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Determinants of Nuclear Weapons Proliferation

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Nuclear weapons proliferation is a topic of intense interest and concern among both academics and policy makers. Diverse opinions exist about the determinants of proliferation and the policy options to alter proliferation incentives. We evaluate a variety of explanations in two stages of nuclear proliferation, the presence of nuclear weapons production programs and the actual possession of nuclear weapons. We examine proliferation quantitatively, using data collected by the authors on national latent nuclear weapons production capability and several other variables, while controlling for the conditionality of nuclear weapons possession based on the presence of a nuclear weapons program. We find that security concerns and technological capabilities are important determinants of whether states form nuclear weapons programs, while security concerns, economic capabilities, and domestic politics help to explain the possession of nuclear weapons. Signatories to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) are less likely to initiate nuclear weapons programs, but the NPT has not deterred proliferation at the system level.

Keywords: *nuclear proliferation; counterproliferation; nuclear weapons; security; nuclear nonproliferation treaty; capabilities; quantitative*

Nuclear proliferation draws considerable speculation and debate among both academic researchers and in policy circles. Much of existing research on nuclear proliferation is qualitative or case based. Relatively few attempts have been made to apply statistical analysis to the subject.[1] Given a diversity of theoretical claims and the complex contingent nature of the topic, we view multivariate regression as an essential part of better understanding and cumulative knowledge of nuclear proliferation. We begin by pointing out that there are two related but also distinct stages of nuclear proliferation—the presence of nuclear weapons programs and the possession of nuclear weapons. A nuclear weapons production program does not necessarily lead to the possession of nuclear weapons. Factors that help to explain the decision to develop a nuclear weapons program may not be as relevant in deciding whether to

produce nuclear weapons. Similarly, policies designed to address proliferation of nuclear weapons may be ineffective in thwarting weapons production. With few systematic tests, it is possible for expert opinion and policy recommendations to be formulated in error.

This study assesses the effect of domestic and international conditions on states' decisions to pursue nuclear weapons production programs and to produce actual nuclear weapons. None of the existing nuclear weapons states obtained their arsenals except through the instrumental step of a nuclear weapons development program. While it is conceivable that weapons may be purchased or stolen in the future, we are not able to apply meaningful empirical tests to such claims in explaining the possession of nuclear weapons in the current nonproliferation regime. Therefore, we introduce a censored model for the second stage where the possession of nuclear weapons is contingent on the presence of a nuclear production program. We also juxtapose a noncensored model and the censored model of nuclear weapons possession. The comparison between the censored model and the noncensored model reveals that assessing the causes of nuclear proliferation without addressing the interaction between the two stages of nuclear proliferation may invite erroneous conclusions.

A Simple Conceptual Framework

We can think of the determinants of nuclear proliferation in terms of opportunity and willingness (Most and Starr 1989).[2] Nuclear opportunity refers to environmental constraints and also the potential for a country to manufacture nuclear weapons (Siverson and Starr 1990, 48). Considering that no state has ever imported or had operational use over nuclear weapons deployed by another state,[3] we treat the capability to build nuclear weapons as comparable to a state's opportunity for nuclear weapons proliferation. Nuclear willingness refers to a set of factors leading to the eagerness of a country to possess nuclear weapons. Willingness includes domestic and geopolitical conditions that influence the decision to seek nuclear weapons. Considering that proliferators are subject to diplomatic pressure and international sanctions, as well as moral and legal condemnation (cf. National Conference of Catholic Bishops 1983), only states that are willing to suffer significant international disapproval and are materially capable of proliferation are likely to proliferate.[4]

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Opportunity

Opportunity refers to "the possibilities that are available to any entity within any environment, representing the total set of environmental constraints and possibilities" (Siverson and Starr 1990, 48). Opportunity for nuclear weapons production can be organized into three categories. The first is the set of technologies (knowledge) related to the manufacture of nuclear weapons. Even though the number of states that could develop nuclear weapons has increased substantially since World War II, nuclear technologies are severe obstacles for poor and undeveloped states. The second category is related to nuclear fissile materials. There have always been severe restrictions on the production and trade of nuclear fissile materials (Helmreich 1986).[5] The third category involves economic capacity. The cost of nuclear weapons proliferation has increased over time because of the need for larger, more sophisticated nuclear arsenals and more complex control and delivery systems (Kincade 1995).[6]

How does opportunity influence nuclear proliferation? Obviously, the capability to develop nuclear weapons depends on possessing the necessary resources. States that lack the basic material capabilities will be excluded from the group of potential proliferators. Furthermore, states that develop nuclear weapons programs risk substantial international pressure. The cost of sanctions and other international counterproliferation efforts existed even before the NPT, although it is arguable that today nuclear weapons proliferators are under even greater pressure. Potential proliferators with limited nuclear production capabilities face a longer period of international pressure and are more vulnerable to these pressures. Libya, although it clearly desired nuclear weapons, abandoned attempts to launch a program because of limited production capacity and the strong likelihood of an international outcry. Libya appeared to switch its emphasis from nuclear weapons to chemical weapons in the late 1980s (Spector 1990, 175-180). Opportunity barriers thus do appear to effectively deter some potential proliferators.

Willingness

Willingness is the second factor we examine in nuclear proliferation. Sagan (1996) identifies three types of proliferation explanation: realist/international security, domestic politics, and norms.[7] His typology seems primarily to capture motivational aspects of the proliferation decision (willingness).

International Security

Conventional or nuclear insecurity is an obvious motive for nuclear weapons possession. Nuclear weapons may deter potential adversaries from initiating conflicts or countervail asymmetry in terms of conventional weaponry (Beaton and Maddox 1962; Dunn and Kahn 1976; Potter 1982; Quester 2005; Rosecrance 1964). In

addition, pariah nations—states politically isolated by their neighbors or by other countries—are more likely to seek nuclear weapons to demonstrate their viability and power to the international community (Quester 1973; Betts 1977; Rosen 1975). Pariah states may also seek nuclear weapons for deterrence to dissuade adversaries from political or military hostilities.

Conversely, states with security commitments from patrons with nuclear weapons may be less likely to proliferate. The presence of a "nuclear umbrella" may be sufficient for many protégés to dampen concerns about security risks, allowing nuclear ambitions to remain dormant. To make nuclear deterrence more credible and in spite of pressure to accept a no-first-use policy on nuclear weapons, the four declared nuclear states besides China have consistently refused to rule out the possibility of relying on nuclear weapons to protect their allies (see United Nations Security Council Resolution 984, April 11, 1995). South Korea, for example, abandoned its nuclear weapons program after receiving assurances of nuclear protection from the United States, even though its own manufacture of nuclear weapons would have been relatively easy (Mazarr 1995, 27).

