PROJECT ON MANAGING THE ATOM

When Did (and Didn't) States Proliferate?

Chronicling the Spread of Nuclear Weapons

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Philipp C. Bleek, "When Did (and Didn't) States Proliferate? Chronicling the Spread of Nuclear Weapons," Discussion Paper (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School and the James Martin Center for Nonproliferation Studies, Middlebury Institute of International Studies, Monterey, CA., June 2017).

Note: This is intended to be a living document, and will be updated periodically, perhaps on an annual basis, as new information emerges. Correspondence should be sent to the author at pbleek@miis.edu, if possible with the email subject line "Proliferation chronicle correspondence."

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Cover photo: 19-kiloton Whitney shot, Operation Plumbbob, September 23, 1957, Nevada Test Site. X-rays generated by the detonation strip electrons off atoms in the air. The electrons then rejoin the atoms, producing a flash of electrical discharge that creates the feathery light seen here. Los Alamos National Laboratory, National Security Science (July 2015), p. 19, shared by Alex Wellerstein.

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About the Author

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Acknowledgments

The author gratefully acknowledges research assistance from Navindra Gunawardena and Danielle Preskitt. He appreciates comments from various colleagues over the past few years that have improved this draft, though he regrets failing to keep track of all of them, so that he could individually acknowledge them without risking overlooking some, and takes full responsibility for any remaining errors.

The Project on Managing the Atom thanks the John D. and Catherine T. MacArthur Foundation and the Carnegie Corporation of New York for their support during the preparation of this paper.

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Los Alamos National Laboratory, National Security Science

1. Introduction

Since the late 1930s and early 1940s, when progress in physics and looming conflict led U.S. and U.K. policymakers to explore the possibility of constructing fission-based explosives, various countries have both engaged in and rolled back nuclear weapons-related proliferation. Thirty-one countries at least opened the door to potential nuclear weapons programs, seventeen of those launched weapons programs, and ten acquired deliverable nuclear weapons. But proliferation has also been complemented by de-proliferation: one state that developed nuclear weapons subsequently gave them up, seven of those who launched programs never or have not yet acquired, and fourteen countries halted their exploration of nuclear weapons without launching programs.

This paper succinctly summarizes all of this nuclear weapons proliferation activity. It focuses on states that engaged in at least some degree of proliferation activity, chronicling both the initiation and, where relevant, the ending of these behaviors. In a few cases, it discusses countries that this author assesses do not merit coding as having engaged in certain behaviors, despite the fact that other analysts have argued they do.

This project has various motivations. Its initial purpose was to establish a well-documented set of codings to support the burgeoning quantitative literature on the causes and consequences of nuclear proliferation. Scholars have been employing various nuclear proliferation codings, some more rigorously documented than others, and none approaching what this paper attempts. This effort can hopefully serve to build consensus as well as more clearly identify where and why some scholars may differ on certain codings. To serve quantitative scholars, this paper codes behavior, provides rationales and documentation for the codings, highlights plausible alternate codings where relevant, and identifies discrepancies between its codings and those of other scholars.

But the paper will hopefully also be of use to scholars, students, and others for whom succinct and well-documented summaries of the proliferation behaviors of various states are a useful reference. This is intended to be a living document. It will be updated periodically based on new information, so feedback is welcome from readers who may quibble with some interpretations or draw attention to key primary or secondary sources that may have been overlooked.

2. Key Concepts

Unless otherwise noted, the term proliferation is used throughout to refer to *nuclear weapons* proliferation, and not to the proliferation of other unconventional weapons, such as biological or chemical weapons, or, for that matter, conventional weapons. Proliferation refers to a spectrum of possible activities related to the exploration, pursuit, or acquisition of nuclear weapons by states. As employed here, it does *not* refer to activities states, non-state groups, or individuals may engage in to assist *other* states (or non-state actors) to explore, pursue, or obtain nuclear weapons.

This paper breaks the spectrum of potential nuclear weapons proliferation activity into three stages: *exploring*, *pursuing*, and *acquiring*.[1] *Exploration* seeks to capture whether leaders are opening the door to potential nuclear weapons programs. Leaders may authorize studies to examine the feasibility and desirability of attempting to acquire nuclear weapons or low-level activities that are intended to bolster nuclear weapons capabilities but that fall short of launching nuclear weapons programs.[2] For example, in the late 1960s, Japanese Prime Minister Eisaku Sato's Cabinet Information Research Office commissioned a secret report from four non-government academics, including one nuclear chemist and three political scientists, assessing the costs and benefits of possible Japanese acquisition of nuclear weapons, particularly in the context of China's recent proliferation.[3] To cite

1 The paper follows Singh and Way with the explore, pursue, and acquire categories. In practice, proliferation entails a spectrum of activities; Rebecca Hersman's metaphor of a proliferation rheostat, with countries dialing up and back down the intensity with which they pursue nuclear weapons, is apt. One could in theory subdivide proliferation behavior into more categories, but while this is intuitively appealing, the challenge of coding consistently rises as categories proliferate. Existing quantitative studies are all based on coding into only one, two, or three distinct categories (plus the null category of no meaningful proliferation behavior). The rheostat metaphor is employed in a discussion of South Korean and Taiwanese proliferation in Rebecca K.C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p. 548. A future iteration of the paper may also add a fourth data point, when each country first possessed an operational nuclear research reactor. Some analysts have used this as a minimal standard for identifying all countries notionally capable of launching nuclear weapons programs, and some international agreements, such as the Comprehensive Nuclear Test Ban Treaty, rely on this standard as well. The standard is almost certainly too permissive, i.e. obtaining and operating a research reactor does not necessarily demonstrate meaningful capability to launch and sustain a serious nuclear weapons program, but the absence of a reactor is a reasonable standard for excluding countries from the proliferation risk pool.

2 Activities like acquiring plutonium separation or uranium enrichment capacity could fall into this category if they are explicitly intended to bolster nuclear weapons-relevant capacity. Again, this highlights the fact that coding, especially of a concept as amorphous as exploration, is as much art as science.

3 Yuri Kase, "The Costs and Benefits of Japan's Nuclearization: An Insight into the 1968/1970 Report," *Nonproliferation Review* (Summer 2001), pp. 55-68. It bears emphasizing that the report's

another example, in 1957 German Defense Minister Franz Josef Strauss, with the support of Chancellor Konrad Adenauer, negotiated a secret agreement to jointly develop nuclear weapons on French soil, in cooperation with France and Italy.[4] The episode ended the following year when Charles de Gaulle assumed the presidency of France and halted implementation of the agreement; the German government expressed its displeasure by canceling a planned purchase of French Mirage III fighter aircraft.[5] One could characterize this episode as unsuccessful pursuit. But in the absence of any German activity toward the actual production of weapons, beyond the organization of a delegation of German scientists and military officers to visit the French uranium enrichment site, itself never carried out due to the halting of cooperation, it falls well short of the sort of concerted behavior required to justify that higher threshold in the way it is conceptualized in this study.[6] At the same time, it clearly falls above the null threshold of no meaningful nuclear weapons proliferation activity. Exploration is the least well-defined of the proliferation behaviors coded here, but sheds light on low-level proliferation behavior that will be relevant to many scholars and analysts. Given its more tenuous conceptualization and coding, some may choose to instead focus on the more robustly defined and more readily coded pursuit and/or acquisition.

Pursuit refers to active programs authorized by leaders with the aim of acquiring nuclear weapons or the capacity to construct them on short notice.[7] In order to qualify as pursuit, leaders do not need to have decided whether they will take the final step in the proliferation process and obtain

primary purpose was apparently to deflect arguments for proliferation from conservative elements, but at the same time, took place in the context of a debate within Japan that included efforts by the prime minister to undercut the taboo against proliferation among the Japanese population and to float the idea of possible Japanese proliferation at some time in future (see Kase, "The Costs and Benefits of Japan's Nuclearization: An Insight into the 1968/1970 Report," pp. 57-59).

4 Franz Josef Strauss, *Die Erinnerungen* (Berlin: Siedler Verlag, 1989), pp. 313-315. The episode is presumably little-known outside Germany because of the paucity of non-German language sources; Strauss' autobiography, for example, has never been translated.

5 Strauss, *Die Erinnerungen*, p. 316.

6 Strauss, *Die Erinnerungen*, p. 316.

7 Note that this definition includes both publicly declared and secret nuclear programs. Such programs might have somewhat different dynamics; publicly declaring a program might foment either (or both) domestic resistance or support, and once declared, domestic audience costs might make it more difficult to later halt efforts. In practice, few programs seem to stay secret for long (although admittedly we don't know what we don't know). Of the countries that obtained nuclear weapons, South Africa appears to have been the only one to keep its proliferation activities relatively secret for a number of years. Both Israel and Pakistan were not able to keep their activities secret for more than a few years, although some ambiguity persisted about how advanced their activities were.

nuclear weapons. However, they do need to have authorized work to develop the capacity to produce nuclear weapons, rather than merely the acquisition of relevant dual-use technologies or materials. Consequently a state that pursued domestic uranium enrichment or plutonium separation capabilities, but where no evidence suggests those activities were ordered in the context of an effort to develop nuclear weapons, and which engaged in no direct nuclear weapons development activities, such as weapons design work, would not be coded as pursuing. As defined here, this includes situations where leaders order work on uranium enrichment or plutonium separation with the intention of giving the state a future nuclear weapons *option*, while postponing any direct weapons activities.[8] In practice, even states whose nuclear efforts are often characterized as falling into this grey zone, for example India or Iran, concurrently engaged in explicit nuclear weapons development activities, such as working on weapons designs and manufacturing weapons components. At times, evidence of leadership intent is not clear cut, and it must be inferred. The important thing in these more ambiguous contexts is to justify particular decisions and identify plausible alternate potential interpretations. For example, Russia is coded as pursuing nuclear weapons beginning in 1943. It had earlier begun exploring in 1942; late that year, after being informed that both the British and the American governments were pursuing nuclear weapons, "Stalin took the decision to restart nuclear research" that had largely ground to a halt due to the war effort against Germany.[9] Earlier contacts between scientists and government officials had focused on the potential for power generation rather than weapons, and even as Soviet scientists began to grasp the potential for nuclear explosives in the early 1940s, they repeatedly found themselves unable to stir government officials to action.[10] The pursuit coding in 1943 hinges on a meeting in February of that year, where "the State Defense Committee adopted a special resolution…on the organization of research into the utilization of atomic energy…a new

8 This grey area corresponds with what is often identified as a "loophole" in the Nuclear Non-Proliferation Treaty, which is that under the terms of the treaty, states can master the enrichment of uranium or manufacture and separation of plutonium, and having done so, can withdraw from the treaty and very quickly obtain nuclear weapons. On the loophole, see Sarah J. Diehl and James C. Moltz, *Nuclear Weapons and Nonproliferation* 2nd Edition (ABC-Clio, 2008), pp. 63-64.

9 David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956* (Yale University Press, 1996), pp. 82-85.

10 Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, pp. 58-78.

laboratory was established in which all nuclear research [including, centrally, weapons-related research] would be concentrated."[11]

Finally, *acquisition* refers to states obtaining at least rudimentary deliverable nuclear-explosive devices. The means of delivery may be, in fact is likely to initially be, very primitive; think the air-dropped gravity bombs the United States deployed against Hiroshima and Nagasaki.[12] Merely conducting an explosive nuclear test is not sufficient to be coded as having acquired nuclear weapons. Although every other state is assessed as acquiring a rudimentary deliverable weapons capability in the year it conducted its first test, India conducted a test in 1974 without producing weapons.[13] Further, some states acquired deliverable nuclear weapons capabilities without or before they conducted their first tests, including South Africa, Israel, and Pakistan.[14]

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11 Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, p. 88.

12 If weaponization is defined as more than extremely crude capabilities, then the time lag following an initial test would be years. Employing such a higher standard for weaponization, Gaurav Kampani argues "...the five permanent members of the United Nations Security Council (P5) took up to two years to make the transition from exploding a test device to building weaponized versions of them. In comparison the process of weaponization in South Africa, India, and Pakistan took eight, fifteen and ten years, a nearly twenty-eight-fold increase on average." Further, Kampani distinguishes between weaponization and operational capability, defining the latter as "the soft institutional, organizational, and training routines essential to using military hardware instrumentally." Future quantitative studies might seek to differentiate these stages, perhaps coding a crude nuclear-explosive capability, a weaponized one, and an operational one separately, though this poses both coding and analytical challenges. Gaurav Kampani, "New Delhi's Long Nuclear Journey: How Secrecy and Institutional Roadblocks Delayed India's Weaponization," *International Security*, Vol. 38, No. 4 (Spring 2014), p. 79.

13 One could code India as briefly possessing a rudimentary deliverable nuclear-explosive capacity in 1974. Given India's decision not to deploy such capabilities after its test, and in fact to effectively freeze its nuclear weapons efforts, I choose not to code it in this way. Whether North Korea acquired even a rudimentary nuclear weapons capability after its apparently failed 2006 test, its subsequent 2009 test, or perhaps a few years earlier or later, remains unclear. All these events fall outside the window of the quantitative analysis published to date, and given how recent they are, there is a strong argument for withholding judgment on them. The same goes for possible Syrian and Burmese nuclear weapons programs; the former is included here, the latter is not.

14 South Africa is sometimes alleged to have conducted a clandestine nuclear test in 1979, perhaps in collaboration with Israel. Opinion on whether this occurred is divided, with reputable analysts taking both sides. For both sides of the argument, see Jeffrey T. Richelson, "The Vela Incident: Nuclear Test or Meteoroid?," National Security Archive Electronic Briefing Book, no. 190, May 5, 2006, http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB190/index.htm (accessed October 20, 2009). Arguing the event was a South African nuclear test, with Israeli assistance, see Kathy Delucas, "Blast from the Past: Los Alamos Scientists Receive Vindication," Los Alamos National Laboratory News Release, July 11, 1997, http://www.lanl.gov/news/index.php/fuseaction/home.story/story_id/1613 (accessed October 20, 2009). Former U.S. Air Force Secretary Thomas Reed has suggested, along with his co-author Danny Stillman, "We believe that during [Benazir] Bhutto's term in office, the People's Republic of China tested Pakistan's first bomb for her in 1990. There are numerous reasons why we believe this to be true, including the design of the weapon and information gathered from discussions with Chinese nuclear experts. That's why the Pakistanis were so quick to respond to the Indian nuclear tests in 1998." Alex Kingsbury, "Why China Helped Countries Like Pakistan, North Korea Build Nuclear Bombs" Interview with Thomas Reed, U.S. News & World Report, January 2, 2009, http://www.usnews.com/articles/news/world/2009/01/02/why-china-helped-countries-like-pakistan-north-korea-build-nuclear-bombs.html (accessed May 26, 2010).

3. Prior Studies

This paper builds on the codings of prior quantitative studies, and identifies discrepancies between its codings and theirs. An early attempt by Kegley (1980) created a taxonomy of nuclear states, nuclear aspirant states, latent nuclear aspirants, and nonproliferating states, but did not attempt to identify time periods when states engaged in these behaviors or changes over time, and is not addressed further here.[15] Meyer (1984) coded states as initiating nuclear weapons programs, which he defined as "decisions to pursue nuclear weapons acquisition," effectively analogous to what is here termed pursuit.[16] Meyer did not code the cessation of such activity.

