ALMOST NUCLEAR: INTRODUCING THE NUCLEAR LATENCY DATASET

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Nuclear Latency

- A country having the capacity to quickly produce nuclear weapons in the event of a crisis
- Limited scholarly research prior to this article
- General questions: How common is nuclear latency? Why do countries develop latent nuclear capabilities? Why do some latent nuclear powers go on to build nuclear weapons, while others are satisfied with just having the technological capacity to make bombs? What are the political effects of nuclear latency?
- Research question: Does nuclear latency influence the likelihood of being targeted in military disputes?

Findings

- Nuclear latency is about three times more common than proliferation

- Preliminary evidence that nuclear latency reduces the likelihood of being targeted in militarized disputes, which suggests similar deterrence benefits of proliferation

Why We Care About Latency

- Only 10 countries have nuclear weapons, 31 have latency
- Could deter an attack but also cause conflict (i.e. crisis over Iran deal)
- Provides political leverage (i.e. Iran has more leverage in the Middle East)
- Could instigate proliferation due to spread of nuclear technology

Nuclear Latency (NL) dataset

- Previous literature fails to clearly define latency, uses old data and ‘‘surrogate indicators’’
- NL dataset presented as a time series, provides information on the global spread of latent nuclear capabilities from 1939 to 2012
- Focuses on the development of enrichment and reprocessing (ENR) facilities
- Contains 241 ENR facilities with information on the operational history, size, purpose (whether it served civilian or military functions), and whether it is multinational

Nuclear Latency (NL) dataset cont'

- Reveals whether facilities were subjected to safeguards administered by the IAEA and whether they were built covertly or with foreign assistance

- Allows researchers to account for variation when measuring nuclear latency (one ENR facility vs a dozen, small amounts of plutonium on a laboratory scale or large amounts)

- Fuhrman and Tkach only provide one empirical application, which shows how the study of nuclear latency can contribute to our understanding of international conflict dynamics

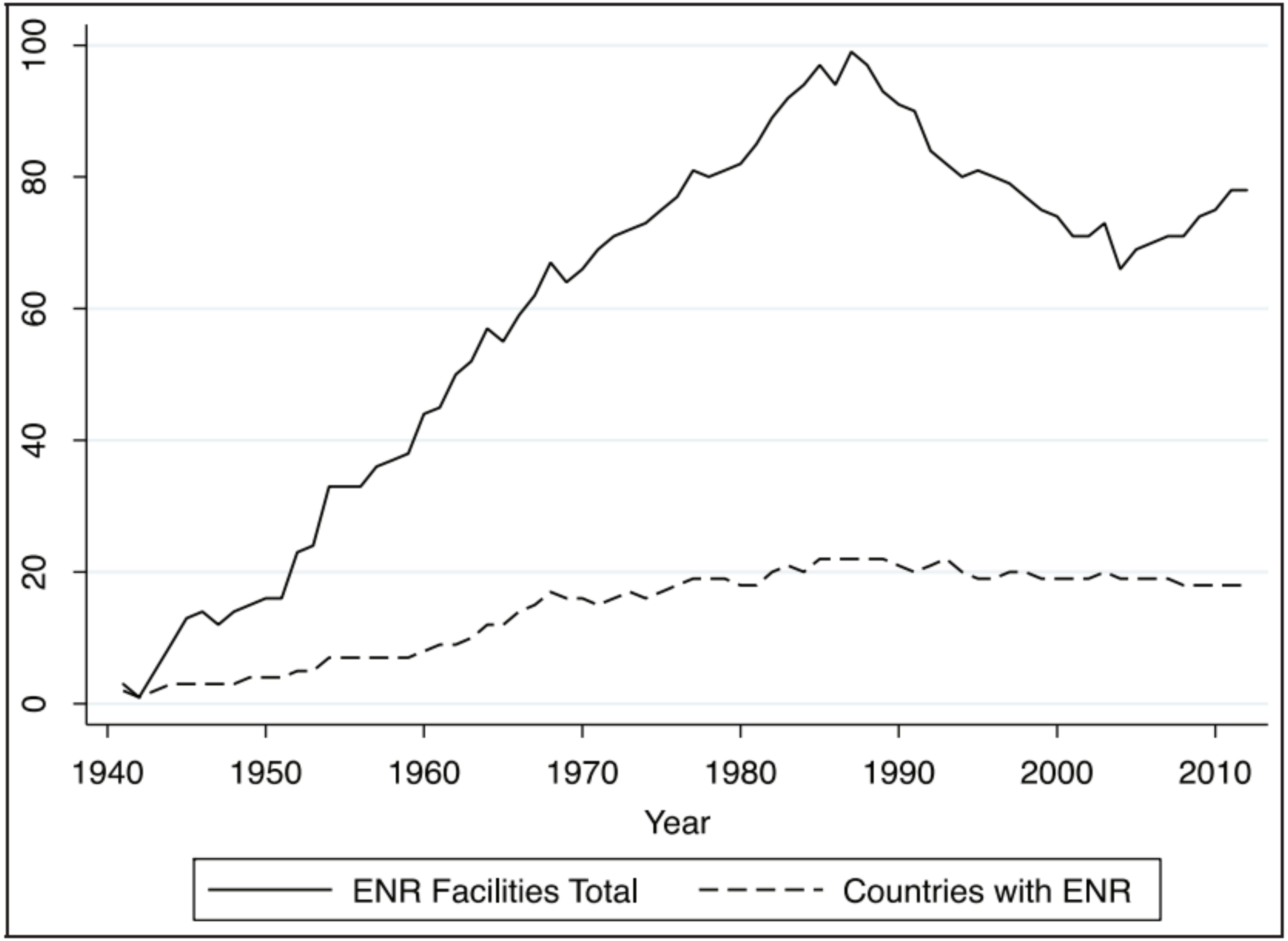

Figure 1. Number of ENR facilities and ENR countries over time.

Table 1. Countries with ENR facilities, 1939–2012

Country	ENR plant operation years
Algeria	1992–2012
Argentina	1968–1973, 1983–1989, 1993–1994
Australia	1972–1983, 1992–2007
Belgium	1966–1974
Brazil	1979–2012
Canada	1944–1976, 1990–1993
China	1960–2012
Czech Republic (Czechoslovakia)	1977–1998
Egypt	1982–2012
France	1949–2012
Germany (West Germany)	1964–2012
India	1964–1973, 1977–2012
Iran	1974–1979, 1985–2012
Iraq	1983–1991
Israel	1963–2012
Italy	1966–1990
Japan	1968–2012
Libya	1982–2003
The Netherlands	1973–2012
North Korea	1975–1993, 2003–2012
Norway	1961–1968
Pakistan	1973–2012
Romania	1985–1989
Russia (Soviet Union)	1941–2012
South Africa	1967–2012
South Korea	1979–1982, 1997–2012
Sweden	1954–1972
Taiwan	1976–1978
UK	1952–2012
USA	1941–2012
Yugoslavia	1954–1978