Domestic Politics

Two domestic considerations have the potential to influence nuclear proliferation. First, states may pursue nuclear ambitions to divert public attention from unfavorable domestic issues (Dunn and Khan 1976; U.S. Office of Technology Assessment 1977; Waltz 2003). Nuclear weapons or nuclear weapons programs respond to—even bolster—nationalist sentiments. States facing domestic turmoil may pursue nuclear weapons programs as a method of diversion. India and Pakistan appear to have successfully diverted public unrest and revived nationalist sentiments in part through the development of nuclear weapons (see Sheikh 1994 for Pakistan; Chellaney 1994 for India).

Second, regime type has the potential to influence nuclear proliferation decisions (Solingen 1994). One group of scholars argues that autocracies may be in a better position to quell domestic objections and pursue the development of nuclear weapons (Chubin 1994; Kincade 1995; Sheikh 1994). Another group of scholars argue the opposite, that democracies may be more disposed to develop nuclear weapons. Populist politicians scrambling to mobilize public opinion may be tempted to pander to nationalist hysteria (Snyder 2000; Perkovich 1999, 404-424 for India; Nizamani 2000 for Pakistan). For example, a Gallup International poll in 1998 found that 97 percent of Pakistani respondents supported the Pakistani nuclear tests during the period. Even years later, support for the bomb remains strong in Pakistan. While it is conceivable that autocrats could have resisted the popular will, democratic dependence on public opinion suggests that it would have been politically impossible for Prime Minister Sharif to turn away from nuclear testing and development.[8]

Norms

Many scholars claim that states adjust their behavior to international expectations either out of a genuine desire to conform or as a result of baser incentives (cf. Wendt 1992, 1999; Katzenstein 1996; Ruggie 1997, 1998; Barnett 2002; Fazal 2004; Finnemore 2004). Other researchers see regimes as a key component in the evolution of international politics (cf. Oye 1985; Young 1986, 1991). The NPT is the most obvious example of efforts to curb the spread of nuclear weapons through the enforcement of an international norm. Leaders who oppose nuclear weapons may use international agreements as barriers against domestic pressure for nuclear proliferation. NPT members formally pledge not to mount a nuclear weapons program so that the treaty serves as a legal and moral barrier against pro-nuclear coalitions in NPT countries (Sagan 1996, 73-82; Scheinman 1990, 222-224).[9] For example, the South African decision to sign the NPT reflects Pretoria's apprehensions about the possibility that the African National Congress would control clandestine nuclear projects.[10] Disingenuously, the de Klerk government claimed that a Black majority government would constitute a greater threat to nuclear proliferation than the White government's own suspicious nuclear activities (Albright and Hibbs 1993).

Status

A nation's regional or global status may also influence decisions to proliferate. Nuclear weapons have been perceived as a symbol of regional or international prominence. States may seek to develop nuclear weapons to represent or enhance their perceived prestige (Beaton and Maddox 1962; Dunn and Kahn 1976; Greenwood, Feiveson, and Taylor 1977; Quester 1977; Wildrich and Taylor 1974).[11] Even though all nuclear contenders seek the same proximate goal, there appears to be a contrast between how proliferation by major powers and nonmajor powers is received by the international community. The five permanent members of the UN Security Council produced nuclear weapons in the face of relatively lighter moral condemnation from other nations.[12] The nuclear ambitions of nonmajor powers bring opprobrium and often yield tangible punishments from other states. The NPT is thus a codification of a dual-standard sovereignty, a hierarchy where what is accepted for some nations is illegitimate for others (Paul 2000).[13] This dual standard might arguably weaken strictures against nuclear ambitions. Conversely, proliferation among the powerful might simply reflect power politics in the nuclear era (Mearsheimer 1990, 2001; Waltz 1990). Thus, whether status is the product of ideational or material forces is ambiguous. However, a comparison of how status functions empirically should allow for some inferences about which set of arguments is correct. In particular, status norms would seem to encourage proliferation among both major and regional powers, while proliferation "because one can" should be most common for major powers.

Research Design and Data

We seek to estimate the effect of measures of opportunity and willingness on nuclear weapons programs and nuclear weapons possession. We adopt a standard cross-section time-series data structure for the period 1939 to 1992. The unit of analysis is the monad (country) year. We use probit regression analysis to estimate the effect of variables on the presence of a nuclear weapons production program and censored probit of the possession of nuclear weapons conditional on a given state having a nuclear weapons program (weapons possession contingent on program status). Combining nuclear weapons program status and nuclear weapons possession yields three potential outcomes: (1) states that lack both nuclear weapons programs and nuclear weapons, (2) states with nuclear weapons programs that have yet acquired nuclear weapons, (3) states that possess both a nuclear weapons program and nuclear weapons.[14] We employ White robust estimation to correct standard errors for spatial dependence and clustering over states to control for heteroskedastic error variance.[15] We also introduce two variables to control for autocorrelation in the dependent variables (Beck, Katz, and Tucker 1998). *Nonnuclear Years* counts the number of years since 1939 that lapse without a state starting a nuclear production program. *Nuclear Program Years* is a count of the number of years since a state passed the first stage of nuclear proliferation.[16] The *Nuclear Program Years* variable also assesses bureaucratic politics and inertia arguments (Halperin 1974; Allison 1971). If nuclear programs tend to proliferate nuclear weapons, then the variable should be positive.

Dependent Variables

We construct two dependent variables and evaluate each variable in our analysis. Both dependent variables are dichotomous and are coded annually. NWEAPON identifies whether a state possesses nuclear weapons in a given year, provided that the state has an active nuclear weapons program. The second dependent variable, NPROGRAM, codes whether a state has an active nuclear weapons development program in a given year.[17] We assess both nuclear weapons development and nuclear weapons possession to show how each dependent variable responds to the effect of the independent variables and to suggest which policy tools are most effective at each stage of proliferation.

Independent Variables

Opportunity Variables

Latent nuclear weapons production capability. We construct a measure of national nuclear weapons production capability by summing the number of resources or

production capacities that a given state has for nuclear weapons production. The resources and capacities consist of the seven components (uranium deposits, metallurgists, chemical engineers, and nuclear engineers/physicists/chemists, electronic/explosive specialists, nitric acid production capacity, and electricity production capacity; a codebook ["Data Notes"] detailing these data is available from the authors at http://www .columbia.edu/~eg589/) . Since there are seven components of the index, the variable varies between zero and seven (seven being highest).

Economic capacity. We construct an index of national economic capacity based on data from the Correlates of War (COW) project that provides annual statistics for each state's energy consumption and iron/steel production. We prefer to use these data rather than gross domestic product (GDP), because GDP data are only available for most countries in recent years. We average the energy consumption and iron or steel production statistics to minimize the effects of noise in the data and measurement error. Economic capacity is measured as follows:

$$\text{Economic capacity} = \left(Energy_i \Big/ \sum Energy + Iron/Steel_i \Big/ \sum Iron/Steel \right) \Big/ 2$$

Diffusion. Knowledge of how to construct nuclear weapons has spread with the passage of time. Researchers in the Manhattan Project in the United States and elsewhere had no idea at first whether the device they were building would actually function. Subsequent proliferators often benefited from equipment and expertise developed elsewhere. Diffusion equals the log transformation of the number of years since 1938.[18] The diffusion of nuclear technology and knowledge probably does not occur monotonically.[19] Log transformation of the time trend allows us to discount differences in later periods much more than those in the earliest periods.