Singh and Way (2004) introduced the explore, pursue, and acquire trichotomy adopted here. They defined exploration as "consider[ing] building nuclear weapons, as demonstrated by political authorization to explore the option or by linking research to defense agencies that would oversee any potential weapons development," effectively analogous to the definition employed in this paper.[17] They defined pursuit as an "active effort to pursue nuclear weapons" evinced by taking "steps aimed at acquiring nuclear weapons, such as a political decision by cabinet-level officials, movement toward weaponization, or development of single-use, dedicated technology," again effectively analogous to the definition employed here.[18] Finally, they defined acquisition as "explod[ing] a nuclear device or assembl[ing] a nuclear weapon," which differs slightly but importantly from possessing a deliverable nuclear device.[19] Way subsequently updated his codings, and in addition to his earlier study, this paper references the most recently available, 2012 version.[20]

15 Charles W. Kegley, "International and Domestic Correlates of Nuclear Proliferation: A Comparative Analysis," *Korea and World Affairs*, Vol. 4 (1980), pp. 5-37.

16 Stephen M. Meyer, *The Dynamics of Nuclear Proliferation* (Chicago: University of Chicago Press, 1984), p. 5.

17 Sonali Singh and Christopher R. Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," *Journal of Conflict Resolution*, Vol. 48, No. 6 (2004), p. 867.

18 Singh and Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," p. 866.

19 Singh and Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," p. 866.

20 Christopher Way, "Nuclear Proliferation Dates," Cornell, June 12, 2012, http://falcon.arts.cornell.edu/crw12/documents/Nuclear%20Proliferation%20Dates.pdf (accessed March 28, 2017).

Jo and Gartzke (2007) focused only on pursuit and acquisition. Their version of pursuit focuses on "whether a state has an active nuclear weapons program in a given year."[21] Their codebook explains that there are two ways for a state to meet this criteria. They code "the year in which the highest decision maker in a given state authorized a nuclear weapons program as the year in which the state first possesses a nuclear weapons program."[22] But since "Little if any clear information can be obtained for non-declared states…since such programs are often of necessity clandestine," they adopt a different standard "For unofficial nuclear weapons states (nuclear weapons programs that are not recognized in the NPT)…the year in which a suspect state's nuclear activities are seen to increase noticeably…"[23] The concept is effectively analogous to that employed here.

Jo and Gartzke's version of acquisition focuses on "whether a state possesses nuclear weapons," and neither their article nor the associated codebook fleshes it out further.[24] This is again effectively analogous to the definition employed in this paper. Gartzke subsequently crafted a revised coding, focused only on acquisition, with Kroenig, and that coding is referenced in what follows also.[25]

Finally, Mueller and Schmidt (2010) code what they term "nuclear weapon activities," which they define somewhat vaguely as "to seriously consider the acquisition of nuclear weapons," and which they code in five-year intervals.[26] This broad category encompasses some of what is here coded as exploration and some as pursuit.

Note that each of these studies defines its categories slightly differently, though they are nonetheless broadly similar. When the codings in this paper differ from those of other studies, those differences are noted in footnotes.

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21 Dong- Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapon Proliferation," *Journal of Conflict Resolution*, Vol. 51, No. 1 (2007), p. 172.

22 Dong-Joon Jo and Erik Gartzke, "Codebook and Data Notes for 'Determinants of Nuclear Weapon Proliferation: A Quantitative Model,'" http://pages.ucsd.edu/~egartzke/data/jo_gartzke_0207_codebk_0906.pdf (accessed March 28, 2017).

23 Jo and Gartzke, "Codebook and Data Notes for 'Determinants of Nuclear Weapon Proliferation: A Quantitative Model.'"

24 Jo and Gartzke, "Determinants of Nuclear Weapon Proliferation," p. 172.

25 Erik Gartzke and Matthew Kroenig, "A Strategic Approach to Nuclear Proliferation," *Journal of Conflict Resolution*, Vol. 53, No. 2 (April 2009), p. 154.

26 Harald Mueller and Andreas Schmidt, "The Little Known Story of De-Proliferation: Why States Give Up Nuclear Weapon Activities" in William C. Potter with Gaukhar Mukhatzhanova (eds.), *Forecasting Nuclear Proliferation in the 21st Century*, Vol. 1 (Stanford: Stanford University Press, 2010).

Table 1: Proliferation Behavior Over Time

Country	Explore	Pursue	Acquire
United States	1939-	1942-	1945-
Russia	1942-	1943-	1949-
United Kingdom	1940-	1941-	1952-
France	1945-	1954-	1960-
China	1952-	1955-	1964-
Israel	1949-	1955-	1967-
South Africa	1969-91	1974-91	1979-91
Pakistan	1972-	1972-	1987-
India	1948-	1964-66, 72-75, 80-	1987-
Korea, North	1962-	1980-	2006-
Yugoslavia	1949-62, 74-87	1953-62, 82-87	
South Korea	1969-81	1970-81	
Libya	1970-2003	1970-2003	
Brazil	1966-90	1975-90	
Iraq	1975-91	1981-91	
Iran	1974-79, 84-	1989-	
Syria	2000-	2002-07	
Germany	1939-45		
Japan	1941-45, 67-72		
Switzerland	1945-69		
Sweden	1945-70		
Norway	1947-62		
Egypt	1955-80		
Italy	1955-58		
Australia	1956-73		
Germany, West	1957-58		
Indonesia	1964-67		
Taiwan	1967-76, 87-88		
Romania	1978-89		
Argentina	1978-90		
Algeria	1983-91		

4. Proliferation Behavior over Time

Coding decisions are summarized in Table 1 and explained in the subsequent discussion of each individual case. Both the table and the subsequent capsule summaries of the proliferation behavior of each state that engaged in at least exploration are organized chronologically based on the most significant proliferation-related behavior engaged in by the state. In other words, all the states that obtained nuclear weapons are listed first, in the chronological order in which they obtained them. Next, all the remaining states that pursued nuclear weapons are listed, in the chronological order in which they initiated that pursuit. Finally, all the remaining states that only explored nuclear weapons are listed, again in the chronological order in which they initiated that activity. So the paper can be read as a rough history of the nuclear age, organized by both the time in which activities took place and the significance of those activities.

United States: The United States is coded as exploring nuclear weapons starting in 1939, when President Franklin D. Roosevelt established the secret Advisory Committee on Uranium under National Bureau of Standards Director Lyman J. Briggs to explore the possibility of fission nuclear explosives among other issues.[27] The committee met for the first time on October 21; Roosevelt ordered its establishment after receiving a letter from Albert Einstein and Leo Szilard on October 11.[28] The United States is coded as pursuing beginning in 1942, when on January 19 President Roosevelt authorized a National Defense Research Committee plan involving

27 Since Singh and Way begin their analysis in 1945, the United States is never coded as exploring or pursuing nuclear weapons but instead simply acquires them in that year. The authors do not discuss why they chose 1945 to begin their analysis, but it appears plausible that they felt that until the United States demonstrated that nuclear weapons were feasible by testing a nuclear explosive device for the first time in 1945, the character of the proliferation environment was very different and therefore 1945 is the most appropriate starting point for the nuclear age. Singh and Way rely on a now-defunct website as their sole source: "Nuclear Files, 1994-2000, Master Timeline," http://www.nuclearfiles.org/chron/40/1940s.html (accessed October 10, 2000). Their source appears to have been updated as "Timeline of the Nuclear Age" NuclearFiles.org, http://www.nuclearfiles.org/menu/timeline/html_index.htm (accessed September 17, 2008). Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986), pp. 314-315. Note that British historian Andrew Brown argues, "The only date I would really take issue with is 1939 for the USA. Lyman Briggs did nothing for 2 years and then when the MAUD report arrived locked it in his safe and showed it to no one. It was Mark Oliphant who came over on a visit and started alerting the Americans to what was happening. Then Bush and Conant got involved." Email to author, October 11, 2009. Notwithstanding this caveat, U.S. behavior in 1939 meets the threshold for exploration.

28 Rhodes, *The Making of the Atomic Bomb*, pp. 313-317.

"forming an engineering group and accelerating physics research… [both] aimed at developing a fission weapon."[29] Finally, the United States is coded as acquiring in 1945, when it conducted the Trinity test, the world's first nuclear fission explosion, on July 16 at Alamogordo, New Mexico, and proceeded to deploy the nuclear weapons used against the Japanese cities Hiroshima and Nagasaki on August 6 and 9, respectively.[30]

Russia (Soviet Union): Russia began exploring in 1942; late that year, after being informed that both the British and the American governments were pursuing nuclear weapons, "Stalin took the decision to restart nuclear research" that had largely ground to a halt due to the war effort against Germany.[31] Earlier contacts between scientists and government officials had focused on the potential for power generation rather than weapons, and even as Soviet scientists began to grasp the potential for nuclear explosives in the early 1940s, they repeatedly found themselves unable to stir government officials to action.[32] Russia initiated pursuit in 1943, when in February "the State Defense Committee adopted a special resolution…on the organization of research into the utilization of atomic energy…a new laboratory was established in which all nuclear research [including, centrally, weapons-related research] would be concentrated."[33] Russia acquired in 1949, after it conducted its first nuclear test explosion on August 29.[34]

United Kingdom: The United Kingdom began exploring in 1940; in the spring of that year, "Confronted with the importance of these conclusions [the secret Peierls-Frisch memorandum on the potential for an extraordinarily powerful uranium-fueled bomb], the British authorities decided to become more involved and entrust the coordination of research to a committee under the Ministry of Aircraft Production…known by the code

29 Gartzke and Jo also code the United States as pursuing in 1942 and acquiring in 1945. Gartzke and Jo rely on K.D. Nichols, *The Road to Trinity* (New York: William Morrow and Company, 1987). Meyer similarly codes pursuit as 1942, while Mueller chooses 1945, perhaps for the same reasons as Singh and Way. Nichols, *The Road to Trinity*, p. 34, also cited in Jo and Gartzke (2007).

30 Rhodes, *The Making of the Atomic Bomb*, pp. 664-670.

31 Singh and Way along with Mueller code Russia as pursuing in 1945. Gartzke and Jo code Russia as pursuing in 1943, whereas Meyer codes Russia as pursuing in 1942. Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, p. 88. Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, p. 215.

32 Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, pp. 58-78.

33 Singh and Way along with Mueller code Russia as pursuing in 1945. Gartzke and Jo code Russia as pursuing in 1943, whereas Meyer codes Russia as pursuing in 1942. Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, p. 88.

34 Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*, p. 215.

name "the Maud Committee.""[35] Pursuit began in 1941, when on September 3, at a meeting with Prime Minister Churchill and the military chiefs of staff, a decision was made to create "an independent organization within the DSIR [Department of Scientific and Industrial Research] responsible for all atomic matters, both military and civilian.[36] It was given the code name "Directorate of Tube Alloys."[37] The independent effort later became part of the U.S. Manhattan Project, with independent efforts eventually reinitiated after the Americans halted cooperation. Acquisition was in 1952, after the United Kingdom conducted its first nuclear test on October 3.[38]

France: France began exploration in 1945; on October 8 of that year France established an Atomic Energy Commission (CEA), with unusual administrative autonomy and reporting directly to the prime minister, whose early emphasis was on civilian power generation but which was also initially tasked to explore military issues.[39] Pursuit began in 1954. Gartzke and Jo assessed that "Prime Minister Pierre Mendes-France authorized a nuclear weapons program on December 26, 1954."[40] However, Scheinman suggests the situation was more complex, with the interministerial group that met that day failing to reach consensus, as a result of which "no official order was ever sent from the office of the Prime Minister to the CEA [but] the CEA proceeded, on the basis of the apparent sympathies of the Prime

35 Singh and Way code the United Kingdom as exploring in 1945; it is unclear whether they chose this date because their analysis begins in that year or because they judged that to be the correct. Mueller also codes 1945, although it is unclear whether this is a result of his decision to begin analysis in that year, as per Singh and Way above. Singh and Way rely on Bruce D. Larkin, *Nuclear Designs: Great Britain, France, and China in the Global Governance of Nuclear Arms* (Transaction Publishers, 1996), and a webpage from the Nuclear Age Peace Foundation that as of August 2010 is no longer accessible at the location they cite. Bertrand Goldschmidt, *Atomic Rivals* (New Brunswick and London: Rutgers University Press, 1990), p. 117.

36 Singh and Way code pursuit in 1947. Gartzke and Jo code pursuit as 1941. Jo and Gartzke rely on Goldschmidt, *Atomic Rivals*, pp. 124-135. Meyer codes initial pursuit as 1942 and restarting pursuit in 1947.

37 Goldschmidt, *Atomic Rivals*, p. 129.

38 Andrew J. Pierre, *Nuclear Politics: The British Experience with an Independent Strategic Force 1939-1970* (London: Oxford University Press, 1972), p. 85.

39 Singh and Way code France as exploring in 1946. Lawrence Scheinman, *Atomic Energy Policy in France under the Fourth Republic* (Princeton: Princeton University Press, 1965), pp. 3-19.

40 Both Singh and Way along with Gartzke and Joe code pursuit in 1954, Meyer codes pursuit as 1956, while Mueller chooses 1951-55. Singh and Way rely on Larkin, *Nuclear Designs: Great Britain, France, and China in the Global Governance of Nuclear Arms*, and a webpage no longer available at the URL they cite as of August 2010. Gartzke and Jo rely on Carey Sublette, "Nuclear Weapons Frequently Asked Questions" (version 2.19: 20), 1999, http://nuclearweaponarchive.org/Nwfaq/Nfaq0.html, updated version accessed as of August 16, 2010.

Minister, to carry out its plans for the establishment of a military program."[41] Though one could argue for not coding 1954 as pursuit, given the lack of a clear political decision, it is difficult to identify another inflection point prior to the 1960 acquisition at which the French nuclear weapons program was initiated. Acquisition was in 1960, when France conducted its first nuclear test on February 13 and moved ahead to weaponize and operationalize a nuclear weapons capability.[42]

China: China began exploring the development of nuclear weapons options in May 1952.[43] The Chinese government did provide modest support for nuclear research as early as the spring of 1949, though there is no evidence that this was oriented toward the exploration of a nuclear weapons option.[44] Notably, this early nuclear development work involved significant contributions by Qian Sanqiang, who had an integral role in the subsequent nuclear weapons program and was also one of the main participants briefing Zhou Enlai on atomic bomb details prior to the January 15th, 1955 Politburo meeting where the decision to pursue was taken.[45] The primary basis for coding explore in 1952 comes from discussions on the First Five-Year Plan found in *China Today: Defense Science and Technology*, a 1993 official publication produced by the Chinese National Defense Industry Press. Under a section titled "Decision Made to Develop Atomic Bombs and Missiles," the First Five-Year Plan for national defense construction was discussed including a May 1952 meeting where Central Military Commission (CMC) leaders "talked about the development of non-conventional weapons and asked related scientists for the comments. Preparations were made for further development."[46] Further development included both nuclear energy development, which Qian Sanqiang introduced a proposal for in 1953, and an assessment for nuclear weapons development which both Qian Sanqiang and geologist Li Siguang gave to Zhou Enlai on January 14th 1955.[47] Pursuit was initiated in 1955 during the

41 Scheinman, *Atomic Energy Policy in France under the Fourth Republic*, pp. 112-114.

42 Scheinman, *Atomic Energy Policy in France under the Fourth Republic*, p. 193.

43 Singh and Way code China as exploring in 1955.

44 John Lewis and Xue Litai, *China Builds the Bomb* (Stanford, CA: Stanford University Press, 1988), p. 36.

45 Editor Yu Yongbo, *China Today: Defense Science and Technology* (Beijing: National Defense Industry Press, 1993), p. 27-28.

