of proliferation. As one means of counter-proliferation, the coercive logic of targeting nuclear scientists asserts that states can target nuclear scientists as a means to stave off these unfavorable shifts in the balance of power, in as much as the future acquisition of nuclear weapons by an adversary could undermine a state's security. Indeed, states worried about the emergence of an adversary's nuclear capability can choose to carry out preventive military action in order to rectify or stave off an unfavorable shift in the balance of power. There are a number of ways that states can use preventive military force to prevent the rise of an adversary's military

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[36]Kenneth N. Waltz, *Theory of International Politics* (New York: McGraw-Hill, 1979); John J. Mearsheimer, *The Tragedy of Great Power Politic*s (New York: W.W. Norton, 2001); Stephen M. Walt, *Origins of Alliances* (Ithaca: Cornell University Press, 1987); Barry Posen, The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars (Ithaca: Cornell University Press, 1986).

[37] Dale Copeland, *The Origins of Major Wars* (Ithaca: Cornell University Press, 2001); Robert Gilpin, *War and Change in World Politics* (Cambridge: Cambridge University Press, 1981); Rachel Elizabeth Whitlark, *All Options on the Table: Leaders, Preventive War, and Nuclear Proliferation* (Ithaca: Cornell University Press, 2021).

capabilities, ranging from a full-scale military invasion to the use of more limited and targeted strikes.

Targeting a state's nuclear scientists is one form of preventive military force intended to prevent an unfavorable shift in the balance of power. Through coercing other states to abandon their nuclear programs, states can gain a relative power advantage. More specifically, targeting nuclear scientists is meant to prevent or forestall the acquisition of an adversary's military capability and undermine the growth of their rivals' military capabilities, and by extension the threat that it poses to the coercer and its allies. This risk would be particularly acute against regional adversaries, as in the case of Israel and Iran. In the data collected for this study, the Israeli government has carried out far more assassinations and attempted assassinations of Iranian scientists than any other state in our dataset. In as much as a potential Iranian nuclear weapons' acquisition could dramatically undermine Israel's current or purported military advantage relative to Iran or help Iran balance against a superior Israel, Israel targeting Iranian scientists helps Israel stave off this eventuality and balance against Iran.

Underlying the strategy of targeting nuclear scientists is the belief that targeting scientists can compel states with nascent or incomplete nuclear programs to abandon their efforts, as well as deter others from undertaking new efforts to develop their own nuclear capability. Targeting can therefore help a state either maintain the existing balance of power or stave off some future decline, relative to a rising adversary.

Targeting scientists as a strategy of preventive force functions similarly to targeting nuclear reactors. Both are critical chokepoints in the nuclear development pathway. Whereas Kreps and

Fuhrmann focus on nuclear facilities as the critical chokepoints,[38] here we identify individuals instead. For Kreps and Fuhrmann, the chokepoint facilities critical to fissile material production and the most valuable targets and therefore the most vulnerable to attacks are uranium enrichment facilities, plutonium reprocessing facilities, and reactors. At the human level, the analogous high-value targets would include physicists, nuclear engineers, and related scientists who operate and whose work is critical to the functioning of those facilities. Considering the isotopes of relevance for fissile material production, there are a number of radioactive elements that are unstable and toxic, and advanced scientific knowledge of their manipulation in various steps in the proliferation pathway is essential to the success of a nuclear program. Additionally, the magnitude of a successful targeting's effect depends on how many scientists have the relevant knowledge. If only one person has the critical knowledge at any relevant point in the process, their death will necessarily complicate efforts and yield a more significant effect. A more diversified scientific population with knowledge redundancies will suffer more modestly by comparison. Likewise, the severity of the consequences of any particular assassination will depend on how advanced the program is at the time of the attack. A program nearing completion, or one that has already successfully mastered weaponization will be less impacted as compared to a new program just getting started.

Thus, targeting nuclear scientists can serve to attempt to coerce another state away from nuclear weapons acquisition. It can happen either via compellence or deterrence, and as follows from the coercive logic, operate either via punishment or denial mechanisms. We unpack the processes below.

[38] Kreps, Sarah E., and Matthew Fuhrmann. "Attacking the Atom: Does Bombing Nuclear Facilities Affect Proliferation?." *Journal of Strategic Studies* 34, no. 2 (2011): 165.

Underlying the decision to target an adversary's nuclear scientists is the belief that targeting can compel states to delay or abandon existing programs or deter states from developing new programs. In international politics, a goal of coercion is to change the behavior of states by manipulating the costs and benefit of action, such that it becomes too costly to undertake or continue a particular course of action.[39] Following Schelling coercion can take two forms -- compellence and deterrence. Compellence involves initiating an action that can cease or become harmless only if an opponent responds, while deterrence is preventing one's adversary from taking action, in other words maintaining the status quo. Both forms of coercion involve "the threat of damage, or of more damage to come, that can make someone yield or comply."[40] The success of coercive strategies rests upon the "power to hurt" and the ability to successfully communicate a threat of force if one's adversary does not comply.