Willingness Variables—International Security

Conventional threat. Conventional military threats combined with military weaknesses could lead states to proliferate (Campbell 2002; Mearsheimer 1984).[20] We construct a measure of conventional threat, using the COW project Composite Index of National Capabilities (CINC) score for each state as well as the CINC scores of all rivals ($j = 1 \ldots j = n$). [21] First, we sum the CINC scores of a state's rivals. We then divide the summed CINC scores by the given state's own CINC score. Finally, after adding 1 to the ratio, we log transform the ratio (natural log). We use Bennett (1996, 180-181) to identify rivals. We rely on *EUG*ene as the source for CINC scores (Bennett and Stam 2002). The conventional threat level is calculated as follows:

$$\text{Conventional threat}_{i,t} = \ln\left(\sum_{j=1}^{n} \frac{CINC_{j,t}}{CINC_{i,t}} + 1\right)$$

Nuclear threat. This is a dummy variable representing nuclear security threats. Some authors have argued that states with nuclear rivals are more likely to proliferate (cf. Foran and Spector 1997; Marwah 1981; Singh 1998).[22] The NPT itself builds on the logic of collective security; states are more likely not to proliferate together. Conversely, a nuclear rival might inhibit opponents from acquiring nuclear weapons (cf. Bueno de Mesquita and Riker 1982; Cropsey 1994; Mandelbaum 1995).[23] The nuclear threat variable is coded 1 for states that have at least one rival with a nuclear weapons program or actual nuclear weapons and 0 otherwise.[24]

Nuclear defense pact. Nuclear proliferation may be influenced by the presence of nuclear protectors. For example, the decisions of Japan and South Korea concerning nuclear proliferation seem to have been heavily influenced by a client relationship with the United States. We code the variable as a dummy that equals 1 if a state has a defense pact with a declared nuclear power and 0 otherwise. We again use data supplied by *EUG*ene.

Diplomatic isolation. Studies of pariah states emphasize that diplomatic isolation is the primary indicator of pariah status (Lake 1994; Harkavy 1977, 1981).[25] We code the level of diplomatic isolation between a state and other politically relevant states (states within 150 miles and major powers). Diplomatic isolation equals the ratio of the number of states with which a given state lacks diplomatic relationships to the number of neighboring states and major powers. We employ Bremer's (2000) COW diplomatic data set (version 2.0) as the source of information on the diplomatic status of states in the international system.[26] Distance data comes from *EUG*ene.

Willingness Variables—Domestic Politics

Domestic unrest. We construct a measure of domestic unrest based on the Banks (1999) data set.[27] We weight the number of reported domestic conflicts in three categories—including antigovernmental demonstrations, strikes, and riots—by the size of the state's population.[28]

Democracy. We use the Polity Project's democracy score (DEMOC), again obtained from *EUG*ene. DEMOC takes on values from 0 = *least democratic* to 10 = *most democratic*.[29] Three of the official five nuclear powers were democracies when they proliferated weapons (United States, United Kingdom, and France). Of four de facto nuclear states, Israel and India were clearly democracies, while South Africa and Pakistan were at least partial democracies.[30]

Willingness Variables—Norms

NPT membership. Almost every claim has been made about the NPT—from largely effective (Simpson and Howlett 1995) to mostly ineffective (Braun and Chyba 2004) to a contributor to future war (Carpenter 1994). A dummy variable is coded 1 for states that ratified the NPT and 0 otherwise.[31] Data are from the United States Arms Control and Disarmament Agency (1996).

NPT (system effect). Normative theories argue that formal agreements can have transformative effects on the behavior of participating states (Finnemore and Sikkink 1998; Wendt 1995). Few international agreements better fit the idea of a social construct than the NPT. *NPT(system effect)* is measured as the proportion of NPT joiners to the total number of states in the world.

Willingness Variables—Status

Major power status. We adopt the standard COW classification. Major powers in the period under study include the United States (1939-1992), United Kingdom (1939-1992), Soviet Union/Russia (1939-1992), France (1939-1940 and 1945-1992), Germany (1939-1945, 1991-1992), Italy (1939-1943), Japan (1939-1945, 1991-1992), and China (1950-1992).

Regional power status. We construct a measure of regional power status using Schweller's (1998) definition of a "pole," a state with "at least half of the resources of the most powerful state in the system" (p. 46). We identify all states with at least half of the resources of the most powerful state in each region using the COW project's code of region and CINC and code the list of states that result—but that are not major powers—as regional powers. Regional powers include China (1939-1949), Egypt (1939-1946, 1949-1992), Ethiopia (1941-1945, 1984, 1987-1990), India (1986-1992), Iran (1939-1945, 1951-1980, 1982-1992), Iraq (1981-1990, 1992), Japan (1986-1990), Nigeria (1960-1992), Saudi Arabia (1979-1987, 1990-1992), South Africa (1939-1991), and Turkey (1939-1992).

Results and Implications

Table 1 presents two models of nuclear proliferation: a probit analysis predicting the presence of a nuclear weapons production program (Model 1) and a censored probit analysis of nuclear weapons possession (Model 2-1).[32] Several points in Table 1 are worth attention. First, the probit analysis of nuclear weapons program status and the censored analysis of nuclear weapons possession appear to explain nuclear proliferation quite well. The pseudo R^2 in the probit analysis of nuclear

weapons programs is 0.82. In the censored analysis of nuclear weapons possession, the R^2 is 0.914. While there are certainly reasons to treat goodness-of-fit statistics with caution, these findings do show that the models are accounting for many of the determinants of nuclear proliferation. Second, *Latent Nuclear Weapons Production Capability, Diplomatic Isolation*, *Domestic Unrest*, and *Democracy* differ in the statistical significance of their coefficients between the censored probit analysis (Model 2-1) and the noncensored probit analysis (Model 2-2).[33] This result implies that noncensored probit analysis models result in an important specification error leading to misleading conclusions. Third, *Latent Nuclear Weapons Production Capability*, *Economic Capacity*, *Nuclear Defender*, and *Democracy* differ in their level of statistical significance for their coefficients between the two stages of nuclear proliferation.

The results reported in Model 1 and Model 2-1 of Table 1 reveal that most of the opportunity variables behave as hypothesized. *Diffusion* increases the predicted probability of a state developing a nuclear weapons program and also raises the risk of nuclear weapons proliferation. *Latent Nuclear Weapons Production Capability* is positively and significantly associated with the presence of nuclear weapons programs only. *Economic Capacity* is positively and significantly associated with the possession of nuclear weapons only. This means that *Economic Capacity* is an important factor to deepening nuclear proliferation, while *Latent Nuclear Weapons Production Capability* is the more salient factor in determining whether states initiate weapons programs. Economically weak states are less likely to deepen their nuclear proliferation, although they might still have nuclear ambitions.