46 Yongbo, *China Today: Defense Science and Technology*, p. 27.

47 Yongbo, *China Today: Defense Science and Technology*, pp. 27-28.

First Taiwan Straits Crisis, when on January 15th, Mao Zedong presided over a Central Secretariat meeting at which "The Chairman 'cheerfully announced that China would immediately devote major efforts to developing atomic energy research' for military purposes."[48] This meeting was followed by agreements with the Soviet Union, following Moscow's 1955 announcement that it would aid China's peaceful nuclear energy efforts, such as the October 1957 agreement in which the Soviet Union agreed to provide a prototype atomic weapon and uranium hexafluoride for the Lanzhou gaseous diffusion plant.[49] This assistance never fully materialized and was stopped completely by 1959 as Sino-Soviet relations deteriorated. China subsequently acquired in 1964, after it conducted its first nuclear test on October 16.[50]

Israel: Israel began exploring in 1949.[51] Prime Minister David Ben Gurion appears to have promulgated efforts to explore chemical and biological weapons as early as 1947 or 1948. Israeli policymakers realized they lacked any meaningful capability to implement their nuclear goals at that time, but authorized efforts to begin exploring a nuclear weapons option in a concerted way by 1949.[52] Pursuit started in 1955, "Soon thereafter [early 1955] [Israeli Defense Minister] Ben Gurion determined that the time had come for Israel to launch a national nuclear energy project, with the objective of developing nuclear weapons…in 1955 EMET [Ministry of Defense Research and Planning Division] began to recruit…the recruits were told by Ratner [future chief of the bomb project] in unequivocal language that they were chosen for Israel's most secret national project—a project that would result in the building of an Israeli nuclear device."[53] The program apparently took a few years to get off the ground, so one could make a reasonable case for coding pursuit as 1957 or 1958, although the coding rubric

48 Singh and Way also code China as pursuing in 1955, Gartzke and Jo code China as pursuing in 1956, Meyer codes China as pursuing in 1957, while Mueller codes China as pursuing 1951-55. Singh and Way rely on Larkin, *Nuclear Designs: Great Britain, France, and China in the Global Governance of Nuclear Arms*; John Lewis and Xue Litai, *China Builds the Bomb*; and a webpage that is no longer accessible as of August 2010. Lewis and Xue, *China Builds the Bomb*, pp. 38-39.

49 Jeffrey Lewis, *Paper Tigers: China's Nuclear Posture* (Routledge, 2014), p. 15; John Wilson Lewis and Xue Litai, "Strategic Weapons and Chinese Power: The Formative Years," *China Quarterly*, No. 112 (December 1987), p. 542.

50 Lewis and Xue, "Strategic Weapons and Chinese Power: The Formative Years", pp. 186-188; Lewis, *Paper Tigers: China's Nuclear Posture*, p. 45.

51 Singh and Way also code Israel as exploring in 1949.

52 Avner Cohen, *Israel and the Bomb* (New York: Columbia University Press, 1998), pp. 11-27.

53 Cohen, *Israel and the Bomb*, pp. 42-43.

employed here emphasizes the political decision rather than its implementation.[54] Acquisition is coded as 1967, on the basis of Avner Cohen's conclusion that in May of that year, "Israel did something it never had done previously. Israeli teams assembled virtually all the components, including the handful of nuclear cores it had, into improvised but operational explosive devices."[55]

South Africa: South Africa is coded as exploring beginning in 1969, when "the AEB [Atomic Energy Board] established an internal committee to investigate the economic and technical aspects of using PNEs [peaceful nuclear explosives] in mining" and government officials decided to build a secret pilot scale uranium enrichment plant.[56] South Africa's program appears to have begun as a "peaceful" effort, shifting to a strategic nuclear deterrent-focused effort in the mid-1970s as the country's perceived security situation deteriorated, but this paper codes any every rudimentarily deliverable nuclear explosive device as a de facto weapon and hence any effort to develop one as a weapons program.[57] But assuming one accepts the PNE motivation, there is a plausible case for not coding this earlier

54 Cohen, *Israel and the Bomb*, p. 19, 23.

55 This diverges strongly from Singh and Way's coding of 1972, which appears unequivocally too late, and less strongly from Gartzke and Jo's coding of 1966, which, according to their coding appendix, citing Cohen (1998), they chose on the basis that Israel was then judged by the U.S. Central Intelligence Agency to be capable of assembling a nuclear weapon in 6-8 weeks. Singh and Way rely on Avner Cohen, "Israel and the Evolution of U.S. Nonproliferation Policy: The Critical Decade (1958-1968)," *Nonproliferation Review* (Winter 1998); R. W. Jones, M. G. McDonough, T. F. Dalton, and G. D. Koblentz, *Tracking Nuclear Proliferation: A Guide in Maps and Charts* (Washington D.C.: Carnegie Endowment for International Peace, 1998); Mitchell Reiss, Without the Bomb: The Politics of Nuclear Non-Proliferation (New York: Columbia University Press, 1988); Spector (1988); and a website no longer accessible as of August 2010. Avner Cohen, "Crossing the Threshold: The Untold Nuclear Dimension of the 1967 Arab-Israeli War and Its Contemporary Lessons," *Arms Control Today* (June 2007).

56 Singh and Way also code exploration as 1969. Singh and Way rely on David Albright, "South Africa and the Affordable Bomb," *Bulletin of the Atomic Scientists* (1994), No. 50, pp. 37-47; R. Horton, "Out Of (South) Africa: Pretoria's Nuclear Weapons Experience," U.S. Air Force Institute for National Security Studies Occasional Paper No. 27, August 1999, www.nyu.edu/globalbeat/nuclear/Horton0899.html (accessed August 16, 2010); Darryl Howlett and John Simpson, "Nuclearisation and Denuclearisation in South Africa," *Survival,* No. 35 (1993), pp. 154-173; Rodney Jones, Mark McDonough, Tobey Dalton, and Gregory Koblentz, *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (Washington, DC: Carnegie Endowment for International Peace, 1998); Frank V. Papian, "South Africa's Nuclear Weapon Program: Lessons for U.S. Nonproliferation Policy," *Nonproliferation Review* (Fall 1995), pp. 1-19; Mitchell Reiss, *Without the Bomb: The Politics of Nuclear Proliferation* (New York: Columbia University Press, 1988); Mitchell Reiss, *Bridled Ambition* (Washington, D.C.: Woodrow Wilson Center Press, 1995); Russian Federation Foreign Intelligence Service "The Nuclear Potential of Individual Countries" (1995) http://www.fas.org/irp/threat/svr_nuke.htm (accessed August 2010); Leonard S. Spector, "Nuclear Proliferation in the Middle East," *Orbis,* Vol. 36, Issue 2 (Spring 1992); Jones et al. *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts*; Ronald W. Walters, *South Africa and the Bomb: Responsibility and Deterrence* (Lexington: D.C. Heath and Company, 1987); and two websites that as of August 2010 are no longer accessible. Mueller codes nuclear weapon activities as 1971-75 with South Africa giving up its weapons in 1991-1995. Albright, "South Africa and the Affordable Bomb," pp. 40-41.

57 Albright, "South Africa and the Affordable Bomb," pp. 42-43.

activity as exploration. Pursuit is coded as 1974, when "Prime Minister John Vorster approved the development of a limited nuclear explosive capability…"[58] Note that while De Klerk and De Villiers both date the decision to develop a limited nuclear deterrent to 1974, Stumpf dates it to 1977 and some Armscor officials to 1978. Acquisition is coded as 1979, when South Africa assembled its first complete nuclear explosive device, though with limited delivery capabilities.[59] Finally, South Africa is coded as returning to no activity in 1991.[60] Albright writes, "On February 26, 1990, de Klerk issued written instructions to terminate the nuclear weapons program and dismantle all existing nuclear weapons…Dismantling started in July 1990. By September 6, 1991, all of the HEU had been removed from the weapons, melted down, and sent back to the AEC [Atomic Energy Commission] for storage."[61]

Pakistan: Unlike in the Indian case, there is no evidence that Pakistan's efforts to launch atomic energy research in the early 1950s had a dual-use motivation.[62] The same holds in later years as Pakistan expanded its civilian nuclear effort, and despite persistent, vocal advocacy for nuclear weapons from foreign minister and later opposition leader Zulfikar Ali Bhutto and some others.[63] Pakistan is coded as both exploring and pursuing beginning in 1972, when in January of that year, one month after Pakistan's overwhelming conventional military defeat by India in the war that led to the creation of Bangladesh out of what was previously East Pakistan, newly elected President and later Prime Minister Bhutto authorized a program

58 Singh and Way also code pursuit as 1974, however, Meyer codes pursuit as 1975, and Gartzke and Jo code pursuit as 1971. Gartzke and Jo's 1971 coding is based on the minister of mines authorizing research and development work, but the resulting work consisted entirely of literature reviews and theoretical studies, not sufficient to merit coding as full pursuit of nuclear weapons, though certainly qualifying as very vigorous exploration of them, see Albright, "South Africa and the Affordable Bomb," p. 41.

59 Singh and Way and Jo and Gartzke both also code acquisition as 1979. Albright, "South Africa and the Affordable Bomb," p. 42.

60 Gartzke and Jo also code return to no activity as 1991. Singh and Way code the return to no activity as 1994. Their considerable later coding appears to be based on the complete destruction of all components of the weapons, which extended into 1994.

61 Albright, "South Africa and the Affordable Bomb," p. 46.

62 See, for example, Ashok Kapur, *Pokhran and Beyond* (Oxford: Oxford University Press, 2001), pp. 34-38, 46-49, 54. Kapur makes just this point in contrasting the Indian and Pakistani efforts, noting that, "As early as 1946, before India's independence, Nehru recognized the possibility and even the necessity of using nuclear energy for defence purposes even though he clearly rejected this as the preferred Indian policy at the time," (p. 44).

63 Kapur, *Pokhran and Beyond*, pp. 55-56, 74, 77-87.

to acquire nuclear weapons.[64] Acquisition is coded as 1987; former U.S. Central Intelligence Agency official Richard J. Kerr recalled for journalist Seymour Hersh that the U.S. government had an "intelligence basis" for not certifying Pakistan as nuclear weapon-free "from 1987 on."[65] Like India, one could make a plausible case for coding this one or several years later.

India: Coding the Indian case is bedeviled, more so than most others, by a lack of more tangible evidence of policymaker intentions and the ambiguity inherent in the exploration and later pursuit of a nuclear *option*, rather than an overt weapons capability. Exploration began in 1948; India created an Atomic Energy Commission in that year, intended to conduct "research and development of atomic energy in complete secrecy."[66] In legislative debate, Prime Minister Jawaharlal Nehru suggested that he did not think it possible to distinguish between peaceful and military research on atomic energy, and while emphasizing the peaceful motivations of the effort, suggested there were circumstances under which India might be "compelled as a nation to use it [atomic energy] for other purposes."[67] Further, contra the conventional wisdom, two prominent scholars of India's nuclear weapons efforts, George Perkovich and Itty Abraham, both document Nehru's consistent support for a policy of developing a nuclear weapons *option*

64 Singh and Way code Pakistan as both exploring and pursuing beginning in 1972. Gartzke and Jo also code pursuit as 1972, though Meyer does not code Pakistan as pursuing. Mueller codes 1961-65 as nuclear weapon activities. Singh and Way rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Federation of American Scientists, "Pakistan Nuclear Weapons: A Brief History of Pakistan's Nuclear Program," December 2002 http://www.fas.org/nuke/guide/pakistan/nuke/index.html (accessed August 16, 2010); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries"; Spector, "Nuclear Proliferation in the Middle East"; and a website no longer accessible as of August 2010. Jo and Gartzke rely on Weissman and Krosney (1981). Kapur, *Pokhran and Beyond*, pp. 137, 141, 145-6. See also Perkovich, p. 194, Weissman and Krosney, pp. 43-46, and P.L. Bhola, *Pakistan's Nuclear Policy* (New Delhi: Sterling Publishers Private Limited, 1993), p. 57.

65 Singh and Way code acquisition as 1990, whereas Gartzke and Jo code acquisition as 1987. Seymour M. Hersh, "On the Nuclear Edge," *New Yorker*, March 29, 1993, p. 60, cited in Hagerty, p. 126.

66 Mueller codes nuclear weapons activities as 1946-1950, strikingly earlier than others. Singh and Way code India as first exploring in 1954 with a return to exploration in 1975. Singh and Way's coding choice of 1954 appears based on the establishment of the Department of Atomic Energy, both expanding and making more autonomous ongoing nuclear research efforts. George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Oakland: University of California Press, 2002), p. 18.

67 Perkovich, *India's Nuclear Bomb*, p. 18, 20. On another occasion, Nehru articulated similar sentiments, "I know how difficult it is for a line to be drawn between scientific work for peace and for war. This great force—atomic energy—that has suddenly come about through scientific research may be used for war or may be used for peace. We cannot neglect it because it may be used for war... we shall develop it, I hope, in co-operation with the rest of the world and for peaceful purposes." Itty Abrahams, "The Making of the Indian Atomic Bomb: Science, Secrecy and the Postcolonial State," *Pacific Affairs*, Vol. 73, No. 4 (1998), p. 47.

for India.[68] Pursuit is coded as beginning in 1964; late that year, Prime Minister Lal Bahadur Shastri authorized efforts by India's Atomic Energy Commission to pursue the development of "nuclear devices" for ostensibly "peaceful benefits," as he indicated in a little-noticed paragraph in a November 27 speech to India's Lok Sabha lower house of parliament.[69] His successor, Prime Minister Indira Gandhi, supported the continuation of these efforts, even hinting on May 10, 1966 that the effort might be motivated by more than merely "peaceful purposes."[70] India ended pursuit and returned to exploration in in 1966, when around June 1, 1966, Vikram Sarabhai, the head of the Atomic Energy Commission appointed by Gandhi, halted work on nuclear explosives.[71] It bears emphasizing that it is unclear whether Prime Minister Gandhi was aware of Sarabhai's initiative, although even if he did not inform her, it is hard to imagine pro-nuclear scientists would have been unable to get word to her, so it seems safe to assume that she either formally or tacitly assented.[72] Further, the effort to halt work on nuclear explosives was apparently only partly successful, and Indian scientists appear to have continued some relevant research in the interim.[73] This behavior is coded as exploration rather than pursuit because that appears to have been the intention of Indian policymakers and because the activity falls well short of a concerted effort to acquire nuclear weapons or a nuclear option, but there is a reasonable case for coding it as pursuit. India returned to pursuit in 1972, when on September 7 Prime Minister Gandhi apparently authorized work on the "fabrication of a device for a peaceful nuclear explosion."[74] It bears emphasizing that there is some uncertainty about precisely when this authorization occurred, with some sources suggesting it may have taken place in 1971.[75]

68 Perkovich, *India's Nuclear Bomb*, pp. 14-15, 20, 34-35. Abraham makes similar points; Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy and the Postcolonial State*, p. 49, 51, 59.

69 Singh and Way code India's initial pursuit as 1964. Gartzke and Jo also code India as pursuing in 1964 while Meyer codes pursuit as 1965. Singh and Way's coding relies on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Ashok Kapur, *Pokhran and Beyond*; O. Marwah & A. Schulz, *Nuclear Proliferation and the Near-Nuclear Countries* (Cambridge: Ballinger Publishing Company, 1975); a webpage inaccessible as of August 2010; Perkovich (1999); Reiss, *Without the Bomb: The Politics of Nuclear Proliferation* (1988); Leonard Spector, *Nuclear Proliferation Today* (New York: Vintage Books, 1984). Jo and Gartzke rely on Perkovich (1999), pp. 82-112, 166-170, 293. Perkovich, *India's Nuclear Bomb*, pp. 82-83.

