Determinants of Nuclear Weapons Proliferation

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Research Question

What makes countries obtain nuclear weapons?

-Quantitative Analysis

-Domestic and International Conditions

2 stages of nuclear proliferation:

1) The presence of nuclear weapons programs
2) The possession of nuclear weapons

2 Models

Authors thoughts:

-weapons may be purchased in the future, no empirical tests could explain the possession of nuclear weapons in the current regimes.

Censored Model: where the possession of nuclear weapons is contingent on the presence of a nuclear production program

Non-censored Model: a control.

Determinants

1) Opportunity:

-constraints from environment

-potential for manufacturing nuclear weapons, capability

-technologies to manufacture, nuclear fissile materials, economic capacity.

-proliferators with limited capabilities face more pressure

Determinants

2) Willingness

-4 types: international security, domestic politics, norms, status

-domestic/geopolitical conditions decisions

-pressures

International Security: insecurity with countries, nuclear or otherwise

-Pariah nations. Why is this the case?

-4 nuclear states besides China have refused to rule out the possibility of relying on nuclear weapons to protect their allies

Domestic Politics:

-2 considerations: pursue proliferation to divert public attention from unfavorable domestic issues, regime type

Norms: -adjust behavior to international expectations

Research Design

-cross-section time series data structure from 1939-1992, analysis is the year.

Goal: combine nuclear weapons program status and nuclear weapons possession.

Three 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

Dependent variables

-2 variables. Dichotomous, coded annually.

NWEAPON: whether state possesses nuclear weapons in a given year, provided that the state has an active nuclear weapons program

NPROGRAM: codes whether a state has an active nuclear weapons development program in a given year.

Independent variables

Opportunity Variables:

Latent Nuclear Weapons Production Capability

1-measure of national nuclear weapons production capability

-resources and capacities consist of seven components:

-uranium deposits, metallurgists, chemical engineers, nuclear engineers/physicists/chemists, electronic/explosive specialists, nitric acid production capacity, and electricity production capacity

-Coded 0 to 7

Independent Variables

Economic capacity:

-developed based on data from the Correlates of War project

Economic capacity measured by this:

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

Independent Variables

Diffusion:

-knowledge has grown

-does not occur monotonically

-equals the log transformation of the number of years since 1938.

Independent Variables

Willingness Variables-International Security:

Conventional Threat:

-military threat combined with military weakness could lead to proliferation

-measure conventional threat using COW Project Composite Index of National Capabilities score and CINC scores of all rivals

-use Bennett (an author) to identify rivals

-EUGene is the sou

calculation:

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

Independent Variables

Nuclear Threat:

-represents nuclear security threats

-argue that states with nuclear rivals are more likely to proliferate (Form and Spector, Marwah, Singh)

-NPT builds on the logic of collective security-states more likely not to proliferate together

-a nuclear rival might inhibit opponents from acquiring nuclear weapons

-coded 1 for states that have at least 1 rival with a nuclear weapons program or have nuclear weapons, 0 otherwise.

Independent Variables

Nuclear Defense Pact:

-nuclear proliferation may be influenced by the presence of nuclear protectors

-dummy that equals 1 if a state has a defense pact with a declared nuclear power and 0 otherwise

-EUGene data

Independent Variables

Diplomatic isolation

-studies of pariah states show that diplomatic isolation is the primary indicator of pariah status

-code level of diplomatic isolation between a state and other politically relevant states

-ratio of the number of states with which a given state lacks diplomatic relationships to the number of neighboring states and major powers

-Bremer's 2000 COW diplomatic data set to get the diplomatic status. Distance from EUGene

Independent Variables

Willingness Variables-Domestic Politics

Domestic Unrest:

-measure of this based on the Bank's 1999 DataSet.

-weigh the number of reported domestic conflicts in three categories

-anti-government demonstrations, strikes, and riots based on size of state population

Independent variables

Democracy:

-Polity Project's democracy score (DEMOC) from EUGene

-values 0 (least democratic) to 10 (most democratic)

Independent variables

Willingness Variables-Norms

NPT Membership

-dummy variable coded for 1 for states that ratified the NPT, 0 otherwise

-Data from United States Arms Control and Disarmament Agency (1996)

NPT System Effect

-proportion of NPT joiners to the total number of states in the world.

Independent variables

Willingness Variables-Status

Major Power Status:

-COW classification

-Major powers in the period under study: United States, UK, USSR/Russia, France, Germany, Italy, Japan, China

Regional Power Status:

-Schweller's definition of a "pole"

-identify all states with at least half of the resources of the most powerful state in each region using COW projects code of region and CINC and code the list of states that result, but not major powers.

