1 *The puzzle of declining nuclear weapons project efficiency*

Policymakers typically ask intelligence analysts two standard questions about the likelihood of nuclear proliferation. First, what might cause a given state to seek the bomb? This is considered to be a "political" question. Second, if the state were to seek the bomb, how quickly could it achieve that goal? This is considered to be a "technical" question.

In this book, however, I argue that it is wrong to view the second question as a purely technical one. Political analysis is essential not merely for evaluating states' propensity to seek nuclear weapons, but also for evaluating their capacity to achieve their nuclear weapons ambitions. For if it is difficult to get intricate centrifuge cascades to spin at high speeds for months on end, it is even more difficult to get large numbers of scientific and technical workers to tackle such challenges with the proper mix of passion and meticulousness. In other words, a crucial, yet widely overlooked determinant of efficient nuclear weapons projects is the top state leadership's adoption of a management approach that respects scientific workers' spirit of professionalism. But the mere fact that this is the right management approach does not mean it will be adopted. In many states, weak state institutions permit, and even encourage, top leaders to take actions that undermine that spirit of professionalism, and thereby unintentionally to thwart their own nuclear ambitions.

Recognizing that nuclear technical achievement is as much about politics as it is about engineering is especially important because in recent years, much of the literature on the topic has unfortunately fallen under the spell of "proliferation determinism" – the idea that getting the bomb today is not so difficult, and therefore that we simply have to admit the inevitability of a cancerous growth of new nuclear weapon states.[1] Yet in fact, although it may be true that in purely

[1] Alexander H. Montgomery, "Ringing in Proliferation: How to Dismantle an Atomic Bomb Network," *International Security* Vol. 30, No. 2 (fall 2005), p. 153.

technical terms it is easier to build the bomb than it used to be, from a managerial and thus political standpoint the challenge of nuclear weapons projects remains extremely high. Therefore, proliferation determinism is deeply mistaken.[2]

Moreover, proliferation determinism is not just mistaken, it is also pernicious. For although the threat of proliferation is surely a serious problem in international security affairs, exaggerated estimates of state nuclear capacities are a serious problem as well, since they encourage unnecessary and disastrous "preemptive" actions such as the Iraq War. Indeed, even after the Iraq nuclear and weapons of mass destruction (WMD) intelligence debacle, the basic assumption that state timelines to the bomb are a simple function of narrow technical variables continues to underlie assessments of the nuclear capacities of other states, such as Iran. If left uncorrected, this assumption is liable to create the conditions for a repetition of the tragic Iraq War blunder.

The empirical puzzle of declining nuclear weapons project efficiency

If the widespread belief that proliferation has become steadily less challenging for states since the 1940s were indeed true, then successive proliferant states should have arrived at their first nuclear bomb with increasing rapidity. At the very least, they should not have been arriving at that milestone with decreasing rapidity. As Figure 1.1 indicates, however, over the course of the decades, the average proliferant state has needed more and more time to achieve its nuclear weapons ambitions, and an increasing number of these projects have even been failing completely.

Figure 1.1 is based on Sonali Singh and Christopher Way's widely used codings of historical dedicated proliferation drives[3] – i.e. states

[2] See William M. Arkin, "The Sky-Is-Still-Falling Profession," *Bulletin of Atomic Scientists* Vol. 50, No. 2 (March–April 1994), p. 64; John Mueller, *Overblown: How Politicians and the Terrorism Industry Inflate National Security Threats, and Why We Believe Them* (New York: Free Press, 2006); Benoît Pelopidas, "The Oracles of Proliferation: How Experts Maintain a Biased Historical Reading That Limits Policy Innovation," *Nonproliferation Review* Vol. 18, No. 1 (February 2011), pp. 297–314.

[3] Sonali Singh and Christopher R. Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," *Journal of Conflict Resolution* Vol. 48,

