陸士論文集 第51輯 1996年 12月

Nuclear Nonproliferation: The Limitations of a Supply-Side Strategy

핵무기 비확산: 공급측면 전략의 한계점들

윤 정 원
(사회과학처 정치학조교수)

< Title >

국문초록

핵무기확산은 핵제조능력과 핵제조의사에 의하여 좌우되기 때문에, 핵비확산전략은 크게 핵확산국가의 기술적 능력을 억제하는 공급측면의 전략과 핵제조의사를 약화시키는 수요측면의 전략으로 대별된다. 하지만 세계적 차원에서의 핵비확산 노력은 주로 핵비확산조약, 국제원자력기구, 핵물자공급국가에 대한 가이드라인, 유엔에 기초한 규제적인 핵무역통제, 핵전환통제, 그리고 강제적 제재 등 공급측면의 정책대안에 의존하여 왔다. 이 글은 공급측면의 핵비확산전략이 갖고 있는 한계점을 분석하고 이에 대한 일반적인 대안을 제시하여 보고자 한다.

I. INTRODUCTION

The end of the Cold War turns our attention from vertical nuclear proliferation within nuclear weapon states (NWSs) to horizontal nuclear proliferation into non-nuclear weapon states (NNWSs). The horizontal

proliferation emerges as a vivid threat to global security, as shown by the emergence of near-nuclear weapon states such as India, Pakistan, Israel, and South Africa, the proliferation threats in the newly independent states (NISs) of the former Soviet Union, Iraq's secret nuclear weapons program detected by UN Special Commission inspection team, the North Korean nuclear crisis, and so on.

In general, the threat of nuclear proliferation stems from nuclear aspirations as well as technological capabilities for producing nuclear weapons. Thus there can be two categorical strategies to nuclear nonproliferation. One is the supply-side strategy which intends to prevent a potential proliferator from attaining nuclear capabilities, and another is the demand-side strategy which purports to reduce or eliminate nuclear aspirations.[1)]

In the past, the supply-side strategy was most commonly used to stop the spread of nuclear weapons. At the global level, the supply-side strategy has been guided mainly by the NPT regime, which includes the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the International Atomic Energy Agency (IAEA) including the Zangger Committee on Nuclear Export Controls, the Nuclear Supplier's Group (NSG), and the United Nations.[2)] These non-hierarchical, autonomous institutional arrangements have been cooperative or complementary in stopping the spread of nuclear weapons. The supply-side strategy of the NPT regime has relied on regulatory policy options which can be categorized into export controls, diversion controls, and

1) For the distinction between the supply-side strategy and the demand-side strategy, see Stephan M. Meyer, *The Dynamics of Nuclear Proliferation* (Chicago and London: The University of Chicago Press, 1984), pp.1-18. William C. Potter, *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective* (Cambridge, Massachusetts: Olegeschlager, Gunn & Hain, Publishers, Inc., 1982), pp.197-241.

2) For the NPT regime, see Joseph Pilat and Robert E. Pendly (eds.), *Beyond 1995: The Future of the NPT Regime* (New York: Plenum Press, 1990). Peter Van Ham, *Managing Non-Proliferation Regime in the 1990s: Power, Politics, and Policies* (London: Royal Institute of International Affairs, 1993). Joseph S. Nye, *The International Nonproliferation Regime* (Muscatine, Iwoa: Stanley Foundation, 1980).

punitive sanctions.

The supply-side strategy has been developed or reinforced in various ways.[3] However, in spite of its remarkable contribution to nuclear nonproliferation, this strategy has faced some weaknesses which cannot be easily ignored. On the one hand these weaknesses have required some efforts to strengthen the supply-side strategy; on the other hand they have increased the necessity to adopt the demand-side strategy.[4] This paper purports to highlight the limitations of the supply-side strategy based on export controls, diversion controls, and punitive sanctions, and to suggest some alternatives. In doing so, this papar focuses on the possible deviant behaviors of nuclear proliferators.