Most but not all of the willingness variables related to security issues operate consistently across both of the two stages of nuclear proliferation. The positive coefficients of *Conventional Threat* in both stages support the common assertion that insecurity is a key factor to propelling proliferation. The negative coefficient for *Nuclear Defender* in the weapons proliferation stage indicates that the nuclear umbrella provided by nuclear patrons dissuades potential nuclear contenders from acquiring nuclear weapons. However, the statistically insignificant coefficient of *Nuclear Defender* in the prior program stage reveals that nuclear protégés are no less likely to initiate nuclear programs. In contrast to yet another conventional wisdom, *Diplomatic Isolation* does not appear to significantly affect *either* decisions about nuclear weapons programs or nuclear weapons possession. This finding implies that diplomatic isolation is not the strong determinant of "at risk" states that pundits have suggested.

Notice that the coefficient for *Nuclear Threat* has negative and statistically significant coefficients in both stages of the (censored) statistical model. States that face rivals with nuclear weapons or nuclear programs tend to refrain from deepening nuclear proliferation. This finding supports the somewhat controversial arguments of proliferation "optimists" that the fear of preventive war from nuclear rivals discourages the pursuit of proliferation (Karl 1996; Sagan and Waltz 2003, 18-20).

Table 1
Statistical Analyses of Nuclear Proliferation

Dependent Variable Nuclear Weapons Possession Status	Model 2-1: Censored Model Coeff.	 S.E.	 Sig.	Model 2-2: Noncensored Model Coeff.	 S.E.	 Sig.
Independent variables						
Latent nuclear weapons production capability$_{i,t-1}$	0.4275	(0.448)		0.6082	(0.233)	***
Economic capacity$_{i,t-1}$	110.5096	(28.70)	****	6.5480	(3.929)	*
Diffusion$_{t-1}$	13.0360	(3.801)	***	1.9503	(0.698)	***
Conventional threat$_{i,t-1}$	2.7294	(0.453)	****	1.3437	(0.258)	****
Nuclear threat$_{i,t-1}$	–5.0045	(0.834)	****	–2.1532	(0.604)	****
Nuclear defender$_{i,t-1}$	–3.5502	(0.902)	****	–1.3794	(0.576)	**
Diplomatic isolation$_{i,t-1}$	0.3904	(1.068)		1.6953	(0.867)	*
Domestic unrest$_{i,t-1}$	0.1632	(0.129)		0.4322	(0.120)	****
Democracy$_{i,t-1}$	0.2709	(0.107)	***	0.0666	(0.059)	
NPT(system effect)$_{t-1}$	–0.0169	(0.035)		0.0007	(0.006)	
Major power status$_{i,t-1}$	7.4898	(1.040)	****	4.6929	(0.741)	****
Regional power status$_{i,t-1}$	1.2096	(0.498)	**	1.5459	(0.495)	***
Count2	–0.1474	(0.029)	****	–0.0652	(0.034)	*
Constant	–53.8317	(10.13)	****	–14.8721	(2.477)	****
Obs.		440			4,697	
Log likelihood		–26.09			–133.16	
Pseudo R^2		0.914			0.861	
Wald chi-square		606,935	****		201.6	****

Table 1 (continued)

Dependent Variable Nuclear Weapons Program Status	Coeff.	Model 1 S.E.	Sig.
Independent variables			
Latent nuclear weapons production capability$_{i,t-}$	0.4836	(0.079)	****
Economic capacity$_{i,t-1}$	1.4826	(1.944)	
Diffusion$_{t-1}$	1.0550	(0.251)	****
Conventional threat$_{i,t-1}$	0.7002	(0.258)	***
Nuclear threat$_{i,t-1}$	–0.9140	(0.364)	**
Nuclear defender$_{i,t-1}$	–0.0976	(0.306)	
Diplomatic isolation$_{i,t-1}$	–0.0602	(0.438)	
Domestic unrest$_{i,t-1}$	–0.1480	(0.096)	
Democracy$_{i,t-1}$	–0.0262	(0.022)	
NPT membership$_{i,t-1}$	–0.7809	(0.363)	**
NPT(system effect)$_{t-1}$	0.0052	(0.004)	
Major power status$_{i,t-1}$	2.0000	(0.388)	****
Regional power status$_{i,t-1}$	1.5491	(0.236)	****
Count1	–0.1132	(0.012)	****
Constant	–6.3543	(1.001)	****
Obs.		4,697	
Log likelihood		–256.71	
Pseudo R^2		0.824	
Wald chi-square		644.5	****

Notes: Statistically significant parameter estimators are denoted by * ($p < .10$), ** ($p < .05$), *** ($p < .01$), and **** ($p < .001$).
The sample in Model 2-1 includes country-years where a given country has an active nuclear weapons program.

The two domestic politics variables produce interesting results. First, *Democracy* has a significant and positive coefficient in the nuclear weapons possession stage only. This finding implies that democratic states are more likely to produce nuclear weapons provided that they have already begun a nuclear development program, while there is no difference in initiating nuclear weapons programs between autocracies and democracies. These results support populist arguments that democracies are more vulnerable to nationalist pressure.[34] Second, *Domestic Unrest* does not affect proliferation at either stage. It appears that support for diversion arguments is very weak or nonexistent.[35]

Results for the norms variables are mixed. As expected, *NPT Membership* decreases the likelihood of having nuclear weapons programs. These results do not necessarily imply that the NPT changes state preferences, however. States might simply join the NPT because they do not plan to acquire nuclear weapons. Indeed, in contrast to ideational explanations, there is no indication of a change in behavior attributable to the NPT as a regime. The finding that *NPT(system effect)* is not statistically significant in either stage indicates that the NPT has not curbed proliferation incentives since the 1970s. NPT protocols requiring the dissemination of nuclear knowledge and materials suggest that the NPT may actually contribute to the quickening pace of nuclear diffusion. These results cast doubt on the validity of constructivist arguments about the transformative effect of international agreements at the system level, at least in the context of nuclear weapons and the NPT.

Status variables, however, do prove consistent determinants of proliferation. *Major Power Status* and *Regional Power Status* increase the likelihood of having nuclear weapons programs and nuclear weapons, although we do not yet know whether this is the result of realist or identity theories.

Finally, both temporal count variables are negative and statistically significant in their respective stage models. The greater the number of *Nonnuclear Years*, the less likely it is that states develop nuclear weapons programs. This relationship is in contrast to the effect of the *Diffusion* variable, which shows that the overall tendency is for nuclear proliferation to increase with time. The count variable for the age of a nuclear program in Model 2-1, *Nuclear Program Years*, also helps to address questions about the tendency of nuclear programs to lead to production of nuclear weapons. There is no indication that older programs are more likely to lead to proliferation. In fact, the passage of time makes states less likely to acquire nuclear weapons.[36] Although popular, bureaucratic politics and inertia explanations do not appear to be supported and are in fact contradicted by this evidence.