-China, Egypt, Ethiopia, India, Iran, Iraq, Japan, Nigeria, Saudi Arabia, South Africa, Turkey

Results

2 models of nuclear proliferation:

1)a probit analysis predicting the presence of a nuclear weapons production models

2)censored probit analysis of nuclear weapons possession

Table 1
Statistical Analyses of Nuclear Proliferation

Dependent Variable Nuclear Weapons Possession Status	Model 2-1: Censored Model			Model 2-2: Noncensored Model		
	Coeff.	S.E.	Sig.	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$_{i,t}$	13.0360	(3.801)	***	1.9503	(0.698)	***
Conventional threat$_{i,t}$	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)$_{i,t}$	−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	****

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Results

Table 1 (continued)

Dependent Variable Nuclear Weapons Program Status	Coeff.	Model 1 S.E.	Sig.
Independent variables			
Latent nuclear weapons production capability$_{t-n}$	0.4836	(0.079)	****
Economic capacity$_{t-1}$	1.4826	(1.944)	
Diffusion$_{t-1}$	1.0550	(0.251)	****
Conventional threat$_{t-1}$	0.7002	(0.258)	***
Nuclear threat$_{t-1}$	–0.9140	(0.364)	**
Nuclear defender$_{t-1}$	–0.0976	(0.306)	
Diplomatic isolation$_{t-1}$	–0.0602	(0.438)	
Domestic unrest$_{t-1}$	–0.1480	(0.096)	
Democracy$_{t-1}$	–0.0262	(0.022)	
NPT membership$_{t-1}$	–0.7809	(0.363)	**
NPT(system effect)$_{t-1}$	0.0052	(0.004)	
Major power status$_{t-1}$	2.0000	(0.388)	****
Regional power status$_{t-1}$	1.5491	(0.236)	****
Count	–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.

Results

Table 1: -probit analysis of nuclear weapons status and the censored analysis.

-non-censored probit analysis models result in an important specification error leading to misleading conclusions

-capability

-insecurity is a key factor in proliferation (Conventional Threat Stat)

-Nuclear defender is insignificant, but proliferation stage indicates that nuclear umbrella provided by nuclear patrons dissuades contenders from getting weapons

Results

Table 1 Continued

-populist arguments that democracies are more vulnerable to nationalist pressure (democracy)

-states that have rivals with nuclear weapons refrain from deepening proliferation

-norms variables are mixed

-status variables are consistent determinants of proliferation (Major Power Status, Regional Power Status)

Results

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

Omitted Independent Variables	Model 1		Model 2	
	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 ****($p < .001$).

Result of log-likelihood ratio (LR) test to check significance of 5 independent variables: opportunity, willingness (norms), willingness (status), willingness (international security), willingness (domestic politics). These are the X squared statistics

Results

-opportunity and status variables similar, but find opportunity matters more for program proliferation

-status important in the decision to proliferate weapons

-security variables have stronger effect on nuclear weapon possession than weapons

-omitting domestic variables has a slight effect on the presence of nuclear weapons possession is similarly modest

-norms matter most at the program stage, while having no effect on weapons stage

Results

STATA used. Changes in the probability of having a nuclear weapons program and the conditional probability of possessing nuclear weapons predicted by

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$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	0.103		0.077	−0.025	−25
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.668		0.412	−0.257	−38
Nuclear defender$_{t-1}$	$Pr(Y_2 = 1)$	0.096		0.093	−0.003	−3
	$Pr(Y_1 = 1 \mid Y_2 = 1)$	0.615		0.456	−0.159	−26
Diplomatic isolation$_{t-1,t-5}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_1 = 1)$	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

Results

Table 3 (continued)

Independent Variables	Probability	Minimum	Mean	Maximum	Pr. Change	Relative Risk %
Major power status$_{t-1}$	$Pr(Y_2 = 1)$	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$_{t-1}$	$Pr(Y_2 = 1)$	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.

Results

-0 to 1 for categorical variables, risks
-Latent Nuclear Weapons Proliferation is the most salient in explaining the presence of a nuclear weapons program
-The economic barrier to nuclear weapons possession is more severe than that to nuclear weapons programs
-developing states equally inhibited by the economic costs of making nuclear weapons (Economic Capacity)
-rising

Results

-diffusion trend variable associated with the possession of nuclear weapons only

-barrier to possession of nuclear weapons has eroded

-Conventional Threat is the most powerful determinant of nuclear proliferation

-states facing substantial conventional threats are much more likely to seek to proliferate

-pariah status is a clue in the search for the determinants of nuclear proliferation (diplomatic isolation)

-Major Power Status turns out to be one of the most important determinants of proliferation

Conclusions

1) States facing major conventional security threats may use nuclear proliferation to countervail conventional disadvantage
2) Nuclear defenders do discourage a deepening of nuclear proliferation among proteges, but there is not much difference between states possessing or lacking nuclear defenders in terms of the likelihood of having a nuclear weapons program
3) States facing threats from nuclear powers demonstrate a significantly lower propensity to pursue nuclear programs proliferation
4) Major Powers have been far more likely to develop nuclear weapons programs and nuclear weapons

Conclusions

5) Regional powers are prone to develop programs but are only slightly likelier to produce weapons

6)Pariah States are neither more likely to initiate nuclear weapons programs not to possess nuclear weapons

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 tendency to pursue nuclear weapons

8)Leaders facing domestic unrest seldom activate the nuclear card

9)Membership in NPT tends modestly to encourage states to maintain pledges of nonproliferation

Conclusions

10) Latent nuclear production capabilities increase the predicted probability of having nuclear weapons programs but that LPC do not have any substantial impact on conditional decision to produce nuclear weapons

11) Diffusion of nuclear knowledge and technology eases opportunity barriers to the proliferation of programs and nuclear weapons

-U.S. has the potential to encourage nuclear proliferation

QUESTIONS?