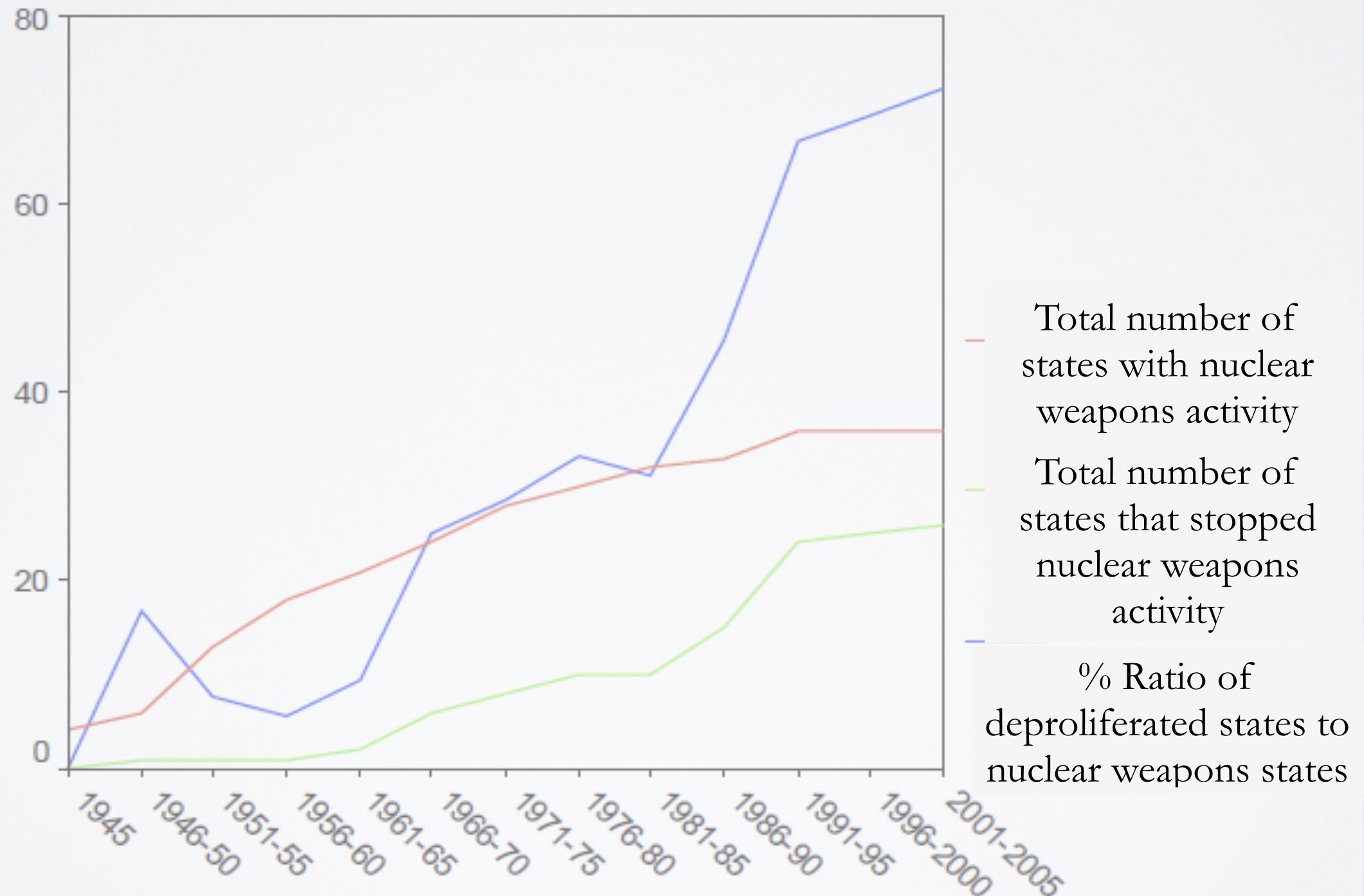# DETERMINANTS OF NUCLEAR REVERSAL: WHY STATES GIVE UP NUCLEAR WEAPONS PROGRAMS

Rupal N. Mehta
Belfer Center, Harvard Kennedy School
University of Nebraska, Lincoln