There are two primary means by which states can attempt to coerce their adversaries, punishment and denial, both of which are critical to understanding the coercive logic of targeting scientists. Punishment strategies inflict or threaten pain upon one's adversaries until the coercer achieves their desired outcomes; they make it prohibitively painful for a coercer to resist complying with a coercer's demands. In contrast, denial strategies seek to make it impossible (or at least more costly) for a target to achieve her goals, such as a successful nuclear program. As Pape argues in his study on coercive air power, denial strategies attempt to make resistance to the coercer's demand pointless and alter their estimate of the probability of achieving victory.[41] Both punishment and denial strategies rest upon a credible threat of force and targeting can serve as a signal of the coercers' ability and willingness to continue attacking scientists until a state has been compelled to

[39] Robert Pape, *Bombing to Win* (Ithaca: Cornell University Press, 1996); Thomas Schelling, *Arms and Influence (*New Haven: Yale University Press, 1966).
[40] Schelling, Arms and Influence, 3.
[41] Pape, Bombing to Win, 19.

halt an existing program, denied the ability to succeed, or deterred from starting new efforts at proliferation. Communication is an essential part of successful coercion, and thus states must signal their resolve and capability to carry out coercive threats today and in the future, should it become necessary. Targeting is thus a costly signal that states communicate for the purpose of coercing another state away from its proliferation goals. These signals can be used to either compel or deter one's adversaries through strategies of denial or punishment.

Compellence

Through targeting scientists, states may seek to compel their adversaries to abandon their efforts at developing a nuclear program. States can compel their adversaries through either a strategy of denial or a strategy of punishment (or both). Denial works through removing key scientists and therefore their critical knowledge, making it significantly more difficult for a state to succeed in their nuclear efforts, through delays or possible outright destruction, and therefore be compelled to halt their program. This mechanism rests upon the fact that requisite scientific knowledge is hard to come by and critical in the ability to develop a successful nuclear program, and specifically to produce and manage the fissile material needed to produce a bomb.

Instances of targeting in one context could be a way to signal to other states in the early stages of developing a nuclear program that their own scientists are not immune from attacks, in essence indicating the possibility of their own future punishment. Ideally therefore, this denial behavior against the first target could compel a second state to abandon nascent efforts towards its own nuclear acquisition (or deter them from starting in the first place). More broadly, this strategy of punishment, whereby the coercer is inflicting pain on the target, signals to all observers a credible threat of further violence if a state is not compelled to abandon its nuclear efforts. It is thus the power to hurt on display and held in reserve that provides a powerful coercive function.

Past instances of targeting, both attempted and successful, explicit or implicit, demonstrate that states have the capability and resolve to successfully target other states' nuclear programs to both deny states the ability to succeed in building nuclear weapons and punish them for attempting to do so. Even if the covert nature of these attacks makes attribution unclear, it is not difficult to surmise the suspected attacker. Thus, would-be targeter states are afforded a strategic advantage in maintaining plausibility deniability while signaling their resolve to states with programs underway and those that may be considering the development of a new program. In both cases, however, even if attacks are not initially effective in killing their target or forcing the abandonment of an entire nuclear program, such attacks can serve as powerful signals to states with nuclear ambitions.

Targeting scientists can also cause reputational harm to a target state on the international stage as previously known elements of a covert nuclear program are revealed to the international community. Status is an important aspect of a state's desire to develop a nuclear capability,[42] and high-profile instances of targeting can be humiliating for targeted states, revealing vulnerabilities mentioned above, but also highlighting the failures of a state's own intelligence capabilities in preventing the attack. In response, states might abandon their program.[43]

As part of a denial strategy, assassinating or capturing nuclear scientists could also aid the targeting state through gaining intelligence regarding an adversary's nuclear program. This notion parallels the literature on the leadership targeting of terrorist organizations, which looks at whether capturing or killing leaders is a more effective means by which to degrade a terrorist organization's

[42] Sagan 1996.
[43] States could also double down given a heightened perception of the need for the security and prestige that a nuclear program affords.

operational capacity.[44] In the terrorism domain, states can gain critical intelligence through the interrogation of captured leaders and documents recovered during targeting operations. As an example, in the aftermath of the Osama bin Laden's death, allied forces discovered a large cache of material about al Qaeda's operations. Targeting may work similarly in the nuclear arena. First, capturing or killing scientists can provide a way for states to gain intelligence about the details of the targeted state's nuclear program and the actors involved. A captured asset may reveal the extent or nature of a program's development when they are questioned. A killed asset may leave behind computer or paper files that may reveal similar programmatic details to the state doing the targeting. Intelligence can also reveal vulnerabilities in a target states' program, enable future counter proliferation operations, or highlight other pathways through which to weaken an adversary's effort. Second, assassination of scientists not only provides intelligence that might be stored in recovered computers or in an individual's home, it might also result in the defection of other key people involved in a program.

The intelligence gained from capturing or killing a scientists can also support states' broader effort to balance against potential shifts in relative power. Specifically, information acquired during an instance of targeting can be used to strengthen one's own nuclear program, weaken the target state, or balance against a third state by preventing that state from gaining critical intelligence to strengthen their own nuclear program. The Alsos Mission, carried out by American and British intelligence during World War II and described more fully in the empirical discussion, illustrates how Allied targeting Nazi nuclear scientists augmented the U.S.'s own nuclear efforts, weakened the Nazi nuclear program, and was intended to also prevent a *Soviet* advantage in military capabilities.

