THE CORRELATES OF NUCLEAR PROLIFERATION: A QUANTITATIVE TEST

By Sonali Singh and Christopher R. Way

Coleby J. Mathews

Abstract

- The threat of nuclear proliferation is the highest it has been since the dawn of the nuclear era.
- There is a lack of dependable information on the determinants of nuclear proliferation
- There are numerous academic theories about the spread of nuclear weapons
  - A lack of empirical data to support these theories
  - Researchers often offer another theory when they are unable to account of specific details of a given situation
- Singh and Way propose a quantitative methodology for studying the determinants of nuclear proliferation

Why Quantitative?

- Three reasons for a quantitative test
  - Most qualitative studies ignore or underemphasize states who have never pursued nuclear weapons.
  - Qualitative studies give probabilistic theories that are tested in a deterministic manner.
  - There are likely multiple determinants and various combinations of factors that lead to the decision to pursue nuclear weapons

Methodology

- 154 Countries between 1945 and 2000
- Continuum rather than dichotomy
  - Four Stages of nuclear proliferation
    - No interest in nuclear weapons
    - Serious exploration of the weapons option
    - Launch of nuclear weapons program
    - Acquisition of nuclear weapons
- Test Hypothesis on three broad approaches to nuclear proliferation
  - Technological determinants
  - External determinants
  - Domestic determinants

Technological Determinants

- Technology is the driving force behind weapons development
  - When a state reaches latent capacity for development, it will acquire weapons
    - Economic prosperity
    - Literacy levels
    - Scientific Development
  - States will develop weapons as a by-product of industrial advancements
  - Nuclear proliferation is impossible to prevent
  - Contrary Evidence
    - States who have met the technological threshold have not pursued weapons
  - An important starting point
    - States can't develop without meeting the threshold

External Determinants

- Emphasizes willingness to develop weapons
  - Threat Environment
    - Presence or absence of a security threat
      - Balance against a nuclear threat
      - Gain an advantage over a foe
    - Presence or absence of a powerful ally
  - Contrary Evidence
    - States who have faced threats have not pursued nuclear weapons
    - States have numerous other options
      - Forging alliances with stronger states
      - Such alliances have weakened since the end of the Cold War
        - Increasing incentives to pursue weapons

Domestic Determinants

- Focus on four factors that influence decisions to pursue weapons
  - Democracy
    - Democratic Peace Theory
    - Reduces likelihood of nuclear proliferation
    - Appeal to nationalist sentiments may prompt pursuit of weapons
  - Liberalizing governments
    - Economic liberalism promotes non-proliferation agreements
    - Economic interdependence reduces desire to pursue weapons
    - Nuclear proliferation has negative affects on regional commerce
  - Autonomous domestic elite
    - Leaders with more autonomy are more likely to pursue weapons
    - Exploit security threats to secure power
  - Symbolic Motivations
    - Nuclear weapons viewed as a status symbol
    - States will pursue weapons as a means or validation

Dependent Variables

- "Degrees of Nuclearness"
- Not dichotomous
- Based on continuum
  - First Explosion/Assembly of Weapons
    - Has successfully detonated a nuclear weapon
    - Has assembled and possessed a nuclear weapon
    - From date of first assembly/detonation until the state has surrendered the arsenal
  - Pursuit of Nuclear Weapons
    - Has made a serious effort to develop a nuclear weapon
    - Irrelevant of the size and stage of development
    - Until it has abandoned its nuclear program
  - Exploration of Weapons
    - Seriously considered nuclear weapons, but never took action
    - Demonstrated by political authorization to explore weapons
    - From the date first considered
  - No Interest
    - Has never pursued/explored nuclear weapons

Explanatory Variables

- Technological Determinants
  - GDP per capita
    - Provides indicator of level of economic development
  - Industrial capacity index
    - Level of industrial capabilities based on domestic electricity and steel production
  - Industrial production and consumption
    - Supplements industrial capacity index
- External Determinants
  - Enduring rivalry
  - Frequency of involvement in disputes
    - Based on militarized interstate dispute (MID) data
  - Security Guarantee
    - Defense agreement with a nuclear-armed state
- Internal Determinants
  - Democracy and democratization
  - Economic interdependence and liberalization
  - Status inconsistency
    - Dissatisfaction with international status

