7 Stop Helping Me

When Nuclear Assistance Impedes Nuclear Programs

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UNTIL RECENTLY, THEORIES OF HOW DIFFERENT FACTORS influence the supply of nuclear technologies have not been as well developed as theories of demand for nuclear weapons. For example, most quantitative studies of nuclear weapons development have used indicators that reflected national resources without including technology transfers from other states (Kegley 1980; Meyer 1984; Singh and Way 2004; Jo and Gartzke 2007). Part of this lack of attention to nuclear technology transfer may be due to the perception that many of the initial nuclear weapons programs attempted to rely on primarily internal, domestic sources of knowledge, technology, and resources for fissile material production and were thus structured as top-down "hierarchies." More recent programs have relied on imports of all three components either in an attempt to cut development times or simply because one or more of these necessary components were not available domestically (Braun and Chyba 2004; Montgomery 2005). With these later nuclear aspirants, domestic capabilities and direct assistance or international proliferation networks were combined to create a supply of nuclear technologies. Recent nuclear programs thus are structured more like networks than hierarchies, although the technical characteristics of nuclear proliferation and the nonproliferation regime have prevented a full-blown market from arising.[1] Publications have lamented the A. Q. Khan network and its deleterious effects on proliferation, emphasizing its clandestine nature and effectiveness and predicting an ominous end to existing nuclear nonproliferation institutions.[2]

Recent work by Fuhrmann (2008, 2009a,b) and Kroenig (2009a,b, 2010) has attempted to tackle both the causes and effects of the supply of both sensitive and peaceful nuclear technologies. The bargain of the nonproliferation regime also seems to be broken: Kroenig finds that sensitive nuclear assistance is more likely to be given by states in the Nuclear Suppliers Group (although Non-Proliferation Treaty [NPT] members are less likely to do so), and Fuhrmann finds that peaceful nuclear cooperation is less likely to be given to states that are part of the NPT. Kroenig argues that countries who receive sensitive nuclear assistance—that is, technologies that are necessary for the construction of a nuclear weapons arsenal, including uranium enrichment, plutonium reprocessing, and nuclear weapons designs—are more likely to start nuclear programs and acquire weapons. Fuhrmann argues that there are several pathways through which civilian nuclear assistance can affect proliferation, including acquisition of dual-use technology and knowledge as well as the creation of bureaucratic interests. Their quantitative findings so far have been disturbing: Both types of nuclear transfer seem to increase the probability that a state will start a nuclear program and that it will succeed.

However, the apparently significant effect of these variables on the likelihood of proliferation is due in part to the use of a model specification that includes a large number of countries in the pool for nuclear acquisition that have never even tried to start a nuclear program. When the pool is limited to countries that have been actively seeking nuclear weapons, the effect is inverted: Instead of increasing proliferation, both sensitive and peaceful nuclear assistance appear to decrease the probability that countries which are pursuing nuclear weapons will succeed.

This counterintuitive result can be explained in part by the inclusion of theories previously excluded from quantitative studies but found in the qualitative literature: the ability of the recipient of such aid to turn it into a bomb. A nuclear weapons program is a large-scale sociotechnical system that requires a long-term investment in multiple technologies, each with its own unique hurdles to overcome. While it is certainly theoretically possible for any state with a sufficient level of industrial capability to construct a nuclear weapon, some states may simply take much longer than others, and some states may have a sufficiently pathological scientific infrastructure as to retard or prevent a program from taking off. In particular, countries that have neopatrimonial ruling structures seek shortcuts through importing nuclear weapons technologies without being able to absorb them properly and so end up taking longer than they would otherwise. This appearance of a negative relationship between assistance and acquisition success is thus due to the inability of certain regimes to absorb inappropriate technologies rather than this being a general effect of nuclear assistance.

Jacques Hymans' (2008) work on the relationship between neopatrimonial ruling structures and an inability to complete large-scale nuclear projects is particularly relevant here. Neopatrimonial regimes are those that undermine traditional bureaucratic structures and rely on individual, personalized rule, with little or no accountability to others.[3] Hymans argues that

> such regimes will (1) alienate or even eliminate their best scientists, promote political hacks, and generally engage in routine, counterproductive churning of personnel; (2) make suboptimal, shifting, and even bizarre technical choices, while undermining efforts to develop a long-term, coherent action plan and indeed setting various wings of the effort at odds with each other; and (3) exhaust the program and its resources through repeated "crash" efforts with unreasonable deadlines and distracting side projects (274).

Consequently, such regimes will take a much longer time to complete nuclear weapons projects, if they do at all. Neopatrimonialism is conceptually different from underdevelopment, although both have a significant effect on proliferation. Underdeveloped countries may not be able to afford certain technologies and may struggle to conduct large-scale projects because of a lack of underlying infrastructure or the materials to build them. By contrast, neopatrimonial regimes are incompetent rather than poor. They lack the ability to develop professional scientific establishments, run projects efficiently, or get good advice on which pathway to the bomb they should take.

Such regimes also will be less able to absorb assistance from other countries. Neither peaceful nuclear cooperation nor sensitive technical assistance have generally increased the likelihood of proliferation, owing to the inability of most regimes that are seeking nuclear weapons to absorb such assistance. Indeed, such assistance may end up setting certain countries back even further than they would be without such assistance by encouraging "crash" efforts based on the imported technologies rather than slowly working on an indigenous program. In part, this is because tacit knowledge, a crucial element of successful nuclear weapons programs, is more difficult to attain when attempting to adapt foreign technologies than when programs are allowed to build from the ground up and experiment through trial and error.[4] To be sure, this is not to argue that assistance, in general, should be given to all countries without any concern. Cases where assistance was given to a country that had governing structures that allowed for the timely completion of large-scale projects, such as Israel, did seem to benefit from it. Hence, past experience with assistance to neopatrimonial regimes should not be taken as a license to spread nuclear technologies to all countries.

Methodology

This paper uses a quantitative model, adopting the Singh and Way (2004) data as the base model, following Fuhrmann (2009a,b) and Kroenig (2009a,b). Singh and Way measure nuclear status along a continuum with four "degrees of nuclearness" (2004: 866): no program, exploration, pursuit, and acquisition. The first degree is no interest in nuclear weapons. The second degree is exploration, which is "demonstrated by political authorization to explore the option or by linking research to defense agencies that would oversee any potential weapons development" (Singh and Way 2004: 867). To qualify as pursuing nuclear weapons, the third degree, states must take steps such as "a political decision by cabinet-level officials, movement toward weaponization, or development of single-use, dedicated technology" (Singh and Way 2004: 866). Finally, states are coded fourth degree, having fully acquired weapons, if they either test or possess a "functional nuclear weapon" (Singh and Way 2004: 866).