Empirical Puzzle:
Nuclear Deproliferation Over Time

States Engaged in Nuclear Weapons Activity: 1945-Present

Total number of states with nuclear weapons activity

Total number of states that stopped nuclear weapons activity

% Ratio of deproliferated states to nuclear weapons states

Empirical Puzzle:
Nuclear Deproliferation Over Time

States That Stopped Nuclear Programs/ Year of Stopping	Remaining Nuclear Weapons States/ Current Proliferators
Algeria (1991)	China
Argentina (1990)	France
Australia (1973)	India
Belarus (1996)	Iran
Brazil (1990)	Israel
Canada (1969)	North Korea
Chile (1995)	Pakistan
Egypt (1980)	Russia
West Germany (1958)	United Kingdom
Indonesia (1967)	United States
Iraq (1995)	
Italy (1958)	
Japan (1970)	
Kazakhstan (1995)	
Libya (2003)	
Norway (1962)	
Romania (1993)	
South Africa (1993)	
South Korea (1978)	
Spain (1988)	
Sweden (1969)	
Switzerland (1969)	
Syria (2007)	
Taiwan (1988)	
Ukraine (1996)	
Yugoslavia (1988)	

Total: 26

Total: 10

3

Extant Literature: Alternative Explanations

Nuclear Proliferation:
Theoretical:

    Optimist/Pessimist

    Three Models: Security, Bureaucratic, Prestige

Large-N Empirical:

    Determinants of Proliferation

    Opportunity/Willingness

Nuclear Deproliferation:
Theoretical:

    Regional:

    Leader-specific:

    Psychology:

Large-N Empirical: **??**

What are the determinants of deproliferation?

Formal Model

On behalf of the international community, a state such as the US ('she'), detects that a proliferator ('he') has an active nuclear program. She attempts to prevent his program through negotiation.

The US is uncertain over the proliferator's value for pursuing nuclear weapons.

Proliferators vary in their value of nuclear weapons.

Doves: low value, not willing to endure higher levels of coercion

Hawks: high value, willing to endure higher levels of coercion

Example:
Canada, Sweden, Switzerland

Example:
India, North Korea, Libya

Formal Model

The US has four options:

        Reward

        Coerce

        Attack

        Do Nothing

The Proliferator has two options:

        Continue

        Stop

Actors' strategies are dependent on:

        value of the nuclear weapons weapons program

        value of the reward

        cost of coercion

Theory of Deproliferation

If the US prefers proliferation to using military force:
  Imagine a proliferator like Sweden or Soviet Union:

  Rewards will stop doves and some hawks (depending on size).
  Sanctions can stop doves but will not work on hawks.

If the US prefers to attack rather than allow proliferation:
  Imagine a proliferator like Syria or Libya:

  Sanctions are not used: too costly, uncertain outcome.
  Rewards will always stop *both* doves and hawks.

Implications

Either rewards or sanctions will stop a dove's weapons program.

Rejecting a reward reveals information about type.

Rewards are highly effective bribes to modify behavior -- can compel even hawks to stop to avoid punishment.

Deproliferation strategy is conditional on a credible threat to use military force by the international community/US.

Hypotheses for Testing

Under these conditions - the credible threat of military force:

Rewards Hypothesis:

Rewards increase the likelihood that a state will stop its nuclear program.

Sanctions Hypothesis:

Sanctions decrease the likelihood that a state will stop its nuclear program.

Model for Deproliferation

Dataset of all nuclear weapons activity from 1945-2007:
    36 states total
    26 deproliferated states

Unit of Analysis: State-year

Number of Observations: 1,823

Dependent Variable (in given state-year):
    1 (stopped/dismantled/returned nuclear program)
    0 otherwise

Independent Variables
    Positive Inducements: political, military, economic & aggregate measure
    Negative Inducements: economic, conflict environment & aggregate measure

Primary Model Specification:
    Binary Time-Series, Cross-Section (robust to other specifications)

Analysis:
Inducements on Deproliferation

	Stop		Continue
Rewards	Argentina Australia Belarus Brazil Canada Chile Egypt Indonesia Italy Japan Kazakhstan	Norway Romania Spain South Africa South Korea Sweden Switzerland Taiwan Ukraine Yugoslavia	France India Israel United Kingdom
Coercion	Syria		China
Both	Germany/West Germany Iraq Libya *Iran?*		North Korea Pakistan

Findings:
Inducements on Deproliferation

	Model 1	Model 2
Positive Inducements	**0.382***	
	(0.124)	
Negative Inducements	**-1.923**	
	(1.336)	
US Economic Aid		0.504
		(0.516)
US Military Aid		**1.094**
		(0.515)
Entrance into WTO		-0.158
		(0.350)
US Economic Sanctions		-1.748
		(1.498)
Credible Threat Condition	0	0
	(0.550)	(0.455)
Controls	YES	YES
Time Trends	YES	YES
Constant	-3.830	-5.958
	(2.161)	(1.958)
Observations	1823	1823
Number of States	35	35
Numbers in parentheses are standard errors for beta coefficients. *p<0.10, **p>0.05, ***p>0.01	Model: Binary Time Series Cross-Section Logit	Model: Binary Time Series Cross-Section Logit