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44 Cronin, Audrey Kurth, "How Al-Qaida Ends: The Decline and Demise of Terrorist Groups." *International Security* 31, no. 1 (Summer 2006): 7-48; Cronin, Audrey Kurth. *How Terrorism Ends: Understanding the Decline and Demise of Terrorist Campaigns* (Princeton: Princeton University Press) 2009; Jordan 2014 and 2019; Price 2012 and 2019.

Deterrence

There are three primary groups that states might attempt to deter through counter-proliferation targeting efforts: scientific communities, foreign suppliers (states or corporations), and potential proliferators. First, targeting can reduce the willingness of domestic scientific communities to participate in a state's nuclear program, particularly if the potential targets have the option to exit work on existing programs or have other options for employment in their field. The larger epistemic community of nuclear scientists is an important source of knowledge in the development of a state's nuclear program.[45] Expertise across a range of disciplines and bodies of knowledge is essential for the completion of a nuclear weapon, as described previously. The larger epistemic community of scientists working in the nuclear domain provides important tacit knowledge, which is gained through experience and is critical to a program's success. As an example, Libya possessed plans and resources necessary to manufacture a nuclear capability but lacked the tacit knowledge necessary to successfully develop a weapon. Similarly, Iran initially had centrifuge plans as well as highly skilled engineers but not sufficient tacit knowledge, which created challenges related to the efficiency of their centrifuges.[46] These anecdotes underscore the important role that epistemic communities play in the provision of tacit knowledge necessary for a program's success. If scientists working on these very specialized areas of knowledge feel threatened, they could be disincentivized from working with, or even providing aid and knowledge to nascent or existing programs.

Second, targeting may offer a deterrent effect on foreign suppliers that may otherwise aid proliferating states, cutting off the supply of industrial capacity and scientific knowledge. Third party

[45] Haas, Peter M. "Epistemic Communities and International Policy Coordination." *International Organization*. Vol. 46. No. 1. Winter. MIT Press, 1992. p. 1-35.
[46] Baxter, Philip M., "Nuclear Communities: Epistemic Community Structure and Nuclear Proliferation Latency," PhD dissertation (Georgia Institute of Technology, 2021).

assistance is important to emerging programs and enables a state's ability to create a weapon.[47] Kreps and Fuhrmann examine this mechanism in the preventive war context and posit that military force as a costly signal might make third parties "less inclined to supply nuclear technology, materials, or know-how to the suspected proliferating state."[48] In order build a nuclear capability, foreign suppliers could need to spend considerable time in the recipient country, increasing the risk of targeting to their personnel. This possibility of loss could deter these parties from providing this expertise, either at the corporate, state, or individual level. Being caught aiding proliferating states could also damage relations with coercing states and other allies that support nonproliferation, potentially harming a state's security or a company's bottom line. Kreps and Fuhrmann argue that aiding a proliferating country could increase the risk of "nuclear war, instigate regional instability, raise the possibility of nonstate actors getting their hands on nuclear weapons, and reduce the supplier's ability to exert influence against the target state."[49] Targeting thus demonstrates that the preventer state is deeply committed to nonproliferation and seeks to deter not only the potential proliferator, but any state (or non-state) supporting their effort.

Third and finally, targeting scientists can deter states who have not yet begun a nuclear program but are considering proliferation. Historically, while attacks on scientists have never been claimed or definitively attributed, they attempt to coerce their targets, as well as third party observers. Targeting can therefore communicate that other states' scientists are not immune. The threat of future punishment to come could provide a powerful deterrent effect for states contemplating their own nuclear program. Both the immediate demonstration of force and the

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[47] Matthew Fuhrmann, "Taking a walk on the supply side: The determinants of civilian nuclear cooperation." *Journal of Conflict Resolution* 53, no. 2 (2009): 181-208; Matthew Kroenig, "Exporting the bomb: Why states provide sensitive nuclear assistance." *American Political Science Review* 103, no. 1 (2009): 113-133.
[48] Kreps and Fuhrmann, Attacking the Atom, 167.
[49] Kreps and Fuhrmann, Attacking the Atom, 168.

threat of more to come could deter states considering their own indigenous programs from initiating new nuclear efforts.[50]

Data and Methods

For a preliminary exploration of the logic through which targeting scientists could delay or forestall an adversarial nuclear program, we analyze an original dataset of all known instances of the attempted or successful targeting that has occurred globally. We constructed the dataset by gathering all publicly reported instances of scientist targeting in news accounts, in the secondary literature on nuclear proliferation and counterproliferation, and in both history and political science monographs chronicling interstate rivalries. Instances need not be reported in all types of sources, but they must appear at least once to be included. As we are unfamiliar with any similar data projects on this empirical phenomenon, we could not compare our dataset to any other existing ones. Instead, we rely on the current scholarship to help populate our full, known universe, using a research method akin to snowball sampling as one source often leads to the next.