Consequently, the factors that lead states in general to explore a nuclear option can be directly compared with factors that lead states to move from exploration to pursuit and from pursuit to acquisition. The transitions in this dataset are diagrammed in Figure 7.1. Not counting the United States (since the dataset starts in 1945), nineteen states have explored a nuclear option; of these, twelve have actively pursued nuclear weapons, while three states (according to their dataset) moved directly to pursuing nuclear weapons. Of the fifteen states that have pursued nuclear weapons, eight are widely considered to have built nuclear weapons by 2000. Ukraine, Belarus, and Kazakhstan are excluded because they acquired weapons without first starting a program.

There are four different types of transition pictured in Figure 7.1: From 0 to 1 (No Program → Explore), from 0 to 2 (No Program → Pursue), from 1

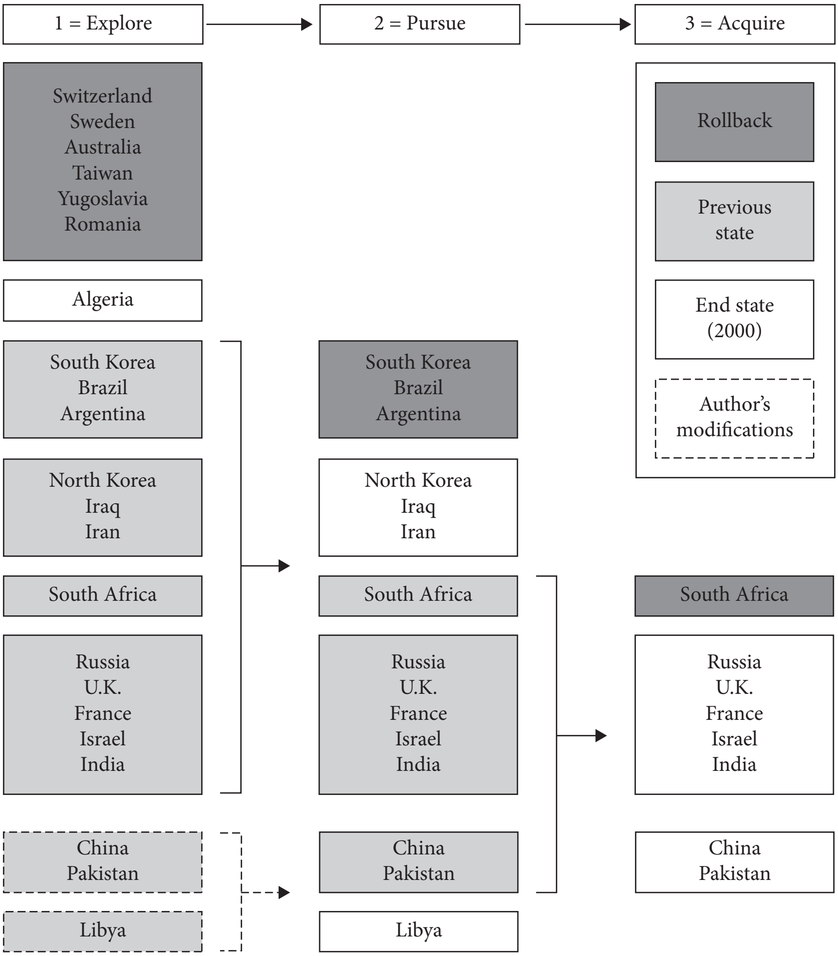

FIGURE 7.1 Proliferation transitions, Singh and Way dataset
NOTE: The United States is not included because of acquisition before the first year in the dataset.

to 2 (Explore → Pursue), and from 2 to 3 (Pursue → Acquire). The total number of countries is low for each transition. In order to give the algorithm the most information possible, a year of exploration was added for China, Pakistan, and Libya before the first year of pursuit, consistent with Montgomery and Sagan (2009). This adds three observations of states moving from 0 to 1, and three from 1 to 2, albeit within a single year, while eliminating the problematic category of moving from 0 to 2. This reflects the much more rapid movement of these three programs and is conceptually consistent with these three states possessing factors that moved them rapidly to pursuing nuclear weapons.

Three different sets of hazard models were thus tested: Model set E(xplore): 0 to 1; Model set P(ursue): 1 to 2; and Model set A(cquire): 2 to 3. In each case, the observations are censored based on the current status of the program, following Jo and Gartzke (2007) and Montgomery and Sagan (2009). A hazard model for each level (1, 2, 3) with the pool restricted to states at the previous level of development (0, 1, 2) is the most empirically relevant way to analyze this data, because it models each level as a prerequisite for the next. Since no state moves from acquiring or pursuing weapons to simply exploring them, the pools for Model set E include only states that have no program; similarly, for Model set P, only states that are exploring nuclear weapons (including Libya, Pakistan, and China for one year) are included, and for Model set A, only states that are pursuing nuclear weapons are included. This contrasts with Singh and Way's, Fuhrmann's, and most of Kroenig's models, which include all countries in all analyses.[5] In these analyses, even states that have no nuclear program are included in their models of nuclear acquisition. Yet states cannot acquire weapons without first pursuing them, and it seems unlikely that states will pursue nuclear weapons without first exploring the option, even if only for a short period of time.

Independent Variables

The variable *sensitive nuclear assistance*, "a dichotomous variable measuring whether a state has ever received the key materials and technologies necessary for the construction of a nuclear-weapons arsenal from a capable nuclear-supplier state" was adopted from Kroenig (2009b: 168). The variable *peaceful nuclear cooperation*, which "measures the aggregate number of [Nuclear Cooperation Agreements] that a state signed in a given year entitling it to nuclear technology, materials, or knowledge from another country," was adopted from Fuhrmann (2009b: 25).

In addition to these two variables, a variable *Neopatrimonialism*[6] was constructed, drawn from the individual component variables of the Polity IV dataset (Marshall and Jaggers 2009). One (1) or zero (0) was added to the variable based on the following assessments: if Competitiveness of Executive Recruitment is coded as unregulated or by selection; if Executive Constraints are coded as unlimited authority; and if Competitiveness of Participation is coded as unregulated, repressed, or suppressed. Three component variables (openness of executive recruitment, regulation of chief executive recruitment and participation) were omitted, since any coding is potentially compatible with a neopatrimonial system. While openness of executive recruitment could plausibly fit the definition, the coding of this variable seems to be suspect. For example, North Korea is coded as "open" recruitment, despite the Kims being in power since 1948. Consequently, it is excluded. This creates a variable with a range from 0 to 3. The variable was then lagged by a year, since Polity scores are based on the regime in place on December 31 of a year.

To give a few examples from the countries in the pool for acquiring nuclear weapons, France scores 0, South Africa scores 1, Iran averages 1.63, and Iraq and Libya score 3. At first glance the scores seem to be appropriate. Hymans does not provide a comprehensive list but discusses Iraq, Libya, North Korea, and Romania. All but Romania are coded 3; Romania only receives a 2 since it was coded 2 instead of a 1 on Executive Constraints (out of 7). Iran's average is brought down by a *neopatrimonialism* score of 0 after the election of Mohammad Khatami; however, this is actually consistent with the argument regarding Iran's success in its nuclear program. Until Khatami's election, the Atomic Energy Organization of Iran (AEOI) was run by "the incompetent Reza Amrollahi and a team chosen more for their revolutionary credentials than their technical skills." As a result "the Iranian nuclear program had stumbled along despite the considerable resources lavished upon it" (Pollack 2004: 362).