Findings:
Nuclear Weapons Activity,
New Leaders, and Foreign Aid

Country	Start	Stop	Duration	New Leader	% Increase in Military Aid
Algeria	1983	1991	8		39.8
Argentina	1968	1990	22	Menem	2634.7
Australia	1956	1973	17	Whitlam	
Belarus	1991	1996	5	Shushkevich	10337.8
Brazil	1955	1990	35		188.3
Canada	1944	1969	25	Trudeau	
Chile	1974	1995	21		424.1
China	*1955*	*Present*			
Egypt	1955	1980	25	Mubarak	819779.2
France	*1946*	*Present*			
W. Germany	1957	1958	1		13262.9
India	*1948*	*Present*			
Indonesia	1965	1967	2	Suharto	1917.7
Iran	*1974*	*2013?*		*Rouhani*	
Iraq	1976	1995	19		
Israel	*1949*	*Present*			
Italy	1955	1958	3	Zoli	385.7
Japan	1945	1970	25		
Kazakhstan	1991	1995	4	Nazarbaev	9416.9
Libya	1970	2003	33		
North Korea	*1965*	*Present*			
Norway	1949	1962	13		34.9
Pakistan	*1972*	*Present*			
Romania	1985	1993	8	Vacariou	1437.6
Russia	*1945*	*Present*			
South Africa	1969	1993	24	de Klerk	2788
South Korea	1959	1978	19		168.7
Spain	1974	1988	14		
Sweden	1954	1969	15	Palme	
Switzerland	1946	1969	23	van Moos	
Syria	1976	2007	31		
Taiwan	1967	1988	21	Lee Teng-Hui	
Ukraine	1991	1996	5	Yuschenko	12338.4
United Kingdom	*1945*	*Present*			
United States	*1945*	*Present*			
Yugoslavia	1954	1988	34	Dizarevic	

Egypt: ~ 800,000% increase in Foreign Aid

Ukraine: ~ 12,000% increase in Foreign Aid

Indonesia: ~ 2000% increase in Foreign Aid

…when programs ended.

Robustness Checks

State-level fixed effects; clustered standard errors by state (some models)

Time trends to account for temporal dependence; Lag/lead to account for historical trends

Mitigate selection bias by controlling for relationship with the US

Alternative operationalizations of constructs

Alternative model specification
    Rare Events Model; Negative Binomial

Other proliferation date coding rules (Way 2012, Bleek 2013, Mueller and Schmidt 2004)

First cut of interaction of type and inducements on deproliferation using predictive probabilities; *S scores*/Affinity Index

Conclusions & Implications

Carrots and Sticks are non-equivalent;
Rewards can be coercive.

Rewards, specifically US military aid, **increase in the likelihood** of deproliferation.

Economic sanctions and military force are **negatively associated** with deproliferation.