Despite the above processes, the resulting dataset is likely incomplete and may not represent all targeting instances throughout history. There are probably instances of targeting scientists that have occurred historically but that have not entered into the public record. We might surmise that this lack of reporting occurs because of some combination of 1) the state doing the targeting wanting to maintain its anonymity, not least to protect its sources and methods to be able to attack again should the situation warrant; 2) the target state wanting to maintain an otherwise covert program away from the prying eyes of the nonproliferation community as well as potentially save face against any additional rivals, state or otherwise; and 3) the targeting occurring in a closed

[50] The logic holds for third party states with nascent programs who observe the targeting in a different state; the third party might similarly be compelled to abandon its own nuclear pursuit.

information environment absent freedoms of the press that might otherwise bring the instance to light. Consequently, the dataset may be missing instances of attempted targeting by democracies whose use of this strategy may not yet be documented; episodes of targeting where the nuclear program was unknown to the international community; or cases where the Soviet Union or North Korea, for example, carried out the attempts. Our hope is that the present work will catalyze others to expand our analysis, which could yield the discovery of new cases to add to the universe. The passing of time may have the same effect.

Nevertheless, the full dataset as it currently stands has an N=48 and includes attacks that were threatened, planned, and carried out; those that resulted in death; and those merely resulting in injury or fear and intimidation. It also includes events where the targets were captured and detained.[51] Each observation records a single attempt at targeting a scientist in another state's nuclear enterprise and includes, when available, the date and location of the targeting attempt; the target's name and profession; the state nuclear program with which the target was affiliated; the alleged identity of the state perpetrator; and the outcome of the attempt (killed, injured, captured, disappeared, resigned, or failed). This information was gathered using information contained in the types of sources described above and additional news searches.

The dataset spans from 1944, from the earliest known targeting attempt by the United States on Dr. Werner Heisenberg, a physicist suspected of involvement with the Nazi nuclear program in Zurich, Switzerland, to the most recent: the 2022 killing of Iranian nuclear scientist Kamran Aghamolaei allegedly by Israel. Stated differently, the earliest attacks occurred during the Second World War; more recent targeting episodes have been clustered throughout the decades in the

[51] Gilbert, Danielle, and Gaëlle Rivard Piché. "Caught Between Giants: Hostage Diplomacy and Negotiation Strategy for Middle Powers (Winter 2021/2022)." *Texas National Security Review* (2022).

1960s, 1980s, the aughts, and the 2010s. More specifically, the targets range from scientists involved in the Nazi nuclear program and targeted by the U.S. and its allies during WWII, to experts involved with the Iraqi nuclear effort in Italy and Iraq proper, who were allegedly killed by Israel in the 1980s. In the more contemporary environment, the data encompasses alleged American and Israeli attacks against Iranian and Syrian scientists in the 2000s, the 2010s, and 2020s. The targets themselves were civil engineers, nuclear scientists, chemists, theoretical physicists, and both plutonium and uranium experts, and the targeting events resulted in attempted attacks, threats on their lives and family, capture, resignation, disappearance, and death.

Note that we only include those cases that are alleged to be state-sponsored attacks or planned attacks against scientific individuals according to the existing reporting and scholarship.[52] These attacks need not be "successful" in that they might miss or "only" maim their target. Those failed attempts nevertheless appear in the dataset. The same is true for cases where the record indicates an attack was planned but then not executed; such an instance of targeting remains in the dataset. We also set aside attacks targeting the physical infrastructure or material components of a state's nuclear program as well as general attacks on the target country. Table 1 below demonstrates the universe. We turn now to demonstrate the plausibility of the logic we theorize is at work with this phenomenon and present illustrative cases from within the full population to do so.

Table 1 About Here

[52] There is one case in the dataset where there are conflicting reports attributing an attack both to a state actor and to a non-state group; we include this case in the dataset.

Illustrative Case Explorations

Israel – Iraq

Israel engaged in a sustained counterproliferation campaign against the Iraqi nuclear weapons program beginning in the 1970s.[53] The campaign largely culminated in Israel's bombing of the Osiraq nuclear reactor in June 1981.[54] Before the preventive attack, however, Israel used a variety of additional counterproliferation strategies including public and private diplomacy and attacks on critical supply chains, to attempt to roll back the Iraqi program. Targeting nuclear scientists was also a key element of the sustained effort.

Indeed, throughout 1980 and in early 1981, Israel allegedly made at least five attacks targeting nuclear scientists associated with the Iraqi nuclear program. Four of the attacks took place in Europe; an additional attack occurred in Baghdad proper. The attacks targeted scientists of varying types of expertise and aimed at both foreign scientists and Iraqis themselves. To begin, in June 1980, Yahi El-Meshad, an Egyptian scientist recruited to head Iraq's nuclear program, was beaten to death in a Paris hotel room; though the French authorities suspected Israel's culpability for the attack, an assailant was never captured.[55] Later that fall, Abd al-Rahman Rasoul a senior Iraqi civil engineer died in Paris under mysterious circumstances; various accounts describe how Rasoul was either poisoned or shot to death.[56] Salman Rashid al-Lami, an electrical engineer working at Iraq's Tuwaitha nuclear reactor was killed by an "unknown virus" while traveling abroad in Geneva.[57]