Neopatrimonialism, while not the opposite of democracy, nonetheless has a correlation of –0.82 with *polity* (which ranges from –10 for an autocracy to +10 for a democracy) in the overall sample, and a correlation of –0.88 in the subset of states that pursued nuclear weapons. Figure 7.2 demonstrates the relationship between *neopatrimonialism* and the standard *polity* score. In this figure, each *x*-axis runs from –10 (total autocracy) on the left to 10 (total democracy) on the right. Each of the four graphs demonstrates the distribution of *polity* given a certain level of *neopatrimonialism*, from 0 (no neopatrimonial characteristics) to 3 (all neopatrimonial characteristics). The height of the graph thus indicates the frequency distribution of different polity scores within a particular *neopatrimonialism* score. The modal democracy score of states with no neopatrimonial characteristics is 10, while the modal score for states with 2 of the 3 neopatrimonial characteristics have an autocracy score of –7. The modal polity score for a completely neopatrimonial state is –9, although –7 is close.

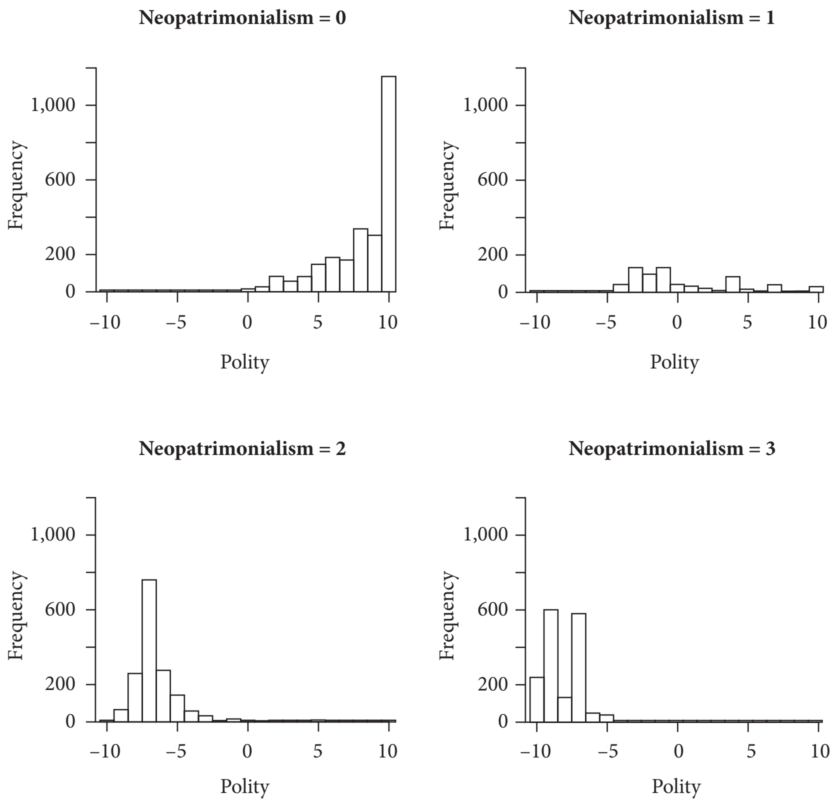

FIGURE 7.2 Frequency distribution of different polity scores within a particular neopatrimonialism score

Control Variables

All of Singh and Way's reported variables are adopted as controls. They employ three technological determinants that represent the domestic capability of a state: *GDP per capita, GDP per capita squared*, and *industrial capacity threshold*. They also include three external determinants: whether a state is involved in an *enduring rivalry*, the average number of *militarized disputes* a state is involved in over a five-year period, and whether a state is in an *alliance* with a nuclear-armed state.[7] Finally, they include five internal determinants: the *polity* score of a state in Polity IV (referred to by Singh and Way as *democracy*), a measure of *democratization* (the change in a state's polity score over a five-year period), the *percentage of democracies* in the international system, *economic openness* to trade, and a measure of *economic liberalization* (the change in trade openness over a five-year period).[8] *NPT membership* is also included in the regressions for exploration, included in Fuhrmann's models. Although it is unclear how to interpret this variable due to the mixed motives of states as they join it (see Montgomery and Sagan 2009), to exclude it entirely could introduce bias.[9]

Results

For each set of models, a base model was first run with only control variables, then each of the three above variables added in individually, then collectively, to each of the three sets of regressions (Explore, Pursue, and Acquire). Below, only regressions in which one or more of these three variables were significant are reported. Each of the control variables with the highest *p* value were eliminated one by one until all of the remaining variables were significant at the 0.10 level or below. A hazard model was used with a Weibull distribution and robust standard errors clustered on individual countries, because it gives additional information in the form of the ancillary parameter *p*.[10] The results are reported as hazard rates, so values above 1 indicate an increase in the likelihood of moving to the next level (e.g., 1.1 indicates a 10 percent increase when that variable is increased by one unit), whereas values below 1 indicate a decrease (e.g., 0.9 indicates a 10 percent decrease when that variable is increased by one unit). Table 7.1 summarizes the statistically significant findings for states moving from no program to exploring nuclear weapons, Table 7.2 from exploring to pursuing, while Tables 7.3 and 7.4 summarize the findings for states moving from pursuing to acquiring nuclear weapons.

For the transition from No Program to Explore, not all of Singh and Way's original findings are significant; for example, *GDP per capita* and its square are insignificant. However, with adding *sensitive nuclear assistance*, the *economic openness* variable seems to have a dampening effect; while neither *militarized disputes* nor *NPT membership* were originally significant in this corrected model, in the process of dropping insignificant variables, it becomes significant in Model E3. This does appear to be good news for promoters of the NPT, as membership decreases the onset of exploration by two-thirds. Neither *peaceful nuclear cooperation*, whether interacted with *militarized disputes* or not, nor *neopatrimonialism* are significant in causing countries to start exploring nuclear weapons programs. *Sensitive nuclear assistance*,

TABLE 7.1 Exploration of nuclear weapons, 1945–2000

	No program → Explore		
	E1	*E2*	*E3*
Sensitive nuclear assistance		6.2554** (0.8812)	3.7861* (0.7936)
GDP per capita	1.0004 (3.00E–04)	1.0004 (3.00E–04)	
GDP per capita squared	1 (2.00E–08)	1 (1.90E–08)	
Industrial capacity index	7.8134*** (0.7893)	7.9515** (0.8221)	8.6845**** (0.6102)
Enduring rivalry	4.1752**** (0.4283)	4.4275*** (0.4592)	4.7194**** (0.4056)
Militarized disputes	1.101 (0.0663)	1.1041 (0.0687)	
Alliance	0.58825 (0.5953)	0.54819 (0.624)	
Polity	1.0088 (0.0355)	1.0082 (0.0357)	
Democratization	0.96156 (0.0552)	0.95883 (0.0519)	
Percentage of democracies	0.96953 (0.0412)	0.94372 (0.0471)	
Economic openness	0.9865 (0.0103)	0.98225** (0.009)	0.98451** (0.0076)
Economic liberalization	0.96191** (0.0166)	0.96027*** (0.0146)	0.95686*** (0.0157)
NPT membership	0.42602 (0.6253)	0.50492 (0.5602)	0.34153** (0.5243)
Ancillary parameter *p*	0.5905*** (0.193)	0.52738*** (0.1975)	0.51848*** (0.207)
N	5,402	5,402	5,501