We use the log-likelihood ratio (*LR*) test to check the joint significance of the five groups of independent variables: opportunity, willingness—international security, willingness—domestic politics, willingness—norms, and willingness—status.[37] Table 2 presents the χ^2 statistics of the differences in the log likelihoods between the two unrestricted models (Model 1 and Model 2-1) and their corresponding restricted probit analyses. The table clarifies several important issues. First, out of the five

Table 2
Log-Likelihood Ratio (*LR*) Test

	Model 1		Model 2	
Omitted Independent Variables	Chi-square	Sig.	Chi-square	Sig.
Opportunity variables	61.20	****	42.50	****
Willingness variables				
International security	8.62	*	59.40	****
Domestic politics	4.88	*	15.63	****
Norms	5.54	*	0.23	
Status	53.83	****	52.07	****

Notes: "Opportunity variables" include latent nuclear weapons production capability, economic capacity, and diffusion.
"Willingness variables—International security" include conventional threat, nuclear threat, nuclear defense pact, and diplomatic isolation.
"Willingness variables—Domestic politics" include domestic unrest and democracy.
"Willingness variables—Norms" include NPT membership, NPT system, major power status, and regional power status.
Statistically significant parameter estimators are denoted by * ($p < .10$), ** ($p < .05$), ***($p < .01$), and ****($p < .001$).

groups of independent variables, there is a near dead heat between opportunity and status variables, although, as we suspected, opportunity matters more for program proliferation, while status is more important in the decision to proliferate weapons. Second, security variables have a much stronger effect on the second stage (nuclear weapon possession) than on weapons programs. Third, omitting the domestic variables has only a slight effect on the presence of nuclear weapons programs, while their impact on nuclear weapons possession is similarly modest. Fourth, norms matter most at the program stage, while having almost no effect at the weapons stage. These results should help to clarify controversies in the literature about the relative importance of different determinants of proliferation, and also help to identify appropriate policy actions (cf. Sagan 1996).

Significance testing is useful in evaluating our hypotheses, but a more intuitive and substantively informative method is to identify the magnitude of the impact of each independent variable on nuclear proliferation. We calculate the probability of having nuclear weapons programs and the conditional probability of having nuclear weapons, given that states already have nuclear weapons programs using "the method of recycled predictions" in STATA (STATACorp 2002). The Pr. Change column in Table 3 presents changes in the probability of having a nuclear weapons program and the conditional probability of possessing nuclear weapons predicted by moving each independent variable from its mean to its maximum value for continuous variables and from 0 to 1 for categorical variables, while all other independent variables retain their normal values.[38] The last column of Table 3 calculates each independent variable's relative risk [(maximum value probability – mean value probability) / mean value probability] according to the above process.

Of the opportunity variables, *Latent Nuclear Weapons Production Capability* is by far the most salient in explaining the presence of a nuclear weapons program. Moving *Latent Nuclear Weapons Production Capability* from its mean to maximum value increases the predicted probability of having a nuclear weapons program by 0.143, from 0.046 to 0.188. Interestingly, *Latent Nuclear Weapons Production Capability* leads to an insignificant change in the probability of possessing nuclear weapons. This result means that latent nuclear capability is a significant barrier to states considering initiating a nuclear weapons program but, once begun, opportunity plays little role in deepening proliferation.

Increasing *Economic Capacity* from its mean (0.094) to maximum value (0.127) yields a significant change in the predicted conditional probability of having nuclear weapons (0.033), while producing a more modest effect on the probability of having a nuclear weapons production program. This finding implies that the economic barrier to nuclear weapons possession is much more severe than that to nuclear weapons programs. Although proliferation scholars have emphasized the technical barriers to proliferation, developing states may be equally inhibited by the economic costs of making nuclear weapons. The finding also weakly supports the argument that the

Table 3
Effect of Changes in Independent Variables on Probability of Proliferation

Independent Variables	Probability	Minimum	Mean	Maximum	Pr. Change	Relative Risk %
Opportunity variables						
Latent nuclear weapons production capability$_{i,t-1}$	$Pr(Y_2 = 1)$	0.010	0.046	0.188	0.143	313
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.502	0.553	0.560	0.007	1
Economic capacity$_{i,t-1}$	$Pr(Y_2 = 1)$	0.094	0.094	0.127	0.033	35
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.391	0.907	0.999	0.092	10
Diffusion$_{t-1}$	$Pr(Y_2 = 1)$	0.015	0.094	0.123	0.029	30
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.050	0.514	0.822	0.308	60
Willingness variables						
Conventional threat$_{i,t-1}$	$Pr(Y_2 = 1)$	0.081	0.086	0.227	0.141	164
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.477	0.557	0.880	0.323	58
Nuclear threat$_{i,t-1}$	$Pr(Y_2 = 1)$	0.103		0.077	–0.025	–25
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.668		0.412	–0.257	–38
Nuclear defender$_{i,t-1}$	$Pr(Y_2 = 1)$	0.096		0.093	–0.003	–3
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.615		0.456	–0.159	–26
Diplomatic isolation$_{i,t-(1-5)}$	$Pr(Y_2 = 1)$	0.095	0.095	0.094	–0.001	–1
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.549	0.553	0.562	0.009	2
Domestic unrest$_{i,t-1}$	$Pr(Y_2 = 1)$	0.098	0.096	0.079	–0.017	–18
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.546	0.552	0.571	0.019	3
Democracy$_{i,t-1}$	$Pr(Y_2 = 1)$	0.098	0.095	0.090	–0.005	–5
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.492	0.553	0.615	0.062	11
NPT membership$_{i,t-1}$	$Pr(Y_1 = 1)$	0.103		0.080	–0.023	–23
NPT(system effect)$_{t-1}$	$Pr(Y_2 = 1)$	0.088	0.096	0.103	0.015	8
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.585	0.553	0.530	–0.055	–4

Table 3 (continued)

Independent Variables	Probability	Minimum	Mean	Maximum	Pr. Change	Relative Risk %
Major power status$_{i,t-1}$	$Pr(Y_2 = 1)$	0.077		0.210	0.133	172
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.386		0.902	0.516	134
Regional power status$_{i,t-1}$	$Pr(Y_2 = 1)$	0.089		0.163	0.074	83
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.544		0.589	0.046	8

Notes: $Pr(Y_2 = 1)$ refers to the predicted probability of having nuclear weapons program.
$Pr(Y_1 = 1 \mid Y_2 = 1)$ refers to the predicted conditional probability of possessing nuclear weapons on the condition of having nuclear weapons program.
Probability changes are computed by moving a corresponding variable from mean to maximum for continuous variables or from zero to one for dummy variables.
Relative risks are probability ratio between mean and maximum for continuous variables and between zero and one for dummy variables.

rising cost of nuclear deployment is a major potential factor in deterring nuclear weapons possession (Kincade 1995).

