Stanton Nuclear Security Fellows Seminar

1. Alexandre Debs, CISAC

Friends and Foes Eyeing Armageddon: A Strategic Theory of Nuclear Proliferation and Interstate Conflict (joint with Nuno Monteiro, Yale)

1. A brief description of your research topic and why you chose it

We are interested to understand the causes of nuclear proliferation, during the Cold War and the post-Cold War periods. We also want to understand the circumstances under which a country's attempt to acquire nuclear weapons triggers a preventive war from an enemy, or sanctions from a superpower ally (in the form of cuts in the transfer of conventional weapons or in nuclear assistance, etc.).

This book project builds upon a working paper of ours, 'Nothing to Fear but Fear Itself? Nuclear Proliferation and Preventive War'. This working paper was our first project on the topic of nuclear proliferation. Let me tell you first how we chose to write this working paper, and second how we decided to build upon the working paper to develop this book project.

Initially, we were interested in the general topic of nuclear proliferation for three reasons. First, we wanted to understand the fact that the rate of nuclear proliferation is now slower than it was during the Cold War. This fact runs contrary to international relations theory, which predicted an increase in nuclear proliferation with the end of the Cold War. Instead of confronting this puzzle, scholars moved away from theories of proliferation based on the world balance of power. While we certainly learned a lot from the nuclear proliferation literature, Nuno and I felt uneasy that there was no systemic theory that could explain the recent drop in the rate of proliferation.

Second, we wanted to understand if the current fears of an explosion of nuclear proliferation were rational, given the low rate of proliferation. If our current fears of nuclear proliferation are not rational, then we might conclude that it is best to reallocate resources from counter-proliferation efforts to other (national security) goals.

Third, we thought that we could combine our different skills to generate new insights on the causes of nuclear proliferation (with Nuno being trained as a security scholar in the realist tradition, and my being trained as an applied game theorist). We were initially surprised that there was no theory of proliferation using game-theoretic tools, especially given that some of the pioneering work in game theory was done by scholars, such as Thomas Schelling, who cared about international relations and nuclear conflicts. It seems that the field of international relations has evolved in such a way that the dialogue between game theorists and security scholars is now very rare. This is especially unfortunate given that the problem of nuclear proliferation is essentially strategic: if a state wants to nuclearize to improve its position vis-à-vis its enemy, the enemy might want to strike preventively. The best course of action for the potential proliferator depends on the behavior of its enemy, and vice-versa. Game theory is very helpful in thinking through such strategic situations.

In particular, consider the claim that with the end of the Cold War, states have more to gain from acquiring their own nuclear capabilities. This is the premise of traditional international relations theories, such as realism, which predicted an explosion in the rate of proliferation with the end of the Cold War. Yet if a potential proliferator has more to gain from acquiring nuclear weapons, then a power-projecting state has more to lose from proliferation, as some scholars have recently argued. Which state is most likely to achieve its goal when nuclearization would produce a bigger shift in the balance of power? We can posit an answer by focusing on the incentives of each country, but it will not be satisfactory unless we can incorporate the incentives of both states in the same framework.

In our working paper, we argue that the deterrer has the advantage in the strategic interaction, since the decision to launch a nuclear weapons program is a costly investment with delayed returns. When nuclearization would produce a bigger shift in the balance of power, the deterrer's threats become more credible, and the potential proliferator is less likely to nuclearize. Therefore, we argue that the drop in the rate of proliferation is due to the greater effectiveness of the U.S.'s counter-proliferation efforts. We illustrate this theory with two case studies, the Soviet nuclearization of 1949 and the U.S. invasion of Iraq in 2003. In the first case, threats of preventive war by the U.S. were not credible, and the Soviet Union acquired nuclear weapons. In the second case, the U.S. could effectively stop the Iraqi nuclear weapons program (yet given the difficulty of proving that the program had indeed ceased, the U.S. launched a preventive war). Taking stock, we conclude that it is the very concern for proliferation which is the foundation of the U.S.'s success. The concern about proliferation is rational, but the implicit criticism of the U.S.'s counter-proliferation efforts is not. The U.S. should maintain its efforts towards counter-proliferation.