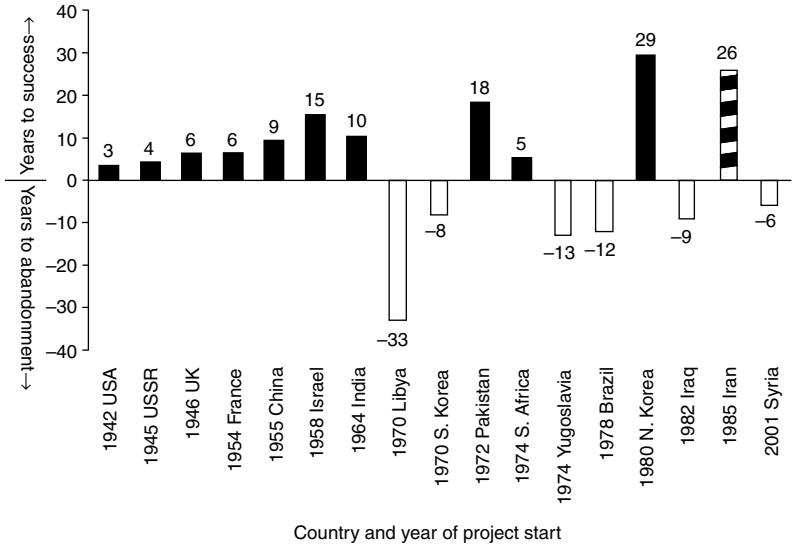

Figure 1.1 Nuclear weapons projects' timelines to success or abandonment
(Black bars: success; White bars: abandonment; Striped bar: outcome uncertain)

that have actually decided to launch a dedicated effort in "pursuit" of the bomb, not the larger group of states that have tried to hedge their bets and develop a merely "exploratory" project.[4] In Figure 1.1,

No. 6 (December 2004), and their data at http://falcon.arts.cornell.edu/crw12/.

[4] Since I do not want to be accused of massaging the data to make things more convenient for my theoretical argument, I have mostly avoided the temptation to alter Singh and Way's codings to suit my own understanding of the historical record. The changes I have made do not substantially affect Figure 1.1's message about the basic trends in nuclear weapons project implementation. First, Singh and Way code Argentina as having "pursued" nuclear weapons from 1978 to 1990, but in fact my detailed study of the case, first published in 2001, demonstrated that Argentina never had a nuclear weapons project. (See Jacques E. C. Hymans, "Of Gauchos and Gringos: Why Argentina Never Wanted the Bomb, and Why the United States Thought It Did," *Security Studies* Vol. 10, No. 3 (spring 2001), pp. 153–185.) Therefore I exclude Argentina from Figure 1.1. Second, Singh and Way code Yugoslavia as having "explored" nuclear weapons from 1954 to 1965 and from 1974 to 1988, but President Tito's 1974 direct order to launch a nuclear weapons project clearly satisfies their coding criteria for "pursuing" the bomb, so I include it as such. Singh and Way appear to have downgraded the project to "exploratory" because it never amounted to anything; but that is precisely what makes it so important to study, and I offer a detailed study

countries' "start date" is the decision to pursue the bomb. For cases of "failure," the end date is the abandonment of that objective. For cases of "success," the end date is the first successful explosive nuclear test, or in rare cases, the direct induction of operational nuclear weapons without a test. (Of course, nuclear weapons projects do not end with the first successful test, but the test is generally perceived as an appropriate dividing line separating "nuclear weapon states" from "non-nuclear weapon states."[5])

Note that the data in Figure 1.1 is hardly unimpeachable. All lists of past nuclear proliferants are quite unreliable, both because of the continuing opacity of states' historical nuclear activities and the data-sets' serious problems of concept and measurement validity and coding implementation.[6] Nonetheless, it is important to note that despite their coding differences, other available lists of dedicated nuclear weapons projects also indicate the same basic trends as those shown in Figure 1.1.

The trends indicated in Figure 1.1 are the opposite of what most proliferation analysts expected to happen, and indeed they are the opposite of what most proliferation analysts today claim *is*

of Yugoslavia in Chapter 5 of this book. Third, Syria's nuclear weapons project has only been known about since 2007, after Singh and Way's article appeared. Although questions still remain about when the Syrian program began, what its true purpose was, and whether it was really ended by the 2007 Israeli air strike on its suspected reactor facility, I include it in Figure 1.1 following the analysis in Leonard S. Spector and Deborah R. Berman, "The Syrian Nuclear Puzzle," in William C. Potter and Gaukhar Mukhatzhanova, eds., *Forecasting Nuclear Proliferation in the 21st Century*, Vol. 2: *A Comparative Perspective* (Stanford University Press, 2010), pp. 100–130. Finally, North Korea's nuclear weapons project was incomplete when Singh and Way's article came out. The correct end point is 2009, when the country's first minimally successful nuclear test took place. North Korea's attempted 2006 test was unsuccessful; see Peter Hayes and Jungmin Kang, "Technical Analysis of the DPRK's Nuclear Test," Nautilus Policy Forum Online 06–89A (October 20, 2006), available at www.nautilus.org/publications/essays/napsnet/forum/security/0689HayesKang.html.