NOTE: $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$, $^{****}p < .001$; Models E1–3 have Explore as the dependent variable.

however, appears at first glance to be highly significant, increasing the hazard rate in Model E2 by 526 percent, although this drops to 279 percent in Model E3 once insignificant variables are excluded. The results for sensitive assistance increasing exploration are due entirely to three cases: Iran, Iraq, and Taiwan, which received assistance in 1984, 1976, and 1975, respectively, with

TABLE 7.2 Pursuit of nuclear weapons, 1945–2000

	Explore → Pursue		
	P1	*P2*	*P3*
Peaceful nuclear cooperation		1.0869* (0.0456)	1.0677** (0.0281)
GDP per capita	1.0004 (5.00E–04)	1.0004 (6.70E–04)	
GDP per capita squared	1 (3.40E–08)	1 (5.00E–08)	
Industrial capacity index	4.9369 (1.799)	3.3117 (1.797)	
Enduring rivalry	4.9109 (1.255)	5.2034 (1.187)	6.6611** (0.7952)
Militarized disputes	1.4334*** (0.1319)	1.4853**** (0.1054)	1.3046*** (0.0809)
Alliance	0.87103 (0.5056)	1.115 (0.7184)	
Polity	1.0232 (0.05)	1.0449 (0.0797)	
Democratization	0.90431 (0.0953)	0.91283 (0.0744)	
Percentage of democracies	0.87503 (0.1158)	0.86038 (0.1629)	
Economic openness	1.003 (0.0256)	1.0221 (0.028)	
Economic liberalization	1.0033 (0.029)	1.0002 (0.0272)	
Ancillary parameter *p*	1.7494 (0.3553)	1.5507 (0.3739)	1.4342* (0.1894)
N	250	250	250

NOTE: $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$, $^{****}p < .001$; Models P1–3 have Pursue as the dependent variable.

the latter coding only affecting Taiwan's second nuclear weapons program in 1987, since it was already exploring nuclear weapons during its first program (1967–1977). In Model E3 of Table 7.1, the parameter *p* is 0.52; after ten years of not exploring nuclear weapons, a country is 9.52 times less likely to fail than after one year, which is good news for the nonproliferation regime: The longer that states do not explore nuclear weapons, the less likely it is that they will ever do so.

TABLE 7.3 Acquisition of nuclear weapons, 1945–2000, single-variable models

	Pursue → Acquire			
	A1	*A2*	*A3*	*A4*
Sensitive nuclear assistance		0.2941* (0.6391)		
Peaceful nuclear cooperation			0.8298** (0.0755)	
Neopatrimonialism				0.5186* (0.3898)
GDP per capita	1 (9.80E–04)	0.9998 (0.001)	1.001 (0.0013)	1 (0.0011)
GDP per capita squared	1 (7.80E–08)	1 (8.00E–08)	1 (9.50E–08)	1 (8.30E–08)
Industrial capacity index	3.1e+07**** (1.306)	2.2e+07**** (1.342)	2.3e+08**** (2.162)	1.2e+07**** (1.398)
Enduring rivalry	4.282 (1.373)	3.264 (1.437)	3.227 (1.446)	4.722 (1.306)
Dispute involvement	1.09 (0.1867)	1.192 (0.1917)	0.9832 (0.205)	1.076 (0.1783)
Alliance	1.057 (1.116)	1.304 (1.209)	1.992 (2.168)	0.894 (1.141)
Polity	1.109 (0.0803)	1.068 (0.0762)	1.276*** (0.0759)	
Democratization	0.9421 (0.0725)	0.9733 (0.0772)	0.9944 (0.1243)	0.9469 (0.0729)
Percentage of democracies	0.9509 (0.1994)	0.9554 (0.1932)	0.7917 (0.1838)	0.9648 (0.1992)
Economic openness	0.9856 (0.0285)	1.004 (0.0339)	0.907 (0.0647)	0.9853 (0.0303)
Economic liberalization	0.9746 (0.0285)	0.9741 (0.0314)	0.9632 (0.0315)	0.9749 (0.0278)
Ancillary parameter *p*	2.152**** (0.2065)	2.264**** (0.1904)	4.584**** (0.3745)	2.095*** (0.236)
N	210	210	210	210

NOTE: *$p < .1$, **$p < .05$, ***$p < .01$, ****$p < .001$; Models A1–4 have Acquire as the dependent variable.

TABLE 7.4 Acquisition of nuclear weapons, 1945–2000, combined models

	Pursue → Acquire			
	A5	*A6*	*A7*	*A8*
Sensitive nuclear assistance	0.1101** (0.8654)	0.2078** (0.7497)	0.7069 (0.5564)	
Peaceful nuclear cooperation	0.7526*** (0.0989)	0.8853**** (0.0258)		0.9271*** (0.0287)
Neopatrimonialism	0.1686*** (0.5441)	0.3166*** (0.4157)	0.6236 (0.3478)	1.793* (0.3515)
Neopatrimonialism* Sensitive nuclear assistance			0.7162 (0.5129)	
Neopatrimonialism* Peaceful nuclear cooperation				0.6561*** (0.134)
GDP per capita	1.001 (0.0017)			
GDP per capita squared	1 (1.20E–07)			
Industrial capacity index	5.7e+07**** (2.899)	1.1e+07**** (0.7429)	6.6e+06**** (0.877)	1.9e+07**** (1.063)
Enduring rivalry	1.864 (1.644)			
Dispute involvement	0.996 (0.1749)			
Alliance	1.005 (2.243)			
Polity				
Democratization	1.165 (0.1432)			
Percentage of democracies	0.7714 (0.2133)			
Economic openness	0.9137 (0.0842)			
Economic liberalization	0.9629 (0.0521)			
Ancillary parameter *p*	5.838**** (0.3565)	3.169**** (0.2498)	1.836**** (0.1637)	3.133**** (0.2066)
N	210	210	210	210

NOTE: $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$, $^{****}p < .001$; Models A5–8 have Acquire as the dependent variable.