The diffusion trend variable is robustly associated with the possession of nuclear weapons only. Moving *Diffusion* from its mean to maximum increases the predicted conditional probability of having nuclear weapons by 0.308, while the same change produces a marginal change of 0.029 in the predicted probability of having a nuclear program. These results imply that the barrier to possession of nuclear weapons has eroded, although the barrier against nuclear weapons programs remains high.

Of the willingness variables related to security issues, *Conventional Threat* turns out to be the most powerful determinant of nuclear proliferation. The predicted probability of a state having a nuclear weapons program changes by 0.141, and the conditional probability of possessing nuclear weapons increases by 0.323 when our measure of *Conventional Threat* shifts from its mean to maximum value. The result implies that states facing substantial conventional threats are much more likely to seek to proliferate. Conversely, *Nuclear Threat* decreases the predicted probability of a nuclear weapons program by 0.025 and the predicted conditional probability of nuclear weapons by 0.257. This may be because of fear of preventive war.[39] *Nuclear Defender* reduces the predicted conditional probability of having nuclear weapons by 0.159, while the variable barely affects the predicted probability of having a nuclear weapons program by 0.003. States that already possess a nuclear weapons program are less likely to deepen their proliferation if they also have a nuclear defender. However, states with a nuclear defender do not behave much differently in the early stages of proliferation than states that lack nuclear protection. *Diplomatic Isolation* decreases the predicted probability of having a nuclear weapons program, but the effect is miniscule (0.001). The variable also marginally increases the predicted conditional probability of having nuclear weapons (0.009). This result clearly indicates that pariah status is a red herring in the search for the determinants of nuclear proliferation.

The domestic variables produce contrasting results of modest magnitude. *Domestic Unrest* does not bring a significant change in the predicted probability of having nuclear weapons program or the predicted conditional probability of having nuclear weapons. The weak effect of domestic unrest implies that nuclear proliferation is not much affected by domestic unrest or appeals to nationalistic fever. *Democracy* produces an insignificant decrease (0.005) in the predicted probability of having a nuclear weapons program and a marginal change (0.062) in the predicted probability of possessing nuclear weapons. This finding suggests that claims made in the literature that domestic political factors influence proliferation decisions are much exaggerated. Democracies with nuclear weapons programs appear slightly more likely to develop weapons, perhaps because partial democratic states use nuclear weapons proliferation as a diversion for domestic political reasons (Snyder 2000).

NPT membership and the NPT regime's norms have modest or marginal impacts on nuclear proliferation. NPT members are less likely to pursue nuclear weapons programs (0.023) than non-NPT members. Counter to the expectations of functionalists and others, the percentage of NPT joiners appears to be associated with an increased risk of proliferation at the nuclear program stage, while systemic NPT participation seems to slightly decrease the probability of deepening nuclear proliferation. These results appear to us to be the product of the diffusion of nuclear technology brought about by the NPT. The NPT system variable probably has a slight normative constraint on proliferation, as the negative coefficient in the weapons stage implies. However, the inhibiting effect of the NPT is overcome by the stronger technological diffusion effect. Enthusiasm for the NPT among proliferation opponents thus appears to be misplaced. We speculate that the most important contribution of the treaty is as a forum for communication and debate about nuclear issues.

Major Power Status turns out to be one of the most potent determinants of proliferation. Major powers are more likely to have nuclear weapons programs (an increase of 0.133) than nonmajor powers. Major powers with nuclear weapons programs are more likely to possess nuclear weapons than nonmajor powers (an increase of 0.516). Note, however, that Japan and Germany returned as major powers only in 1991 according to the COW coding. Both states are legally obligated not to pursue proliferation so that the apparent effect of *Major Power Status* is somewhat exaggerated by these statistics. Conversely, *Regional Power Status* is a marginal factor in nuclear proliferation. Being a regional power leads states to be slightly more likely to have a nuclear weapons program (by 0.074), while the conditional increase in the probability of possessing nuclear weapons given a weapons program is only 0.046. The disparity between the effect of status on major power and regional powers at the weapons proliferation stage in particular seems difficult to explain in terms of nominal prestige. We know of no researcher or policy maker who has argued that nuclear programs have anything like the effect of prestige that possession of nuclear weapons is said to confer. Rather, there are logistical advantages possessed by major powers that make the costs of weapons proliferation in particular a less onerous burden. Nuclear weapons, to a greater degree than even other defense goods, have huge fixed development costs and substantial economies of scale in production. One hundred nuclear weapons are not much more expensive to build than the first one, and a thousand warheads are certainly not ten times as expensive as one hundred. While we assess the decision to proliferate in stages in terms of the first test or device, we note that nuclear weapons states tend to build many more weapons after the first few, an action necessary for simple second strike deterrence (Betts 1984; Powell 1987). It seems likely that the deployment of nuclear weapons, often in large numbers, best addresses the needs of states with special global security interests. Major powers are among the few states to actually conceive of a use for nuclear weapons, an issue that has plagued scholars and planners since the age of nuclear Armageddon began (Brodie 1959; Schelling 1960; Kahn 1961).

Conclusion

We examine the nuclear proliferation process in terms of two conceptual components: willingness and opportunity. Some states are willing to seek nuclear options because of their external concerns. (1) States facing major conventional security threats may use nuclear proliferation to countervail conventional disadvantage (Israel and Pakistan). (2) Nuclear defenders do discourage a deepening of nuclear proliferation among protégés, but there is not much difference between states possessing or lacking nuclear defenders in terms of the likelihood of having a nuclear weapons program (Romania and South Korea). (3) Perhaps fearing nuclear preemption (Jervis 1984), states facing threats from nuclear powers demonstrate a significantly lower propensity to pursue nuclear programs or weapons proliferation (Cuba). (4) Major powers have been far more likely to develop nuclear weapons programs and nuclear weapons. (5) Regional powers are prone to develop programs but are only slightly likelier to produce weapons (Argentina, Brazil, India, and South Africa). (6) Pariah states are neither more likely to initiate nuclear weapons programs nor to possess nuclear weapons.

Other considerations appear only marginally to affect states' decisions to pursue proliferation. (7) Democracy turns out to deepen nuclear proliferation once a nuclear weapons infrastructure is in place, but there is no difference between democracy and autocracy in terms of a tendency to pursue nuclear weapons production programs. (8) Leaders facing domestic unrest or internal bureaucratic pressures to proliferate seldom activate the nuclear card for these reasons (India). (9) Membership in the NPT tends modestly to encourage states to maintain pledges of nonproliferation, while systemic normative constraints of the NPT regime do not exist or are counteracted by the other part of the NPT bargain, the dissemination of technology and nuclear know-how.