II. EXPORT CONTROLS

Export controls attempt to restrain or prohibit the transfer of sensitive nuclear materials, facilities, or technology - such as enriched uranium, plutonium, uranium enrichment plant, plutonium reprocessing plant, and nuclear reactors - to potential proliferators. At the global level, export controls rely on the NPT, IAEA safeguards, and the Guidelines of the NSG which are basically independent but mutually complementary.

The NPT requires its members to accept full-scope IAEA safeguards covering all sensitive nuclear materials, equipments within the recipient states' controls, and prohibits nuclear transfers to those states that refuse to

3) Harald Muller, David Fischer and Wolfgan Kotter, *Nuclear Non-Proliferation and Global Order* (Oxford and New York: Oxford University Press, 1994), pp.15-30. John Simpson, "Trends in Nuclear Proliferation and Supply-side Controls," in Jean-Francois Rioux (ed.), *Limiting the Proliferation of Weapons: The Role of Supply-Side Strategies* (Ottawa, Canada: Carleton University Press, 1992), pp.11-24.

4) Brad Robert, "From Nonproliferation to Antiproliferation," *International Security*, Vol.18, No.1 (Summer 1993), pp.139-173. Baker Spring, "Controlling the Bomb: International Constraints on Nuclear Weapons Are Not Enough," *The Backgrounder*, No.941 (May 1993), pp.1-12.

accept IAEA nuclear safeguards.[5] However, the NPT applies no limit to the transfer of sensitive nuclear technologgy, facilities, and materials as far as the nuclear recipient shows no military intent to develop nuclear weapons at the moment of nuclear transfer. Moreover, the NPT allows its members to transfer nuclear items to non-NPT members which accept only partial IAEA nuclear safeguards. As the NPT aims at promoting the peaceful use of nuclear energy as well as nuclear nonproliferation, it cannot be only control-oriented.

In contrast, although the Guidelines of the NSG do not require its members to accept full-scope IAEA safeguards, they commit its members to greater restraint on nuclear transfers by prohibiting the transfer of some sensitive nuclear items of dual use.[6] The Guidelines rely on the "principle of denial" based on distrust. In this sense, the Guidelines can be seen as stricter than the NPT in imposing controls on nuclear trades.

However, despite global export controls, potential proliferators can enhance their nuclear capabilities which are usable for military purposes. There are three loopholes which limit the efficacy of export controls.

1. Safeguarded transfers under the disguided acceptance of IAEA safeguards

According to Article III.2 of the NPT, any nuclear transfer for peaceful purposes is not allowed if the nuclear items transferred are not under IAEA safeguards. The Zangger Committee was set up, in the early 1970s, to produce and keep up-to-date a list of nuclear material or equipment which must trigger safeguards under the NPT. However, as far as a recipient state accepts IAEA safeguards legally, it can have access to sensitive nuclear items.

---

5) For the content of the NPT, see Jozef Goldblat, *Twenty Years of the Nonproliferation Treaty : Implementation and Prospects* (Oslo : PRIO, 1990), pp.65-71

6) Ibid., pp.123-131.

Basically, the NPT rests on an optimistic assumption that, despite the dual-use character of some nuclear technologies, it is possible to establish appropriate rules and conditions for cooperation that can facilitate access to nuclear energy without enhancing the risk of proliferation.[7] However, in reality, a country may ratify IAEA safeguards to make it easier to acquire weapon-grade material capacity, with the secret intention of denouncing or violating the NPT and its safeguards agreement at a later date.[8] A nuclear proliferator can attain or accumulate sensitive nuclear items through safeguarded nuclear transfers although its genuine motive is to gain access to nuclear technology and to get close to acquiring weapons-usable material, without necessarily appearing to do so, for a military purpose.[9]