Moving from Explore to Pursue, very few of Singh and Way's original findings persist; only *militarized disputes* are significant in Model P1, although *enduring rivalry* becomes significant by Model P3. Neither *neopatrimonialism* nor *sensitive nuclear assistance* affect the rate of moving from exploration to pursuit; however, an increase in *peaceful nuclear cooperation* by one unit increases the hazard rate by 8.7 and 6.8 percent in Models P2 and P3, respectively. An interaction term between *peaceful nuclear cooperation* and *militarized disputes*, significant in Fuhrmann's original findings, is insignificant for Model P2. Including a variable for the NPT as per Fuhrmann's specification in Models P2 and P3 does make a *peaceful cooperation–militarized disputes* interaction term significant while making both lower-order terms insignificant, commensurate with his original findings. Here, the news in the ancillary parameter is less favorable: When exploring a nuclear weapons program, after ten years a country is 2.72 times more likely to pursue in Model P3 than after just one year. Modeling a two-step instead of a three-step model produces results similar to Fuhrmann's original results (unsurprising, since half of his models test precisely that proposition), while providing no new significant coefficients for *neopatrimonialism* or *sensitive nuclear assistance*.

Moving from pursuit to acquisition in Table 7.4, few control variables are still significant: Only *industrial capacity index* is consistent, although *polity* is briefly significant in Model A3. This is probably due to the negative correlation between *neopatrimonialism* and *polity*. Both *sensitive nuclear assistance* and *peaceful nuclear cooperation* are significant—but in the opposite expected direction. In Model A2, *sensitive nuclear assistance* decreases the hazard rate by 70 percent, while a one-unit increase in *peaceful nuclear cooperation* in Model A3 decreases it by 17 percent. Moreover, *neopatrimonialism* decreases the hazard rate by 48 percent in Model A4. When run together with all of the controls in Model A5 in Table 7.4, they decrease the hazard rate even further, by 89, 25, and 83 percent, respectively. Since the *industrial capacity index* has such an overwhelming effect here, a separate model was run with just the three independent variables; all were significant at the 0.05 level, and decreased the hazard rate by 84, 12, and 72 percent, respectively.

Because of the low number of observations, it is difficult to determine statistically whether there is a quantitatively observable interaction effect between *neopatrimonialism* and nuclear assistance. Although interaction terms were generally in the expected direction, they were frequently insignificant. In a model (A7) with only *neopatrimonialism*, *sensitive nuclear assistance*, the interaction between the two, and *industrial capacity*, all coefficients were in the expected direction but insignificant; that is, states that were neopatrimonial and received assistance did even worse than would be expected from either of those alone. When combining *neopatrimonialism*, *peaceful nuclear cooperation*, the interaction between the two, and *industrial capacity*, the results were significant, although there appears to be a strange neopatrimonial bonus if they receive no cooperation at all. This would presumably be the rare weapons-seeking state that did not seek external peaceful assistance as well, and is caused by the inclusion of the Soviet Union and China (and the exclusion of the United States) in the dataset; without those two observations, no bonus exists.

Finally, there does seem to be some urgency around stopping serious nuclear programs early; in Model A6, according to the ancillary parameter, a country still pursuing nuclear weapons after ten years is 147 times more likely to acquire them than after one year. This is likely a partial artifact of the physical reality that even the most accelerated nuclear weapons program takes a significant amount of time.

Discussion

Table 7.5 lists the characteristics of every state that pursued nuclear acquisition and offers some significant clues to the puzzle of why nuclear assistance seems to backfire. Among the top group, states that had no assistance took less time to complete their successful nuclear development program; the average number of years in the pool regardless of success or failure for states receiving assistance is 18.0, versus 8.3 for those not receiving it. Those successful without assistance took an average of about 7.3 years, while those with assistance took double the time: about 14.6 years. This compares poorly with the 6.5-year estimate by Harney et al. for a first nuclear weapon in a country with a low level of resources (Harney et al. 2006). Note that the Acquire Pool Years may in some cases seem inaccurate. Iraq's program could be reasonably coded as ending in 1991 instead of post-2000. North Korea's plutonium program was effectively suspended as of 1994, so it was only 14.0 instead of 20.0 years in development by 2000. Iran's program as of 2010 would be 25.0 years in with still no bomb. India's program could be seen as a "double-dip" as far as the variables go, but if the United States were included instead, that would be a wash for two of the three variables in question and would intensify the effect of peaceful

TABLE 7.5 Characteristics of success and failure (Singh and Way dataset)

Country	*Acquire pool years*	*Years in pool*	*Assist year*	*Neopat. (mean)*	*NCA to date (mean)*	*Main method*	*2000 result*
Russia	1945–1949	5		3.00	0.0	Pu	Success
United Kingdom	1947–1952	6		0.00	0.0	Pu	Success
France	1954–1960	7		0.00	6.7	Pu	Success
China	1955–1964	10	1958	2.00	1.9	HEU-GD	Success
Israel	1958–1972	15	1959	0.00	4.5	Pu	Success
India (1)	1964–1974	11		0.00	21.7	Pu	Success
India (2)	1980–1988	9		0.00	21.7	Pu	Success
Pakistan	1972–1990	19	1974	1.58	16.6	HEU-Cent	Success
South Africa	1974–1979	6		1.00	3.7	HEU-Aero	Success
Average success		**9.8**		**0.76**	**7.7**		
Korea (South)	1970–1978	9		2.00	4.3	Pu	Quit
Libya	1970–	31	1997	3.00	9.8	HEU-Cent	Still trying (quit 2003)
Argentina	1978–1990	13		1.38	37.6	HEU-GD	Quit
Brazil	1978–1990	13	1979	1.00	45.1	HEU-Cent	Quit
Korea (North)	1980–	21	1997	3.00	3.5	Pu	Still trying (test 2006)
Iraq	1982–	19	1976	3.00	9.9	HEU-Cent	Still trying (invaded 2003)
Iran	1985–	16	1984	1.63	15.7	HEU-Cent	Still trying
Average failure		**17.4**		**2.14**	**18.0**		

NOTE: NCA = nuclear cooperation agreement. Main methods are plutonium (Pu) or highly enriched uranium (HEU), of which there are three variants here: centrifuges (Cent), gaseous diffusion (GD), and aerodynamic separation (Aero).

nuclear cooperation dampening the likelihood of acquisition. However, none of the possible modifications would significantly alter the patterns in the table or regressions. The same applies to civilian nuclear assistance. Comparing the top and bottom groups, those that received less civilian nuclear aid were more likely to succeed (7.7 nuclear cooperation agreements [NCAs] versus 18.0 NCAs). What explains these counterintuitive results for nuclear assistance?

First, sensitive assistance tends to be given to states that are at least weakly neopatrimonial; out of the twelve cases of sensitive assistance in total, only three had neopatrimonial scores of 0 at the time (Israel, Japan, and Pakistan); five had a score of 2 (Iran, Taiwan, Egypt, Brazil, and China), and four had a score of 3 (North Korea, Algeria, Iraq, and Libya). The average neopatrimonial level of a state that succeeded was far less (0.76) than those that failed (2.14). Put another way, every state except China that had a neopatrimonial score of 2 or higher at the time of assistance failed to develop nuclear weapons by the end of the data sample.

