IMPORTING THE BOMB

SENSITIVE NUCLEAR ASSISTANCE AND NUCLEAR PROLIFERATION

By: Abi Ernharth

KROENIGS' ARGUMENT / HYPOTHESIS

- Does international nuclear assistance contributes to the spread of nuclear weapons?
- **States that receive sensitive nuclear assistance can better overcome the common obstacles that states encounter as they attempt to develop a nuclear-weapons arsenal.**
  - Can skip technical stages
  - Gain knowledge from more advanced scientific communities
  - Economize on the costs of nuclear development
  - Avoid international pressure to abandon a nuclear program
- **Nuclear Assistance is an important determinant of nuclear proliferation**
  - States that receive assistance are more likely to acquire nuclear weapons
  - States at a more advanced industrial level are also more likely to acquire
- **The spread of nuclear weapons is more threatening to powerful states than to weak states**
- **States are more likely to provide sensitive assistance under 3 conditions:**
  - The more powerful a state is relative to the participant, the less likely it is to supply
  - More likely to provide to states that share a common enemy
  - States less vulnerable to superpower pressure are more likely to provide

EXPLAINING NUCLEAR PROLIFERATION – DEMAND-SIDE APPROACH

- A state's *opportunity* to acquire nuclear weapons
- Sagan (1996/1997) identifies 3 reasons:
  - Competitive security environments desire nuclear weapons to deter external aggression
  - Domestic political lobbies can pursue a national nuclear program parochial reasons
  - Internal norms of prestige associated with having a nuclear weapons program

Etel Solingen (1994, 1998, 2007):

- Political coalitions & economic development strategies determine need for acquisition

Hymans (2006):

- Leaders' conceptions of their own national identities is the key to explaining

EXPLAINING NUCLEAR PROLIFERATION - SUPPLY-SIDE APPROACHES

- A states *willingness* to acquire nuclear weapons - believes the demand-side only offers a partial explanation
  - Opportunity can shape willingness
  - Whether a state wants nuclear weapons or not is irrelevant if they are unable to acquire them
- Singh and Way (2004):
  - "once a country acquires the latent capacity to develop nuclear weapons, it is only a matter of time until it is expected to do so."
- Claims that states with an advanced industrial capacity can more easily create and maintain a program and therefore are more likely to acquire

IMPORTING THE BOMB

- Why do states rely on the assistance from a more advanced nuclear state?
  - Designs for many technologies are not available in the public realm
  - Construction and successful operation requires trial and error
  - Developing nuclear weapons infrastructure from scratch is very expensive
  - Must overcome these challenges while under international pressure

CASE STUDIES

- France provided nuclear assistance to Israel, which greatly enhanced their ability to produce
  - Constructed their facilities, their materials, transferred a design, trained scientists, and allowed observers at their weapons tests → 7 years later, Israel could build their first nuclear weapon
- 1958 – 1960: Soviet Union provided China with key parts for nuclear plants, contributing to China's ability to conduct its first test
- 1981-1986: China transferred Uranium, important technology, and designs to Pakistan
- 1987 – 2002: Pakistan distributed technologies and materials to Iran, Libya, and North Korea

---

On the other hand…

Egypt has sought information from China & Soviet Union (may have met with Pakistan) and

DEPENDENT VARIABLE

- Nuclear Proliferation: Whether a state acquires nuclear weapons within a given year
- To Code:
  - Either when a state first explodes a nuclear device OR when it assembles a deliverable nuclear weapon
  - Used dates from Gartzke and Kroenig (2009)

INDEPENDENT VARIABLE

- **Sensitive Nuclear Assistance** – measures whether a state has ever received materials and technologies from a more advanced state
  - can take 3 forms:
    1. States receive help in the design & construction
    2. receive significant quantities of weapons-grade fissile material
    3. receive assistance in the construction of facilities that could produce the material
  - Excludes other types of cooperation less relevant to the development of a nuclear program
- To code:
  - Began with an online nuclear-weapons database maintained by the Nuclear Threat Initiative
  - Drew on reviews on the proliferation of nuclear weapons and on historical studies of countries' nuclear weapons programs

Table 1
Cases of Sensitive Nuclear Assistance

Recipient	Year of First Assistance	Supplier(s)	Type of Assistance
China	1958	Soviet Union	Plutonium reprocessing, uranium enrichment
Israel	1959	France	Plutonium reprocessing, nuclear-weapon design
Japan	1971	France	Plutonium reprocessing
Pakistan	1974	France, China	Plutonium reprocessing, uranium enrichment, nuclear-weapon design
Taiwan	1975	France	Plutonium reprocessing
Iraq	1976	Italy	Plutonium reprocessing
Brazil	1979	Germany	Plutonium reprocessing, uranium enrichment
Egypt	1980	France	Plutonium reprocessing
Iran	1984–1995	China, Pakistan	Plutonium reprocessing, uranium enrichment[a]
Algeria	1986	China	Plutonium reprocessing
Libya	1997	Pakistan	Plutonium reprocessing, uranium enrichment, nuclear-weapon design
North Korea	1997	Pakistan	Plutonium reprocessing, uranium enrichment[a]

a. It is widely suspected that Pakistan provided a nuclear-weapon design to Iran and North Korea, although, as of yet, there is no firm evidence to prove it.