As we are building on this working paper to develop the book project, we now wish to take a closer look at proliferation dynamics within alliances. The assumption that nuclearization leads to a larger shift in the balance of power (relative to the cost of war) in the post-Cold War period is useful as a first approximation and as a solution to the initial puzzle. The nuclearization of the client of a superpower (such as France or the U.K. during the Cold War) would not lead to a large shift in the balance of power, relative to the cost of a preventive war (which could escalate to the superpower ally). Thus, threats lacked credibility during the Cold War, and proliferation proceeded. Yet there are important dynamics within an alliance that are worth investigation: How confident are the clients of a superpower that it would honor its security guarantees in the event of a conflict? When would a superpower provide sensitive nuclear assistance to an ally? When would it prefer to transfer conventional weapons?

We decided to investigate these questions further because many states now entertain friendly relations with the U.S., and have regional security concerns. As such, we may learn about the optimal counter-proliferation policy from looking at the historical record of security assurances to allies.

2. Your research methodology – how you propose to investigate the topic that you have chosen

We will employ two main methodologies:

A. Game theory: As I argued above, game theory is very helpful in understanding strategic situations, such as the problem of nuclear proliferation.

B. Qualitative tools: In order to understand the interests of the actors involved, and the constraints that they faced, it is important that we collect qualitative evidence. We will read secondary-source materials describing the history of particular cases, we will interview policy-makers involved in recent crises, and we may conduct original archival research, if the information that we need has not been collected yet.

In the last four months, with the help of five RAs at Yale and Stanford, we have collected information on the following countries: Argentina, Brazil, India, Iran, North Korea, Pakistan, South Korea, Sweden, Switzerland, Taiwan, West Germany, Yugoslavia.

3. How you believe the results of your research will contribute to the policy process

It is important to understand why and how counter proliferation measures are useful, whether the U.S. is trying to deter enemies from acquiring nuclear weapons or to reassure allies that they do not need such capacity. The rise of China may bring dynamics reminiscent of the Cold War. In the meantime, as I mentioned above, many states entertain friendly relations with the U.S., and have regional security concerns, they may face situations similar to those of U.S. allies during the Cold War.

4. Who is the target audience (title, organization, country)?

Given the substantive concerns and the methodological approach, this book will be of interest to two communities within international relations: nuclear proliferation experts (Scott Sagan, Stanford, USA; Etel Solingen, UC-Irvine, USA; Matthew Kroenig, Georgetown, USA; Matthew Fuhrmann, Texas A&M, USA; Christopher Way, Cornell, USA; Erik Gartzke, UC-San Diego, USA; T.V. Paul, McGill, Canada; Francis Gavin, UT-Austin; etc.), and game theorists (James Fearon, Stanford, USA; Robert Powell, UC-Berkeley, USA; Kristopher Ramsay, Princeton, USA; Branislav Slantchev, UC-San Diego, USA; Massimo Morelli, Columbia, USA; Kenneth Schultz, Stanford, USA).

The book may also be of interest to a policy audience and the general public. We will strive to convey clearly the intuition for our game-theoretic results, so as to make the book accessible to a wide audience.

5. What you expect to find (your null hypothesis)?

We think that the U.S.'s ability to convince its allies to refrain from nuclearization depends on the relative strategic importance of the ally. We may expect that strategically important allies would receive greater transfers of conventional weapons, but less nuclear assistance.

2. Lance Kim, RAND

Exploiting Dual Use: A Choice Theoretic Approach to Managing the Global Expansion of Nuclear Energy

Introduction

The "interchangeable and interdependent" nature of nuclear infrastructure utilized in the production of energy and weapons presents the central challenge for managing the proliferation and security risks arising from a global expansion of nuclear energy. That nuclear energy and weapons share a common technological basis not only reduces barriers to weapons, these commonalities increase the ambiguity of state's intent to acquire nuclear technology and reduce the responsiveness of the international community to proliferation threats. Too often, however, analyses of proliferation risk are decoupled into risk minimization and strategic analysis frameworks. Whereas the former seeks to address supply-side determinants in the form of technological features related to fissile material production, attractiveness, and accessibility, the latter focuses on demand-side factors related to security, domestic politics, and normative influences on decisions.