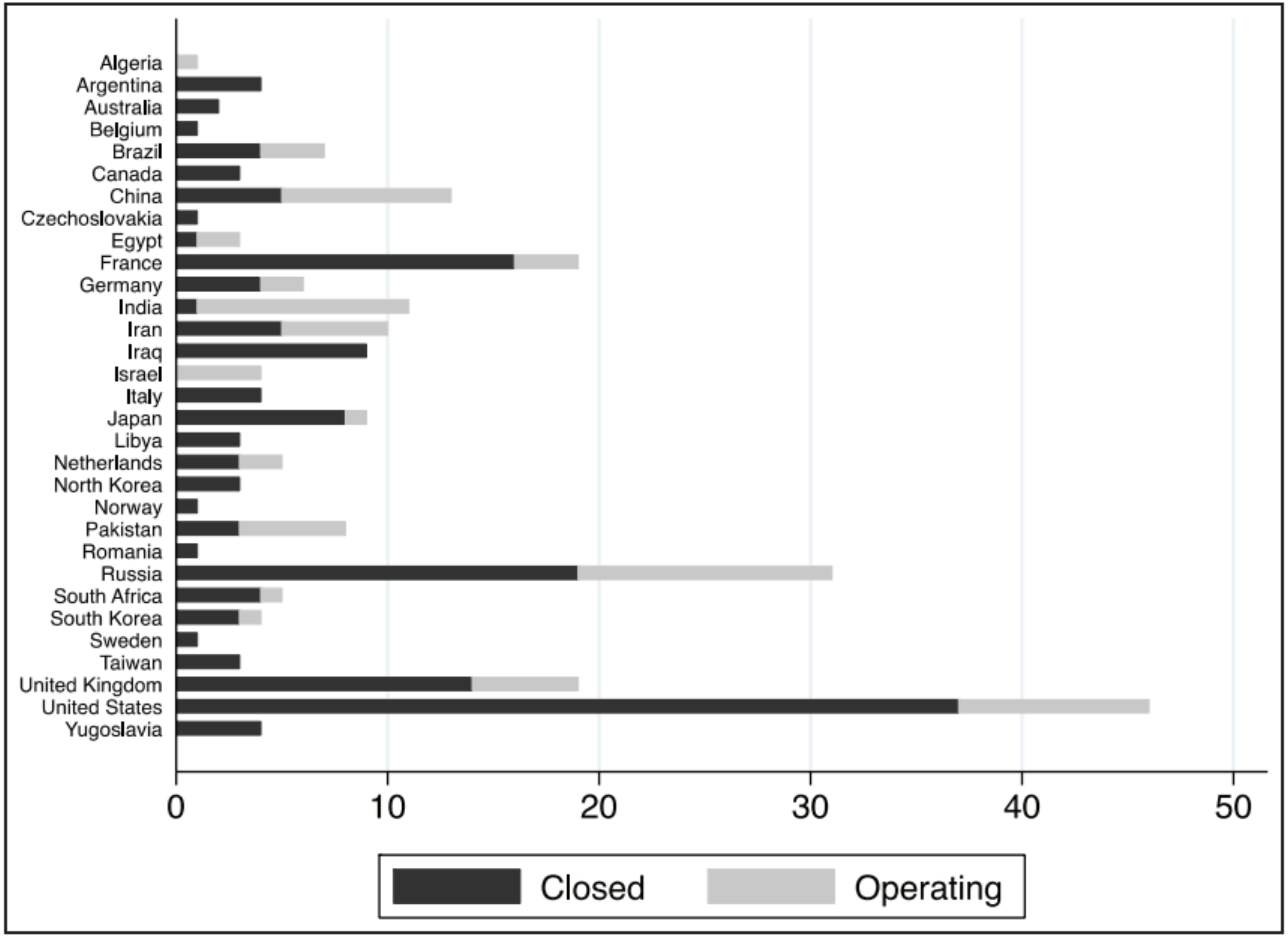

Figure 2. Number of ENR facilities by country.

Empirical Application for International Conflict Dynamics

- Built on an existing study that examines the relationship between nuclear weapons and military conflict (Gartzke and Jo, 2009)
- Uses a standard time-series cross-sectional dataset that covers the period from 1945 to 2000, the unit of observation is the directed-dyad-year
- The dependent variable comes from the Correlates of War Militarized Interstate Dispute dataset (Ghosn et al., 2004) MID Initiation is coded 1 if the potential challenger initiates a militarized dispute against the target and 0 otherwise
- Primary independent variable of interest (Nuclear Latency B) measures whether the potential target in a militarized dispute has latent nuclear capabilities in a given year, coded 1 or 0
- Latency status of the challenger (Nuclear Latency A) is also measured

Theoretical Expectations

- Hypothesis 1: Having nuclear latency reduces the likelihood of being targeted in a militarized interstate dispute.

- Hypothesis 1A: Having nuclear latency increases the likelihood of being targeted in a militarized interstate dispute.

Table 2. Probit analysis of militarized conflict

	(1) Gartzke and Jo (2009)	(2) Latency added	(3) Pursuit added
Nuclear Latency A		0.151**	0.072
		(0.049)	(0.053)
Nuclear Latency B		−0.133**	−0.148**
		(0.044)	(0.052)
Nuclear Weapons Pursuit A			0.182**
			(0.061)
Nuclear Weapons Pursuit B			0.040
			(0.068)
Nuclear Weapons A	0.260**	0.316**	0.333**
	(0.070)	(0.071)	(0.069)
Nuclear Weapons B	−0.001	−0.053	−0.049
	(0.077)	(0.082)	(0.082)
Nuke A × Nuke B	−0.212	−0.210	−0.204
	(0.135)	(0.136)	(0.138)
Democracy A	0.023**	0.020**	0.021**
	(0.006)	(0.006)	(0.006)
Democracy B	0.041**	0.043**	0.043**
	(0.006)	(0.006)	(0.006)
Democracy A × Democracy B	−0.005**	−0.005**	−0.005**
	(0.001)	(0.001)	(0.001)
Rivalry Status A	0.293**	0.286**	0.277**
	(0.032)	(0.032)	(0.031)
Rivalry Status B	0.157**	0.162**	0.160**
	(0.030)	(0.030)	(0.030)
Dyadic Rivalry	1.113**	1.116**	1.109**
	(0.051)	(0.051)	(0.051)
Contiguity	−0.137**	−0.137**	−0.139**
	(0.044)	(0.044)	(0.044)
Distance (ln)	−0.050†	−0.050†	−0.049†
	(0.026)	(0.026)	(0.026)
Alliance	0.043	0.044	0.045
	(0.040)	(0.040)	(0.040)
CINC A	0.778	0.398	0.265
	(0.707)	(0.724)	(0.708)
CINC B	1.589†	1.972*	1.923*
	(0.829)	(0.864)	(0.862)
CINC A × CINC B	0.207	0.064	0.395
	(15.833)	(16.132)	(16.164)
Peace Years	−0.062**	−0.061**	−0.061**
	(0.008)	(0.008)	(0.008)
Spline 1	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)
Spline 2	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)
Spline 3	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Constant	−2.308**	−2.314**	−2.315**
	(0.081)	(0.080)	(0.080)
N	1,051,218	1,051,218	1,051,218

Notes: Standard errors in parentheses; $^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, two-tailed tests.