CONTROL VARIABLES

- Other variables thought to influence the likelihood of nuclear proliferation (drawn from Singh & Way 2004)
  - **GDP / capita in 1996 dollars** – assess a country's domestic capacity to produce
  - **GDP ^{2}** – test for a relationship b/w level of economic, development, and nuclear acquisition
  - **Industrial Capacity –** whether a country produces steel domestically & can generate electricity at > 5000 MW
  - **Rivalry –** states in threatening environments may pursue nuclear weapons in order to improve their security
  - **Alliance –** whether a state is in a defense pact with a nuclear-armed state
  - **Regime Type –** measures a country's domestic political regime type (Polity IV Index)
  - **Openness –** a state's openness to the international economy & calculated by country's trade ratio
  - **Liberalization –** measures changes in a country's trade ratio over spans of 3, 5, & 10 years

DATA ANALYSIS

1. Uses Cox proportional-hazard models to test claims about the correlates of nuclear acquisition
    1. Robust standard errors are adjusted for clustering by country
2. Examine simple bivariate relationship b/w sensitive nuclear assistance & nuclear proliferation (T2, M1)
    1. evaluated the effect of sensitive nuclear assistance after including the control variables (T2,M2)
    2. Estimates a trimmed model that includes only the variables that were statistically significant in the previous model (T2, M3)
    3. To assess the relationship, he used a censored hazard model (T2, M4)

Table 2
Hazard Models of Nuclear Proliferation

	Model			
Independent Variable	1	2	3	4
Sensitive nuclear assistance	3.323**** (0.951)	2.093**** (0.641)	2.024*** (0.786)	1.478** (0.694)
GDP		0.649*** (0.240)	0.625*** (0.227)	0.609 (0.378)
GDP squared		–5.13e–5**** (1.54e–5)	–5.69e–5*** (2.03e–5)	–4.60e–5 (3.02e–5)
Industrial capacity (0.756)		3.430**** (0.387)	3.606**** (0.497)	3.276****
Rivalry		2.382* (1.367)	2.371* (1.252)	1.517 (1.651)
Alliance		–1.800* (1.061)	–1.705* (0.945)	–.8253 (0.835)
Regime type		0.114** (0.050)	0.112** (0.055)	0.112** (0.050)
Openness		–0.022 (0.018)		–0.027 (0.026)
Liberalization		0.028 (0.026)		0.059** (0.028)
Log likelihood	–32.669	–18.784	–19.260	–15.413
Number of countries	156	156	156	18
Total observations	5,901	5,901	5,901	398

Note: Statistically significant parameter estimators are denoted by *($p = .10$); **($p = .05$); ***($p = .01$); ****($p = .001$). Coefficients are estimates for Cox proportional hazard models; robust standard errors, adjusted for clustering by country, are in parentheses. GDP = gross domestic product.

FINDINGS THAT SUPPORT SUPPLY-SIDE

- Relationship between sensitive nuclear assistance and nuclear proliferation is positive and statistically significant in every model
- GDP & GDP ^{2} both have positive signs and are statistically significant in 2/3 of the models
  - Provides some support for the existence of a nonmonotonic relationship b/w economic development & proliferation
- Industrial capacity is positive and statistically significant in every model
  - more advanced states are more likely to acquire nuclear weapons

FINDINGS THAT SUPPORT DEMAND-SIDE

- Rivalry: + and S.S. (2/3 of the models)
  - Consistent with security based approaches & findings from previous studies
- Alliance: – and S.S. (2/3 of the models)
- Regime Type: + and S.S
  - Supports the notion that democratic states are more likely to proliferate
- No discernable relationship b/w economic openness and nuclear proliferation
  - Openness is not SS in any model
- Liberalization: + and S.S. (M4 only)
  - Suggests that liberalizing states may be more likely to acquire

** finds modest support for demand-side approach, believes security & domestic politics can influence it **

Table 3
Substantive Effects of the Explanatory Variables on the Likelihood of Nuclear Proliferation

	Percentage Change in the Hazard Ratios	
Variable Censored	Uncensored	
Sensitive nuclear assistance	+711	+338
Industrial capacity	+2,986	+2,546
Regime type	+12	+12

Note: Hazard ratios on whether a state acquires a nuclear weapon are based on the hazard models reported in Table 2, models 2 and 4.