Conventional policy solutions that emerge from these reductionistic approaches tend to propose piecemeal strategies such as safeguards, multilateral control, and demand-side measures that reinforce nonproliferation norms, reduce the impact of domestic political factors, and guarantee security. While such efforts are likely to be necessary features of any comprehensive nonproliferation regime, these solutions may paper over insecurities and be fragile to failure modes. In the case of multilateral nuclear approaches, the acceptability, feasibility, and sustainability of these arrangements are questionable given the longevity of nuclear infrastructure, the required diversity of supply, and the fluidity of international relationships. Furthermore, fuel and waste shipments raise security and public acceptance issues. And ultimately, many of these measures do little to address the Non-Proliferation Treaty trump card guaranteeing the inalienable right to peaceful nuclear technology. Moreover, a "glass half full" view of these measures fails to recognize that outlier states constitute proliferation risk - solutions must address extant nonproliferation challenges, not simply gain the cooperation of already cooperative states.

Moreover, these measures lack the power to differentiate between technology options. Technology control and demand-side measures could conceivably manage any type of fuel cycle, centralizing highly sensitive elements of the fuel cycle, restricting their transfer, and reducing the demand for nuclear weapons through diplomacy and security guarantees.[1] Meanwhile, technical judgments on proliferation risk are hampered by the complexity, uncertainty, and ambiguity associated with evaluations of nuclear energy technologies. A clearly superior system is difficult to identify across incommensurable criteria and definitive assessments are elusive, often resulting in strategies that maintain the status quo.

Policy inconsistencies and disruptive policy shifts have emerged from this lack of consensus. The extent to which demand-side factors combined with supply mechanisms contribute to the risk of proliferation

[1]Multilateral fuel cycles may also impede technological innovation by limiting choices to globally available fuel cycles.

leads to highly varied policy recommendations ranging from restrictions on deployed nuclear weapons to the complete abandonment of nuclear energy. Nuclear supply agreements with de facto nuclear weapons states not party to the Nonproliferation Treaty and acceptance of sensitive fuel cycle facilities in Non-Nuclear Weapons States contrast with an ongoing dispute over a suspected weapons program and bilateral restrictions on reprocessing. Furthermore, constantly shifting R&D priorities create uncertainties for technology developers and investors.

Methodology: Elements of an Alternative Choice Theoretic Approach

Resource economics and choice theory may provide an alternative approach to assessing proliferation risk. While dual-use is commonly seen as detrimental to nonproliferation efforts, this property may also be exploited to effect positive behavior. A choice-theoretic approach may yield policy insights by unifying risk minimization and strategic analysis frameworks while also accounting for the benefits of different nuclear fuel cycles.

The classic microeconomic model of choice under resource constraints is at the kernel of the problem - a state faces a choice between allocating limited resources between energy production and weapons. Focusing on material constraints for the moment, a state can allocate sources of fissile and fertile materials to energy production, weapons, or both. The state's decision will depend on the relative valuation of these two economic "goods" and the technological opportunities afforded by nuclear fuel cycle options, subject to the constraints on available fissile and fertile material resources.

While the introduction of more sustainable closed fuel cycles is often feared to increase proliferation risk, the transition from viewing plutonium as a liability to a resource may result in a larger proportion of resources allocated to energy production. Ceterus paribus, a pure technology substitution effect that increases resource utilization increases the value of fissile material in energy generation and could draw material from weapons to energy. However, the production of additional fissile material through breeding introduces an "income effect" where a lower proportion of material is allocated to weapons, but more weapons are produced nonetheless.