70 Perkovich, *India's Nuclear Bomb*, p. 119.

71 Gartzke and Jo along with Meyer also code pursuit as ending in 1966, but Singh and Way do not. Perkovich, *India's Nuclear Bomb*, pp. 122-125.

72 Perkovich, *India's Nuclear Bomb*, pp. 122-125.

73 Perkovich, *India's Nuclear Bomb*, pp. 122-125, 171.

74 Perkovich, *India's Nuclear Bomb*, pp. 171-172.

75 Perkovich, *India's Nuclear Bomb*, pp. 171-172.

India's first nuclear test on May 18, 1974 is not coded as acquisition, since there is no evidence that India proceeded to acquire a deliverable nuclear weapons capability at this time.[76] India returned to exploration in 1975.[77] As Perkovich writes, "…Indira Gandhi evinced no interest in furthering India's nuclear weapon potential. As [nuclear scientist] Raja Ramanna put it in a 1996 interview, 'Once [Pokhran] was done, Mrs. Gandhi said, 'No more. That's it." [Nuclear scientist] Homi Sethna confirmed this: "We said to Mrs. Gandhi, 'Do you want another one?' She said, 'I'll let you know.' She never let us know, so we stopped.'"[78] Although direct work on nuclear explosives was halted, the nuclear establishment did apparently continue relevant exploratory work.[79] India returned to pursuit in 1980, based on circumstantial but strong evidence that Indian policymakers had decided to reinvigorate their nuclear program.[80] It bears emphasizing that in the subsequent decade they declined to authorize further testing or overt weaponization, instead pursuing a "nuclear option strategy," considerably complicating coding.[81] A credible journalistic account suggests that "from the end of 1980 onwards, work on the development of components needed for another nuclear device was once again stepped up at the BARC [Bhabha Atomic Research Centre]."[82] This is reinforced by other subsequent developments. The pro-nuclear Raja Ramanna resumed his post as director of the BARC in January 1981, positioning him to push forward efforts "to design a smaller, more efficient nuclear explosive device."[83] In February, excavations apparently began for another nuclear test site.[84] In 1983 India launched a "comprehensive effort to produce ballistic missiles," albeit with potential non-nuclear application in space launch and delivering non-nuclear payloads.[85] Prime Minister Gandhi also briefly authorized another

76 Singh and Way code the 1974 test as acquisition, but dropping out of that category in 1975. Perkovich, *India's Nuclear Bomb*, p. 178.

77 Singh and Way also code 1975 as a return to exploration.

78 Perkovich, *India's Nuclear Bomb*, p. 192.

79 Perkovich, *India's Nuclear Bomb*, p. 242.

80 Singh and Way also code a return to pursuit in 1980.

81 Perkovich, *India's Nuclear Bomb*, pp. 226-292, 3.

82 Yogi Aggarwal, "India Makes Another Bomb," *Sunday Observer* (August 31, 1981), reprinted in U.S. Consul (Bombay) to Secretary of State, Cable No. 3265, September 1981, in FOIA files, India, National Security Archive, Washington, D.C., cited in Perkovich, *India's Nuclear Bomb*, p. 228.

83 Perkovich, *India's Nuclear Bomb*, p. 228.

84 Perkovich, *India's Nuclear Bomb*, pp. 227-228.

85 Perkovich, *India's Nuclear Bomb*, pp. 244-249.

nuclear test in late 1982 or early 1983, but quickly changed her mind.[86] After Indira Gandhi was assassinated in 1984, her son Rajiv Gandhi served as prime minister until 1989, consistently declining to authorize further testing or acquisition of an overt nuclear weapons capability, but displaying "acquiescence in, if not encouragement of, the ongoing expansion of nuclear weapons capabilities."[87] As the above discussion suggests, one could make a plausible case that pursuit should be coded one or more years later. Acquisition is coded as 1987.[88] Prime Minister Gandhi publicly stated in March 1987 that India had not built nuclear weapons but that "if we decided to become a nuclear power, it would take a few weeks or a few months."[89] Other sources suggest the date should be slightly later; for example, Perkovich writes, "Between 1988 and 1990, according to one source [key former official K. Subrahmanyam], [India] readied at least two dozen nuclear weapons for quick assembly and potential dispersal to airbases for delivery by aircraft for retaliatory attacks against Pakistan."[90] And if the definition of nuclear acquisition were based not merely on a crude deliverable capability, but on a more sophisticated one or even the organizational and procedural ability to employ nuclear weapons, then one could argue for an even later coding. In a recent article, Gaurav Kampani argues that although "India acquired nuclear weapons in 1989–90…it lacked the capacity to deliver them reliably and safely until 1994–95 or possibly 1996. More significant, even after Indian scientists and engineers solved the technical challenges of delivery, political leaders refrained from embedding the weapons within organizational and procedural routines that would render them operational in the military sense of the term."[91]

North Korea: The evidence on North Korea's nuclear weapons efforts is not as robust as in other cases and some if it is highly circumstantial. North Korean nuclear research dates back to at least 1955, and in the mid-to-late 1950s Pyongyang signed nuclear cooperation agreements with both the

86 Perkovich, *India's Nuclear Bomb*, pp. 242-244.

87 Perkovich, *India's Nuclear Bomb*, p. 287, see also pp. 261-292.

88 Singh and Way code acquisition as 1988 as do Gartzke and Jo.

89 Devin Hagerty, *The Consequences of Nuclear Proliferation: Lessons from South East Asia* (Cambridge, MA: MIT Press, 1998), p. 121.

90 Perkovich, *India's Nuclear Bomb*, p. 293. Prime Minister Gandhi publicly stated in March 1987 that India had not built nuclear weapons but that "if we decided to become a nuclear power, it would take a few weeks or a few months." Hagerty, "The Consequences of Nuclear Proliferation," p. 121.

91 Gaurav Kampani, "New Delhi's Long Nuclear Journey: How Secrecy and Institutional Roadblocks Delayed India's Weaponization," *International Security*, Vol. 38, No. 4 (Spring 2014), p.81.

Soviet Union and China, but there is no evidence that its activities were weapons-related at that point.[92] Exploration is coded as 1962.[93] A former senior high-ranking official who defected subsequently contended that "Pyongyang's serious interest in nuclear weapons began in the first half of the 1960s—just after Kim's December 1962 call for nationwide military preparedness."[94] In 1964, a nuclear research facility was established at Yongbyon, North Korea initiated a major uranium mining survey that discovered large indigenous supplies, and Pyongyang reportedly requested Chinese assistance in developing nuclear weapons but was rebuffed.[95] In 1965 the Soviet Union agreed to provide a research reactor to North Korea, which began operation in 1967.[96] In 1975, North Korea reportedly again requested Chinese assistance with a nuclear weapons program, and received some assistance, though precisely what this entailed is unclear.[97] Pursuit is coded as beginning in 1980, when a U.S. spy satellite discovered a second, larger reactor suitable for producing bomb-quantities of plutonium under construction at Yongbyon.[98] The reactor became operational in 1987, and around the same time, evidence surfaced of powerful conventional explosive tests at Yongbyon related to the development of an implosion nuclear weapon.[99] North Korea's subsequent progress to the bomb was far from a linear effort, but this paper codes it as continuing pursuit.[100] There is a plausible case to be made for a later (as well as an earlier) coding of

92 Michael J. Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation* (New York: St. Martins, 1995), pp. 24-25.

93 Singh and Way code North Korea exploring in 1965. Meyer does not code North Korea, while Mueller codes it beginning nuclear weapon activities in 1976-80. Singh and Way rely on Engelhardt (1996); Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Federation of American Scientists, "[North Korea] Nuclear Weapons Program: Current Status," http://www.fas.org/nuke/guide/dprk/nuke/index.html (accessed August 17, 2010); Russian Federation Foreign Intelligence Service, The "Nuclear Potential of Individual Countries", Henry Sokolski, *Fighting Proliferation: New Concerns for the Nineties* (Maxwell Air Force Base, Ala: Air University Press, 1996); and a website no longer accessible as of August 2010.

94 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 24.

95 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 25; Joel S. Wit, Daniel B. Poneman and Robert L. Gallucci, *Going Critical: The First North Korean Nuclear Crisis* (Washington: Brookings Institution Press, 2004), pp. 2-3.

96 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 25.

97 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 28.

98 Singh and Way also code pursuit as 1980. Jo and Gartzke code pursuit in 1982. Jo and Gartzke rely on Central Information Agency, "North Korea: Nuclear Reactor" (July 9, 1982) declassified document http://www2.gwu.edu/~nsarchiv/NSAEBB/NSAEBB87/nk01.pdf (accessed August 17, 2010) Wit et al., *Going Critical: The First North Korean Nuclear Crisis* (2004), p. 1; Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 36.

99 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, pp. 40; Wit et al., *Going Critical: The First North Korean Nuclear Crisis* (2004), p. 6.

100 Leon V. Sigal, *Disarming Strangers: Nuclear Diplomacy with North Korea* (Princeton: Princeton University Press, 1998), p. 6.

pursuit. Acquisition is coded as 2006, after North Korea conducted its first nuclear test. That test was widely considered a fizzle, so there is a plausible case for coding acquisition following the subsequent 2009 test or even later. It seems likely that at some time since 2006 North Korea has obtained at least a crude deliverable nuclear weapons capability, even if more sophisticated means of delivery, specifically missiles, have likely so far eluded it.

Yugoslavia: Yugoslavia is among the cases with somewhat less robust, more circumstantial evidence on which to base codings. Exploration is coded beginning in 1949, when, according to a key scientist who would later become the director of the important Vinca Institute of Nuclear Sciences, "the government of Josip Broz Tito decided to develop the capability to build nuclear weapons."[101] This conclusion is bolstered by the fact that in 1950, a close collaborator of Tito's indicated the purpose of the program was to develop nuclear weapons.[102] Pursuit is coded as 1953, when an internal memorandum for the top political leadership indicated the program's purpose was the development of both weapons and civilian power.[103] This interpretation is bolstered by a 1954 U.S. diplomatic communiqué that judged Yugoslavia had commenced a nuclear weapons program.[104] Yugoslavia returned to no activity in 1962, when William Potter, the scholar most knowledgeable about the program, judges Tito to have "deactivated" it, although he does not provide concrete evidence for this assertion.[105] A return to exploration is coded in 1974, when, in two meetings with Tito, key nuclear officials were told they would be pursuing nuclear weapons. Since "relatively few resources were invested in weapons research and development during [1975-1981]," this is coded as exploration rather than pursuit.[106] Pursuit resumed in 1982, when "the newly appointed secretary of defense began to forcefully promote the weapons program," including "a dedicated nuclear weapons effort known as Project A."[107] Note, however, that Potter concludes that "the Yugoslav weapons program was never characterized

101 Singh and Way code Yugoslavia as exploring in 1954, returning to no activity in 1966, and exploring for a second time in 1974. Singh and Way's coding appendix does not list sources for Yugoslavia. Meyer does not code nuclear weapons activity, while Mueller codes activity beginning in 1951-55 and ending in 1986-90. William C. Potter, Djuro Miljanic, and Ivo Slaus, "Tito's Nuclear Legacy" *Bulletin of the Atomic Scientists*, Vol. 56, No. 2 (March/April 2000), p. 64.

102 Potter, Miljanic, Slaus "Tito's Nuclear Legacy," p. 64.

103 Jo and Gartzke code as pursuing in 1953, ending 1964, and again pursuing in 1982, ending in 1988. Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 64.

104 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 64.

105 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 65.

106 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 66.

107 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 67.

by a sense of urgency," so much so that one could make a plausible case for instead coding Yugoslavia as only engaging in exploration, not pursuit.[108] Yugoslavia returned to no activity in 1987, when at a meeting a key official was informed that the president had decided to terminate the program.[109]

South Korea: South Korea is coded as beginning exploration in 1969.[110] The announcement of Nixon's Guam Doctrine in the summer of 1969, including the removal of one of two infantry divisions from the Korean Peninsula, apparently catalyzed ROK exploration of a nuclear weapons option.[111] According to Michael Siler, "In late 1969, the Park Government began its review of possibly acquiring nuclear weapons through both an accelerated indigenous nuclear arms development program and accessing the international nuclear weapons market," though Siler does not cite the specific evidence that led him to this conclusion.[112] Alternately, one could code exploration as beginning concurrently with pursuit in 1970. While it is possible that South Korea explored nuclear weapons during the 1950s and most of the 1960s, this paper finds no evidence for this conclusion. Its nuclear research efforts date back to 1959, but concerted efforts to develop a civil nuclear power program appear to have developed in parallel with the nuclear weapons effort outlined here.[113] Pursuit is coded as 1970.[114] Selig Harrison writes, "General Kim Yoon Ho, former chairman of the Joint Chiefs of Staff and an adviser to the late President Park Chung Hee, told me that Park decided upon a secret "Master Plan" for producing nuclear weapons in 1970…"[115] Another report suggests that "In 1971, President

108 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 68.

109 Potter, Miljanic, Slaus, "Tito's Nuclear Legacy," p. 68.

110 Singh and Way code South Korea exploring in 1959, Mueller codes activity beginning 1966-70 and ending 1986-90, Meyer codes nuclear weapons activity in 1972, ending 1975. Singh and Way rely on M. J. Engelhardt, "Rewarding Non-Proliferation: The South and North Korean Cases," *Nonproliferation Review*, Vol. 3, No. 3 (Spring/Summer 1996); Reiss, *Without the Bomb: The Politics of Nuclear Proliferation* (1988); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries", and a website no longer accessible as of August 2010.

111 Michael J. Siler, "U.S. Nuclear Nonproliferation Policy in the Northeast Asian Region During the Cold War: The South Korean Case," *East Asian Studies* (Autumn/Winter 1998).

112 Siler, "U.S. Nuclear Nonproliferation Policy in the Northeast Asian Region During the Cold War: The South Korean Case," p. 59.

113 Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries"; Mitchell Reiss, *Without the Bomb: The Politics of Nuclear Proliferation*, pp. 86-89.

114 Singh and Way code South Korea pursuing in 1970, Jo and Gartzke code pursuit in 1971.

115 Selig S. Harrison, "A Yen for the Bomb? Nervous Japan Rethinks the Nuclear Option," *Washington Post* (October 31, 1993), p. C1. Bolstering the 1970 coding, see also Jonathan D. Pollack and Mitchell B. Reiss, 'South Korea: The Tyranny of Geography and the Vexations of History', in Kurt Campbell et al. (eds), *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington DC: Brookings Institute, 2004), Chapter 10, p. 262.