Iraq ratified the NPT in 1969 and signed a nuclear safeguards agreement with the IAEA in 1972. Iraq, as an NPT member under full-scope IAEA safeguards, could legally import sensitive nuclear items such as research reactor, hot cells for plutonium reprocessing, and the technology of uranium enrichment, which became the basis of Iraq's secert nuclear weapons program. India, Israel, Pakistan and South Africa as the threshold proliferators accepted partial agreements with the IAEA for the application of safeguards on materials, technologies or facilities transferred while refusing to enter the NPT.[10] Therefore they could succeed in importing nuclear items which were essential for developing a nuclear weapons program. Nuclear suppliers exported sensitive nuclear items to the non-NPT members which concealed their aspirations for nuclear weapons. The NPT allows nuclear transfers regardless of the actual compliance of a nuclear recipient with IAEA safeguards. Hence even safeguarded nuclear transfers can pose serious

7) Lawrence Scheinman, *The Proliferation Role of the International Atomic Agency: A Critical Assessment* (Washington D.C.: Resources for the Future, 1985), p.6.
8) David Fischer, "The Technical Basis," in Jozef Goldbat (ed.), *Safeguarding the Atom: A Critical Appraisal* (London and Philadelphia: Taylor & Francis, 1985), p.19.
9) Lawrence Scheinman, op. cit., p.16.
10) Jozef Goldblat (ed.), *Non-proliferation: The Why and the Wherefore* (London and Philadelphia: Taylor & Francis, 1985), pp.297-315.

threats to nuclear nonproliferation if a nuclear recepient has aspirations for nuclear weapons.

The Nuclear Suppliers' Group was set up to overcome the weaknesses of the NPT which relies on the *de jure* acceptance of IAEA safeguards. Especially, the Indian nuclear test in 1974, in the name of peaceful nuclear explosion, triggered the creation of the Nuclear Suppliers' Group. In 1977, the leading nuclear suppliers met in London and agreed to a large number of additional controls and restraints, beyond those imposed by Article III.2 of the NPT, to ensure that exports must not be used to make nuclear explosives, to require adequate physical protection of all exports, and to exercise restraint in the export of sensitive technologies such as enrichment, reprocessing, and heavy water production.[11]

The Guidelines of the NSG require nuclear suppliers to be more cautious in transferring sensitive nuclear items. The nuclear suppliers should encourage the recipient to accept, as an alternative to national plants, supplier involvement and/ or other appropriate multinational participation in resulting facilities. For example, the nuclear suppliers should confirm that the recipient will not use enrichment facilities, equipment and technology to produce enriched uranium greater than 20% without consent of the supplier. To impose controls on supplied or derived weapon-usable material, the supplier and the recipient should make a mutual agreement on arrangements for reprocessing, storage, alteration, use, transfer, or retransfer of any weapon-usable material involved.[12]

In this sense, the Guidelines of the NSG can contribute to nuclear nonproliferation through tight export controls on sensitive nuclear items. Nevertheless, the Guidelines do not rest on the complete denial of sensitive nuclear items. So, if a recipient state accepts IAEA safeguards and agrees on

11) David Fischer, "The London Club and the Zangger Committee : How Effective ?," in Kathleen Bailey & Robert Rudney (eds.), *Proliferation and Export Controls* (New York: University Press of America, 1993), p.40.
12) Jozef Goldblat, op. cit., p.124.

additional controls relevant to nuclear transfer, it can have access to sensitive materials, technologies or facilities even from the members of the NSG. Even under the Guidelines, a determined proliferator can import sensitive nuclear items, hiding its desires for nuclear weapons. Most Western European countries have kept open the option of continuing nuclear trade with countries which have not accepted full-scope safeguards and which are thus keeping their military nuclear option.[13] There does not exist any central authority to coordinate the members of the NSG. Moreover, none of emerging suppliers does not participate in the NSG. The limited membership and the lack of central authority reduce the efficacy of the NSG.[14]

Both the NPT and the NSG impose export controls on nuclear transfers in order to halt the spread of nuclear weapons. However, they are unlikely to be effective unless they can detect the deceptive aspirations of nuclear proliferators for nuclear weapons under the *de jure* acceptance of IAEA safeguards or additional requirements. Therefore nuclear transfers should be allowed discriminatorily according to the degree of the *de facto* acceptance, by the recipient state, of international monitoring. A strong discrimination can reduce the danger that nuclear exports will be abused.[15] However, to impose discriminatory export controls, it is necessary to gain sufficient information on the degree of the *de facto* compliance with international safeguards.