Though the "income effect" associated with breeding additional fissile material may overwhelm substitution effects and result in more weapons, the diminishing marginal returns associated with expanding fissile material inventories may lead to fewer nuclear weapons. Irrespective of the choice of nuclear energy system option, acquiring a nuclear reactor and its fissile material represents a significant boost to capabilities. The difference in proliferation and security risk between a state with a large inventory of fissile material and a state with an even larger inventory may be less important.

For proliferation risk, a state's valuation of fissile material inventory is likely to be strongly coupled to nuclear weapons doctrine. Though states have pursued large arsenals to achieve credible first and second strike capabilities, moving towards minimum deterrence or disarmament may reduce the threshold beyond which additional fissile material is less valuable - as a hedge against another arms race or as a bargaining chip, but not directly contributing to deterrence.

As a final methodological note, the outcomes of a choice theoretic analysis may be dynamically linked to the physical evolution of the nuclear fuel cycle and sensitive to initial conditions. Transitions from the

status quo (which vary from state to state) to more sustainable nuclear fuel cycles may pose long-term and transient challenges as a consequence of the longevity of nuclear infrastructure and the resulting stocks and flows of radionuclides. For example, achieving a high growth rate of breeder reactors without resorting to enriching uranium may require significant out-of-core inventories of fissile material for startup cores.

Summary and Policy Implications

A model of constrained resource allocation could unify reductionistic social science and engineering discussions that tend to focus on either the supply or demand determinants of proliferation risk. Moreover, a choice theoretic approach could more definitively differentiate between nuclear fuel cycles by comparing technological opportunities rather than a narrowly defined focus on downside risks. Quantifying the size of the competing effects in the resource allocation problem may offer insights into alternative nonproliferation strategies and technology pathways that drive states towards a corner solution where states have greater incentives to a) allocate fissile material to peaceful purposes and b) better protect these materials as a valuable resource. Insights from this approach can augment the design of nonproliferation regimes and inform R&D portfolio decisions.

3. James Platte, BCSIA

National Decision Making and Nuclear Fuel Cycles: An Analysis of Influences

Research Summary

My research examines the factors that influence national decisions about developing a nuclear fuel cycle. In addition, the risks involved with particular decisions regarding a nuclear fuel cycle are explored, and three country cases – India, Japan, and South Korea – are studied in this regard. Prospect theory is utilized in this study to delve into how countries, particularly the three country cases, make these decisions in the context of their domestic and international frames. Many factors, such as national goals, economic conditions, security concerns, and regional relations, determine a country's frame of reference, and the concept of strategic culture is employed to help determine frame of reference.

My motivation for studying this topic came out of a long-standing interest in the issues surrounding nuclear power. As the nuclear industry experienced growth in Asia during recent years, I became interested in studying how and why individual countries develop different nuclear energy policies, including the type of fuel cycle employed by each country. I believe that this research is important because nuclear politics, whether regarding nuclear weapons or civilian power, continues to play a major role in international affairs. Thus, understanding how and why countries have developed certain nuclear fuel cycle policies can help to understand how countries interested in developing some level of indigenous nuclear capacity will set their nuclear fuel cycle policies.

Research Methodology

This study employs prospect theory and strategic culture to examine the decision making behind national nuclear fuel cycle policy. It focuses on how a country's reference point determines how a country views itself in the international setting and how that guides nuclear fuel cycle policy. Other factors, such as strategic culture, are used to help determine reference points and explain a country's decision making environment. A qualitative approach is used throughout the study. After using prospect theory and strategic culture to create an analytical framework, three country case studies will be examined.

When using prospect theory to analyze nuclear fuel cycle decision making, it is important to first determine a country's reference point. While the reference point here should specifically concern the nuclear fuel cycle, some general points must also be considered in order to establish a baseline reference for a country. It is important to note that a country's reference point can change over time, so the reference point for each particular decision must be determined. After determining individual points, a general trend of decision making can be determined.

With this reference point identified, a change in the status quo can be translated into whether a country is in a gains or losses frame and thus whether it will seek relative or absolute gains. Of course, the main reason to go through this analytic process is to answer a puzzle that has not satisfactorily been answered by other theories, such as why Japan has chosen to reprocess spent nuclear fuel but South Korea uses a once-through fuel cycle.