Park reportedly ordered his Weapons Exploitation Committee to explore the possibility of producing an indigenous nuclear arsenal."[116] Under intense pressure from US Secretary of State Henry Kissinger, Park apparently ordered a halt to the nuclear weapons effort in 1975.[117] But according to Mark Fitzpatrick,

> "Park's termination order was soon reversed. The November 1976 election of Jimmy Carter, who during the campaign had pledged to withdraw all US troops from South Korea and who had been highly critical of South Korean human-rights failings, confirmed Park's worst fears, prompting him to resume the secret nuclear programme. This time, however, he directed officials to seek technology indirectly, in a manner that would not invite foreign pressure. In December 1976, officials established the Korea Nuclear Fuel Development Institute, which sent researchers to France and Belgium to learn about reprocessing techniques. Work also began on designs for an indigenous plutonium-production reactor. US intelligence agencies learned of these efforts but could not find convincing evidence of weapons-related activity… Scientists involved in the programme told their superiors in 1978 that a weapon could be produced by 1981. When nuclear engineers involved in the programme were later interviewed, however, they indicated that this claim was exaggerated; all the ROK had at the time were blueprints...The counter-factual claim that South Korea would have had nuclear weapons by the mid-1980s if the US had not intervened is overstated."[118]

Though his chapter on Korea's nuclear history draws on a rich array of primary and secondary sources, Fitzpatrick provides no citations to bolster the claim that in 1976 Park ordered a resumption of the secret nuclear weapons program, though he does source other information such as the 1978 assessment by scientists.[119] The apparent suspension in 1975 and resumption in 1976 means that for the purposes of coding, South Korea's pursuit of nuclear weapons continues, since both 1975 and 1976 are coded

116 Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, p. 26.

117 Peter Hayes, "The Republic of Korea and the Nuclear Issue," in Andrew Mack (ed.), *Asian Flashpoints: Security and the Korean Peninsula* (Canberra: Allen and Unwin, 1993), Chapter 6, p. 52.

118 Mark Fitzpatrick (ed.), *Iran's Strategic Weapons Programmes: A Net Assessment* (London: The International Institute for Strategic Studies, 2005), pp. 20-21.

119 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, pp. 20-21.

as pursuit. One alternative, if one wanted to capture the apparent short break and reinitiation of the nuclear weapons program, would be to code either 1975 or 1976 as exploration or no activity, though that would be inconsistent with the coding approach adopted here. According to Fitzpatrick, "After Park was assassinated, in October 1979, his successor Chun Doo-hwan ended nuclear-weapons-related activities, disbanding a group of 870 scientists engaged in sensitive work. Having seized power via a military coup and ruthlessly suppressed an uprising in Kwangju, Chun needed the legitimacy provided by friendly relations with the US."[120] But precisely when nuclear weapons-related activities ended remains unclear, and the Reagan administration that came to power in 1981 still felt it necessary to put in place an incentive-punishment deal that gave a strengthened security guarantee if South Korea shut down its weapons program but promised sanctions if they refused; interestingly, Fitzpatrick does not mention this episode in his account.[121] One could code the cessation of the nuclear weapons program as early as 1979 and as late as 1981; this paper chooses the latter, both because it would have taken some time for Park's successor to halt relevant activities and because the Reagan administration judged it necessary to bargain and coerce South Korea to halt its weapons-related activities in 1981.

Libya: Libya is coded as initiating both exploration and pursuit in 1970.[122] In that year, a senior Libyan official visited China for the first of several visits to try to purchase nuclear weapons.[123] In subsequent years, Libya reportedly tried to obtain weapons or weapons-related assistance from India, the Soviet Union, China, Pakistan, France, and Argentina, launched a war with Chad to gain control of an area presumed to be rich in uranium deposits, and began nuclear cooperation with Pakistan, including the

120 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, p. 21.

121 Don Oberdorfer, *The Two Koreas: A Contemporary History* (New York: Basic Books, 2001), p.173.

122 Singh and Way code exploration in 1970 and pursuit in 1970. Jo and Gartzke do not code Libya; neither does Meyer. Mueller codes nuclear weapon activities beginning in 1981-85 and ending in 2001-05. Singh and Way rely on M. Barletta and E. Jorgensen, "Weapons of Mass Destruction in the Middle East: Libya" (1998), updated version accessible at http://nti.org/e_research/profiles/Libya/index.html (accessed August 17, 2010); Joseph Cirincione with Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals: Tracking Weapons of Mass Destruction* (Washington D.C.: Carnegie Endowment for International Peace, 2002); Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Marwah and Schulz, *Nuclear Proliferation and the Near-Nuclear Countries* (1975); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries"; Spector (1988).

123 Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East* (Princeton: Princeton University Press, 2007), p. 213.

acquisition of centrifuges for uranium enrichment.[124] There is a plausible case for coding these activities, and this rather circumstantial evidence, as exploration instead. Libya returned to no activity in 2003, when Libya announced that it was abandoning its weapons of mass destruction programs and allowing international inspections.[125] The following year, Libya allowed the U.S. military to airlift its nuclear equipment and materials to the United States.[126]

Brazil: Brazilian nuclear research dates back to the 1930s; while its National Commission for Nuclear Energy was established in 1956.[127] It is plausible that Brazil may have explored nuclear weapons in the 1950s or early in the 1960s, but there is no evidence to support this conclusion. Exploration is coded as 1966.[128] Following a 1964 military coup, Brazil officially declared in 1966 its refusal to give up the right to develop peaceful nuclear explosives.[129] Brazil's nuclear efforts remained relatively modest through the early 1970s. Pursuit is coded as 1975.[130] In the mid-1970s it launched an ambitious effort to expand its civilian nuclear power infrastructure and leapfrog rival Argentina.[131] At the same time, it launched what later became known as the "parallel program," an effort to develop nuclear weapons under the auspices of three branches of the military.[132] In 1984-85, the air force constructed what appeared to be a nuclear test site; when it was exposed in a Brazilian newspaper article, policymakers claimed it had been part of a mineral exploration project, while the armed forces suggested it was intended for testing equipment and materials for an "aerospace

124 Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*, p. 213.

125 Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*, p. 214; Bruce W. Jentleson and Christopher A. Whytock, "Who "Won" Libya? The Force-Diplomacy Debate and its Implications for Theory and Policy," *International Security* (2005/6), p. 47.

126 Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*, p. 214.

127 Jean Krasno, "Brazil's Secret Nuclear 'Parallel Program," *Orbis*, Vol. 38, No. 3 (Summer 1994).

128 Singh and Way code Brazil as exploring in 1953. Singh and Way rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Krasno, "Brazil's Secret Nuclear 'Parallel Program'," pp. 425-437; Reiss, *Bridled Ambition*; Spector, "Nuclear Proliferation in the Middle East" and two websites no longer accessible as of August 2010.

129 Monica Serrano,"Brazil and Argentina," in Mitchell Reiss and Robert S. Litwak, *Nuclear Proliferation after the Cold War* (Washington: Woodrow Wilson Center Press, 1994), p. 236.

130 Singh and Way code Brazil as pursuing in 1978. Jo and Gartkze code Brazil as pursuing in 1978, ending in 1991. Jo and Gartzke rely on Reiss, *Bridled Ambition*, pp. 58-60; Leonard Spector and Jacqueline Smith, *Nuclear Ambitions* (Boulder: Westview Press, 1990), pp. 243-249; Sublette, "Nuclear Weapons Frequently Asked Questions."

131 Reiss, *Bridled Ambition*, p. 49.

132 Reiss, *Bridled Ambition*, p. 50; Krasno, "Brazil's Secret Nuclear 'Parallel Program"; GlobalSecurity.org, "Brazil: Nuclear Weapons Programs," http://www.globalsecurity.org/wmd/world/brazil/nuke.htm (accessed September 25, 2008).

capability."[133] A return to no activity is coded in 1990, when Brazil signed agreements with its main rival, Argentina, which established a bilateral nuclear inspection system, opened nuclear installations on both sides to the International Atomic Energy Agency, and agreed to revise and fully implement a previously negotiated nuclear weapons-free zone.[134]

Iraq: Iraqi exploration is coded as 1975, though the evidence is somewhat circumstantial, and pursuit is coded as 1981, returning to no activity in 1991.[135] Drawing on newly available sources, Malfrid Braut-Hegghammer summarizes "Iraq's efforts to acquire nuclear weapons…over two separate phases: a drift toward a nuclear weapons option from 1975 to 1981 and a covert nuclear weapons program from 1981 to 1991," with the key inflection point being the 1981 Israeli attack on the Osiraq reactor.[136] Braut-Hegghammer observes that beginning the late 1960s, after the 1968 Baathist coup that began Saddam Hussein's trajectory toward ruling Iraq, and into the 1970s, individuals within the nuclear program discussed and advocated for the pursuit of a nuclear weapons option, while the intentions of the political leadership remained unclear.[137] Braut-Hegghammer, like others, is skeptical of Iraqi weapons scientist Khidhir Hamza, who wrote, "In 1971, on the orders of Saddam Hussein, we set out to build a nuclear bomb."[138] In the mid-1970s, Saddam initiated the robust pursuit of civil nuclear power capabilities, including the pursuit of the full nuclear fuel cycle, which would give Iraq weapons-relevant plutonium production capabilities.[139] In 1976, Iraq purchased the Osiraq reactor from France, which was unusually large for a research reactor and potentially capable of irradiating natural uranium to produce weapon quantities of plutonium.[140] Iraq also acquired three hot cells in which plutonium could be extracted,

133 Reiss, *Bridled Ambition*, p. 51; Krasno, "Brazil's Secret Nuclear 'Parallel Program'".

134 Singh and Way code Brazil as returning to no activity in 1991 as does Jo and Gartzke. Reiss, *Bridled Ambition*, pp. 45, 59.

135 Singh and Way code Iraq as exploring in 1976 and pursuing in 1982. Singh and Way rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Spector (1998); and a website no longer accessible as of August 2010. Jo and Gartzke code pursuit as 1973. Jo and Gartzke rely on Khidhir Hamza, *Saddam's Bombmaker* (New York: Scribner, 2000). Meyer does not code any level of nuclear weapons activity, while Mueller does activity beginning in 1971-75 and ending in 1991-1995.

136 Malfrid Braut-Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," *International Security*, Vol. 36, No. 1 (2011), p. 102.

137 Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," p. 105.

138 Hamza, *Saddam's Bombmaker*, p. 64-73, 333.

139 Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," pp. 106-107.

140 Spector, "Nuclear Proliferation in the Middle East," p. 208.

albeit in quantities that would require several years to produce sufficient plutonium for one weapon, as well as a model of a larger reprocessing facility.[141] In 1980 and 1981, Iraq purchased large quantities of natural uranium, which could be irradiated to produce plutonium, from Brazil, Portugal, Niger, and Italy. Finally, in 1980 Iraq placed an order with a West German firm for a very large quantity of depleted uranium fuel pins that could have been irradiated to produce plutonium and "were unsuitable to any other nuclear purpose—including use in a lab-scale "subcritical assembly," which was the stated end-use…"[142] In June 1980, Saddam, who had recently assumed the presidency of Iraq, apparently decided the country should pursue nuclear weapons, but failed to act on this decision in any substantial way, leaving the Iraqi program "directionless and disorganized."[143] Iraq's activities prior to 1981, including as described by Braut-Hegghammer, are sufficiently robust that one might reasonably code them as pursuit rather than merely exploration, though that does raise the challenge of when to code the beginning of that pursuit behavior. After the 1981 Israeli attack, Saddam supported and his scientists initiated a full-fledged nuclear weapons program, albeit one that still struggled with various external and internal challenges.[144] Iraq's pursuit ended in 1991, when in the aftermath of the first Gulf War it was forced to give up its mass destruction capabilities and submit to an intensive verification regime.[145]Although the administration of US President George W. Bush accused Iraq of having continued to pursue nuclear weapons in the run-up to the 2003 war, the evidence presented to support that claim was weak prior to the war and debunked in its aftermath.[146]

Iran: Exploration is coded beginning in 1974.[147] While Iran's nuclear research efforts date back to 1958, and although weapons exploration in

141 Spector, "Nuclear Proliferation in the Middle East," p. 208.

142 Spector, "Nuclear Proliferation in the Middle East," pp. 208-209.

143 Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," pp. 109-110.

144 Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," pp. 116-127.

145 Hegghammer, "Revising Osirak: Preventive Attacks and Nuclear Proliferation Risks," p. 127.

146 Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: March 31, 2015), https://fas.org/irp/offdocs/wmd_report.pdf (accessed March 28, 2017).

147 Singh and Way code Iran as exploring in 1984 and pursuing in 1985. Singh and Way rely on Frank Barnaby, *How Nuclear Weapons Spread: Nuclear Weapons Proliferation in the 1990s* (New York: Routledge, 1993); Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Marwah & Schulz, *Nuclear Proliferation and the Near-Nuclear Countries* (1975); Spector (1988); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Coun-

the early years appears plausible, this paper finds no evidence to support such a coding decision.[148] In 1974, the Shah established the Atomic Energy Organization of Iran to pursue a grandiose nuclear energy plan. Some analysts have suggested that at the same time Iran initiated an undeclared nuclear weapons research and development effort, including enrichment, reprocessing, and weapons design, in parallel.[149] Further, when asked that year in an interview with a French magazine whether Iran would one day possess nuclear weapons, he reportedly said, "Undoubtedly, and sooner than it is believed," although he later denied this.[150] Other analysts suggest that suspicions notwithstanding, "no evidence has emerged confirming that Iran actually began a dedicated nuclear weapons programme under the Shah—in the sense of making a political decision to acquire nuclear weapons and beginning to construct secret facilities for the production of nuclear weapons."[151] A return to no activity is coded starting in 1979, when beginning in January the Islamic Revolution ousted the Shah and effectively paralyzed nuclear activity in Iran. Many of Iran's nuclear scientists, along with other western-educated professionals, fled the country; the new government showed little enthusiasm for all things nuclear, which Supreme Leader Khomeini viewed with suspicion, and therefore various civil nuclear projects were canceled; and western suppliers became more reluctant to cooperate with Iran.[152] Iran is coded as resuming exploration in 1984, when it reinvigorated covert work on uranium conversion, fuel fabrication, and most importantly enrichment, undeclared to the IAEA. Iran expanded its undeclared activities in the early 1990s, following Khomeini's death in 1989. Iran is coded as pursuing nuclear weapons beginning in 1989 and up through the present; the evidence is circumstantial, and there is a plausible case for coding nuclear weapons pursuit in the early or even

tries". Jo and Gartzke code pursuit in 1974, ending in 1979, and again pursuit again in 1984. Meyer does not code Iran as engaging in nuclear weapons activity, while Mueller codes it as initiating activity in 1971-75. Jo and Gartzke rely on Leonard Spector, *Nuclear Ambitions: The Spread of Nuclear Weapons, 1989-1990* (Boulder, CO: Westview Press, 1990), pp. 203-215; Anthony H. Cordesman, *Iran and Iraq: The Threat from the Northern Gulf* (Boulder, CO: Westview Press, 1994), pp. 103-111.

148 Shyam Bhatia, *Nuclear Rivals in the Middle East* (London: Routledge, 1988), p. 83.

149 Leonard Spector, *Going Nuclear* (Ballinger, 1987), pp. 45-46; Spector and Smith, *Nuclear Ambitions*, p. 206.

150 Bhatia, Nuclear Rivals in the Middle East, p. 84; Zdenek Červenka and Barbara Rogers, *The Nuclear Axis: Secret Collaboration between West Germany and South Africa* (Times Books, 1978), p. 332.

151 Mark Fitzpatrick (ed.), *Iran's Strategic Weapons Programmes: A Net Assessment* (London: The International Institute for Strategic Studies, 2005).