2. Unsafeguarded transfers through illicit channels

Some states seek unsafeguarded nuclear items when they face strict export controls on nuclear transfers, or when they want to avoid intrternational

13) Bertrand Goldschmidt, "Proliferation and Non-Proliferation in Western Europe : A Historical Survey," in Herald Muller, *A European Non-Proliferation Policy : Prospects and Problems* (Oxford: Clarendon Press, 1987), pp.28-29.

14) David Fischer (1993), op. cit., pp.41-48.

15) William Walker, "Nuclear trade relations in the decade to 1995," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), p.79. David Fischer (1993), op. cit., p.149.

monitoring to facilitate a secret nuclear weapons program. It is evident that unsafeguarded nuclear items can be more easily misused for military purposes.

In general, there are two kinds of restrictions on nuclear transfers. One is the denial of even general nuclear items to the unsafeguarded NNWSs. Another is the restraint of some sensitive nuclear items to the safeguarded NNWSs as well as the unsafeguarded NNWSs.

According to the Article III.2 of the NPT, each member of the NPT should not provide (a) source or special fissionable material , or (b) equipment or material especially designed or prepared for the processing , use, or production of special fissionable material, to any NNWS for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards of IAEA.[16] The NPT calls mainly for safeguards on nuclear material rather than on nuclear plants or components. The supplier is under no serious obligation to notify the IAEA of every nuclear facility to the recipient. To make up for such weakness of the NPT, the Guidelines of the NSG don't permit the transfer of some sensitive nuclear facilities unless those facilities are covered under IAEA safeguards and meet some additional requirements. However, in reality, the supplier is not likely to impose strict export controls which may lead to lose their nuclear markets. Therefore it is not easy to expect high consensus among the suppliers on tight export controls on the transfer of sensitive nuclear facilities.

In this situation, a determined proliferator may seek illicit and unsafeguarded transactions of nuclear items which make it easy to avoid international monitoring. The unsafeguarded nuclear items are conducive to keeping the secrets of nuclear weapons program. The nuclear 'black' or 'grey' market has supplemented and sometimes materially helped the nuclear weapons program of some proliferators.[17]

---

16) Jozef Goldblat (1990), op. cit., p.66.

17) David Fischer, *Stopping the Spread of Nuclear Weapons* (London and New York : Routledge, 1992), pp.137-140.

For example, Pakistan acquired the means of making weapon material largely by a carefully planned series of illegal transactions. In the late 1970s, after Dr. Abdul Qadir Khan had purloined Deutch enrichment technology, Pakistan obtained various components for gas centrifuges and prohibited computer technology from Switzerland and Holland. In the mid-1980s, Israel and Pakistan agents also tried to procure 'keytrons' in the USA but their conspiracy were detected. India was able to obtain the suppliers, from illegal transactions involving West German firms, of heavy water essential for the operation of nuclear reactors. So, India was able to avoid safeguards on many of its nuclear power plants and thus to produce impressive amounts of unsafeguarded plutonium. Other illegal or dubious exports include shipment of several hundred tons of heavy water from Norway and China to India and Pakistan as well as of low-enriched uranium from China to South Africa.

Although nuclear export controls are designed to discourage potential proliferators from enhancing their nuclear capabilities, they may induce recipient states to seek illicit or unsafeguarded transactions of nuclear items. Of course, such illicit transfers are impossible without the consent of some supplier states or firms which pursue political, strategic, or commercial interests through illicit nuclear trades.