It is also crucial to understand what relative gains and absolute gains mean in national nuclear fuel cycle policy. Absolute gains would seem to be the development of new nuclear fuel cycle capabilities, such as creating a domestic uranium enrichment program. Relative gains would seem to be expanding the scale of a country's existing nuclear fuel cycle without significantly modifying capabilities. Without understanding relative and absolute gains in the nuclear fuel cycle, it would be difficult to definitively conclude that a country is in a gains or losses frame.

For the case studies, the time frame for analysis is from 1960 to 1978. Starting in 1960, initial policies, ambitions, and goals for nuclear energy are established for each of the three case studies, and then the development of each country's nuclear fuel cycle policy over the next two decades is analyzed. In the analysis of each individual case study, both internal and external factors are analyzed throughout the time frame, and a comparative section of the study focuses on four events that can be viewed as shocks or changes to the international nuclear order during the 1960s and 1970s. Namely, the study examines how the governments of India, Japan, and South Korea reacted, in terms of their nuclear fuel cycle policies, to these four events: the first Chinese nuclear test in 1964, the signing of the Nuclear Non-Proliferation Treaty in 1968, the Arab oil embargo in 1973, and India's first nuclear test and the subsequent creation of the Nuclear Suppliers Group in 1974. In addition, particular decisions by each country are placed on a relative spectrum of whether a decision was made more for military/security reasons or for civilian/commercial reasons.

This study relies principally on primary sources, namely government reports and data concerning the nuclear industries in the three case studies. Secondary reporting in newspapers, journals, and other accounts will be used to fill data gaps. It is anticipated that more secondary sources, such as newspaper and journal articles, will be used to gain insight into the reference points of a country. Interviews with important figures related to nuclear fuel cycle decision-making also is used to gather information.

Policy Relevance

India, Japan, and South Korea all are major players in the global nuclear arena and are of significant interest to policy makers in the United States. With India, the United States signed a landmark civilian nuclear cooperation deal in 2005, but the deal has yet to be implemented fully in practice. South Korea's current nuclear cooperation agreement with the United States is set to expire in 2014, and the two countries already have begun negotiations over a new nuclear cooperation agreement. Japan's nuclear cooperation agreement with the United States expires in 2018, but the more immediate concern is how Japanese policymakers will react to the accident at the Fukushima Daiichi nuclear power station caused by the Great East Japan Earthquake of March 11, 2011. Many of the fundamental nuclear policies in all three countries were set prior to 1980, so this study will help policy makers in the United States to understand how the nuclear sector in each country developed to their current points and what paths they may take in the future.

Moreover, this study will provide a more general understanding of how countries formulate nuclear fuel cycle policy and what factors influence those policies. The framework developed here can be adapted and employed to other countries, including those with existing nuclear industries and those attempting to develop an indigenous nuclear industry.

In addition to policy makers in the U.S. government, the results of this study will be useful for decision makers at nuclear supply companies, such as GE-Hitachi, the Westinghouse Electric Company, AREVA, and Doosan Heavy Industries & Construction. Given the deep ties between governments and nuclear industries, private companies have much interest in the nuclear policies of national governments and in how those policies could affect their business.

Expected Outcome

There are two hypotheses that describe the expected outcome of this study.

H1: A country's decisions regarding nuclear fuel cycle policy can be described, in large part, based on that country's frame of reference (in terms of gains and losses frames described by prospect theory), while the frame of reference is determined by various factors, such as a country's strategic culture, economic and security situation, relations with major powers and status in the international community, technological capability, etc.

H2: Security concerns, be it defined traditionally in terms of national security or in terms of economic security, are always a primary driver of starting and maintaining a nuclear program, even if the program does not include developing nuclear weapons. This is due to the technological experience that a country gains through operating a large-scale nuclear program.

Adding to H1, I expect that domestic factors will outweigh external factors.