152 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment.*

late 1990s instead.[153] A 2007 National Intelligence Estimate assessed that Iran expended "considerable effort from at least the late 1980s to 2003 to develop such [nuclear] weapons."[154] There is a broad consensus among analysts that Iran presently has a nuclear weapons program, even if it may have suspended explicit weaponization efforts in recent years. As Mark Fitzpatrick notes, "If one were inclined to give Iran the benefit of the doubt, each of the pieces of evidence might be explained away. But in totality, they add up to a strong indictment…"[155] That said, one could reasonably code Iran as dropping from pursuit down to exploration either after 2003, based on the 2007 National Intelligence Assessment, or in 2015, when Iran agreed to significantly constrain its nuclear program under the Joint Comprehensive Plan of Action.[156]

Syria: Not surprisingly given how recently key events have transpired, the empirical evidence on Syrian nuclear weapons-related activities is thin, essentially limited to journalistic accounts, US government intelligence briefings in the aftermath of the 2007 Israeli strike on a covert Syrian reactor, and allegations in a recent book by a well-regarded Israeli journalist. Based on those sources, Syria is coded as beginning exploration in 2000.[157] Syria's nuclear program apparently centered around extensive technical collaboration with the North Korean regime and alleged support from Iran. Following Hafez Assad's death and Bashar Assad's succession that year, high-level North Korean representatives visited Syria for meetings, including Kim Jong Il's eldest son Kim Jong Nam; according to Ronen Bergman, these meetings discussed "the possibility that the North Koreans would supply Syria with a facility that would enable it to produce a nuclear bomb."[158] The meetings were followed up with suspension of peaceful nuclear development agreements with Russia and the creation of new institutions under the Syrian Scientific Research Council and Atomic Energy Commission such as the Supreme Council of Science, which directs top

153 Spector and Smith, *Nuclear Ambitions*, p. 206; Cordesman, *Iran and Iraq: The Threat from the Northern Gulf*, p. 104.

154 National Intelligence Council, "Iran: Nuclear Intentions and Capabilities," National Intelligence Council Press Release, November 2007, http://www.dni.gov/press_releases/20071203_release.pdf, p. 7 (accessed August 17, 2010).

155 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*.

156 Joint Comprehensive Plan of Action, Department of State, http://www.state.gov/e/eb/tfs/spi/iran/jcpoa (accessed July 14, 2016).

157 Chris Way's updated coding (revised 6/12/2012) codes Syria as pursuing from 2000 with no end.

158 Ronen Bergman, *The Secret War with Iran* (New York: Free Press, 2008), p. 355.

level military scientific research projects.[159] A case can be made for an earlier coding of exploration, since the U.S. Central Intelligence Agency (CIA) assessed that nuclear weapon program-related talks occurred as early as 1997.[160] However, lack of further evidence leads this paper to select the later coding. Pursuit is coded as 2002, when construction of the Al-Kibar facility was initated. According to Bergman, "At a summit conference in Damascus in July 2002, the details were worked out. Shortly thereafter, ships began arriving in Syria loaded with components for the project and carrying North Korean scientists and technicians."[161] United States intelligence evidence shows the beginning of construction of the Al-Kibar facility by September 2002, construction which was not present in May 2001.[162] The Al-Kibar facility construction is considered evidence for pursuit because of its covert nature and resemblance to North Korea's Yongbyon gas cooled, graphite moderated plutonium production reactor, the fact that it was not declared to the IAEA for safeguards purposes, because the reactor's small size and configuration were not suited for either research or power generation, including a lack of high tension cables to transmit power, and because of apparent weapons-related cooperation with North Korea.[163] The coding of pursuit is strengthened by accounts of information given by Iranian General Ali Reza Askari when he defected to the CIA in February of 2007. According to Bergman, Askari revealed that "Iran was financing a joint nuclear venture launched by North Korea and Syria" with a goal of developing nuclear weapons.[164] Syria returned to exploring in 2007 following the destruction of the Al-Kibar facility by Israel on September 6, 2007. There is no publicly available evidence of political decisions to either continue or cease activity on which to base a coding of continued exploration. On the one hand, the ongoing conflict is unlikely to have reduced the Syrian regime's apparent interest in nuclear weapons; on the other hand, it has almost certainly consumed resources and leadership

159 Bergman, *The Secret War with Iran*, p. 355.

160 "Background Briefing with Senior U.S. Officials on Syria's Covert Nuclear Reactor and North Korea's Involvement" (April 24, 2008) http://i.cfr.org/content/publications/attachments/NKSyriapdf.pdf (accessed March 28, 2017).

161 Bergman, *The Secret War with Iran*, p. 355.

162 David Albright and Paul Brannan, "The Al Kibar Reactor: Extraordinary Camouflage, Troubling Implications" Institute for Science and International Security Report (May 12, 2008), http://www.isis-online.org/publications/syria/SyriaReactorReport_12May2008.pdf (accessed March 28, 2017).

163 Bergman, *The Secret War with Iran*, pp. 362-363.

164 Bergman, *The Secret War with Iran*, pp. 350-351, 358.

bandwidth that might otherwise have been applied toward the nuclear issue. On balance, exploration is continued, but one could also plausibly code it as ending alongside pursuit in 2007.

Germany: German exploration is coded as beginning in 1939, when two uranium research programs were initiated, one under the auspices of the Reich Research Council, the other the Army Ordnance department, although bureaucratic chains of responsibility over the programs would shift in subsequent years.[165] Germany dropped back down to no activity status in 1945, when it lost World War II. This paper does not code Germany as advancing to pursuit during World War II, for various reasons, the program was never highly prioritized, despite mistaken perceptions on the other side of the Atlantic.[166] It appears that early on, Germany's military successes led its leaders to conclude that new weapons would not be needed; later, once a weapon that might stem or turn the tide that had shifted against Germany would have been welcomed, scientists informed leaders that weapons were too distant a prospect; finally, in the final stages of World War II, Germany resources were prioritized for the conventional war effort rather than a crash bomb program.[167] *Note*: There is a separate entry for West Germany's nuclear weapons-related activities.

Japan: Japan is coded as exploring beginning in 1941, when both the Japanese Imperial Army Air Force and Navy authorized research toward the development of an atomic bomb.[168] The previous year, the director of the army's Aviation Technology Research Institute had commissioned a report

165 Singh and Way do not code Germany as engaging in any level of nuclear weapons-related activity, apparently because they choose to begin their analysis in 1945. David Irving, *The German Atomic Bomb: The History of Nuclear Research in Nazi Germany* (New York: Simon and Schuster, 1967), pp. 36-37; Wolfgang Krieger, *The Germans and the Nuclear Question*, Fifth Alois Mertes Memorial Lecture (Washington: German Historical Institute, 1995), p. 12; Mark Walker, *German National Socialism and the Quest for Nuclear Power, 1939-1949* (Cambridge: Cambridge University Press, 1989), pp. 17-18.

166 Jo and Gartzke code pursuit in 1941 based on their contention that "The German Army Weapons Research Office issued a patent to make "nuclear reactor-bombs" in 1941." See Jo and Gartzke, coding appendix, p. 5. Their source for this contention indicates that the text of the patent is lost, while the title of the patent refers only to the generation of energy through the fission of uranium or related heavy elements. Further, there is no evidence to suggest an invigoration of the tepid German weapons program at this time. Meyer codes Germany as pursuing in 1940, Mueller codes German nuclear weapon activities in 1956-60 and ending in 1966-70, perhaps neglecting earlier German nuclear weapons activity for the same reason Singh and Way do.

167 Krieger, *The Germans and the Nuclear Question*, p. 12; Walker, *German National Socialism and the Quest for Nuclear Power, 1939-1949,* pp. 42, 44-45.

168 Singh and Way do not code Japan as engaging in any level of nuclear-weapon activity, apparently because they choose to begin their analysis in 1945. Rhodes, *The Making of the Atomic Bomb*, pp. 346, 457-459, 580-582, 612.

from an aide on the issue, but this is insufficient to meet the exploration threshold.[169] Japan returned to no activity in 1945, when it lost World War II. This paper does not code Japan as advancing to pursuit, finding no evidence that policymakers signed off on a full-scale weapons development effort, apparently in large part because scientists were pessimistic about the near-term prospects of such an effort.[170] Japan is again coded as exploring in 1967, ending 1972. Apparently triggered both by China's proliferation, including its 1964 test, and the late 1960s negotiation of the NPT, opened for signature in 1968 but not ratified by Japan until 1976, Japanese policymakers authorized a series of studies to weigh the pros and cons of proliferating. According to Mark Fitzpatrick, between the 1967 and 1972, "at least five different government-related studies assessing the pros and cons of developing nuclear weapons" were apparently conducted. "They all concluded that the best option was continued reliance on US nuclear deterrence."[171] Japan's pursuit of a robust plutonium program for allegedly civil purposes does seem to have been motivated in part by a desire to hedge its nuclear weapons-related capabilities.[172] There are at least two additional time periods during which one might argue Japan should be coded as exploring, though on balance the author believes such codings are not warranted. In the mid-1990s, apparently triggered by the end of the Cold War, North Korea's nuclear activities, Chinese military modernization, and debates around the indefinite extension of the NPT, the Japanese Defense Agency again commissioned a study assessing the desirability of proliferation, albeit with the explicit intention of bolstering the case against proliferating.[173] And even more recently, the nuclear issue has been revisited in the context of growing North Korean nuclear

169 Rhodes, *The Making of the Atomic Bomb*, p. 327, 346.

170 Jo and Gartzke code Japan as pursuing in 1943 and ending in 1946, relying on Rhodes, *The Making of the Atomic Bomb*, p. 327, 346 and Wilcox (1995). Note that in labeling Japanese efforts as full-blown pursuit, Jo and Gartzke's main source is a sensationalistic, undocumented, journalistic volume that begins by chronicling a supposed August 10, 1945 Japanese atmospheric nuclear test from a robotic ship and ends by noting the alleged "continuing cover-up of part of the secret history of World War II." See Wilcox, pp. 15-16, 213. Meyer codes Japan as pursuing in 1941, while Mueller codes it as engaging in weapon activities in 1966-70, ending 1971-75, perhaps ignoring earlier activity for the same reasons Singh and Way do. It is uncertain to what Mueller's late 1960s-early 1970s coding of nuclear weapons activity refers to. Rhodes, *The Making of the Atomic Bomb*, pp. 457-459, 580-582.

171 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, p. 67. See also Kase, "The Costs and Benefits of Japan's Nuclearization: An Insight into the 1968/1970 Report", pp. 55-68; Maria Rost Rublee, *Nonproliferation Norms: Why States Choose Nuclear Restraint* (Athens, GA: University of Georgia Press, 2009), p. 62; Selig S. Harrison (ed.), *Japan's Nuclear Future: The Plutonium Debate and East Asian Security* (Carnegie Endowment for International Peace, 1996), pp. 7-13.

172 Harrison, *Japan's Nuclear Future: The Plutonium Debate and East Asian Security*.

173 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, p. 69.

and missile capabilities and China's increasing assertiveness. A 2006 report on Japan's nuclear weapons production capabilities was apparently "produced without the knowledge of government leaders by bureaucrats who wanted to be in a position to offer analysis in the event they were asked about the nation's latent nuclear capability."[174] Finally and more broadly, coding of Japanese proliferation behavior is complicated by the fact that it demonstrates the highest degree of nuclear latency of any non-nuclear weapons-possessing country in the world. This latency is a function of the robust plutonium and highly enriched uranium production capabilities in its civil nuclear energy program, the stocks of weapons-useable material it has accumulated in that civil program, its space launch program which could be repurposed for ballistic missile delivery of nuclear warheads, and its highly advanced technological, industrial, and nuclear-specific capabilities.[175] The extent to which this latency is a function of an explicit nuclear weapons-related capability hedging strategy, rather than simply an unintended consequence of a robust civil nuclear energy program, is a matter of lively debate, as is precisely how far Japan currently is from a nuclear weapons capability.[176] If one interprets aspects of Japan's development of its nuclear infrastructure as driven primarily by hedging motivations, that might motivate different exploration or perhaps even pursuit codings.

Switzerland: Swiss exploration is coded as 1945, when the Atomic Energy Committee was established and tasked with "investigation of all aspects of nuclear weapons…and study of the requirements for developing nuclear weapons."[177] Between 1945 and 1963, several military studies advocated acquisition of nuclear weapons and various feasibility studies were conducted, but there is no evidence of outright pursuit of weapons.[178] A return to no activity in 1969, when Switzerland signed the Nuclear Non-Proliferation Treaty.[179] Although it did not ratify until 1977, it appears that after the mid-1960s policy makers no longer kept the nuclear option open.[180]

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174 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, pp. 69-70.

175 Harrison, *Japan's Nuclear Future: The Plutonium Debate and East Asian Security*.

176 Llewelyn Hughes, "Why Japan Will Not Go Nuclear (Yet): International and Domestic Constraints on the Nuclearization of Japan," *International Security*, Vol. 31, No. 4 (Spring 2007), pp. 67-96.

177 Singh and Way code exploration in 1946. Singh and Way rely on Paul (2000) and a website no longer accessible as of August 2010. Jo and Gartzke and Meyer do not code Switzerland. Mueller codes nuclear weapon activities beginning 1956-60 and ending 1976-80. T.V. Paul, *Power versus Prudence* (Montreal, Que.: McGill-Queen's University Press, 2000), pp. 91-92.

178 Paul, *Power versus Prudence*, pp. 93-95.

179 Singh and Way code a return to no activity in 1970. Paul, *Power versus Prudence*, p. 95.

180 Paul, *Power versus Prudence*, p. 91, 95.

Sweden: Exploration is coded as beginning in 1945, when the National Defense Research Institute was established "to consolidate and coordinate military research [on a] domestic nuclear weapon production capability."[181] Although Sweden developed a nuclear weapons option, policymakers also made a clear decision not to move toward the production of actual nuclear-weapons.[182] Sweden terminated its program in 1970, when it acceded to the Nuclear Non-Proliferation Treaty.[183]

Norway: Norwegian exploration is coded beginning in 1947, when Norway decided to construct a nuclear research reactor, which went critical in 1951, under the auspices of the Ministry of Defense.[184] In 1946, internal government discussions had reviewed and rejected near-term efforts to develop nuclear weapons, but had explicitly decided not to foreclose the option.[185] At the beginning of World War II, Norway was the world's only heavy water producer, and it served as a key supplier to both the French and later the Israeli nuclear programs.[186] Norwegian scientists also developed a technique for the separation of plutonium as early as 1955, and subsequently utilized it to separate small quantities.[187] By the early 1960s, Norway's nuclear efforts were in decline due to financial, resource, and political constraints.[188] A return to no activity is coded in 1962, when the Norwegian government publicly declared that it had no intention of acquiring nuclear weapons.[189]

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181 Singh and Way code Sweden as exploring in 1954, dropping back to no activity in 1970. Jo and Gartzke code pursuit as 1946, ending 1969. Meyer does not code any activity for Sweden, while Mueller codes activity beginning 1946-50 and ending 1966-70. Singh and Way rely on Wilhelm Agrell, "The Bomb That Never Was: The Rise and Fall of the Swedish Nuclear Weapons Programme," in Nils Peter Gleditsch and Olav Njolstad (eds.), *Arms Races: Technological and Political Dynamics* (Newbury Park: Sage, 1990); Reiss (1998); and a website that as of August 2010 is no longer accessible. Paul M. Cole, "Atomic Bombast: Nuclear Weapon Decisionmaking in Sweden, 1945-1972," Occasional Paper, No. 26 (Washington: Henry L. Stimson Center, 1996) http://www.stimson.org/wmd/pdf/cole.pdf, p. 10 (accessed September 23, 2008).