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53 Nakdimon 1987; Perlmutter et al, 2003, etc.
54 Claire 2004; Whitlark 2021, chapter 6.
55 Tobey, 2012, 64.
56 Ofek, "Operation Opera," https://www.israeldefense.co.il/en/content/operation-opera-intelligence-behind-scenes'; https://www.aljazeera.com/news/2006/6/7/the-death-of-a-nuclear-dream
57 Braut-Hegghammer, 59, 61, 81; https://www.aljazeera.com/news/2006/6/7/the-death-of-a-nuclear-dream

In August, threats were made against, and multiple bombs targeted Italian technicians and employees of SNIA-Techint, an Italian company that supplied Iraq with plutonium separation facilities and other sensitive capabilities. Likewise, Mario Fiorelli, chief director of SNIA-Techint escaped a bomb that exploded at his home while he and his family were summering elsewhere. Large numbers of Italian scientists subsequently resigned the Iraqi project and requested transfer to a different assignment.[58] French scientists working for companies assisting the Iraqi effort fared similarly; dozens of threatening calls and intimidating letters were sent to the scientists' homes threatening their loved ones who would be left behind when the scientists traveled to Iraq. Suggesting some effectiveness to the coercive logic and conditional threats, prior to their scheduled departure, Sadot reports that some 20 French scientists resigned their appointments.[59]

These episodes individually and collectively demonstrate Israel's use of targeting nuclear scientists as a coercive strategy to counter Iraq's nuclear program. Recall that coercion attempts to modify another actor's behavior in pursuit of some goal by manipulating the costs and benefits associated with that goal. Here the coercion targeted multiple actors simultaneously. First, via denial, Israel sought to make it more difficult for Iraq to accomplish its goal of successfully acquiring a nuclear weapon by degrading the knowledge base and destroying the technical skill necessary to complete the scientific endeavor. Second, Israel likely sought and may have succeeded in dissuading or deterring new scientists from taking the place of their slain or departed colleagues. Similarly, as with the French scientists, Israel used targeting to deter other scientists from continuing their own participation in the Iraqi weapons effort and compelling their resignation. Third, the repeated targeting of scientists by Israel likely communicated the threat of more punishment to come if the

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[58] Sadot, 657-658, citing Fulvio Martini, head of Italian intelligence (SISMI), Nome in Codice: Ulisse: Trent'anni di Storia Italiana Nelle Memorie di un Protagonista dei Servizi Segreti (Milan: Rizzoli, 1999), 25.
[59] Sadot, 658.

Iraqis did not abandon their nuclear attempt. Though the coercive threat might not have worked, Israel at least attempted to compel such a change in Iraqi behavior. Finally, we can surmise that Israel's attacks likely aimed to target the foreign suppliers themselves at the level of the scientific companies and tried to compel them to halt their cooperation in the Iraqi project.

Israel – Iran

International efforts to counter Iran's attempt at proliferation are also illustrative. Like with the Iraqi program, Iranian scientists have been targeted in assassination plots at least nine times in the 2007-2022 period. Within that time frame, targets ranged from nuclear physicists to nuclear engineers and included other scientists working on the Iranian program. These individuals were killed by gas poisoning, by bombs placed on their motor vehicles, or by snipers' gunshots.[60] We theorize that these attacks individually and collectively were designed to deny Iran the ability to succeed in its nuclear weapons endeavors. By removing existing technical know-how and degrading and deterring the skill base that could contribute to the program's future development, Iran's effort becomes more costly and more difficult to complete. Though to-date Iran has not abandoned all nuclear efforts as some officials might prefer, it is possible that the cumulative effect of these targeting attacks and other counter-proliferation strategies might eventually yield that desired result.

Of the nine attacks in this period, only one episode took place outside of Iranian territory with nuclear scientist Dr. Shahram Amiri disappearing while on the hajj in Mecca in 2009. Though the details remain murky, Dr. Amiri either defected from Iran or was kidnapped by American forces while abroad. Allegedly, during his "detention," Amiri provided the United States with intelligence

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[60] William Tobey, "Nuclear scientists as assassination targets," 61-62; Charlotte Spencer-Smith. "Alleged Iran Plot Would Be Latest in Clash of Spies and Assassinations." Atlantic Online. October 24, 2011. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5BD2-RT71-DYY9-J4BY-00000-00&context=1516831.

on the Iranian nuclear program. Later, following his return to Iran, Amiri was arrested and executed for treason by the Iranian regime.[61] Amiri's case offers what is perhaps only a more recent example of the use of targeting for the purpose of coercion as well as intelligence gathering; we turn now to the earliest known episode of this approach.