- Model 1 is a replica of Gartzke and Jo's (2009) model
- Model 2 adds the variables Nuclear Latency A and Nuclear Latency B.
- The coefficient on Nuclear Latency B is negative and statistically significant, indicating that nuclear latency is associated with a lower risk of being targeted in military disputes
- Model 3 adds variables that measure whether the challenger and target have active bomb programs (Nuclear Weapons Pursuit A and Nuclear Weapons Pursuit B), no important change

Shortcomings

- Does not examine how varying degrees of nuclear latency may influence international conflict dynamics
- Does not explore why latency appears to reduce the risk of being targeted in military disputes
- If a country without a research reactor in operation has ENR facilities, its ENR activity would not be included in the NL dataset (very unlikely to actually occur)
- Cannot be certain that dataset contains all ENR plants, since some facilities may remain covert

INTRODUCING NU-CLEAR: A LATENT VARIABLE APPROACH TO MEASURING NUCLEAR PROFICIENCY

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Problem with Previous Research

- Researchers tend to use observable characteristics as a proxy for nuclear latency
- Implicitly assumes that each indicator is equally informative and that measurement error is not a concern
- Nu-CLEAR applies a statistical measurement model to directly estimate nuclear proficiency from observed indicators
- Finds that weapons exploration, reprocessing, and power plants are relatively noisy indicators of nuclear capacity

How it Works

- Weights each nuclear-related activity appropriately
- Acknowledges some activities may be noisier indicators of nuclear proficiency than others, independent of their technical difficulty
- Treats unobservable factors as latent traits and learns about them using appropriate statistical models of observed actions
- Specifically, Nu-CLEAR adopts a latent-variable model grounded in item-response theory (IRT) and takes a Bayesian approach to estimation
- IRT uses the responses of individuals to “items” to recover estimates of unobservable quantities of interest (i.e. a legislator’s voting record reveals information about their ideological preferences, a state’s performance on activities related to nuclear production provides information about their underlying nuclear proficiency)

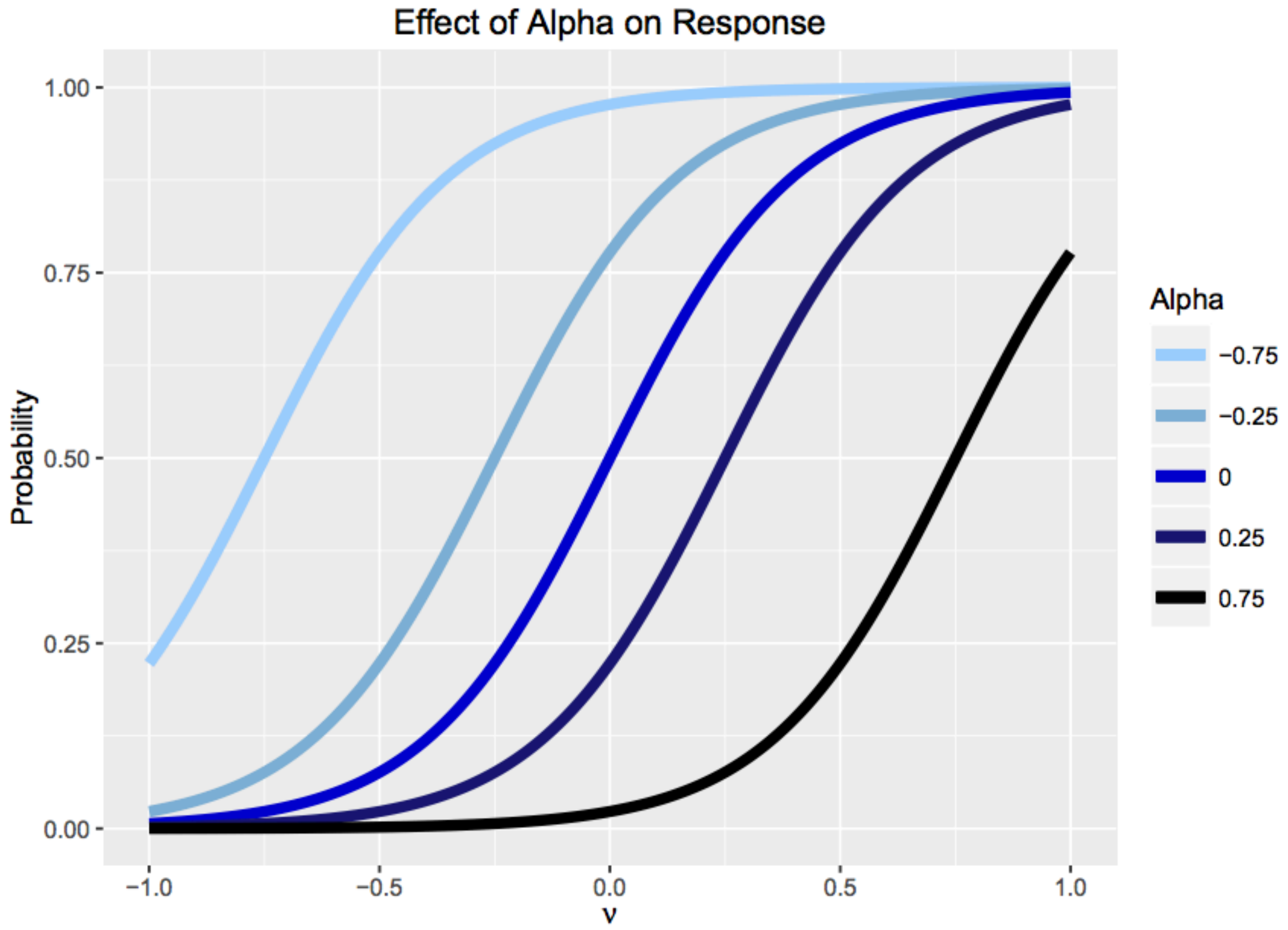

Figure 1: The influence of variations in α on the relationship between proficiency and participation in an activity with $\beta = 5$.