182 Cole, "Atomic Bombast: Nuclear Weapon Decisionmaking in Sweden, 1945-1972," pp. 15, 20, 85-89.

183 Cole, "Atomic Bombast: Nuclear Weapon Decisionmaking in Sweden, 1945-1972," pp. 2, 10, 30; United Nations Office for Disarmament Affairs, "Status of Multilateral Arms Regulation and Disarmament Agreements," undated, http://disarmament.un.org/TreatyStatus.nsf/952a13b-8945f4b07852568770078d9c2/31b2df31fa0f91af8525688f006d26b2?OpenDocument (accessed September 23, 2008).

184 Singh and Way, Jo and Gartzke, and Meyer do not code Norway. Mueller codes nuclear weapon activities beginning in 1951-55 and ending in 1961-65. Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review* (Winter 1997), p. 1, 3, 5.

185 Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," pp. 3-5.

186 Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," pp. 2, 3, 6, 10-11.

187 Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," pp. 1, 8-9.

188 Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," pp. 2, 11-12, 14.

189 Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," p. 13.

Egypt: Exploration is coded as beginning in 1955.[190] That year, Nasser established the Atomic Energy Establishment, organized to focus on peaceful applications while preserving future military options.[191] Thereis a case to be made for coding pursuit in the early 1960s, but on balance the evidence supports exploration. After Israel confirmed the existence of the Dimona reactor in 1961, Egypt appears to have ramped up its nuclear efforts, and there are reports that it asked both the Soviet Union and China to provide it with nuclear weapons.[192] But at the same time Egypt appears never to have committed to acquiring nuclear weapons indigenously, perhaps in part because of internal bureaucratic and budgetary challenges.[193] Egypt returned to no activity in 1980. Egypt signed the NPT in 1968, but refused to ratify it until rival Israel did.[194] Egypt and Israel made peace in 1979, and the following year Egypt ratified the NPT after an internal commission had assessed the issue, including whether Egypt could and should develop nuclear weapons.[195] There is a case to be made for coding the end of Egypt's exploration earlier; after Nasser died in September 1970, Anwar Sadat came to power, and in contrast to Nasser, was apparently more interested in nuclear power than nuclear weapons. But in 1980, Sadat also appointed "a special commission headed by Boutrous Boutrous Ghali to assess the issue of NPT ratification. In its deliberations, the commission explicitly examined whether Egypt *could* develop nuclear weapons ("how far can we go") as well as whether the country *should* develop nuclear weapons."[196] Although some commission members favored attempting to acquire nuclear weapons—some, including the minister of defense, reportedly arguing it should do so within the auspices of the NPT, which would

190 Singh and Way do not code Egypt. Gartzke and Jo also do not code Egypt. Meyer does not code Egypt, while Mueller codes nuclear weapon activities beginning in 1951-55 and ending in 1976-80. Singh and Way rely on Mohammad El-Sayed Selim, "Egypt and the Middle Eastern Nuclear Issue," *Strategic Analysis,* Vol. 18 (1996), pp. 1381-1398; Mohammad El-Sayed Selim, "Egypt" in James Katz (ed.) *Nuclear Power in Developing Countries* (Lexington, MA: Lexington Books, 1984). Jo and Gartzke rely on Robert J. Einhorn, "Egypt: Frustrated But Still on a Non-Nuclear Course," in Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss, *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington: Brookings Institution Press, 2004), pp. 45-48.

191 James J. Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics." PhD dissertation, Massachusetts Institute of Technology, 2001, p. 168; Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*, p. 229; Campbell, Einhorn, *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, p. 45.

192 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," p. 174, 202; Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*, p. 229.

193 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," pp. 201-202.

194 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," p. 210.

195 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," p. 211.

196 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," p. 211, citing both published Egyptian Ministry of Foreign Affairs information and an anonymous source.

provide more ready access to needed technology transfers—the dominant view favored joining the NPT and not pursuing nuclear weapons.[197] Sadat ultimately took this perspective, announcing in December 1980 that Egypt would ratify the NPT and shortly thereafter concluding a safeguards agreement with the IAEA.[198]

Italy: Italy is coded as beginning exploring in 1955, when "the Ministry of Defense authorized the creation of a Centre for the Military Applications of Nuclear Energy" tasked with conducting "research into all possible fields of application of nuclear energy, from propulsion to atomic bombs."[199] Further, in 1957, Italy entered into a secret agreement with France and Germany to jointly develop nuclear weapons on French soil.[200] Italy returned to no activity in 1958, when Charles de Gaulle assumed the presidency of France and halted implementation of the joint agreement.[201] After 1958, Italy focused on nuclear cooperation within NATO rather than on independent development of nuclear weapons. This episode is coded as exploration rather than pursuit because there is no evidence of any Italian activity toward the actual production of weapons.[202] National nuclear research centers had previously been established in 1951 and 1952, but these "had no authority to deal with military applications of nuclear power."[203] A military committee established in 1954 studied nuclear, biological, and chemical weapons, but appears to have focused on their battlefield implications rather than on the possibility that Italy might acquire such weapons itself.[204]

197 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," p. 211, citing interviews with senior Egyptian government officials, secondary source books, and anonymous sources.

198 Walsh, "Bombs Unbuilt: Power, Ideas, and Institutions in International Politics," pp. 211-212.

199 Singh and Way, Jo and Gartzke, and Meyer do not code Italy. Mueller codes nuclear weapon activities beginning in 1956-60 and ending in 1966-70. Leopoldo Nuti, "'Me Too, Please': Italy and the Politics of Nuclear Weapons, 1945-1975," *Diplomacy and Statecraft*, Vol. 4, No. 1 (March 1993), p. 118.

200 Strauss, *Die Erinnerungen*, pp. 313-314; Nuti, "'Me Too, Please': Italy and the Politics of Nuclear Weapons, 1945-1975," p. 120.

201 Strauss, *Die Erinnerungen*, p. 316; Nuti, "'Me Too, Please': Italy and the Politics of Nuclear Weapons, 1945-1975," p. 121.

202 Strauss, *Die Erinnerungen*, p. 316.

203 Nuti, "'Me Too, Please': Italy and the Politics of Nuclear Weapons, 1945-1975," p. 117.

204 Nuti, "'Me Too, Please': Italy and the Politics of Nuclear Weapons, 1945-1975," p. 118.

Australia: Australian exploration is coded as beginning in 1956.[205] In that year, Australia began sporadic efforts to secure nuclear weapons from the British, including both formal and informal requests.[206] When these failed, beginning in 1968 policy makers pursued the possibility of an "on-demand" transfer option with the British government should Australia's security situation deteriorate in future.[207] After this too failed, Australia explored domestic production of nuclear weapons beginning in 1968, including Cabinet-ordered studies of potential cost and feasibility; it is unclear to what extent development activities were also carried out.[208] Return to no activity is coded as 1973, when Australia signed the Nuclear Non-Proliferation Treaty.[209] Although some advocacy for the pursuit of nuclear weapons persisted in subsequent years within the government, enthusiasm had waned dramatically by this time and Australia appears never to have again seriously considered the option.[210]

West Germany: West Germany started exploring in 1957, when West German Defense Minister Franz Josef Strauss, with the support of Chancellor Konrad Adenauer, negotiated a secret agreement to jointly develop nuclear weapons on French soil, in cooperation with France and Italy.[211] Germany returned to no activity in 1958, when Charles de Gaulle assumed the presidency of France and halted implementation of the agreement; the German government expressed its displeasure by cancelling a planned purchase of French Mirage III fighter aircraft.[212] There is a case to be made for coding the end of exploration as late as 1964; apparently senior German defense officials were still contemplating nuclear weapons in 1960, and de Gaulle in 1964 made what some senior German officials interpreted as a veiled offer to reestablish cooperation, which Germany chose not to act on, but the balance of the evidence favors 1958.[213] Further, this episode is

205 Singh and Way code Australia as exploring in 1956. Jo and Gartzke do not code Australia; neither does Meyer. Singh and Way rely on Robert M. Lawrence and Joel Larus, *Nuclear Proliferation: Phase II* (Kansas: University Press of Kansas, 1974); Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," pp. 1-20; Paul, *Power versus Prudence*.

206 Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions", pp. 52-68.

207 Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," pp. 68-72.

208 Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," pp. 73-87.

209 Singh and Way code Australia as returning to no activity in 1974. Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," pp. 87-88.

210 Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," pp. 87-88.

211 Strauss, *Die Erinnerungen*, pp. 313-315.

212 Strauss, *Die Erinnerungen*, p. 316.

213 Strauss, *Die Erinnerungen*, p. 319.

coded as exploration rather than pursuit because there is no evidence of any German activity toward the actual production of weapons, beyond the organization of a delegation of German scientists and military officers to visit the French uranium enrichment site, itself never carried out due to the halting of cooperation.[214]

Note that the above interpretation is explicitly challenged by Gene Gerzhoy, who argues that it "overlook[s] evidence that Germany sought to acquire an independent nuclear deterrent from 1956 to 1963, and that it fought to retain its weapons option from 1964 to 1969."[215] Gerzhoy documents Adenauer's interest, as early as 1956 and continuing through the late 1960s, in keeping open the possibility of Germany eventually obtaining nuclear weapons.[216] Germany undertook various political actions between 1956 and 1969 to try not to foreclose the possibility of future nuclear weapons, but the 1957-58 episode recounted above appears to represent the only concrete actions the government took to actually bolster its nuclear weapons-related capabilities.[217] One could make the case that Germany's behavior between 1956 and 1969 should be coded as exploring, though this author regards it as falling short of that bar.

Indonesia: Exploration is coded as beginning 1964, when on November 15 Brigadier General Hartono, director of the Army Ordnance Department, told an Indonesian news agency that his country intended to explode an atomic bomb the following year, and he later indicated 200 scientists were working on the project.[218] The following year, President Sukarno announced on July 24 that, "God willing, Indonesia will shortly produce its own atom bomb.[219] Despite this rhetoric, there is little evidence to suggest a concerted weapons program; in fact, one could make a reasonable case

214 Strauss, *Die Erinnerungen*, p. 316.

215 Gene Gerzhoy, "Alliance Coercion and Nuclear Restraint: How the United States Thwarted West Germany's Nuclear Ambitions," *International Security*, Vol. 39, No. 4 (Spring 2015), p. 94.

216 Gerzhoy, "Alliance Coercion and Nuclear Restraint: How the United States Thwarted West Germany's Nuclear Ambitions", p. 109.

217 Gerzhoy, "Alliance Coercion and Nuclear Restraint: How the United States Thwarted West Germany's Nuclear Ambitions", pp. 105-124; the tripartite initiative is discussed on pp. 109-111.

218 Singh and Way, Jo and Gartzke, and Meyer do not code Indonesia. Mueller codes nuclear weapon activities beginning in 1961-65 and ending in 1966-70. Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review* (Summer 2000), p. 33, 35.

219 Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," p. 35.

for not even coding this as exploration.[220] Indonesia returned to no activity in 1967. An aborted 1965 coup undercut Sukarno, who transferred power to General Suharto in 1966, and in 1967 Indonesia agreed to international safeguards on the sensitive nuclear material and equipment it had previously received from the United States.[221]

Taiwan: Exploration is coded as beginning in 1967.[222] In that year, based on an interview with Ta-You Wu, President Chiang Kai-shek's science advisor, "the defense ministry floated a $140-million proposal for developing nuclear weapons."[223] Asked to critique the proposal, the science advisor recommended rejecting it, and was told the president had accepted his recommendation.[224] However, the science advisor also wrote that "he had no objection to obtaining nuclear science or technology, or to training personnel for both civilian *and military* purposes."[225] Following his recommendation, the nuclear program was placed under a civilian oversight body, but one that included a military general who had been "the driving force behind the nuclear weapons proposal."[226] The subsequent program pursued a very modest plutonium production, separation, and reduction to metallic form capability, unusual for a purely civilian effort; this appears to have been independently authorized by the president's son, Chiang Ching-kuo, then serving at the defense ministry.[227] This paper codes a return to no activity in 1976, when, "Under continuing U.S. pressure, on September 14

220 Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," passim.

221 Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," p. 38.

222 Singh and Way code Taiwan exploring in 1967, ending 1978, and again exploring in 1987. Singh and Way rely on David Albright and Corey Gay, "Taiwan's Former Nuclear Bomb Program Revealed," Institute for Science and International Security, December 19, 1997, http://isis-online.org/isis-reports/detail/taiwans-former-nuclear-bomb-program-revealed/(accessed August 16, 2010); David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of the Atomic Scientists*, Vol.51, No.1 (January/February 1998); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries"; Gerald Segal, "Taiwan's Nuclear Card," *The Asian Wall Street Journal*, August 5, 1998; and a website no longer accessible as of August 2010. Jo and Gartzke code pursuit in 1967, ending in 1977; however, they do not code a second pursuit. Jo and Gartzke rely on Albright and Gay, "Taiwan: Nuclear Nightmare Averted" (1998). Meyer chooses not to code nuclear weapons activity, instead interpreting Taiwan's activity as merely advancing a nuclear option, although he notes that one could make a reasonable case that Taiwan pursued from 1975 until 1977 or 1978. Meyer (1984) p. 134. Mueller codes nuclear weapon activities beginning 1966-70 and ending 1986-90.

223 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," p. 55.

224 Albright, Gay, "Taiwan: Nuclear Nightmare Averted", p. 56.

225 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," p. 56, emphasis added.

226 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," p. 56.

227 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," pp. 56-57.

then-Premier Chiang Ching-kuo made a promise to the U.S. ambassador—followed three days later by a diplomatic note to the same effect—that Taiwan would not acquire its own reprocessing facilities or engage in any activities related to reprocessing."[228] In 1977, U.S. scientists radioactively scanned each of Taiwan's fuel elements to ensure future diversions of material could be detected, and in 1978 Taiwan returned plutonium the United States had previously supplied it.[229] A second exploration is coded in 1987, when at the direction of Chiang Ching-kuo, Taiwan's "INER [Institute of Nuclear Energy Research] began building a multiple hot cell facility [to process plutonium] in violation of its 1976 commitments."[230] Finally, a return to no activity is coded in 1988. After the United States apparently learned of the facility from a defector, and facing strong pressure, Taiwan halted its efforts and also agreed to convert its plutonium-producing heavy water reactor to a more proliferation-resistant light-water reactor.[231]

Taiwan's activities fall on a spectrum somewhere between mere exploration and full-blown pursuit of nuclear weapons as those concepts are defined in this paper. On balance, as noted above, the author judges its activities to fall short of the threshold for coding pursuit, but there is a case for coding those activities, and especially the earlier of the two episodes, as pursuit. Taiwan's activities described above are often referred to as a nuclear weapons program, albeit in contexts where that term is not carefully defined. For example, writing in 2016, Fitzpatrick dates the launch of Taiwan's "secret nuclear-weapons programme" to 1964, but supports that claim only with a citation to Derek J. Mitchell's 2004 book chapter.[232] That chapter notes that "Taiwan did not launch a full-scale nuclear program until *after* 1964," identifying 1967 as the date when "Taiwan actively began to consider an indigenous nuclear program," sourcing the claim entirely to Albright and Gay's 1998 article.[233] That article—the primary source for the historical discussion above—included only modest citations, so the

228 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," p. 58.

229 Albright, Gay, "Taiwan: Nuclear Nightmare Averted," p. 59.

230 Albright, Gay, "Taiwan: Nuclear Nightmare Averted."

231 Gay, "Taiwan: Nuclear Nightmare Averted," p. 60. Archival documents related to the second episode at William Burr, "U.S. Opposed Taiwanese Bomb during 1970s," June 15, 2007, National Security Archive, http://nsarchive.gwu.edu/nukevault/ebb221/(accessed March 28, 2017).