United States – Germany

The United States engaged in a targeting campaign against nuclear scientists in an attempt to counter German proliferations efforts and balance against the Soviet Union, by preventing their acquisition of nuclear expertise. The Alsos Mission was developed as part of the Manhattan Project's efforts to gather intelligence on the German atomic energy program.[40] The mission, carried out by the Army's G-2 Intelligence unit, along with the Office of Scientific Research and Development, and the Office of Naval Intelligence, was tasked with reporting on the extent of German nuclear capabilities, as well the German biological weapons program.[41] The broader goal of the mission was to "secure 'all available intelligence on enemy scientific research and development, particularly with reference to military application.'"[42] As part of the mission, in 1943, General Leslie Groves, director of the Manhattan Project, worked with senior military officials to send a group of civilian scientists and military personnel to investigate German scientific projects and interview scientists involved in its nuclear program.

In 1944, Colonel Boris Pash, a U.S. Army military intelligence officer who served as commander of the Alsos Mission, received a cable from Washington reporting that a considerable amount of uranium ore had been moved from Belgium to a plant in Stassfurt, Germany, an area that would soon fall under Soviet control. The Soviets had a parallel program intended to exploit

[61] Merrit Kennedy, "Iran Executes Scientist, Bringing Deadly end to a 'Wilderness of Mirrors," https://www.npr.org/sections/thetwo-way/2016/08/07/489061978/iran-executes-mysterious-nuclear-scientist

intelligence about the German program for use in their own atomic efforts. U.S. army intelligence had also suspected that the Soviets were engaged in espionage at the U.S. Radiation Laboratory at the University of California, Berkeley, and feared a Soviet capture of key German scientists. Not wanting the scientists to fall into Russian hands, Operation HARBORAGE, part of the ALSOS mission, was led by Colonel John Lansdale Jr. with the goal of providing support to enable the capture of German nuclear scientists, seize all available records, and destroy any remaining facilities.[43] In April 1945, the team successfully captured twenty-five of the most senior members of the German nuclear program, including Otto Hahn, Carl Friedrich von Weizsäcker, Kurt Diebner, Walther Gerlach, Erich Bagge, Paul Harteck, Horst Korsching, Max von Laue, Karl Wirtz, and Richard Kuhn. One month later, the team also apprehended Werner Heisenberg, a theoretical physicist and chief scientist of the German program, at his home. Samuel Goudsmit, the scientific lead for the Alsos Mission subsequently questioned the captives. As a Dutch American atomic physicist, he was well positioned to interrogate the scientists and examine captured documents that related to the progress of the German nuclear program.

It soon became clear that the German capability was far less developed than expected. Goudsmit later reflected on the mission, "Among the documents we found, the most interesting were the reports on general progress as prepared by Gerlach. Again, these confirmed our former conclusions; the German uranium project was only in a very initial stage. But the present information acted like the focusing of a picture on the screen. Before we studied these documents we had a rather vague impression of the whole enterprise; now it all became sharp and well defined. Now we began to know names and dates and amounts of money spent on the project."[44] The success of the mission was not tied to the defeat of the Germans by the Allied forces, but rather in its success in obtaining important intelligence regarding the extent of German nuclear progress. The larger program also resulted in the removal of a large stockpile of uranium, the identification of the location of key plants, and the discovery of documents that provide details about the program itself. Moreover, the operation was strategically well timed and provided a way to prevent key German intelligence from landing in Soviet hands.

Discussion, Implications, and Conclusions

To understand how targeting might "work" to forestall existing nuclear endeavors or prevent new programs, this theory building article has offered a coercive logic of counter-proliferation that focuses on compellence and deterrence in the nuclear realm. The acquisition of nuclear weapons by one's rival can result in adverse shifts in the balance of power, and in an effort to balance against a potential decline in relative power, states may choose to engage in preventive military action. Targeting scientists is one option available to states who believe that capturing or killing nuclear scientists may work to coerce rival states - compelling a state to abandon a current nuclear program or deterring states who may be considering proliferation. States can do so using either strategies of denial or punishment. The coercive logic suggests that targeting scientists might deter not only proliferators and potential proliferators but also states and scientists supporting these emerging nuclear programs. We demonstrate how this logic functions in three plausibility probes derived from a new dataset of 48 known attempts that occurred from 1944-2022, focusing on targeting scientists involved in the Iranian, Iraqi, and German nuclear programs.

Future Research

In this paper we purposefully set aside related but distinct questions regarding the efficacy of targeting as a counter proliferation strategy. Yet, the question of efficacy is an important and unexplored issue in the literature and has implications for understanding a state's choice of counterproliferation tools. We plan to explore this question in future work by exploiting multiple forms of within case variation present in the empirical universe. First, thinking about the long dyadic rivalries that exist in this space, for example between Israel and Iraq and Israel and Iran, each case offers the potential to examine the decision-making of the targeter over time and compare it against the reactions (if any) of the target over that same long period. Second, with a target state's attempt at proliferation, sometimes spanning multiple decades, we can assess the degree to which episodes of targeting catalyzed particular changes in the state's approach to proliferation. For example, we know that after concerted external pressure, Iraq pivoted from a plutonium to a uranium pathway to nuclear weapons,[62] and we can explore the extent to which such changes correspond to particular coercive events. Third, we plan to compare targeting to other counter-proliferation tools employed during the same time period to discern the relative impact of each tool. Additionally, we intend to explore available decision-making records from both the would be targeter as well as the target state in order to understand both if the logics we hypothesize are operative for states considering targeting other states' nuclear scientists as well as the extent to which such targeting instances have the theorized effect on the ground.