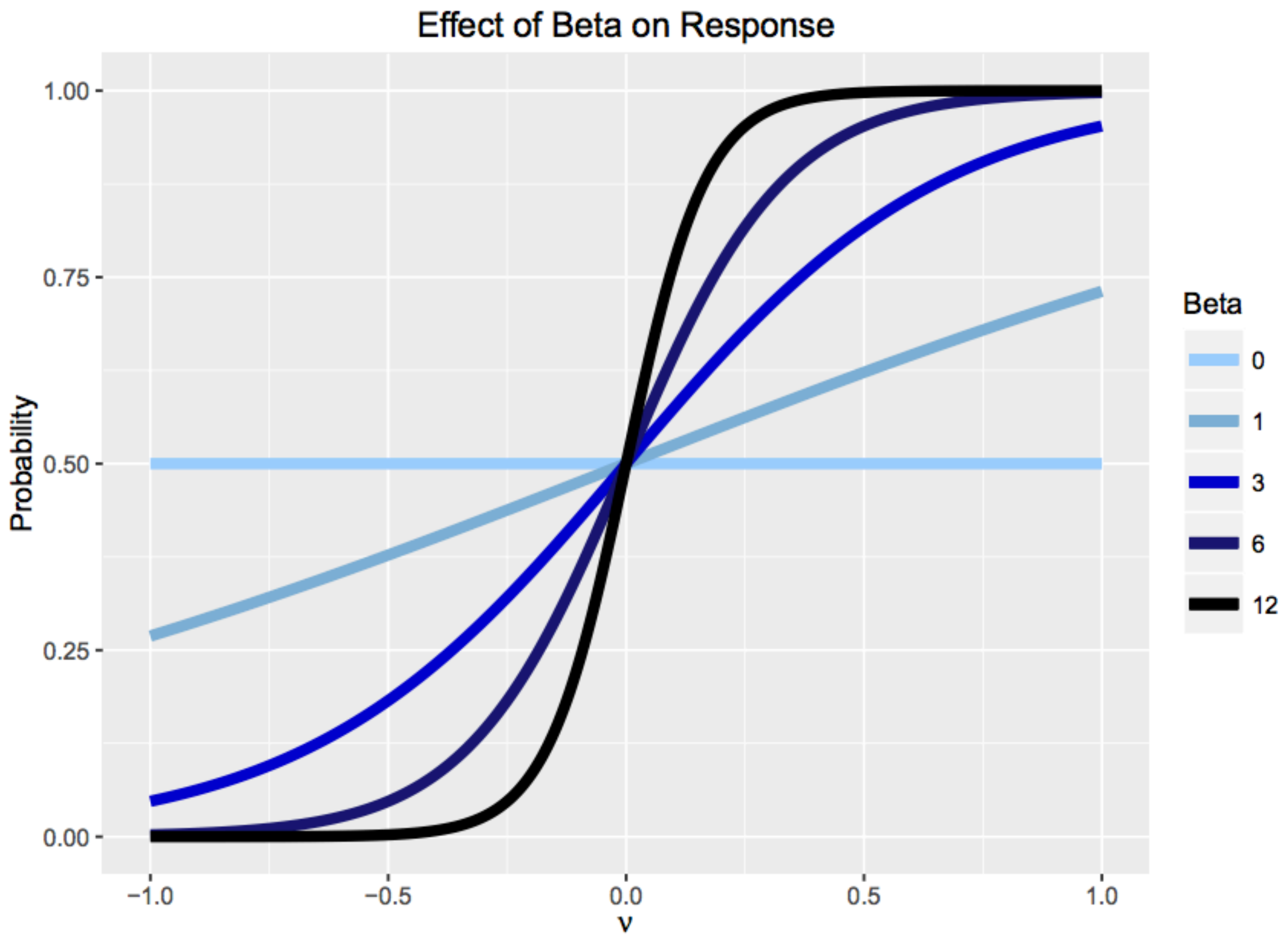

Figure 2: The influence of variations in β on the relationship between proficiency and participation in an activity with $\alpha = 0$.

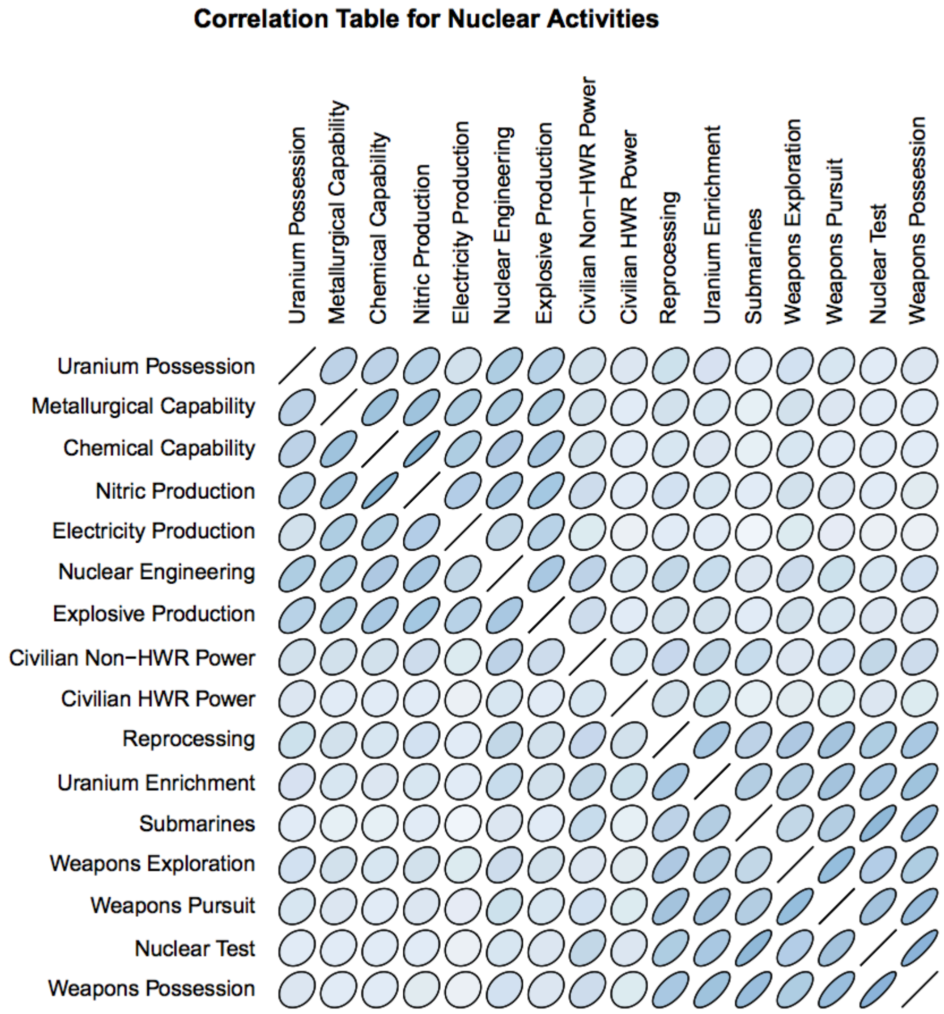

Figure 3: The correlations of each component in our model. Sharper, darker ovals indicate correlations closer to 1, while lighter circles indicate correlations closer to 0. No variables are negatively correlated.