EXPLANATORY VARIABLES

TABLE 1
Theoretical Expectations and Measures

Explanatory Variable	*Anticipated Direction of Effect*	*Operationalizations*
Technological determinism		
Level of development	Positive	Gross domestic product (GDP) per capita; energy consumption per capita
Industrial capacity	Positive	Index based on steel production and electrical-generating capacity; aggregate and per capita electricity and steel production
External determinants		
Security threat	Positive	Participation in enduring rivalry; frequency of militarized interstate dispute (MID) involvement
Security guarantee	Negative	Alliance with great power
Internal determinants		
Democracy	Negative	Polity IV democracy scale
Democratization	Uncertain	Change in Polity IV democracy scale (3-, 5-, and 10-year periods)
Global democracy	Negative	Percentage of democracies among states in system
Exposure to global economy	Negative	(Exports and imports)/GDP
Economic liberalization	Negative	Change in trade ratio (3-, 5-, and 10-year periods)
Dissatisfaction/symbolic motivations	Positive	S score or Tau-b with either global or regional hegemon

RESULTS

TABLE 2
The Correlates of Nuclear Weapons Proliferation

	Dependent Variable		
Independent Variable	*Explore*	*Pursue*	*Acquire*
Technological determinants			
GDP per capita	0.00052[.119]	**0.001**[.017]	0.0002[.378]
	(0.0003)	(0.0004)	(0.0003)
GDP squared	**–3.66e-08**[.094]	**–7.92e-08**[.017]	**–2.36-08**[.100]
	(2.19e-08)	(3.11e-08)	(1.43e-08)
Industrial capacity index	**1.89**[.016]	**1.46**[.046]	**3.19**[< .001]
	(0.78)	(0.73)	(0.91)
External determinants			
Enduring rivalry	**1.57**[.002]	**1.83**[.024]	**2.13**[.076]
	(0.50)	(0.81)	(1.77)
Dispute involvement	**0.17**[.010]	**0.38**[< .001]	**0.23**[.070]
	(0.07)	(0.09)	(0.13)
Alliance	–0.67[.260]	–0.83[.194]	–1.01[.225]
	(0.59)	(0.64)	(0.83)
Internal determinants			
Democracy	0.02[.525]	**0.070**[.084]	0.092[.123]
	(0.038)	(0.038)	(0.059)
Democratization	–0.03[.578]	–0.080[.323]	0.016[.895]
	(0.056)	(0.081)	(0.120)
Percentage of democracies	–0.05[.204]	**–0.186**[.007]	–0.094[.351]
	(0.04)	(0.069)	(0.101)
Economic openness	–0.01[.235]	–0.018[.112]	0.0002[.989]
	(0.01)	(0.012)	(0.015)
Economic liberalization	**–0.037**[.030]	**0.35**[.010]	–0.001[.963]
	(0.017)	(0.014)	(0.018)
Constant	**–4.66**[< .001]	**–6.34**[.016]	–7.52[.022]
	(1.32)	(2.63)	(3.29)
Ancillary parameter (p)	0.55	1.42	1.04
Standard error (p)	0.113	0.48	0.36
Log likelihood	–56.12	–28.57	–19.61
Number of countries	149	149	149
Total observations	5,215	5,578	5,784

NOTE: Coefficients are estimates for parametric survival models with a Weibull distribution; robust standard errors, adjusted for clustering by country, are in parentheses. p values are superscripted and are for two-sided tests. Coefficients that are significant at better than the 10% level are bold. GDP = gross domestic product.

Results: Level 1

- Technological Determinants
  - GDP and ICI have strong effects on hazard rate
    - For low levels, growth steadily increases hazard rate
    - Hazard rates level off at higher levels and decreases at very high levels of GDP and ICI
- External Determinants
  - Enduring rivalry and frequency of involvement in disputes are linked to a higher risk
  - Alliance with nuclear power has a negative effect on hazard rate, but is statistically insignificant
- Internal Determinants
  - Level of institutional restraint has a positive coefficient
  - Democratization has is negative
  - Economic interdependence and liberalization are both negative
  - Dissatisfaction with international status has no effect

Results: Level 3

- Technological Determinants
  - GDP has a lesser effect
  - ICI has a greater effect
- External Determinants
  - Enduring rivalry has a greater effect
  - Frequency of involvement in disputes has varies over time and its effects are harder to measure
  - Alliance with nuclear power has a much greater effect
- Internal Determinants
  - Effects of democracy are still statistically insignificant
    - Democratic states are more likely to acquire weapons – event when controlling for economic factors
  - Economic interdependence and liberalization lose significance

RESULTS: LEVEL 3

TABLE 3
Substantive Effects of the Explanatory Variables on the Likelihood of Exploring Nuclear Weapons

Variable	*Percentage Change from Baseline Hazard Rate*	
	Explore	*Acquire*
Great-power military alliance	–49	–64
Participation in ongoing enduring rivalry	+382	+743
Increase in frequency of MIDs (two more/year)	+38	+52
Industrial capacity threshold	+563	+2,340
Increase in trade openness	–72	–2
Increase in per capita GDP—$500 at very low level	+26	+12
Increase in per capita GDP—$500 at high level	–20	–17
Satisfaction	+40	–82
Increase in democracy	+25	+94

NOTE: MID = militarized interstate dispute; GDP = gross domestic product.