We also leave for future work identifying the conditions under which states are likely to choose targeting scientists over other strategies of counterproliferation. Combined, these two questions highlight a further empirical puzzle worth considering: If targeting nuclear scientists is an effective and perhaps low-cost counter-proliferation strategy, why don't states use it more often? By contrast, if the strategy is ineffective or counterproductive, why do at least Israel and the United States continue to pursue its use? These questions are beyond the scope of the present paper but are important to consider when developing a comprehensive understanding of targeting as a counterproliferation tool.

Implications

Finally, related to both the aforementioned questions concerning efficacy and a state's decision to choose the targeting of scientists relative to other counter-proliferation strategies, targeting has the potential to result in considerable counterproductive consequences that could have implications beyond the immediate efforts to delay a state's nuclear ambitions. Due to the potential

[62] Kreps and Fuhrmann, Attacking the Atom, 171.

for blowback, states may be disinclined from choosing targeting as a primary strategy. We identify three potential consequences: a martyrdom effect, an increase in domestic support for the target's program, and the moral and legal implications of targeting.

First, as demonstrated in the literature on the leadership decapitation of terrorist organizations, the assassination of nuclear scientists has the potential to create a martyrdom effect, whereby the scientist comes to be revered by both local and international audiences. As an example, following the death of top Iranian scientist Mohsen Fakhrizadeh in 2020, martyrdom posters hung throughout Tehran. In fact, the concept of becoming a martyr was not foreign to Mr. Fakhrizadeh. In a recording with Mehr News, he stated, "Let them kill…Kill as much as they want, but we won't be grounded. They've killed scientists, so we have hope to become a martyr even though we don't go to Syria and we don't go to Iraq."[63] The desire to be seen as a martyr for one's nation could incentivize scientists to take risks inherent to working on a state's nuclear program, undermining the impact of coercive efforts. This effect is not exclusive to assassination, however: captured leaders can also be seen as having sacrificed for the cause, creating support for the target regime.

Second, targeting scientists may result in an increase in public support for a country's nuclear efforts. Given norms against assassinations, the targeting of scientists can cause public outrage against a coercer state's heavy handed-counter proliferation tactics, particularly if scientists are seen as civilian non-combatants. This public outrage can translate into increased support for the regime and its proliferation goals, particularly as the country may be perceived as vulnerable to external aggression in the wake of such attacks. This increase in support could inadvertently embolden the target state, further confirming that a nuclear capability is critical to its security and thus increasing its resolve to continue with the nuclear program.

[63] Bergman, Ronen and Farnaz Fassihi. "The Scientists and the A.I.-Assisted, Remote-Control Killing Machine." *The New York Times*. Published September 18, 2021, and updated October 26, 2021 https://www.nytimes.com/2021/09/18/world/middleeast/iran-nuclear-fakhrizadeh-assassination-israel.html

Finally, while research on just war theory raises questions about the combatant status of civilians working on a state's military programs during wartime, and the moral and legal implications of targeting are beyond the scope of the paper, it is an important consideration within the context of blowback. Moral and legal arguments could be used to legitimize the targeting of one's own nuclear scientists[64] and even further legitimize the killing of any foreign citizen seen as posing the threat to a country's military capacity.[65] In addition to the broader moral and legal condemnation that a state engaging in targeting operations may be likely to face, the risk to one's own scientists is a consideration that a coercing state cannot overlook.

[64] Meisels 2014.
[65] Tobey 2012, 67

Table 1 (N=48)

Case #	Date	Target(s)	Location	Program	Attacker (Alleged)	Method of Attack	Outcome
1	Nov. 1944	Werner Heisenberg	Zurich, Switzerland	Germany	United States	Gunshot	Planned
2	Mar. 1945	Richard Kuhn	Heidelberg, Germany	Germany	United States and Allies	Arrest	Captured
3	Apr. 1945	Otto Hahn	Tailfingen, Germany	Germany	United States and Allies	Arrest	Captured
4	Apr. 23, 1945	Carl Friedrich von Weizsäcker	Hechingen, Germany	Germany	United States and Allies	Arrest	Captured
5	Apr. 23, 1945	Erich Bagge	Hechingen, Germany	Germany	United States and Allies	Arrest	Captured
6	Apr. 23, 1945	Horst Korsching	Hechingen, Germany	Germany	United States and Allies	Arrest	Captured
7	Apr. 23, 1945	Karl Wirtz	Hechingen, Germany	Germany	United States and Allies	Arrest	Captured
8	Apr. 23, 1945	Max von Laue	Hechingen, Germany	Germany	United States and Allies	Arrest	Captured
9	May 1945	Paul Harteck	Hamburg, Germany	Germany	United States and Allies	"Kidnapping"/arrest	Captured
10	May 1-3, 1945	Kurt Diebner	Munich, Germany	Germany	United States and Allies	Arrest	Captured