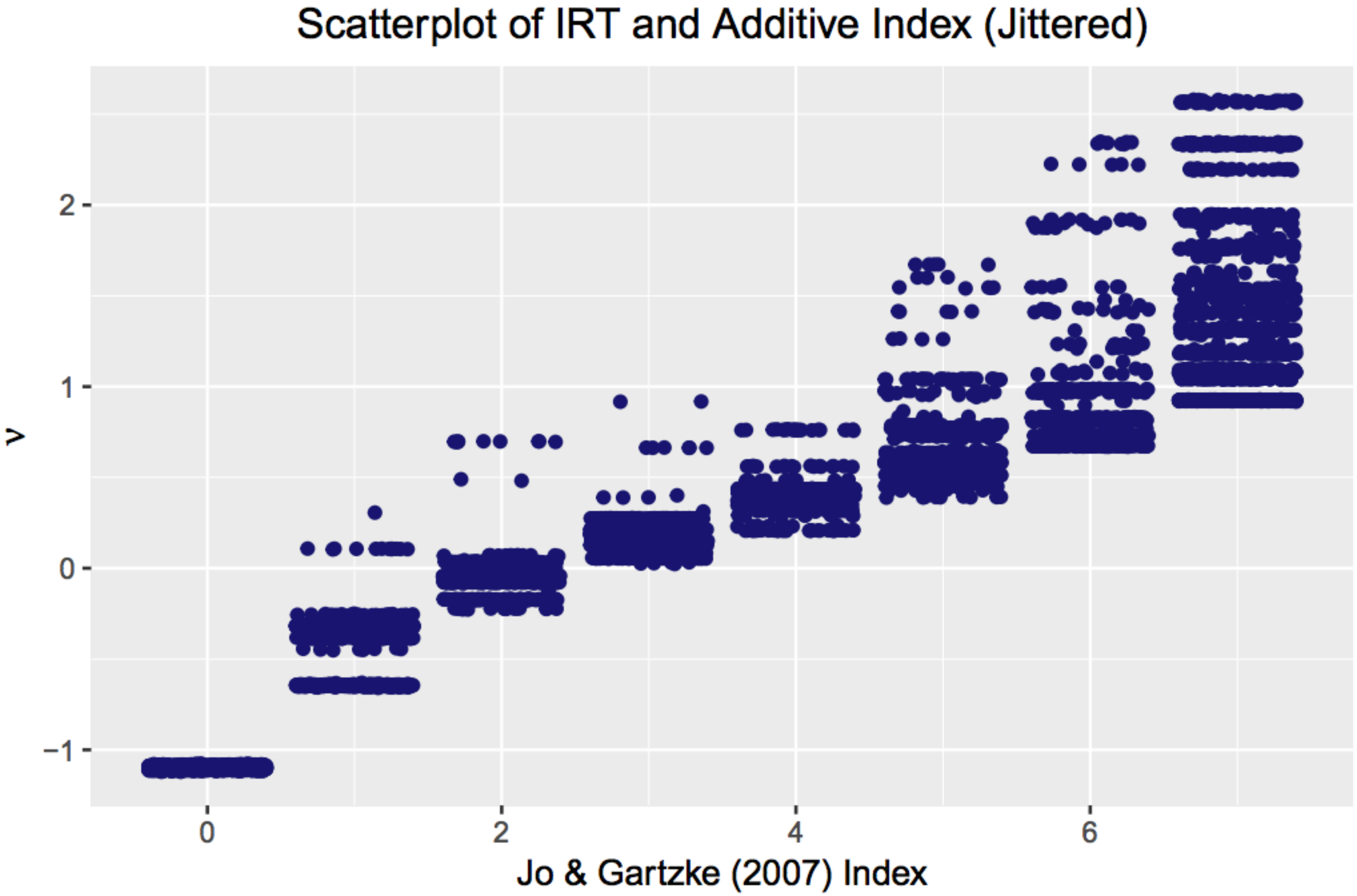

Figure 4: Comparison of ν and Additive Index.

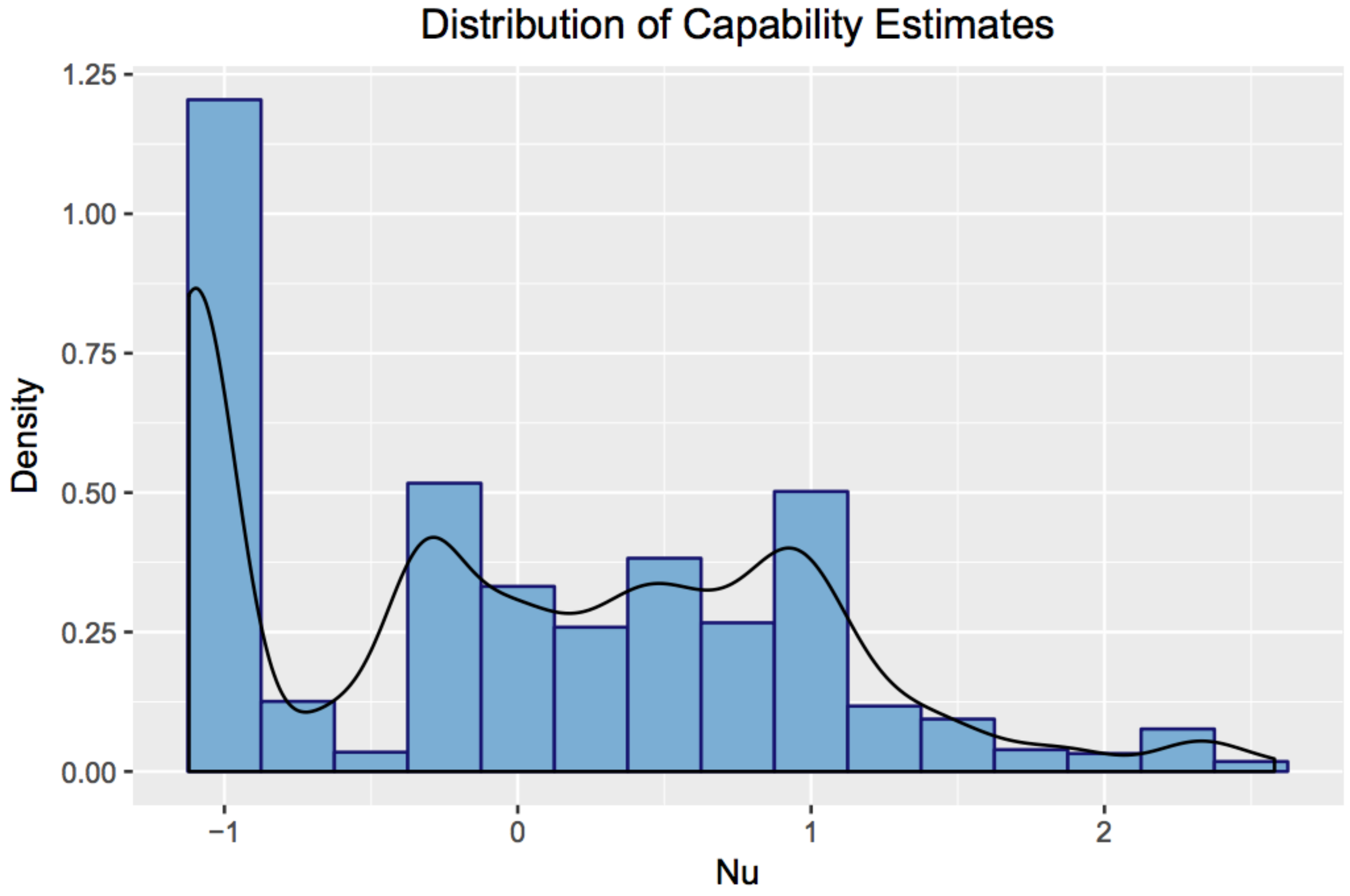

Figure 5: Density and histogram of ν-CLEAR estimates across the entire temporal range.