The complement to nuclear proliferation willingness is opportunity. Since it remains difficult to obtain nuclear weapons by trade, states that lack the requisite production capabilities have largely been precluded from proliferating. States that lack the ability to produce nuclear weapons are likely to seek other options such as enhancing their conventional forces or pursuing diplomatic solutions (Libya). (10) We find that latent nuclear production capabilities increase the predicted probability of having nuclear weapons programs but that latent production capabilities do not have any substantial impact on the conditional decision to produce nuclear weapons. Thus, latent nuclear capability is a critical factor early in proliferation but less so later on. (11) The diffusion of nuclear knowledge and technology eases opportunity barriers to the proliferation of programs and nuclear weapons.

Our research allows us to offer predictions about several nuclear proliferation trends. The number of states with either nuclear weapons programs or nuclear weapons is likely to continue to grow at a gradual, though gradually increasing pace, buffeted at times by changes in the structure of threats, such as the U.S. preemption

policy. As they less often possess the latent ability to produce nuclear weapons and are more likely to succumb to pressure from the international community, minor powers will generally not attempt to proliferate. At the same time, most major powers already have nuclear weapons or are precluded from acquiring them. It is thus regional and other middle powers that are most likely to proliferate. Many of these states have already attained latent nuclear weapons production capabilities but have refrained from nuclear weapons development for a variety of idiosyncratic reasons. When they face security threats in terms of conventional capabilities, midsized powers are much more likely to attempt to pursue the nuclear option. Yet even if regional and middle powers develop nuclear weapons, this does not appear to increase the proliferation risk among neighboring states, perhaps because small nuclear arsenals are seen as largely defensive.

Ironically, our research implies that United States hegemony has the potential to encourage nuclear proliferation. The United States appears much more willing to intervene in contests that previously would have invited opposition from the Soviet Union. States in the developing world can no longer look to the nuclear umbrella of the Soviet Union to protect them. The lack of a nuclear defender increases the willingness to proliferate, provided that a state possesses a nuclear program. Meanwhile, the diffusion of nuclear knowledge and technology continues. Middle powers, opposed to U.S. hegemony and which currently lack nuclear programs, may be the most easily dissuaded of all nuclear proliferators. A strong policy of asymmetric nuclear deterrence may deliver the United States a world with few nuclear adversaries but at the risk of greater friction and possibly nuclear war. Similarly, while a national missile defense system might make it harder for proliferators to directly challenge the United States (Powell 2003), states facing more proximate conventional threats or states that plan to target U.S. allies may still find that nuclear weapons are an appealing option in an uncertain world.

Notes

1. Meyer (1984) conducts pioneering quantitative research on proliferation but does not use multivariate regression. Singh and Way (2004) carry out a recent multinomial logit analysis, but the study does not address the conditionality of nuclear weapons possession based on the presence of a nuclear weapons program.

2. A willingness to proliferate may lead to investments in nuclear infrastructure that in turn increase nuclear opportunity over a long time span. While plausible, we do not believe this obstructs our findings. First, key indicators of opportunity matter statistically significant at only one of two stages of proliferation. To the degree that a state's willingness to proliferate affects opportunity, it should presumably affect both stages of proliferation. Second, correlation of independent variables would tend to bias downward the statistical significance of our findings. We find that likely candidates in both categories (opportunity and willingness) are highly significant.

3. Several states have made unsuccessful attempts to purchase nuclear weapons. Egypt tried several times to purchase "the bomb" and weapon-making technologies between 1963 to 1967 from China and the Soviet Union (Bhatia 1988, 59; Lefever 1979, 73). Libya sought to buy a few nuclear weapons from

China in 1969. China rejected the Libyan bid, although Chinese military leaders favored the Libyan offer (Heikal 1975). In March 1960, the Swiss military sent a proposal to purchase nuclear weapons to the Federal Council of Ministers. The Federal Council chose instead to reinforce conventional Swiss forces (Stüssi-Lauterburg 1996). Belarus, Kazakhstan, and the Ukraine have also made unsuccessful attempts to control nuclear weapons deployed within their soil by the former Soviet Union. Russia operationally controlled all nuclear devices located in the three newly independent countries at all times from independence to dates when all facilities and instruments related to nuclear weapons programs were shipped to Russia or disabled (Jones and McDonough 1998, 25-29). All known attempts by nonstate actors to obtain nuclear weapons have also been unsuccessful. Hafiz Muhammad Saeed of Jammat-ad Dawa (Party of Preachers) alleged that the party had loyalists controlling two missiles with nuclear warheads in 2002. Similarly, in 1985, the Armenian Scientific Group claimed to have stolen "three nuclear devices" from Soviet stockpiles (Jenkins 1985). Both claims, however, succeeded in their nominal purpose of creating psychological terror. The fear of nuclear terrorism may be more potent than its practice.

4. Opportunity and willingness are widely applied in other guises. "Nuclear proliferation is a function of two variables: technological capability *and* political motivation . . . capability without motivation is innocuous . . . [and] motivation without capability is futile" (Reiss 1988, 247, quoted in Shimko 2005; emphasis added).

5. Although recent news reports indicate that Pakistani officials sold nuclear insights and equipment to other nations (particularly Libya), acquisition of actual nuclear fissile materials has proven much more difficult.

6. It is estimated that the Indian nuclear test in 1974 cost only about $500,000 (Barnaby 1977).

7. We add a fourth category, status, to represent the potential attraction of proliferation for regional and major powers. It is unclear empirically whether the effects of status are the result of material or immaterial motives.

8. Kifner, John. "Complex Pressures, Dominated by Islam, Led to Testing" *New York Times*, June 1, 1998, A6.

9. As signatories to the NPT, the declared nuclear powers can continue weapon-oriented research, although they are obliged to "pursue negotiations in good faith on effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament, and to a treaty on general and complete disbarment under strict and effective international control" (Article VI). Article V states that "potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear weapon states . . ." (http://www.un.org/events/npt2005/npttreaty.html).

10. Since South Africa is the only example in which a state first produced and later decommissioned nuclear weapons, we lack the basis to do more than speculate about causes of deproliferation (see Liberman 2001; Purkitt, Burgess, and Liberman 2002). However, it appears that South Africa's decision was not the result of foreign pressure or changes in security conditions (Pabian 1995; Purkitt and Burgess 2005). Rather, South Africa deproliferated in anticipation of the transfer to majority rule (Babbage 2004). While South Africa has been treated as a model of effective deproliferation policy (Etzioni 2004), it is, if anything, an indication of the impotence of such efforts, given the highly unusual circumstances for decommissioning and the lack of other examples.

11. See O'Neill (2006) for an analysis of the symbolic effects of nuclear proliferation using game theory.

12. Condemnation of nuclear weapons has seemed to harden with time, but this may be the result of who is attempting to proliferate, how many states are proliferating, where states are in the process, or evolving norms. Allowing for path dependence among established nuclear powers, we expect to see the greatest resistance to new proliferators, who are also overwhelmingly minor or regional powers. We control for these effects in part by including temporal splines for nonproliferation and by including the diffusion variable.

13. There are many who argue that the dual standard is in fact a "double standard" and that the failure of the major powers to build down their nuclear arsenals is hurting the credibility of the NPT (cf. Deutch 2005).