How do *neopatrimonialism* and *sensitive assistance* combine to slow countries down? Given that China managed to do so despite this combination, it bears a closer look. China, to a certain extent, managed to develop nuclear weapons despite the constant internal political interference in their program and despite the assistance that was first given to them, then removed, by the Soviet Union. According to Lewis and Xue, the Soviets refused to train Chinese engineers in their gaseous diffusion plants and refused to give access to the original blueprints. Chinese workers then "wantonly" attempted to modify nuclear industrial equipment supplied by the Soviet Union due to political pressures from well-connected individuals during the Great Leap Forward, causing over 290 accidents. The minister in charge had to appeal directly to Mao Zedong in order to stop the workers from modifying the equipment (Lewis and Xue 1988: 117–125).

Combining sensitive assistance with a neopatrimonial system that could not absorb it led to a lack of tacit knowledge on the shop floor, which significantly delayed the Chinese program. The Soviets simply refused to train workers. A Chinese survey in 1961 after the advisors left discovered 1,395 technical problem areas, the most troublesome of which resulted from the "inexperience and low technical level of most of the staff" (Lewis and Xue 1988: 124). The pumps had to be lubricated specially to prevent corrosion from uranium hexafluoride; the Soviets had locked away these special lubricants and took them with them when they left the country, leading to a frantic mission to find a suitable replacement. Moving from an external supplier's technology to indigenous technology cost the Chinese an estimated 700 days, a length comparable to the time that the Soviet advisors had "assisted" the Chinese (Lewis and Xue 1988: 117–125). Although it is difficult to spin out the full counterfactual, it is certainly plausible that if the Chinese had relied on building up indigenous technologies instead of having to reverse engineer lubricants and re-create missing blueprints, it would have taken them less time overall. Hymans argues that China is the exception that proves the rule for neopatrimonial states, since the nuclear program was protected by "military and party heavyweights" (Hymans 2008: 276).

The Chinese may have gotten lucky. Most proliferators who received (or stole) foreign assistance stuck with the technological paths that their supposed benefactors started them on, even when they were abandoned (North Korea is a notable exception, which may be why they ultimately succeeded). Those that were given relatively straightforward, if inefficient, technologies succeeded (the Chinese and Israelis), while those that were given centrifuges stuck with them—to their probable detriment. Centrifuges are "self-disassembling" machines that require a number of high-precision parts and careful trial-and-error experiments in order to operate correctly. Those who adopted centrifuges have spent on average 19.6 years in the pool, with a single success (Pakistan). Gaseous diffusion is a much better choice; if the United States were in the pool, the average number of years in the pool would be 9.0, with two successes. Even this number is deceptively high, since Argentina announced its facility in 1983, although it is unclear at what level, if any, it worked at (Montgomery and Mount 2010). Plutonium from natural uranium reactors is also a good choice, with 10.4 average years in the pool and a 75 percent success rate, although the former is somewhat inflated by continuing to count North Korea's program during the Agreed Framework, which froze the Democratic People's Republic of Korea's plutonium program. Rolling your own technology seems to work even better: South Africa completed its first device in only 6.0 years, although Pretoria did not produce fully weaponized devices for a couple more years.

Poor technology choice can be exacerbated not only by assistance (which creates and reinforces poor technological paths) but also by neopatrimonial government (which undermines competent administration). The Iraqis tried practically every technology, dividing efforts and minimizing progress; the Libyans proved incapable even at setting up the centrifuges that they received from the A. Q. Khan network; the Iranians put an incompetent political appointee in charge of their program; and the North Koreans failed to produce a full nuclear yield from either of their tests.[11] Pakistan took 19.0 years in the dataset (most of it as a neopatrimonial state) to develop a nuclear capability despite having more recorded assistance than any other country. Recently,

A. Q. Khan has claimed that China transferred not only uranium enrichment technology, plutonium reprocessing assistance, and a nuclear weapons design to Pakistan, but also 50 kilograms of highly enriched uranium (Smith and Warrick 2009). Even if this were not true, the Pakistani program probably received more help than any other—and yet still took more years than any other successful country in the dataset.

Israel is the only case in which sensitive nuclear assistance was given and seemed to fully succeed; it is also the only case of assistance in which the government was free of neopatrimonial pathologies. Consequently, it is also the case to be most wary of for nonproliferation. Sustained assistance with proven technologies from a friendly foreign government that was already on the verge of exploding its own nuclear weapon seems to have helped the program; yet it still took a longer period than any country other than Pakistan to acquire nuclear capability. Conversely, other datasets argue for periods up to six years shorter (1966 or 1967), although even with more optimistic dates, the Israeli program is at best average in completion time. Nonetheless, Israel's strategy was risky as well; the French government delayed the project twice for a significant period, and when Charles de Gaulle decided to cancel nuclear assistance, the Israelis had to convince the French government to allow the French contractor to finish Dimona (Cohen 1998: 75).

There are other risks involved in seeking foreign assistance for nuclear programs, in that the help that may be received—especially parts—can be sabotaged. The quality of parts given through clandestine nuclear assistance—especially those transmitted through proliferation networks—is even worse than the quality of the vehicles sold by unscrupulous used car salesman. The centrifuges spread through the A. Q. Khan network were probably used rejects from their program, evidenced by traces of highly enriched uranium on the Iranian imports. When the United States refused to assist Israel in bombing the Iranian program in 2008, it impressed upon the Israelis that they were actively sabotaging the Iranian program (Sanger 2009). The United States has had a long history of attempting to misguide Iran; even in the days of the Shah, the United States permitted the export of lasers intended for uranium enrichment, since U.S. government specialists had concluded that the technology in question was unworkable (Spector and Smith 1990: 207). Of course, even sabotage can backfire. James Risen has claimed that the Central Intelligence Agency leaked part of a nuclear weapons design to the Iranians with an intentional flaw that might have been discovered, thereby accelerating the program (Risen 2006).

What about peaceful nuclear assistance? It is clear that the states that had succeeded by 2000 had a very low average assistance (7.7) compared to the failed group, which had a great deal of assistance (averaging 18.0). The only additional success since then has been North Korea, the state with the fewest average NCAs in the failure pool. It is also worth reexamining the two states that had the highest levels of civilian nuclear assistance and still succeeded in developing nuclear weapons: Pakistan and India. Despite extensive peaceful nuclear assistance, both of them took a lengthy amount of time to finish their nuclear programs. While Pakistan received a great deal of peaceful nuclear assistance with their plutonium program, it was ultimately the uranium route which they chose, where most of the assistance they received was helping themselves: A. Q. Khan stole blueprints for centrifuges from the consortium of operational enrichment plants in Europe (URENCO) then built them by creating a clandestine network to produce parts that could not be made at home. Hardly peaceful nuclear assistance!

India is, if anything, the poster child for how peaceful nuclear assistance can lead to proliferation. At the same time, India's experiences also demonstrate the problems of attempting to import nuclear technology for proliferation instead of building technologies indigenously. Bhabha predicted in 1965 that India could produce a nuclear explosive in eighteen months; instead, it took nine years. The Phoenix plutonium extraction plant, built by Indians with U.S. blueprints and assistance, suffered from explosions and was "wholly dependent on the availability and utilization of fittings and supplies from the USA or elsewhere." India had severe difficulties building and operating heavy water reactors after it was cut off: The successor to the Cirus reactor, the Dhruva, had severe vibrations in the reactor core and had to be shut down soon after starting operation. It did not reach full operating capacity until 1988, two and a half years after it went critical (Perkovich 1999: 95).