US counter-proliferation policy should *initially* incorporate the use of rewards in negotiations with proliferators, even committed proliferators like Iran.
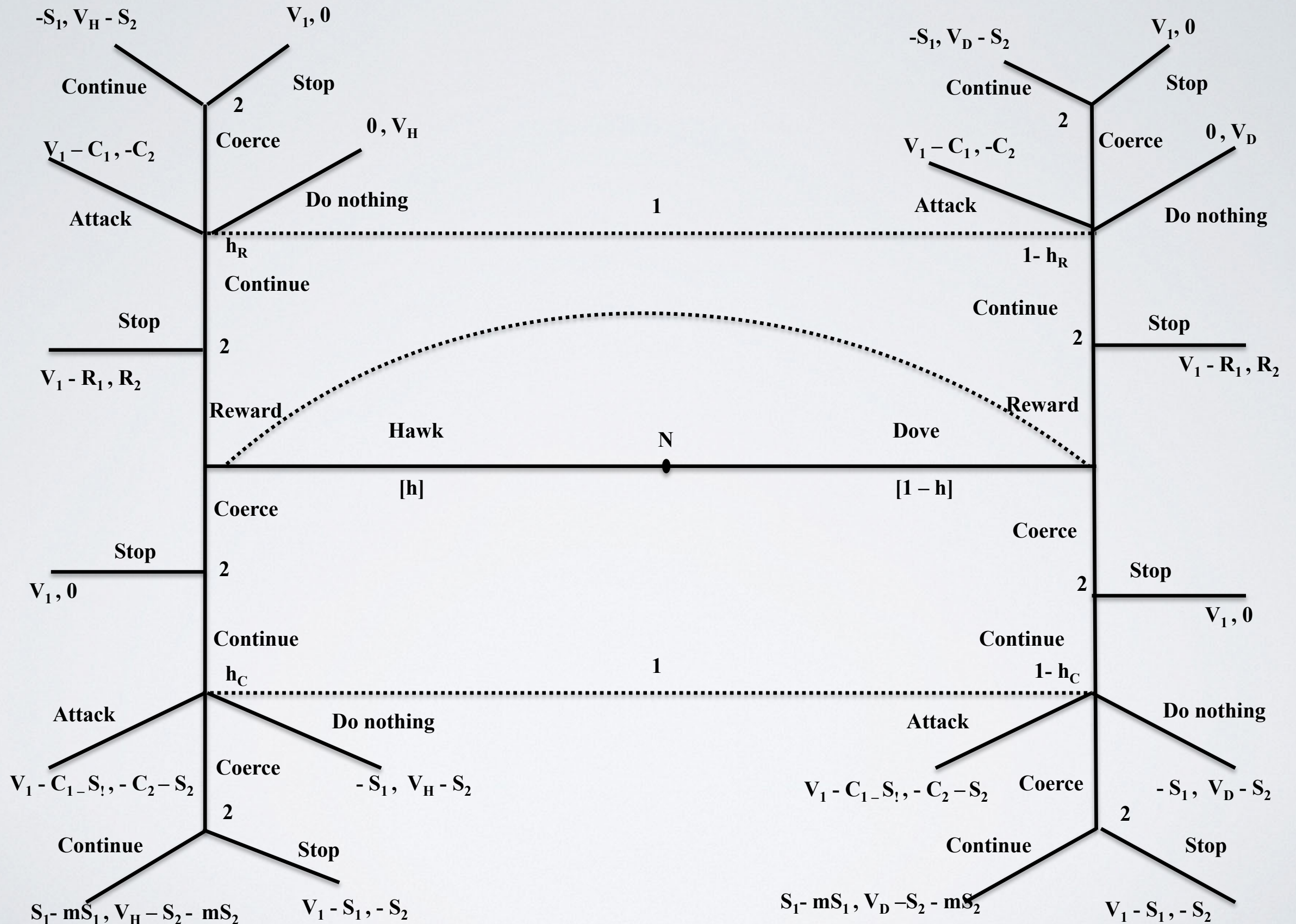
Credibility, of threats and promises, is critical.

Thank You!

Rupal_Mehta@hks.harvard.edu

Formal Model

-S$_1$, V$_H$ - S$_2$

V$_1$, 0

Continue

Stop

2

Coerce

0 , V$_H$

V$_1$ – C$_1$, -C$_2$

Do nothing

1

Attack

h$_R$

Continue

Stop

2

V$_1$ - R$_1$, R$_2$

Reward

Hawk

N

Coerce

Stop

2

V$_1$, 0

Continue

h$_C$

1

Attack

Do nothing

Coerce

- S$_1$, V$_H$ - S$_2$

V$_1$ - C$_1$ _ S$_!$, - C$_2$ – S$_2$

2

Continue

Stop

S$_1$- mS$_1$, V$_H$ – S$_2$ - mS$_2$

V$_1$ - S$_1$, - S$_2$

[h]

Dove

[1 – h]

-S$_1$, V$_D$ - S$_2$

V$_1$, 0

Continue

Stop

2

Coerce

0 , V$_D$

V$_1$ – C$_1$, -C$_2$

Attack

Do nothing

1- h$_R$

Continue

Stop

2

V$_1$ - R$_1$, R$_2$

Reward

Coerce

Stop

2

V$_1$, 0

Continue

1- h$_C$

Attack

Do nothing

V$_1$ - C$_1$ _ S$_!$, - C$_2$ – S$_2$

Coerce

- S$_1$, V$_D$ - S$_2$

2

Continue

Stop

S$_1$- mS$_1$, V$_D$ –S$_2$ - mS$_2$

V$_1$ - S$_1$, - S$_2$

Independent Variables:
Theoretical Constructs and Operationalizations

Construct	Measure	Sources
Positive Inducements	Aggregate of Positive Rewards	Leeds 2002 and USAID
Negative Inducements	Aggregate of Negative Inducements	Furhmann and Kreps 2011; Hufbauer 2007

Independent Variables:
Theoretical Constructs and Operationalizations

Construct	Measure
Positive Inducements	**Aggregate of Positive Inducements**
Positive Economic Reward	US Economic Aid
	Alternative Operationalization: Economic Openness
Positive Military Reward	US Military Aid
	Alternative Operationalization: Security Guarantees
Positive Political Reward	Entrance into WTO
	Alternative Operationalization: NATO, UN
Negative Inducements	**Aggregate of Negative Inducements**
Negative Economic Inducements	US Economic Sanctions
	Alternative Operationalization: UN Economic Sanctions
Negative Military Inducements	Attack on Nuclear Facilities
	Alternative Operationalization: MID Involvement