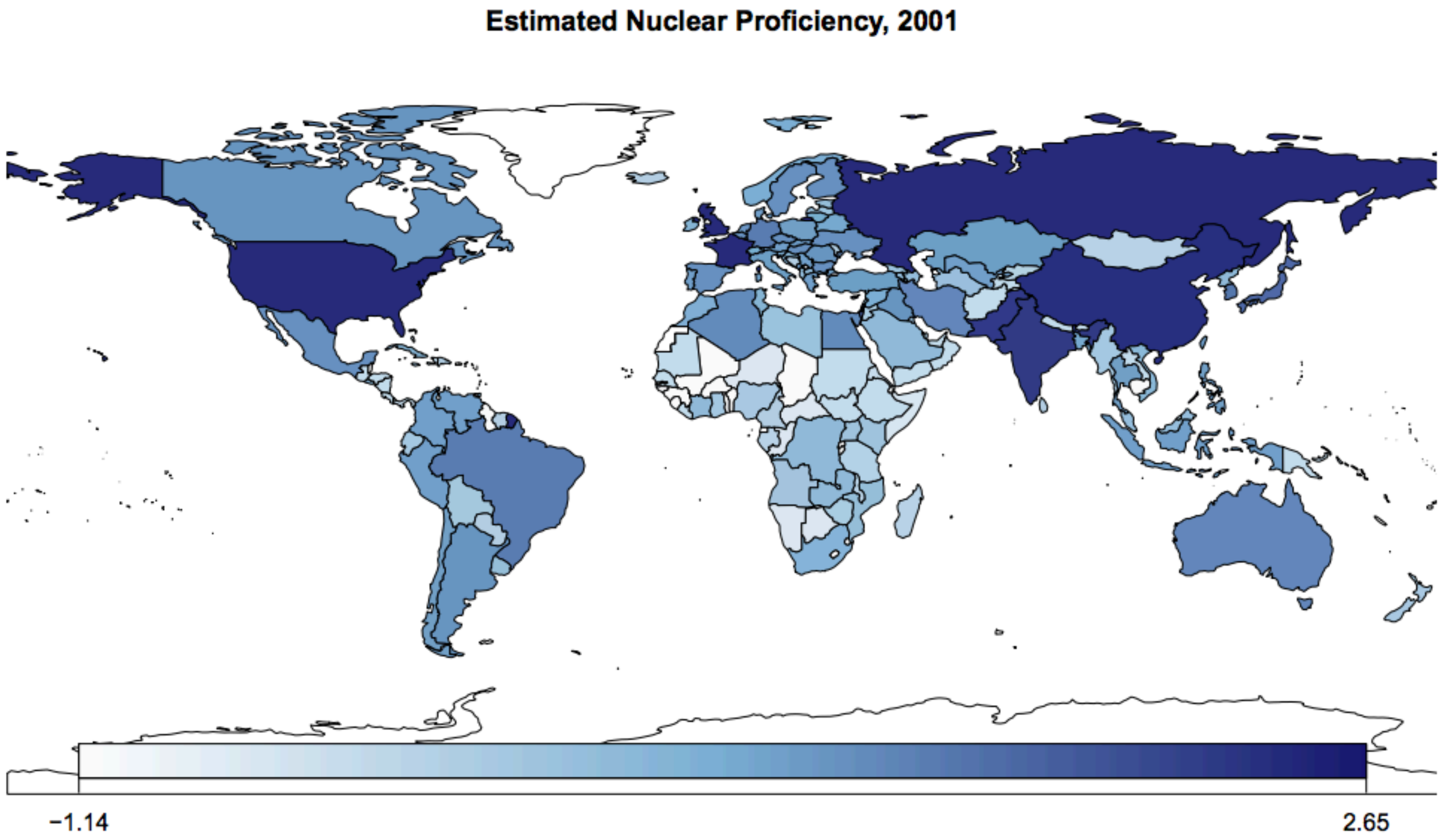

Figure 6: Estimated nuclear proficiencies in 2001 according to ν-CLEAR. Darker shades indicate higher estimates of ν.

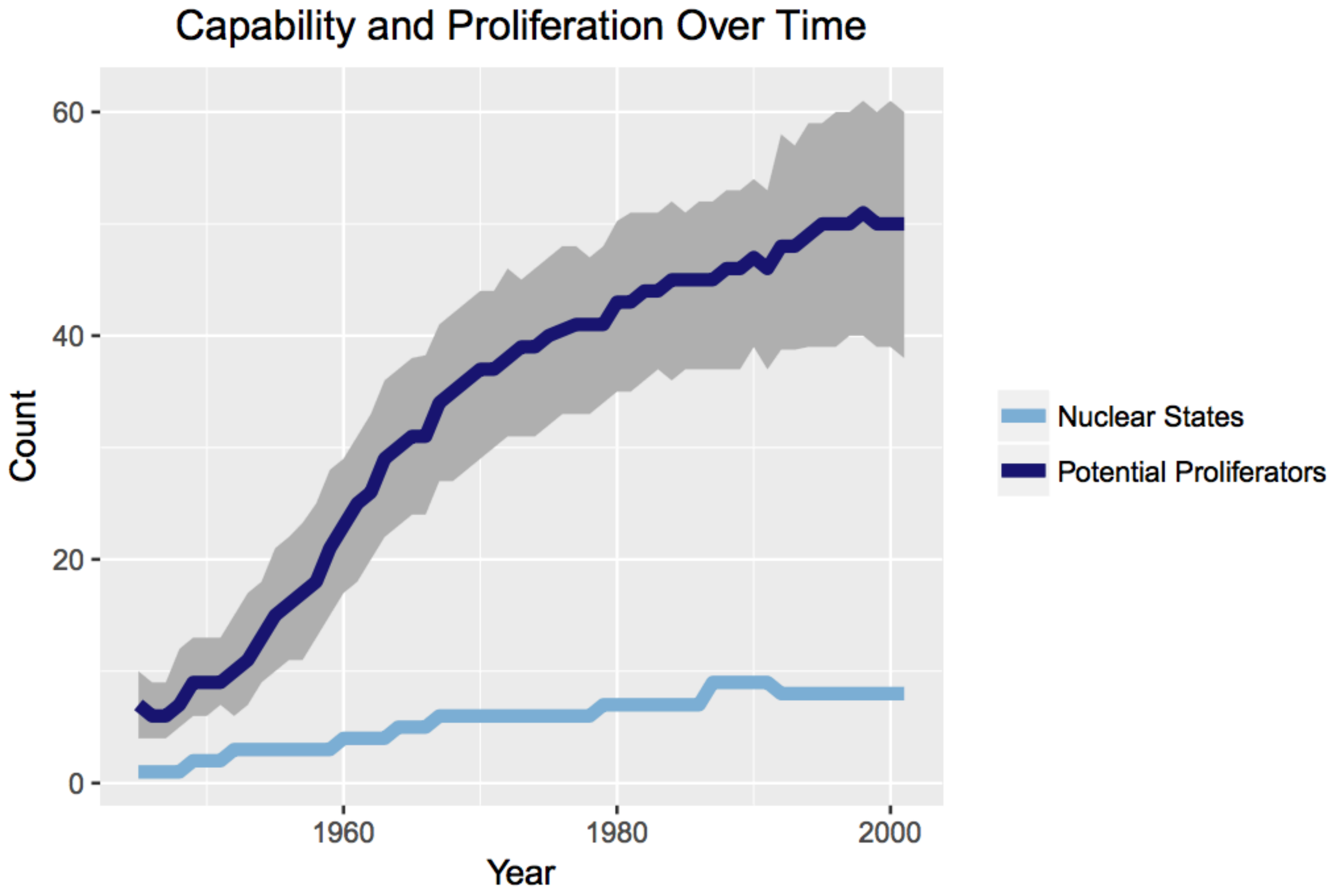

Figure 7: Nuclear weapons states versus potential proliferators across time. The shaded region reflects the uncertainty in the posterior distribution.