This is not to argue that India was held back by peaceful nuclear assistance. Rather, India's experience demonstrates that there are significant problems in relying on foreign assistance, and that those areas of foreign assistance that are most useful are easily identified. The controls on the spread of plutonium separation technology and heavy water reactors that are known as bomb factories have probably helped significantly. Further, India still lacked crucial components for building a larger, deliverable arsenal; the 1974 test was a device that weighed 1,000 kilograms, and Indian scientists did not develop a smaller weapon until 1982. Yet India still could not produce a sufficient amount of heavy water indigenously and lacked a domestic supply of beryllium. Had the Germans not had such lax export controls, India could have been denied one or both—since India had to smuggle Chinese heavy water through a German source in the early 1980s and simply bought beryllium from a German company in 1984 (Perkovich 1999: 242, 250, 271).

Finally, these variables have emphasized primarily the quantity of help, not the quality. Some types of nuclear assistance are much more likely than others to advance nuclear weapons programs. Heavy water reactors, such as the one used by India as the source of the plutonium for their first atomic explosive, certainly help more than safety assistance or large, light water power reactors. Kroenig found that peaceful nuclear assistance in the form of research or power reactors decreases the probability of a nuclear weapons program (Kroenig 2009b: 178, fn. 21). Even within the category of sensitive assistance, some types of assistance are likely to help more than others; a nuclear weapons design or transferred sensitive nuclear materials are more likely to lead to proliferation than more generic help, such as smaller hot cells capable of reprocessing plutonium in small, but not industrial-size, quantities.

Conclusion

While it is clear that the spread of both sensitive and peaceful nuclear assistance has had much less of an impact on nuclear proliferation than generally has been thought, this does not imply that peaceful or sensitive nuclear assistance should be spread throughout the world without concern. It does indicate that such assistance may be less likely to cause nuclear proliferation than has been previously thought. The bargain of the nonproliferation regime seems to be holding, at least in part, since the net effect of increased peaceful assistance seems to be a decrease in the overall likelihood of the country acquiring a nuclear weapon. The results from models of exploration also offer some hope, since NPT membership in the final model decreased the likelihood of exploration of a nuclear option by two-thirds. Also, the longer a country abstains from exploring nuclear weapons programs, the less likely it is to start. Outside of the models here, it is worth noting that the spread of peaceful nuclear assistance is a valuable bargaining tool. For example, since nuclear technology brings prestige to countries, substituting nuclear prestige in the form of light water power plants for nuclear prestige in the form of nuclear weapons seems like a pretty good bargain. However, as more countries develop governing structures that can competently handle large-scale projects, the value (and danger) of nuclear assistance is likely to increase. For these states, nuclear assistance could truncate timelines for an existing nuclear weapons program and, perhaps, increase countries' incentives to pursue nuclear weapons in the first place.

Conclusions here are similar to those of Kroenig (Chapter 8 in this volume) but for very different reasons. He finds no support for the proposition that countries trade sensitive nuclear technologies for economic motives; rather, it is only under specific and rare circumstances that countries will supply such technologies. Consequently, we do not need to fear at least this mechanism for nuclear proliferation if a nuclear renaissance occurs.

This chapter's conclusions agree, with a second argument added: The lack of apparently harmful effects is simply due to the inability of countries to absorb technologies. This is particularly the case for neopatrimonial regimes, which are less likely to be able to successfully complete a nuclear weapons program than are other countries. The dual problem of developing the requisite tacit knowledge for fissile materials production combined with the difficulty of competently building and running large-scale technological systems is too much for these countries. When countries are run by fear and management positions are handed out as patronage, good scientific advice and management are very hard to attain. Such countries do not have the patience or ability to cycle through the expensive trial-and-error learning that is required to develop the requisite tacit knowledge. In these situations, importing nuclear technology is less likely to lead to nuclear weapons programs, or even effective nuclear power programs. Yet this does not mean that such countries are entirely incapable of producing either. The example of China is instructive: It managed to succeed despite assistance, and despite the usual neopatrimonial governing structures. Similarly, North Korea succeeded, but only after trying for a very long time. In part, both of these cases succeeded because they chose their technologies well, adopting simpler methods. These cases also point to a caution: While tacit knowledge and neopatrimonialism may slow the spread of some technologies, others are less constrained. For example, while plutonium reprocessing in a neopatrimonial state such as North Korea may be dirty, slow, and inefficient, it will still work. An omitted variable that undoubtedly affects these results is the question of how hard different countries are trying—perhaps many of these regimes are not succeeding simply because they are not nearly as pressed as others are.

The potential broadening of worldwide nuclear power should not be a concern for proliferation to regimes that lack the governance structures to develop weapons. However, regimes that have the requisite structures may still be at risk for proliferation. By the same token, the Fukushima accident is a reminder that even the most seemingly competent regimes can make errors in their deployment of large-scale technologies; even such states may struggle to translate outside assistance into effective nuclear energy programs, let alone nuclear weapons. The nonproliferation regime has adapted over time to prevent the most proliferation-prone types of dual-use technology, making peaceful nuclear assistance even safer than before. If any future expansion of nuclear power takes the form that it has in the more recent past—that is, primarily light water nuclear power reactors—then nuclear weapons proliferation will likely remain as it has been in the past, if not slower. To adopt Kenneth Waltz's phrase, it will hardly be proliferation; at most, it will be glacial spread (Sagan, Waltz, and Betts 2007: 136).

Notes

1. On the market/hierarchy distinction, see Williamson 1985; on network forms of transactions, see Powell 1990, Podolny and Page 1998. On the relationship between the transaction types and proliferation, see Montgomery 2008. See Montgomery 2005 on how these characteristics have limited proliferation.

2. This literature is exemplified by Langewiesche 2007; for an incisive critique, see Bunn 2007.

3. Hymans draws his characterization from Eisenstadt 1973, Clapham 1985, Chehabi and Linz 1998.

4. MacKenzie and Spinardi 1995, MacKenzie 1999, Montgomery 2005.

5. Model 4 of Table 2 of Kroenig (2009b) on p. 171 includes a censored hazard model, although oddly enough, the list of states that could acquire nuclear weapons was obtained from a different dataset (Jo and Gartzke 2007).

6. Thanks to Bryan Nakayama for his original construction of the variable.

7. Since Fuhrmann 2009a,b recalculates their disputes variable and uses the new calculation to create interaction effects, his version of the disputes variable was used.

8. The percentage of democracies is a systemic variable rather than an internal one.

9. This variable was only significant for one regression in Explore and none for Pursue or Acquire, so it is included only in the Explore results.

10. When $p > 1$, the hazard increases over time; when $p < 1$, it decreases over time. Cox models turned out statistically similar results, with no changes in the significance of the results for almost all models, including the last (and probably best) model for exploration, pursuit, and acquisition.