RESULTS: MULTINOMIAL LOGIT MODELS

TABLE 4

Pathways to Proliferation: Multinomial Logit Models

	Level		
Independent Variable	*1 (Explore)*	*2 (Pursue)*	*3 (Acquire)*
Technological determinism			
GDP per capita	**0.0003**$^{<.001}$	**0.0005**$^{<.001}$	**0.0004**$^{<.001}$
	(0.00005)	(0.0001)	(0.0001)
GDP squared	**–1.55e-08**$^{<.001}$	**–4.36e-08**$^{<.001}$	**–1.00e-08**$^{<.001}$
	(2.73e-09)	(7.86e-09)	(1.80e-09)
Industrial capacity index	**2.88**$^{<.001}$	**2.41**$^{<.001}$	**22.59**$^{<.001}$
	(0.270)	(0.280)	(0.664)
External determinants			
Enduring rivalry	**0.43**$^{.017}$	**0.67**$^{.003}$	**1.61**$^{<.001}$
	(0.179)	(0.221)	(0.240)
Dispute involvement	**0.31**$^{.002}$	**0.77**$^{<.001}$	**0.86**$^{<.001}$
	(0.099)	(0.105)	(0.119)
Alliance	**–1.24**$^{<.001}$	–0.22$^{.205}$	**–1.25**$^{<.001}$
	(0.19)	(0.18)	(0.18)
Internal determinants			
Democracy	**0.020**$^{.073}$	**–0.027**$^{.055}$	**0.029**$^{.018}$
	(0.011)	(0.014)	(0.012)
Democratization	–0.005$^{.790}$	0.003$^{.937}$	–0.023$^{.334}$
	(0.020)	(0.032)	(0.024)
Percentage of democracies	**–0.122**$^{<.001}$	0.017$^{.390}$	**0.036**$^{.066}$
	(0.017)	(0.019)	(0.019)
Economic openness	**–0.028**$^{<.001}$	**–0.012**$^{.001}$	**–0.027**$^{<.001}$
	(0.003)	(0.003)	(0.003)
Economic liberalization	0.002$^{.917}$	–0.007$^{.299}$	0.003$^{.675}$
	(0.009)	(0.007)	(0.007)
Constant	**–1.47**$^{.006}$	**–6.95**$^{<.001}$	**–28.31**$^{<.001}$
	(0.538)	(0.745)	(0.339)

NOTE: Log pseudo-likelihood = –1874; pseudo-R^2 = 0.39; total observations = 6,125. The reference category is no steps to pursue nuclear weapons. Coefficients are estimates for multinomial logit regression models, with robust standard errors in parentheses. *p* values are superscripted and are for two-sided tests. Coefficients that are significant at better than the 10% level are in bold. GDP = gross domestic product.

MISSES

TABLE 5

Dogs That Didn't Bark? Countries That Did Not Seriously Explore the Nuclear Option . . . but Should Have

Country	*Years of Maximum Predicted Hazard*
Saudi Arabia	Mid-1980s to mid-1990s
West Germany	Mid-1950s to early 1960s
Japan	Mid-1950s to 1960s
Turkey	Late 1960s to 2000
Bulgaria	1950s
Spain	1960s to early 1970s
Greece	1960s and 1980s
Italy	1950s to early 1960s
Syria	Various

Conclusion

- Existing theories on nuclear proliferation deserve more credit
  - Economic and external threat factors play a significant role
- Findings suggest implications for policy and future research
  - Provide empirical data on the effects of economic interdependence and liberalization on nuclear proliferation
    - Entering into mutually beneficial economic relationships may prevent states from pursuing weapons
  - Effects National Missile Defense (NMD) will vary depending on how a state views the program
    - States under its umbrella are less likely to pursue nuclear deterrents
    - States whose nuclear capabilities are offset by NMD may increase their nuclear arsenal and pursue alternative delivery methods
  - Many current U.S. policies on deterrence of nuclear proliferation may increase the hazard rate

QUESTIONS