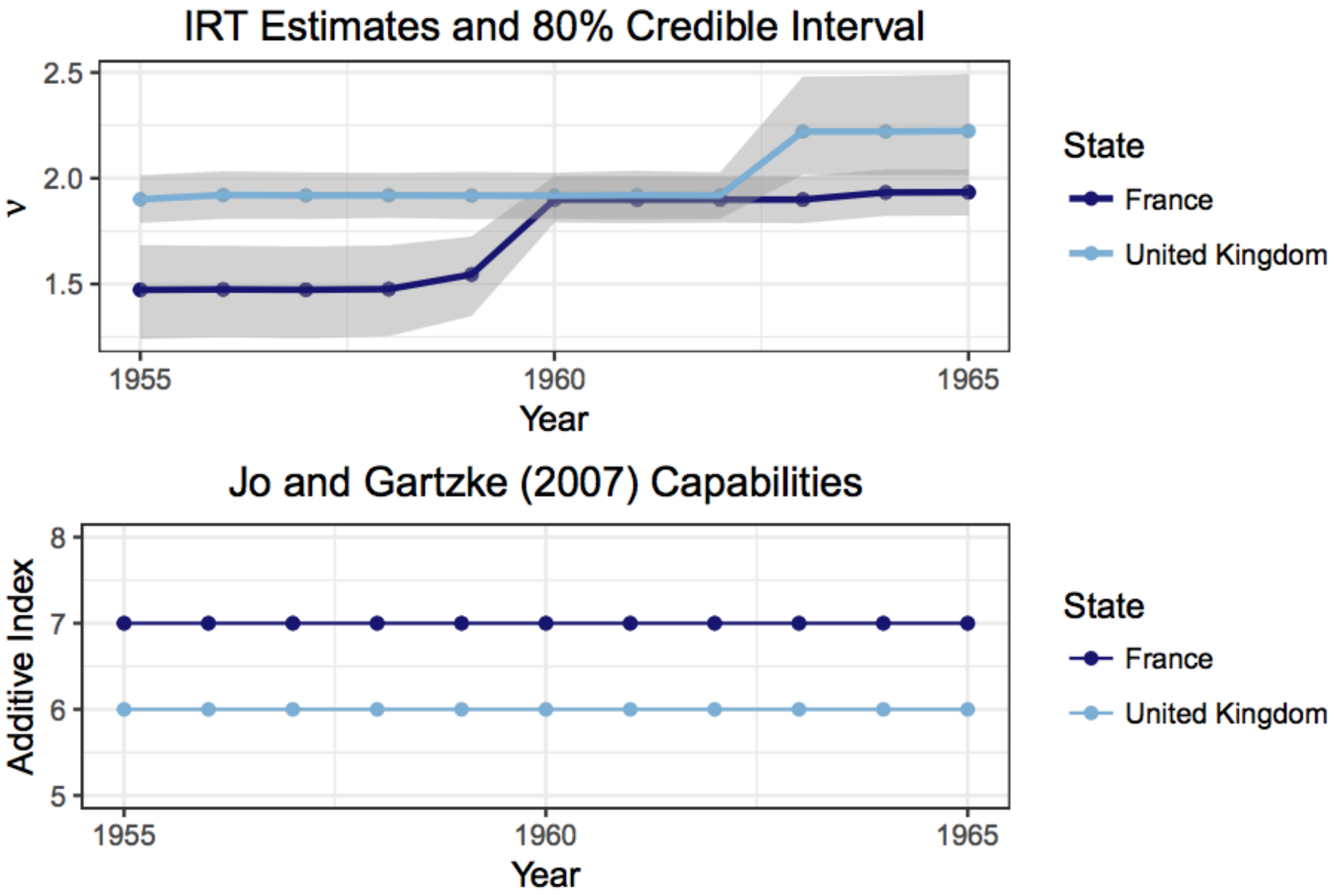

Figure 8: Comparison of France's and the United Kingdom's proficiencies from 1955 to 1965.