11. On North Korea, Libya, and Iraq, see Hymans 2008; on troubles with tacit knowledge and nuclear networks with North Korea, Libya, and Iran, see Montgomery 2005. On the North Korean tests, see Garwin and von Hippel 2006 and Shanker and Broad 2009.

References

Braun, Chaim, and Christopher F. Chyba. 2004. "Proliferation Rings: New Challenges to the Nuclear Nonproliferation Regime." *International Security* 29 (2): 5–49.

Bunn, Matthew. 2007. "Bombs We Can Stop." *American Scientist* 95 (5): 452–454.

Chehabi, Houchang E., and Juan J. Linz. 1998. *Sultanistic Regimes*. Baltimore, MD: Johns Hopkins University Press.

Clapham, Christopher S. 1985. *Third World Politics: An Introduction*. Madison: University of Wisconsin Press.

Cohen, Avner. 1998. *Israel and the Bomb*. New York: Columbia University Press.

Eisenstadt, Shmuel N. 1973. *Traditional Patrimonialism and Modern Neopatrimonialism*. Beverly Hills, CA: Sage Publications.

Fuhrmann, Matthew. 2008. "Exporting Mass Destruction? The Determinants of Dual-Use Trade." *Journal of Peace Research* 45 (5): 633–652.

———. 2009a. "Taking a Walk on the Supply Side: The Determinants of Civilian Nuclear Cooperation." *Journal of Conflict Resolution* 53 (2): 181–208.

———. 2009b. "Spreading Temptation: Proliferation and Peaceful Nuclear Cooperation Agreements." *International Security* 34 (1): 7–41.

Garwin, Richard L., and Frank N. von Hippel. 2006. "A Technical Analysis of North Korea's Oct. 9 Nuclear Test." *Arms Control Today* 36 (9): 3.

Harney, Robert, Gerald Brown, Matthew Carlyle, Eric Skroch, and Kevin Wood. 2006. "Anatomy of a Project to Produce a First Nuclear Weapon." *Science and Global Security* 14 (2–3): 163–182.

Hymans, Jacques E. C. 2008. "Assessing North Korean Nuclear Intentions and Capacities: A New Approach." *Journal of East Asian Studies* 8 (2): 259–292.

Jo, Dong-Joon, and Erik Gartzke. 2007. "Determinants of Nuclear Weapons Proliferation." *Journal of Conflict Resolution* 51 (1): 1–28.

Kegley, Charles W. 1980. "International and Domestic Correlates of Nuclear Proliferation: A Comparative Analysis." *Korea and World Affairs* 4: 5–37.

Kroenig, Matthew. 2009a. "Exporting the Bomb: Why States Provide Sensitive Nuclear Assistance." *American Political Science Review* 103 (1): 113–133.

———. 2009b. "Importing the Bomb: Sensitive Nuclear Assistance and Nuclear Proliferation." *Journal of Conflict Resolution* 53 (2): 161–180.

———. 2010. *Exporting the Bomb: Technology Transfer and the Spread of Nuclear Weapons*. Ithaca, NY: Cornell University Press.

Langewiesche, William. 2007. *The Atomic Bazaar: The Rise of the Nuclear Poor*. New York: Farrar, Straus.

Lewis, John Wilson, and Litai Xue. 1988. *China Builds the Bomb*. Stanford, CA: Stanford University Press.

MacKenzie, Donald. 1999. "Theories of Technology and the Abolition of Nuclear Weapons." In *The Social Shaping of Technology*, eds. D. A. MacKenzie and J. Wajcman. Philadelphia, PA: Open University Press.

MacKenzie, Donald, and Graham Spinardi. 1995. "Tacit Knowledge, Weapons Design, and the Uninvention of Nuclear Weapons." *American Journal of Sociology* 101 (1): 44–99.

Marshall, Monty, and Keith Jaggers. 2009. "Polity IV Project: Political Regime Characteristics and Transitions, 1800–2007." Severn, MD: Center for Systematic Peace.

Meyer, Stephen M. 1984. *The Dynamics of Nuclear Proliferation*. Chicago: University of Chicago Press.

Montgomery, Alexander H. 2005. "Ringing in Proliferation: How to Dismantle an Atomic Bomb Network." *International Security* 30 (2): 153–187.

———. 2008. "Proliferation Networks in Theory and Practice." In *Globalization and WMD Proliferation: Terrorism, Transnational Networks, and International Security*, eds. J. A. Russell and J. J. Wirtz. London: Routledge.

Montgomery, Alexander H., and Scott D. Sagan. 2009. "The Perils of Predicting Proliferation." *Journal of Conflict Resolution* 53 (2): 302–328.

Montgomery, Alexander H., and Adam J. Mount. 2010. "Misunderestimation: Explaining US Failures to Predict Nuclear Weapons Programs." Paper presented at the Intelligence and Nuclear Proliferation Conference. London, UK. June 3–4.

Perkovich, George. 1999. *India's Nuclear Bomb: The Impact on Global Proliferation*. Berkeley: University of California Press.

Podolny, Joel M., and Karen L. Page. 1998. "Network Forms of Organization." *Annual Review of Sociology* 24: 57–76.

Pollack, Kenneth M. 2004. *The Persian Puzzle: The Conflict between Iran and America*. New York: Random House.

Powell, Robert. 1990. *Nuclear Deterrence Theory: The Search for Credibility*. New York: Cambridge University Press.

Risen, James. 2006. "George Bush Insists that Iran Must Not Be Allowed to Develop Nuclear Weapons. So Why, Six Years Ago, Did the CIA Give the Iranians Blueprints to Build a Bomb?" *Guardian*, January 5. Available at: http://www.guardian.co.uk/environment/2006/jan/05/energy.g2/print.

Sagan, Scott D, Kenneth Waltz, and Richard K. Betts. 2007. "A Nuclear Iran: Promoting Stability or Courting Disaster?" *Journal of International Affairs* 60 (2): 135–150.

Sanger, David E. 2009. "U.S. Rejected Aid for Israeli Raid on Nuclear Site." *New York Times*, January 11. Available at: http://www.nytimes.com/2009/01/11/washington/11iran.html?pagewanted=all.

Shanker, Thom, and William J. Broad. 2009. "Seismic Readings Point to a Small Nuclear Test." *New York Times*, May 26. Available at: http://www.nytimes.com/2009/05/26/world/asia/26threat.html.

Singh, Sonali, and Christopher Way. 2004. "The Correlates of Nuclear Proliferation: A Quantitative Test." *Journal of Conflict Resolution* 48 (6): 859–885.

Smith, R. Jeffrey, and Joby Warrick. 2009. "A Nuclear Power's Act of Proliferation." *Washington Post*, November 13. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2009/11/12/AR2009111211060.html.

Spector, Leonard S., and Jacqueline R. Smith. 1990. *Nuclear Ambitions: The Spread of Nuclear Weapons, 1989–1990*. Boulder, CO: Westview Press.

Williamson, Oliver E. 1985. *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York: Free Press.