[5] For a detailed analysis of the measurement issues here, see Jacques E. C. Hymans, "When Does a State Become a 'Nuclear Weapon State'? An Exercise in Measurement Validation," *Nonproliferation Review* Vol. 17, No. 1 (March 2010), pp. 161–180.

[6] For an account of some of the differences between, and common problems of, the existing data sets, see Alexander H. Montgomery and Scott D. Sagan, "The Perils of Predicting Proliferation," *Journal of Conflict Resolution* Vol. 53, No. 2 (April 2009), pp. 302–328.

happening. According to Figure 1.1, there are 17 historical cases of "pursuit" of nuclear weapons.[7] Seven nuclear weapons projects were launched between the 1940s and 1960s; these projects all succeeded. By contrast, of the 10 nuclear weapons projects that were launched between 1970 and 2010, only three have succeeded, with the case of Iran still a question mark.[8] This is an impressive decline in the success rate. Moreover, focusing on the successful projects only, there has been a remarkable increase in the time they have needed to achieve success. The average timeline to the bomb for successful projects launched before 1970 was about seven years; the average timeline to the bomb for successful projects launched after 1970 was about 17 years. Iran's nuclear weapons project is now a quarter-century old by this point, so even if its nuclear weapons effort were to succeed tomorrow, the new data point would reinforce the identified trend.

How might we explain the patterns revealed by Figure 1.1? As noted above, very few scholars or analysts of proliferation have focused their attention on this empirical puzzle.[9]

It is possible, however, to imagine how some standard variables might be used to try to explain the patterns. I begin my discussion of alternative hypotheses with a further consideration of the potential utility of narrow engineering, or "techno-centric" perspectives. Then I consider the following variables in turn: (1) the top leadership's will to go nuclear; (2) the Non-Proliferation Treaty (NPT); (3) entangling alliances; (4) military threats; and (5) economic resources. I conclude that these standard variables are all useful but ultimately cannot provide a satisfying answer to the puzzle. Therefore, I argue that we need to develop a new perspective that focuses much more on states' internal political dynamics.

[7] NB India's project from 1964 to 1974 was not a nuclear "weapons" project per se, but rather sought to create a "peaceful nuclear explosive."

[8] One might also append a question mark to the case of Syria. Although its apparent nuclear weapons project was dealt a setback by the Israeli air strike against its secret nuclear reactor construction site, one has to be somewhat cautious about declaring the project over in light of Iraq's reconstitution of its nuclear weapons efforts after the 1981 Israeli air strike against its Osiraq reactor.

[9] But see Lewis A. Dunn, "The NPT: Assessing the Past, Building the Future," *Nonproliferation Review* Vol. 16, No. 2 (July 2009), pp. 143–172. I discuss Dunn's argument in depth below.

The simple techno-centric perspective

As noted above, analysts who focus on global technological progress would have expected the empirical trends in Figure 1.1 to have gone in the opposite direction. For instance, already in 1976 Thomas Schelling was arguing, "As a national enterprise with government support it is not going to be difficult, ten or fifteen years from now, even in comparatively non-industrial countries, to produce nuclear bombs."[10] Schelling's conclusions about the ease of nuclear proliferation were rather daring in their day, but by now they are standard assumptions in the literature. After all, the science and technology of nuclear weapons is now over six decades old; surely everyone must have gotten the memo by now. The US Atomic Energy Commission alumni Thomas C. Reed and Danny B. Stillman offer the following grim set of conclusions about the contemporary ease of proliferation from their recent comprehensive survey of nuclear history. I quote from their book *The Nuclear Express*:

1. Technology does not respect national boundaries; the word travels fast; nuclear secrets do not keep …
2. Any well-industrialized society with the intellectual firepower, economic resources, and government determination can join the nuclear club less than three years from "go." (Think Germany, Taiwan, Brazil, etc. It's a long list.)
3. This time span can be shortened if the society of interest has plutonium-producing nuclear reactors or uranium-enrichment machinery already in place as part of its energy economy. (Think Japan, India, or the Koreas.)
4. It may take a little longer if the would-be nuclear power lacks a full industrial base, but national will counts for a great deal. (We speak of Iran here as well as Pakistan and, once again, North Korea.)[11]