11	May 1-3, 1945	Walther Gerlach	Munich, Germany	Germany	United States and Allies	Arrest	Captured
12	May 1-3, 1945	Werner Heisenberg	Bavaria, Germany	Germany	United States and Allies	Arrest	Captured
13	Nov. 29, 1945	Rudolf Fleischmann	Strasbourg, France	Germany	United States and Allies	Arrest	Captured
14	Nov. 29, 1945	Werner Maurer	Strasbourg, France	Germany	United States and Allies	Arrest	Captured
15	Aug. 5, 1952	Sameera Moussa	California, US	Egypt	United States and Israel	Car crash	Killed
16	1962	Arms Dealer (unknown)	Northern Germany	Egypt	Unknown	Airplane explosion	Failed
17	Sep. 11, 1962	Heinz Krug	Munich, Germany	Egypt	Israel	Disappearance	Disappeared
18	Nov. 27, 1962	Wolfgang Pilz	Egypt	Egypt	Israel	Letter bombs	Failed; Resigned
19	Feb. 1963	Hans Kleinwachter	Switzerland	Egypt	Israel	Gunshot(s)	Failed
20	Mar. 1963	Paul Goerke (Goercke)	N/A	Egypt	Israel	Threats to daughter	Threatened
21	Jan. 24, 1966	Homi Jehangir Bhabha	Mont Blanc, France	India	United States	Plane Crash	Killed

22	Aug. 18, 1967	Sameer Najeeb	Detroit, United States	Egypt	United States	Hit and run	Killed
23	1980	French Scientists	N/A	Iraq	Israel	Threatening letter, calls	Resigned
24	1980	Italian Technicians	N/A	Iraq	Israel	Threats	Resigned
25	Jun. 14, 1980	Yahya el-Mashad	Paris, France	Iraq	Israel	Beating	Killed
26	Aug. 07, 1980	Manager of Osirak	Paris, France	Iraq	Committee to Safeguard the Islamic Revolution; Israel	Bombing of house	Failed
27	Aug. 07, 1980	Mario Fiorelli	Rome, Italy	Iraq	Committee to Safeguard the Islamic Revolution; Israel	Bombing of house	Failed
28	Aug. 07, 1980	SNIA-Techint Employees/Infrastruc ture	Rome, Italy	Iraq	Committee to Safeguard the Islamic Revolution; Israel	Two bombs	Unknown
29	Dec. 13, 1980	Abd al-Rahman Rasoul	Paris, France	Iraq	Israel	Poison or gunshot(s)	Killed
30	1981	Peter Griffin	Bonn, Germany	Pakistan	Israel	In-person threat	Threatened
31	Jan. 13, 1981	European Scientists, multiple	Baghdad, Iraq	Iraq	Shia non-state group; Israel; Iran	Bombing, multiple gunshots	Failed

32	Feb. 20, 1981	Eduard German	Berne, Switzerland	Pakistan	Group for Non-Proliferation in South Asia; Israel	Bomb, multiple threats	Failed, Resigned
33	1981	Heinz Mebus	Erlangen, Germany	Pakistan	Israel	Letter bomb	Failed
34	Jun. 09, 1981	Salman Rashid al-Lami	Geneva, Switzerland	Iraq	Unknown	Unknown virus	Killed
35	Nov. 1981	Albrecht Migule	Freiberg, Germany	Pakistan	Israel	Letter bomb	Failed
36	1990	Gerald Bull	Brussels, Belgium	Iran, Iraq	Israel (suspected)	Gunshot(s)	Killed
37	Dec. 21, 2004	Taleb Ibrahim al-Daher	Baqouba, Iraq	Iraq	Israel	Gunshot in car	Killed
38	Jan. 15, 2007	Ardeshire Hassanpour	Iran	Iran	Israel or Iran	Gas Poisoning	Killed
39	Aug. 1, 2008	Muhammad Suleiman	Tartus, Syria	Syria	Israel	Gunshot	Killed
40	May/Jun. 2009	Shahram Amiri	Saudi Arabia	Iran	United States	Kidnapping or defection	Disappeared
41	Jan. 12, 2010	Masoud Ali-Mohammadi	Tehran, Iran	Iran	Iran, Israel, and/or US	Remote bomb	Killed
42	Nov. 29, 2010	Fereydoon Abassi-Davani	Tehran, Iran	Iran	Israel, US, and/or UK	Bomb	Injured

43	Nov. 29, 2010	Majid Shahriari	Tehran, Iran	Iran	Israel and/or US	Bomb on car	Killed
44	Jul. 23, 2011	Darioush Rezaeinejad (Rezai-Nejad)	Tehran, Iran	Iran	Israel and/or US	Gunshot(s)	Killed
45	Jan. 11, 2012	Mostafa Ahmadi Roshan	Tehran, Iran	Iran	Israel and/or US	Bomb	Killed
46	Aug. 8. 2018	Aziz Asbar	Masyaf, Syria	Syria	Israel	Car bomb	Killed
47	Nov. 27, 2020	Mohsen Fakhrizadeh	Absard, Iran	Iran	Unknown	Gunshot(s)	Killed
48	May 25, 2022	Kamran Aghamolaei	Yazd, Iran	Iran	Israel	Poison	Killed