FINDINGS - TABLE 3

- Finds a substantive effect of the variables that were statistically significant
  - Providing a state with sensitive nuclear assistance increases the chance of them acquire by > 700%
  - Industrial capacity has a substantive effect on nuclear proliferation
    - If you are above a certain threshold, you have are more likely to proliferate > 29% than people below it
  - Regime type has a smaller substantive effect
    - If you increase a state's level of democracy by 1, then it increases the risk by 12%

ADDRESSING PROBLEMS

- Non-Random Assignment of Treatment:
  - sensitive nuclear assistance is not randomly assigned
  - states who receive are very different from states who do not receive information
- To correct this problem:
  - Ho et. al recommends preprocessing data using matching techniques to match up treated cases with similar untreated cases
  - control - states that did not receive assistance; treatment - states that did
- Analysis:
  - Identifies GDP, GDP ^{2} , rivalry, alliance, regime type, openness, and liberalization as confounding variables
  - One-to-one nearest neighbor matching was used
  - They indicate that excellent balance was achieved…
    - All t-tests > 0.56 (except alliance at 0.111), QQ stats improve in all but alliance and regime type

Table 4
Balance Statistics

Std. Variable		Mean Treated	Mean Control	*t*-test *p* value	K-S test *p* value	Var. ratio (Tr/Co)	Mean eQQ Diff.
GDP	Before matching	7,057.700	5,452.500	0.000	0.000	1.077	0.114
	After matching	6,943.900	6,608.600	0.574	0.144	1.063	0.046
GDP squared	Before matching	86,540,299.000	63,991,650.000	0.031	0.000	0.976	0.105
	After matching	84,853,891.000	78,135,099.000	0.625	0.144	1.154	0.045
Industrial capacity	Before matching	0.746	0.229	0.000		1.079	0.259
	After matching	0.751	0.726	0.571		0.940	0.012
Rivalry	Before matching	0.761	0.269	0.000		0.929	0.246
	After matching	0.766	0.741	0.564		0.934	0.012
Alliance	Before matching	0.462	0.466	0.915		1.004	0.002
	After matching	0.453	0.532	0.111		0.995	0.040
Regime type	Before matching	–0.523	–0.274	0.647	0.124	0.968	0.035
	After matching	–0.692	–0.557	0.860	0.114	0.936	0.049
Openness	Before matching	39.030	52.432	0.000	0.000	0.370	0.096
	After matching	38.304	38.621	0.902	0.273	1.239	0.028
Liberalization	Before matching	–0.195	2.587	0.008	0.195	0.697	0.033
	After matching	–0.185	0.044	0.869	0.330	1.037	0.029

Note: GDP = gross domestic product.

Presents the before and after balance statistics using 5 standard indicators of balance: (1) difference in means, (2) the p- values from a t-test on the difference of means, (3) the p values from a K-S test of similar distributions, (4) the ratio of the variances of the treated and control samples, (5) the mean standardized differences from the QQ plot

Table 5
Hazard Model of Nuclear Proliferation, Postmatching

Matched observations	280
Number of countries	48
Coefficient	2.552
Standard error	1.029
p value	.013

- Presents the effect of sensitive nuclear assistance on nuclear acquisition as estimated by the Cox regression in the **matched** sample
- The matched data suggests that sensitive nuclear assistance may have an even larger substantive effect than in the unmatched sample
- Sensitive nuclear assistance increased chance of acquisition by > 1,200% (as opposed to 700%)

ROBUSTNESS CHECKS

- Examines the extent to which the results depend on the coding of the dependent variable, model specification, and the nuclear - proliferation of a few key states.
  - Difficult to define when states acquire or successfully test nuclear weapons
  - Checks using alternate coding's reveal that the results are not sensitive to different measurements of the dependent variable
  - Reran dozens of models, omitting different variables on the right hand side, and the results were not affected
  - To determine if the findings were affected by the proliferation behavior of certain states, he dropped the observations containing China, Israel, and Pakistan, and it did not affect the findings.

CONCLUSION

- In order to explain patterns of nuclear proliferation, one must look to international transfers of sensitive nuclear materials and technology
- This article provided strong support for the supply-side approach to nuclear proliferation
- In contrast, they found less support for the demand-side variables.
- Concludes that there must be more research on the consequences and causes of nuclear proliferation

Questions?