Reed and Stillman are voicing the conventional wisdom. In fact, today the only real debate that most contributors to this literature

[10] Thomas Schelling, "Who Will Have the Bomb?" *International Security* Vol. 1, No. 1 (summer 1976), p. 83.
[11] Thomas C. Reed and Danny B. Stillman, *The Nuclear Express: A Political History of the Bomb and its Proliferation* (Minneapolis: Zenith Press, 2009), p. 18.

appear to think worth having is whether even *terrorist groups*, which are smaller and less stable than the weakest of states, might also have the technical capacity to acquire the bomb. Writing in the early 1980s, Schelling thought he knew the answer to this one, too: "Sometime in the 1980s an organization that is not a national government may acquire a few nuclear weapons. If not in the 1980s then in the 1990s."[12] Usually such claims are somewhat tempered by the admission that only states have the wherewithal to produce fissile material, so terrorists would have to buy or steal it.[13] Graham Allison, however, believes that terrorists are capable of producing the fissile material themselves. To back up his claim, he cites – without irony – an analysis conducted by science fiction writer Tom Clancy. Clancy concluded that "the fact of the matter is that a sufficiently wealthy individual could, over a period of five to ten years, produce a multi-stage thermonuclear device. Science is all in the public domain, and allows few secrets."[14] Allison then adds ominously, "Clancy wrote this afterword in 1992, which means his five- to ten-year period has elapsed."[15]

If building the bomb from scratch has come within the reach even of rich individuals, then it almost goes without saying that it should be child's play for the vast majority of states.[16] Nonetheless, perhaps we should pause a bit before turning the study of nuclear proliferation over to Tom Clancy. The story Figure 1.1 tells is not one of dramatically declining barriers to entry into the nuclear weapon state club. Techno-centric authors fail to acknowledge, much less account for, the fact that over time states' timelines to the bomb have been slowing down rather than speeding up, and that an increasing number have been ending up as outright failures.

[12] Thomas C. Schelling, "Thinking about Nuclear Terrorism," *International Security* Vol. 6, No. 4 (spring 1982), p. 61.
[13] Matthew Bunn and Anthony Wier, "Terrorist Nuclear Weapon Construction: How Difficult?" *The Annals of the American Academy of Political and Social Science* No. 607 (September 2006), pp. 133–149.
[14] Tom Clancy quoted in Graham T. Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe* (New York: Times Books, 2005), pp. 11–12.
[15] *Ibid.*, p. 12.
[16] Note, however, that Allison also contends, somewhat in contradiction of his claims cited above, that most terrorist groups have it easier than states because they are seeking only a single nuclear device, not "a weapons production line, including their own capacity to make fissile material." *Ibid.*, pp. 97–98.

More sophisticated techno-centric claims

The basic techno-centric claim that with the passage of time it has become easier to build the bomb does not explain the trends shown in Figure 1.1. However, there are two common, more sophisticated techno-centric claims that might be able to provide at least some explanatory leverage.

First, it stands to reason that states that have more prior experience with nuclear technology might be able to make the bomb more quickly after deciding to do so. Sensible though this point undoubtedly is, however, it also fails to explain the empirical variation in the duration and success rate of nuclear weapons projects that is shown by Figure 1.1. When the United States, USSR, and the UK tried to get the bomb, nuclear energy was a strange new field of human endeavor, but they finished their projects quickly. By contrast, most of the proliferant states since 1970 have had years of experience running at least a research reactor before deciding to try to go nuclear (the only exceptions to the rule are Libya and North Korea, and both of them got research reactors not long after their initial decisions to seek nuclear weapons).[17] Moreover, of all the states listed in Figure 1.1, only India had ready access to separated fissile material at the time it launched its nuclear weapons (or to be precise, "peaceful nuclear explosives") project. So, although in principle having more experience with nuclear technology may greatly advance a nuclear weapons project, in fact this variable is not very helpful for explaining the empirical record of nuclear weapons projects' varying levels of efficiency.

Second, another commonly voiced techno-centric argument is the idea that the technology for highly-enriched uranium (HEU) production is harder to master than the technology for reprocessing spent reactor fuel to extract plutonium, and therefore that states pursuing the HEU path to the bomb will need more time.[18] Might this explain

[17] Data on research reactors from http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1.