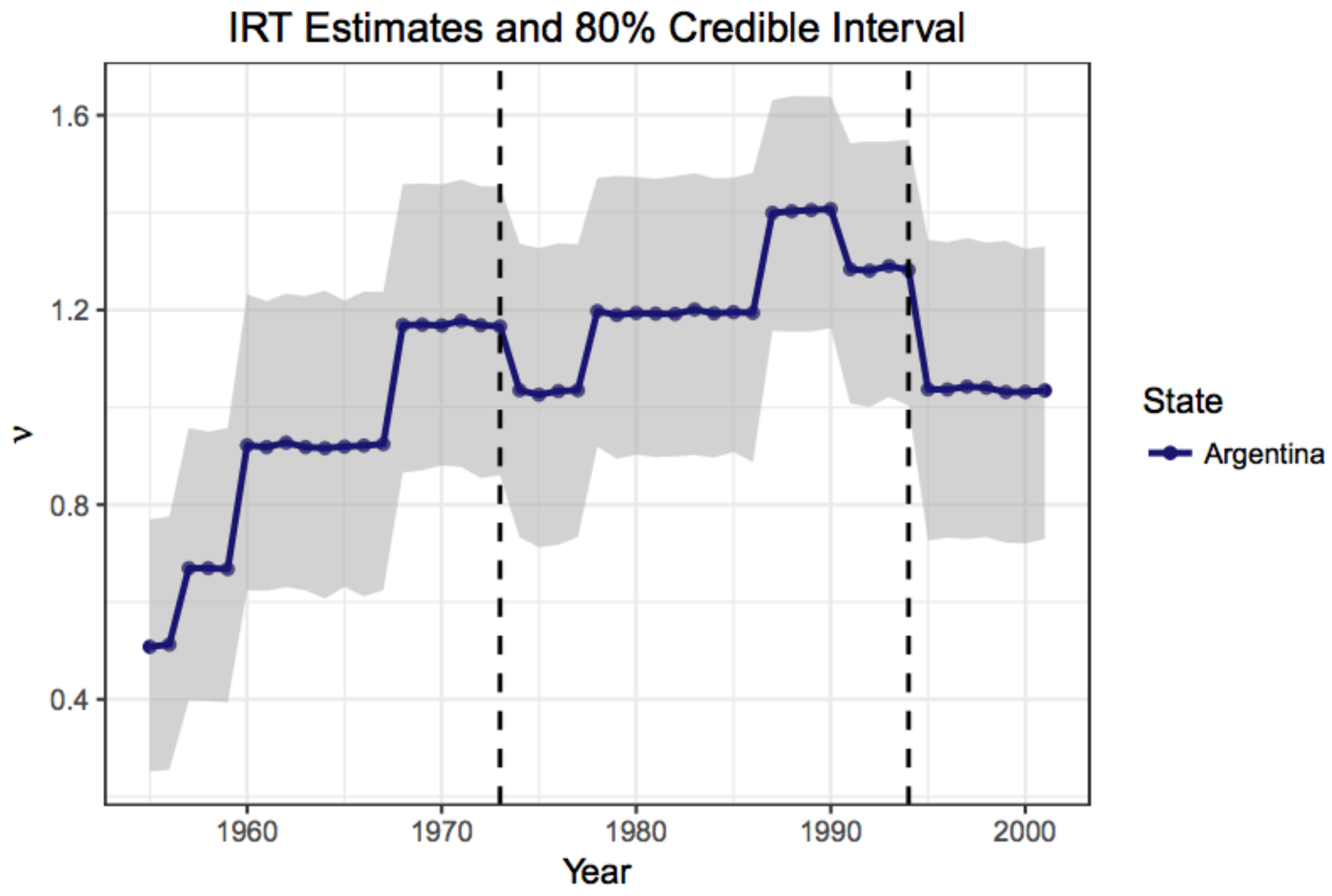

Figure 9: Proficiency estimates for Argentina show temporal variation consistent with its exploration into nuclear weapons. We have highlighted two important points that our measure captures with dotted vertical lines. First, in 1973 a short drop in proficiency corresponds to the closing of reprocessing facilities. A drop also occurs at the second dotted line in 1994 when Argentina ends its foray into enrichment.

Table 1: Estimates of α for each activity

	Mean	10th Percentile	90th Percentile
Electricity Production	-0.41	-0.43	-0.39
Metallurgical Capability	0.16	0.14	0.18
Chemical Capability	0.20	0.18	0.22
Nitric Production	0.35	0.33	0.37
Explosive Production	0.43	0.41	0.45
Uranium Possession	0.59	0.57	0.62
Nuclear Engineering	0.62	0.60	0.64
Reprocessing	1.44	1.41	1.48
Exploration	1.46	1.43	1.50
Non-HWR Power	1.53	1.49	1.57
Uranium Enrichment	1.53	1.50	1.57
Pursuit	1.62	1.58	1.66
Nuclear Weapons	1.74	1.70	1.77
Nuclear Test	1.82	1.78	1.86
Submarines	2.01	1.97	2.05
HWR Power	2.44	2.35	2.53

Table 2: Estimates of β for each Activity

	β mean	10th Percentile	90th Percentile
Uranium Possession	2.02	1.95	2.09
HWR Power	2.13	1.99	2.27
Non-HWR Power	2.81	2.67	2.96
Exploration	3.11	2.95	3.28
Explosive Production	3.63	3.50	3.77
Metallurgical Capability	4.25	4.08	4.42
Pursuit	4.31	4.03	4.59
Reprocessing	4.76	4.44	5.09
Nuclear Engineering	4.84	4.63	5.06
Uranium Enrichment	4.97	4.64	5.33
Electricity Production	5.00	4.71	5.28
Nitric Production	5.79	5.51	6.09
Chemical Capability	5.81	5.52	6.11
Nuclear Weapons	14.56	11.99	17.54
Nuclear Test	23.59	16.74	32.00
Submarines	30.50	18.35	45.28

Table 3: Replication of Jo and Gartzke (2007) Using ν-CLEAR

	Dependent variable:	
	Weapons Program	
	(1)	(2)
ν	1.014*** (0.102)	
Jo & Gartzke Measure		0.484*** (0.079)
Economic Capacity	0.872 (1.265)	1.483 (1.944)
Diffusion	0.851*** (0.178)	1.055*** (0.251)
Conventional Threat	0.697*** (0.108)	0.700*** (0.258)
Nuclear Rival	−0.837*** (0.238)	−0.914*** (0.364)
Nuclear Defender	0.171 (0.141)	−0.098 (0.306)
Diplomatic Isolation	−0.007 (0.222)	−0.060 (0.438)
Domestic Unrest	−0.059 (0.071)	−0.148** (0.096)
Democracy	−0.018 (0.014)	−0.026* (0.022)
NPT Ratification	−0.589*** (0.182)	−0.781*** (0.363)
NPT (system effect)	0.006** (0.003)	0.005* (0.004)
Major Power	1.856*** (0.297)	2.000*** (0.388)
Regional Power	1.530*** (0.183)	1.549*** (0.236)
Count 1	−0.118*** (0.017)	−0.113*** (0.012)
Constant	−4.070*** (0.565)	−6.354*** (1.001)
Observations	4,697	4,697
Log Likelihood	−273.505	−256.712
Akaike Inf. Crit.	577.010	543.424
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 4: Replication of Fuhrmann and Tkach (2015) using ν-CLEAR

	Dependent variable:	
	Conflict Initiation	
	(1)	(2)
ν_A	0.107*** (0.020)	
ν_B	0.020 (0.017)	
Latency A		0.151*** (0.040)
Latency B		−0.133*** (0.047)
Nuclear Weapons A	0.150** (0.063)	0.316*** (0.071)
Nuclear Weapons B	−0.035 (0.068)	−0.053 (0.082)
Nuke A * Nuke B	−0.237 (0.153)	−0.210 (0.136)
Democracy A	0.015*** (0.006)	0.020*** (0.006)
Democracy B	0.040*** (0.005)	0.043*** (0.006)
Democracy A * Democracy B	−0.005*** (0.001)	−0.005*** (0.001)
Rivalry A	0.270*** (0.028)	0.286*** (0.032)
Rivalry B	0.160*** (0.028)	0.162*** (0.030)
Dyadic Rivalry	1.101*** (0.042)	1.116*** (0.051)
Contiguity	−0.140*** (0.029)	−0.137*** (0.044)
ln(distance)	−0.048*** (0.017)	−0.050*** (0.026)
Alliance	0.057 (0.037)	0.044 (0.040)
CINC A	−0.185 (0.595)	0.398 (0.724)
CINC B	1.304* (0.687)	1.972*** (0.864)
CINC A * CINC B	3.060 (10.058)	0.064 (16.132)
Peace Years	−0.062*** (0.007)	−0.061*** (0.008)
Spline 1	−0.0002*** (0.0001)	−0.0002*** (0.000)
Spline 2	0.0001*** (0.00003)	0.0001*** (0.000)
Spline 3	0.00000 (0.00001)	0.00001 (0.000)
Constant	−2.249*** (0.071)	−2.314*** (0.080)
Observations	1,051,218	1,051,218
Log Likelihood	−5,976.087	−5,997.659
Akaike Inf. Crit.	11,996.170	12,039.320

Note: *p<0.1; **p<0.05; ***p<0.01

Shortcomings

- Does not explicitly account for dynamics in the estimation procedure or model potential dependence among activities
- "Let the data speak," while objectively superior to avoid bias, is more inaccessible to policymakers and others outside of academia who do not know how to read data