232 Fitzpatrick, *Iran's Strategic Weapons Programmes: A Net Assessment*, pp. 127-128.

233 Derek J. Mitchell, "Taiwan's Hsin Chu Program: Deterrence, Abandonment, and Honor" in Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss (eds.), *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington: Brookings Institution Press, 2004), p. 296, emphasis added.

sources of its factual claims are not always clear, but this claim appears to be sourced to both a translated 1997 Chinese newspaper article and, more reassuringly, an interview with Wu, the science advisor. And as noted above, the information Wu actually shared with Albright and Gay suggests activity well short of what this paper defines as pursuit. As the National Security Archive noted in 1999, when it released archival material that it noted "confirms some of Albright's and Gay's findings, but it goes beyond them by adding highly significant, hitherto obscure, information to the record…The inner history of the Taiwan nuclear program remains to be told."[234] Perhaps additional information will emerge that suggests changes to the codings above are warranted, and specifically that Taiwan's activities were more robust than it appears based on currently available evidence.

Romania: There is little literature on Romania's nuclear activities, with the significant exception of Romanian scholar Eliza Gheorghe's work. Gheorghe describes how Romania, like many other countries, pursued dual-use technology early in the nuclear age, beginning in 1948.[235] The degree to which efforts were motivated by a desire to either hedge or obtain the capability to produce nuclear weapons remains ambiguous, though Romania apparently did ask the Soviet leadership to provide it with forward-deployed nuclear weapons beginning in the early 1960s and perhaps earlier, requests that were rebuffed.[236] Bucharest's dissatisfaction with Moscow, including the latter's unwillingness to share much of the nuclear technology it sought, led it in the mid-1960s to engage other countries in the West, who were willing partners as part of a divide and conquer strategy toward Moscow.[237] Romania sought natural uranium-fueled heavy water reactor technology in part because of "Ceaușescu's desire to keep the nuclear [weapons] option on the table," Gheorghe assesses, explaining that "the natural uranium design appealed to Ceausescu since the IAEA safeguards system did not extend to heavy water plants at that time, creating

234 William Burr, "New Archival Evidence on Taiwanese Nuclear Intentions, 1966-1975," October 13, 1999, http://nsarchive.gwu.edu/NSAEBB/NSAEBB20/(accessed March 28, 2017).

235 Eliza Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," *Cold War History*, Vol. 13, No. 3 (2013), p. 374.

236 Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," p. 376 and Eliza Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975" draft paper, October 31, 2013, pp. 5-6.

237 Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," pp. 376-377.

less foreign interference in Romanian's nuclear program."[238] Though the interpretation appears plausible, Gheorghe does not explain why this necessarily entails a weapons option. Bolstering Gheorghe's interpretation, albeit consistent with the behavior of a number of other countries, in the mid-1960s Romania worked to prevent the creation of a nuclear weapons "monopoly" in the NPT negotiations, apparently telling the Soviets they did not want to give up the possibility of acquiring their own nuclear weapons in future.[239] And in 1967 Romanian Prime Minister Maurer apparently told Brezhnev that, according to Gheorghe, "We do not have a military nuclear program right now, but we would build an atomic weapon if we had the necessary means to do so," though the country appears never to have robustly pursued that capability.[240] According to Gheorghe, archival evidence suggests Ceaușescu, who ruled until 1989, hoped Romania would have a nuclear weapon by the year 2000.[241] She describes him as working "tirelessly to acquire the technical capabilities which would have turned his ambitions into reality," though at other times describes his regime's approach more as an effort to keep the door to possible future proliferation open than to try to obtain nuclear weapons.[242]

On the basis of Gheorghe's interpretations of the historical evidence, Romania is coded as exploring nuclear weapons beginning in 1965, when Ceaușescu came to power and also when the country began to seek dual-use nuclear technology from countries other than the Soviet Union.[243] One could also code this behavior as beginning earlier, in the early 1960s or even earlier, when Romania first sought dual-use nuclear technology from Moscow. Or one could code Romania as never or only later exploring nuclear weapons. One could also code Romania as pursuing nuclear weapons, but there is insufficient evidence of a full-fledged effort to do so, rather

238 Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," pp. 377-378.

239 Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," pp. 380-381.

240 Gheorghe, "Atomic Maverick: Romania's Negotiations for Nuclear Technology, 1964–1970," pp. 384-385 and Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975," p. 11.

241 Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975," p. 1.

242 Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975," p. 1.

243 Singh and Way code Romania as exploring beginning 1985. Singh and Way rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries". Meyer does not code Romania, while Mueller codes it beginning nuclear weapon activities in 1981-85 and ending them in 1986-90.

than merely to keep the door open.[244] It bears emphasizing that Gheorghe herself reaches somewhat different conclusions. She describes Romania as engaged in a sort of ambivalent pursuit of dual-use capabilities from 1962 to 1974, as exploring from 1974 to 1985, and as pursuing between 1985 and 1989.[245] Her exploration assessment is based on Bucharest working "to insure that the NPT would not block its efforts to acquire sensitive nuclear technologies and materials and its research activities." Her pursuit assessment is based on the fact that "in 1985, Romanian scientists managed to reprocess a small quantity of Pu-239 at the Nuclear Technologies Institute in Pitesti," which does not come close to meeting the threshold for pursuit as defined in this paper.[246] Similarly, a Russian intelligence report suggests that Romania had a nuclear weapons program before 2000, and states that IAEA inspections in 1990 and 1992 "showed that beginning in 1985, Romania was conducting secret experiments on chemical production of weapons-grade plutonium…and a small quantity of enriched uranium…"[247] Finally, a Wikipedia entry cites a Romanian-language source in which the former director of the research institute at which Romania's mass destruction weapons efforts were apparently housed indicates that the program, initiated in 1978, had "three departments: one which dealt with the development of nuclear weapons, one for the development of medium-range missiles and a third which dealt with chemical and biological weapons."[248] None of this is sufficient to justify a pursuit coding.

Romania is coded as returned to no activity in 1989, when Nicolae Ceaușescu's government was overthrown and he and his wife were executed. Subsequently, in 1991, Romania agreed to put its nuclear facilities under full International Atomic Energy oversight.[249] Inspections in 1992 uncovered a modest quantity of plutonium at a secret laboratory. Romania subsequently agreed to a variety of IAEA demands and was allowed

244 Jo and Gartzke code pursuit in 1981, ending 1990. Jo and Gartzke rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1988), p. 11.

245 Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975," p. 4.

246 Gheorghe, "A Flash in the Pan: Romania and the NPT, 1968-1975," p. 4. Two other sources, Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998) and GlobalSecurity.org (2008), use the existence of this experimental plutonium extraction effort to allege that Romania was pursuing a covert nuclear weapons program.

247 Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries."

248 "Romania and weapons of mass destruction" Wikipedia, (2010), available at: https://en.wikipedia.org/wiki/Romania_and_weapons_of_mass_destruction.

249 Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries."

to resume civilian nuclear activity with IAEA support in 1994.[250] As noted above, some sources allege nuclear weapons-related activities following Ceaușescu's overthrow, but the evidence is not sufficient to merit an exploration, or for that matter pursuit, coding.

Argentina: Argentina began a nuclear program in the late 1940s or early 1950s; in 1950, it established a National Atomic Energy Commission. While it is plausible that it explored nuclear weapons in the 1950s or 1960s, there is no evidence to support this coding. Its nuclear efforts ramped up in the late 1960s and early 1970s, as it moved to acquire a robust civilian nuclear power capability with potential applicability to the development of nuclear weapons. Exploration is coded as 1978, when Argentina decided to construct both a plutonium reprocessing plant and a clandestine uranium enrichment program.[251] These could be the basis for nuclear weapons pursuit, but there is no evidence that this was the case. This paper does, however, judge them sufficiently compelling circumstantial evidence of at least an exploratory interest in nuclear weapons. A return to no activity is coded as 1990, when Argentina signed agreements with its main rival, Brazil, which established a bilateral nuclear inspection system, opened nuclear installations on both sides to the International Atomic Energy Agency, and agreed to revise and fully implement a previously negotiated nuclear weapons-free zone.[252]

Algeria: The literature on Algeria and nuclear weapons proliferation is very thin, although this appears to be at least partly a reflection of its very modest proliferation endeavors. Algeria is coded as exploring in 1983, when it signed an agreement to secretly procure a large research reactor

250 Russian Federation Foreign Intelligence Service, "The Nuclear Potential of Individual Countries."

251 Singh and Way code Argentina as exploring in 1968 and pursuing in 1978. Singh and Way rely on Barnaby, *How Nuclear Weapons Spread: Nuclear Weapons Proliferation in the 1990s* (1993); Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Mitchell Reiss & Robert S. Litwak, *Nuclear Proliferation after the Cold War* (Washington D.C.: Woodrow Wilson Center Press, 1994); Spector (1988); and two websites no longer accessible as of August 2010. Jo and Gartzke code pursuit in 1976, ending in 1991. Jo and Gartzke rely on Reiss, *Bridled Ambition*, pp. 46-47, 52-66; Spector (1990), pp. 223-224; C. H. Waisman, "Incentives for Nuclear Proliferation: The Case of Argentina," in Onkar Marwah and Ann Schulz (eds.) *Nuclear Proliferation and the Near-Nuclear Countries* (Cambridge, MA: Ballinger Publishing Co., 1975), pp. 282-283. Meyer does not code nuclear weapons activity, while Mueller codes activity beginning in 1951-55 and ending in 1991-95. Reiss, *Bridled Ambition*, p. 47, Spector and Smith, *Nuclear Ambitions*, p. 224.

252 Reiss, *Bridled Ambition*, p. 45, 59.

from China.[253] The partially completed facility was discovered by U.S. intelligence in 1991, and its size, together with the prior secrecy, the fact that the site was defended by surface-to-air missile batteries, and reports of a co-located reprocessing facility all raised proliferation suspicious.[254] Algeria returned to no activity in 1991, because it agreed to place the reactor under International Atomic Energy Agency safeguards at that time, and subsequently joined the Nuclear Non-Proliferation Treaty in 1995.[255] Like some other cases, one could plausible also not code this as exploration at all (and conversely, if more robust evidence emerges in future, it is conceivable it would support a coding of pursuit).

253 Singh and Way also code Algeria exploring in 1983. Singh and Way rely on Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts* (1998); Leonard S. Spector, "Nuclear Proliferation in the Middle East," *Orbis* Volume 36, Issue 2 (Spring 1992), pp. 181-198; and a website no longer accessible as of August 2010. Gartzke and Jo do not code Algeria. Meyer does not code Algeria, while Mueller codes it beginning nuclear weapon activities in 1986-90 and ending in 1991-1995. Bruno Tertrais, *Le Marché noir de la Bombe. Enquête sur la prolifération nucléaire*, (Paris: Buchet/Chastel, 2009).

254 Spector, "Nuclear Proliferation in the Middle East"; Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts*, p. 163.

255 Jones et al., *Tracking Nuclear Proliferation, 1998: A Guide to Maps and Charts*, p. 163.

5. Selected Countries *Not* Coded as Proliferating

Several countries have been identified by other analysts as engaging in some degree of nuclear weapons proliferation-related behavior, but are not assessed to meet the bar for any degree of proliferation-related behavior coded here.

Canada: Although one could make the case that Canada's involvement in the Manhattan Project, together with the United States and the United Kingdom, warrants a coding of exploration or perhaps even pursuit, there is no evidence of intent to explore or pursue an independent Canadian nuclear capability, and hence this paper does not code any level of nuclear weapons activity.[256]

Chile: There is no evidence that Chile engaged in meaningful nuclear weapons-related activity.[257]

Spain: There is no evidence to suggest that Spain engaged in any level of nuclear weapons-related activity.[258]

Ukraine: This paper does not code Ukraine as engaging in any level of nuclear-weapons related activity.[259] Although nuclear weapons remained on its soil after the collapse of the Soviet Union in 1991, Ukraine never exercised operational control over those weapons.[260] Ukraine reportedly

256 Duane Bratt, "Canada's Nuclear Schizophrenia," *Bulletin of the Atomic Scientists*, Vol. 58, No. 2 (March/April 2002), pp. 45-50; William C. Potter, *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective* (Cambridge: Oelgeschlager, Gunn, and Hain, 1982), p. 174. Singh and Way, Jo and Gartzke, and Meyer do not code Canada. Mueller codes it as pursuing nuclear weapons activities beginning 1945 and ending 1946-50.

257 Singh and Way, Jo and Gartzke, and Meyer do not code Chile as engaging in nuclear weapons activity. Mueller codes nuclear weapon activities beginning 1961-65 and ending 1991-95, although unfortunately offers no argument or citations for this assertion.

258 Singh and Way, Jo and Gartzke, and Meyer do not code Spain. Mueller codes nuclear weapon activities beginning 1971-75 and ending 1986-90. Mueller bases his coding off one source, whose only relevant data point appears to be a sentence, without attribution, about press reports of Spanish intentions to develop nuclear weapons between 1979 and 1981. See Angel Vinas, "Spain," in Jozef Goldblat (ed.), *Non-proliferation: The why and the wherefore* (London: Taylor and Francis, 1985), p. 164.

259 Singh and Way, Jo and Gartzke, and Meyer do not code Ukraine as engaging in any level of nuclear weapons activity. Mueller codes weapons activity beginning in 1991-95 and ending in 1991-95.

260 Barry R. Schneider and William L. Dowdy, *Pulling Back from the Nuclear Brink: Reducing and Countering Nuclear Threats* (London: Frank Cass, 1998), pp. 89-90; Philipp C. Bleek, "Ukraine and the 1994 Budapest Memorandum," ArmsControlWonk.com, April 29, 2014, http://www.armscontrolwonk.com/archive/207316/ukraine-and-the-1994-budapest-memorandum/(accessed March 28, 2017).

did explore how it might obtain control of the weapons, and one could plausibly code that as exploration.[261]

Belarus: This paper does not code Belarus as engaging in any level of nuclear-weapons related activity.[262] Although nuclear weapons remained on its soil after the collapse of the Soviet Union in 1991, Belarus never exercised operational control over those weapons. Unlike Ukraine, there is no evidence that Belarus explored how it might obtain control of the weapons.

Kazakhstan: This paper does not code Kazakhstan as engaging in any level of nuclear-weapons related activity.[263] Although nuclear weapons remained on its soil after the collapse of the Soviet Union in 1991, Kazakhstan never exercised operational control over those weapons. Unlike Ukraine, there is no evidence that Kazakhstan explored how it might obtain control of the weapons.

Nigeria: This paper finds no evidence that Nigeria engaged in nuclear weapons-related activities.[264]

261 William C. Martel and William T. Pendley, "Nuclear Coexistence: Rethinking U.S. Policy to Promote Stability in an Era f Proliferation," *Air War College Studies in National Security*, No. 1 (April 1994), pp. 51-54.

262 Singh and Way, Jo and Gartzke, and Meyer do not code Belarus as engaging in any level of nuclear weapons activity. Mueller codes weapons activity beginning in 1991-95 and ending in 1991-95.

263 Singh and Way, Jo and Gartzke, and Meyer do not code Kazakhstan as engaging in any level of nuclear weapons activity. Mueller codes weapons activity beginning in 1991-95 and ending in 1991-95.

264 Singh and Way, Jo and Gartzke, and Meyer do not code Nigeria. Mueller codes nuclear weapon activity beginning in 1976-80 and ending in 1991-95, but does so on the basis of an unpublished paper.

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Printed in the United States of America