[18] On the other hand, it is also often claimed that the fabrication of a simple gun-type fission device using HEU is much more straightforward than the implosion device that is necessary if one is working with plutonium. Thus, for instance, the United States used an untested HEU-fueled bomb on Hiroshima whereas it needed to test its plutonium bomb before dropping it on Nagasaki. So perhaps states focusing on plutonium have a higher chance of failure at the device design stage. But generally speaking it is the acquisition of fissile material that is considered to be the "hardest" step.

the variation in Figure 1.1? In fact, however, the notion that the HEU path is inherently harder than the plutonium path is debatable. States' specific technical strengths and weaknesses count for more than the inherent qualities of the technology itself. The vast majority of proliferant states have sought both weapons-grade plutonium and HEU, sometimes simultaneously, sometimes in sequence, and sometimes toggling back and forth before settling on the path that appears easiest *for them*. Moreover, the historical record of nuclear weapons projects does not suggest that either of these routes to the bomb is much more advantageous than the other. In the Manhattan Project, the United States pursued both routes and finished both at almost exactly the same time; the bomb that destroyed Hiroshima was fueled with HEU, while the bomb that destroyed Nagasaki was fueled with plutonium. Among the successful proliferants other than the United States, six had their first success with plutonium (USSR, UK, France, Israel, India, North Korea), while three had their first success with HEU (China, South Africa, Pakistan). So although historically more states have been successful taking the plutonium track, on the other hand two of the poorest states to achieve the bomb, China and Pakistan, did so using HEU, and South Africa's HEU-based nuclear weapons project was the only one launched after 1970 that was truly efficient.

All in all, while any account of the implementation of nuclear weapons ambitions must recognize that this is a deeply complex technical matter, narrow technical issues on their own cannot provide a solid answer to the empirical puzzle indicated by Figure 1.1.

The will to go nuclear

Another hypothesis that is commonly offered to explain one or another nuclear weapons project failure is the idea that the top political leadership of the proliferant state ultimately did not have a strong enough will to achieve the bomb. Might this variable explain our puzzle?

There can be no question that ultimate nuclear intentions are crucially important for explaining the overall pattern of nonproliferation. In fact in my prior book, *The Psychology of Nuclear Proliferation*, I argued that the most important reason why still fewer than 10 states actually possess the bomb today, even though many more have long had the basic technical and industrial wherewithal to achieve that, is that most top state leaders shy away from making the definitive

decision to go for the bomb.[19] So I would be the last person to contend that the lack of a clear will to go nuclear is unimportant to the end result.

Figure 1.1, however, lists only those 17 states that are generally believed to have launched *dedicated* nuclear weapons projects, as opposed to a larger number of states that are generally judged to have merely dipped their toes in the water: states such as Nazi Germany in the 1940s, Switzerland and Sweden in the 1950s and 1960s, Taiwan in the 1970s and 1980s, and so on. Of course, some of these codings may be wrong. As noted previously, however, despite their coding differences, the available lists of dedicated proliferant states all indicate the same basic trends as those shown in Figure 1.1.[20]

It is certainly interesting to ask why some states decide for a dedicated nuclear weapons project whereas others merely hedge, but that is not the question I am asking here. My question here is about the level of efficiency of dedicated nuclear weapons projects. Therefore, the "they didn't really mean it" argument is more or less beside the point.

In addition, although a top-down decision to get the bomb is certainly necessary at some point in the process, consistently strong top leadership desires for the bomb are not a necessary condition for nuclear weapons project efficiency. Indeed, waffling or mixed feelings at the top have not been limited to those states whose nuclear weapons projects failed or took an inordinate amount of time to reach their ultimate goal. For instance, take the case of France. Although fewer than six years separate Prime Minister Pierre Mendès France's transcendental decision to "go nuclear" on December 26, 1954 and the first French nuclear test on February 13, 1960, in between those two bookmark dates, various French prime ministers tried to sweep Mendès France's decision under the rug.[21]

[19] Jacques E. C. Hymans, *The Psychology of Nuclear Proliferation; Identity, Emotions, and Foreign Policy* (Cambridge University Press, 2006), esp. ch. 1.

[20] See especially the excellent effort by Philipp C. Bleek, "When Did (and Didn't) States Proliferate? Coding the Spread of Nuclear Weapons throughout the Atomic Age," Occasional Paper, Working Draft 2.1 (2011 revision), James Martin Center for Nonproliferation Studies, Monterey Institute of International Studies, Monterey, CA. See also Dunn , "The NPT," p. 156.

[21] See Hymans, *The Psychology of Nuclear Proliferation*, ch. 4.