14. Selection models are not appropriate in situations where some outcomes are a null set. While we certainly do not reject the possibility that in the future, nations or nonstate actors will obtain nuclear weapons through other means, we lack the ability to engage the issue empirically or to estimate such a model (Reed 2000).

15. We use the PROBIT procedure in STATA 7.0.

16. We consider several methods of addressing temporal dependence in the model. Spline variables advocated by Beck, Katz, and Tucker (1998) are nearly perfectly collinear. Unlike conflicts that occur, subside, and then recur in time-series, proliferation involves a strong linear trend. "Curve fitting" through spline variables is thus redundant and unnecessary. The two count variables act just like the "peace-year" variables common in studies of militarized disputes. We also considered a count for years since weapons proliferation, but there is only one case of "failure" (South Africa), where a state deproliferates once nuclear weapons are obtained by our criteria. Other checks and a comparison of the effects of count variables are available from the authors.

17. Since nuclear weapons programs are typically clandestine, there are bound to be countries that sit in a gray area where it is not clear whether they possess/possessed programs. Ambiguous cases include Australia, Algeria, Egypt, Libya, Romania, and Yugoslavia (Levite 2002). We coded Romania as having a nuclear weapons program from 1981 to 1989 and Yugoslavia from 1953 to 1963 and from 1982 to 1987. Coding any combination of the remaining countries (Australia, Algeria, Libya, and Egypt) has no significant effect on our results. For details, see the "Data Notes" for this study at http://www.columbia.edu/~eg589/.

18. Leo Szilard drafted the famous Einstein letter to President Roosevelt in 1939, converting fission to politics.

19. We also run analyses using just the number of years since 1938 and find no significant change in results.

20. For discussions of the use of proliferation as a bargaining chip, see Quester (1981) and Reynolds (1996).

21. A measure based only on the number of military personnel and military expenditures produces similar results.

22. Journalist Mike Shuster in summarizing the views of Scott Sagan and other scholars stated that "Security concerns about neighbors and other nuclear powers drive most decisions to pursue nuclear weapons" (National Public Radio, May 27, 2005. http://www.npr.org/templates/story/ story.php?storyId=4670216).

23. A debate over Ukrainian nuclear status featured protagonists who agreed that nuclear states could inhibit proliferation in other states (Mearsheimer 1993, Miller 1993) but disagreed about which states (and why).

24. We also examine a dummy variable coded 1 only when at least one rival possessed nuclear weapons (in contrast to simply having a weapons program). We have found no significant change in the results.

25. Caprioli and Trumbore (2005) show that pariah nations are no more war-prone than other states.

26. COW diplomatic data are available in five-year increments. We replace missing values with lags.

27. Boehmer (2001) identifies two patterns in Banks' domestic conflict data, one involving antigovernment demonstrations, strikes, and riots and the other among guerrilla warfare, governmental crises, and revolutions.

28. A logged count variable (adding 1) of the three domestic unrest indicators yields equivalent findings.

29. Polity data provide separate indicators for formal constraints on the executive and institutional support for democracy (DEMOC and AUTOC). The measures are distinct but correlate strongly (Jaggers and Gurr 1995, 471-472). DEMOC is similar to Kantian executive constraints and accounts for most of the variance in composite indicators (Gleditsch and Ward 1997).

30. The Polity Project codes Pakistan in 1997 as a 7, just above the standard "democracy" threshold (out of 10). South Africa is also coded as a 7 by Polity for the entire period of its proliferation

(1979-1991). North Korea is said to have recently produced a few nuclear weapons after the end date of our current data set.

31. There is no significant change if we use the signature date for the NPT instead of the date of ratification.

32. Multinomial MLE estimation of the stages of nuclear weapons proliferation involves a specification error. Empirically, nuclear development programs have always preceded nuclear weapons proliferation. Since states without nuclear weapons programs have never produced nuclear weapons, treating the stages of proliferation as substitute forces the estimator to estimate the probability of a state of the world occurring that has never occurred. Nested logit analysis is not applicable, because attributes of the first stage (nuclear weapons program) are very similar to those of the second stage (possession of nuclear weapons). See Reed (2000) for a discussion.

33. Of the 440 observations from Model 2-1, the five NPT nuclear states have 191 country-years with nuclear weapons and 15 country-years without nuclear weapons; the four de facto nuclear states have 52 country-years with nuclear weapons and 182 country-years without nuclear weapons. We ran a separate probit analysis to examine the robustness of factors leading states with programs to deepen proliferation. After deleting all country-years subsequent to the initial year of weapons possession, results show the following: (1) the variables *Diffusion* and *Conventional Threat* cause nuclear aspirants to deepen proliferation, (2) *Nuclear Threat* discourages nuclear aspirants from deepening proliferation, and (3) the remaining variables are not statistically significant.

34. We also examine a trichotomous democracy variable: autocracy (from 0 to 3), partial democracy (from 4 to 7), and democracy (above 7) based on the Polity coding. We obtain 78 autocracy-years involving nuclear weapons, 24 partial democracy-years with nuclear weapons, and 165 democracy-years with nuclear weapons. This specification does not produce any significant difference between democracy and partial democracy. However, the difference between autocracy and (partial) democracy is statistically significant. The result indicates that it is not the case that a few highly democratic proliferators (United States, United Kingdom, and France) are responsible for the reported relationship between democracy and proliferation.

35. *Domestic Unrest* results in a positive and statistically significant coefficient for nuclear weapons possession in tests using multinomial logit or simple probit analyses. Again, we suspect this results from specification error.

36. We have also examined the regressions without the temporal count variables present. The results are largely the same, though some changes exist. These results are available to download with the data set.

37. As the maximum likelihood estimation maximizes the log-likelihood function, iteratively omitting one set of independent variables reduces the log-likelihood statistics. By comparing the log-likelihood statistics of an unrestricted model and those of restricted models, the *LR* test provides an opportunity to check whether dropping independent variables produces a significant change in the ability of the model to explain the variance in the dependent variable(s). Dropping "important" variables reduces the log-likelihood statistic much; dropping unimportant variables decreases it little (see Wooldridge [1999] 2002, 557-9).

38. The method of recycling in this analysis takes several steps. First, we run Model 1. Second, we replace a given independent variable with standard values (minimum, mean, and maximum). Third, we predict the average probability of having a nuclear weapons program using actual values for other variables. Means of the predicted probabilities of having a nuclear weapons program are reported for the different standard values in Table 3. Finally, the actual values of the independent variable manipulated in the second step are restored. These steps are then repeated for the next independent variable and so on. Similarly, Model 2-1 is run, and the previous steps are repeated to obtain the predicted conditional probability of nuclear weapons.

39. Israel's air raid on the Iraqi Osiraq reactor in 1981, Iraq's attacks on Iranian nuclear facilities, and U.S. plans for surgical attacks against North Korea in 1994 demonstrate the vulnerability of nuclear weapons programs.

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