A supplier state can expand its political or military influence over the recipient state in return for providing sensitive nuclear items through illicit and unsafeguarded channels. Such strategic considerations can induce a supplier state not to tightly comply with international nuclear safeguards. In this sense, it is difficult to block the black loopholes in the nuclear markets without the strong will of the suppliers for nuclear nonproliferation. Moreover, some nuclear suppliers may want to promote their industrial or economic interests through illicit nuclear transfers. They can sign secret and unsafeguarded nuclear contracts to satisfy some recipients which want to avoid IAEA safeguards on purpose. Especially, the situation of oversupply in nuclear market can tempt some suppliers to commit the violations of safeguards.[18] Competition among the nuclear suppliers in a shrunken market

might be at the cost of international safeguards and of the nonproliferation system.[19]

If a potential proliferator can increase its nuclear capabilities through illicit or unsafeguarded channels, export controls based on international nuclear safeguards become inevitably less effective in stopping nuclear proliferation. In this sense, the closing of such 'grey market' loophole is a pivotal task in enhancing the NPT regime.[20] It is urgent to induce or enforce all NNWS to actually comply with full-scope international nuclear safeguards which aim at blocking the illicit loopholes in nuclear transfers. Moreover, nonproliferation norms should be elevated to reinforce the political will of the suppliers for nonproliferation, and cooperation among the suppliers should be enhanced to solve the problem of oversupply in the nuclear markets. To deter illicit nuclear transfers, the IAEA should be able to advance its information capacity pertaining to deviant nuclear transfers and subsequently detect such nuclear transfers timely.

3. The indigenous development of nuclear technology

Export controls on nuclear transfers can induce a proliferator to search for the indigenous development of nuclear technology as well as illicit nuclear trades. Moreover, the high price of the transferred nuclear items can stimulate some recipient states to promote its domestic nuclear industry for import-substitution.

For example, India supported its nuclear programs in a drive for self-reliance. Although nuclear self-sufficiency was not fully achieved,

---

18) William Walker, op. cit., pp.64-81.

19) David Fischer, "The Role of the IAEA," in John Simpson & Anthony G. McGrew (eds.), *The International Nuclear Non-Proliferation System : Challenges and Choices* (New York :St. Martin Press, 1984), pp.60-61.

20) Harald Muller, "Smoothing the path to 1995 amending the Nuclear Non-Proliferation Treaty and enhancing the regime," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), pp.125.

considerable progress was in that direction.[21] Argentina and Brazil also have developed their indigenous nuclear technologies or facilities. India, Argentine, and Brazil tended to refuse the application of international safeguards to their indigenous nuclear industry, and promoted their nuclear weapons program while avoiding international monitoring. Nowadays, German, Japan, and most of other Western advanced states possess, to a remarkable extent, indigenous nuclear technology and facilities under IAEA safeguards. These nuclear capabilities can pose substantial threats to nuclear nonproliferation unless they are covered by international safeguards. The more indigenous nuclear capabilities such as nuclear reactor, uranium enrichment, plutonium reprocessing, fuel fabrication are installed at the national level, the more easily a proliferator can develope its nuclear weapons program. Nonetheless, it is inevitable that more countries can develop sensitive indigenous nuclear capabilities as time goes on.

In this sense, the policy of nuclear denial or restraint cannot be perfect in controlling the spread of sensitive nuclear technology or materials. In a sense, embargoes may serve some economic or political purpose in the short term and introduce delays but, in the long run, will prove to be counterproductive by providing the political motivation to seek nuclear autarky in sensitive areas.[22]

If export controls stimulate recipient states to enhance their nuclear autarky, they will become less effective in restraining the nuclear capabilities of potential proliferators. If then, nuclear trade will be relevant mainly to the target state which lacks basic internal capability.[23] If a state is completely

---

21) David Hart, "India," in Harald Muller (ed.), *A European Non- proliferation Policy : Prospects and Problems* (Oxford : Clarendon Press, 1987), pp.139.

22) Munir Ahmad Khan, "Toward a Universal Framework of Nuclear Restraint," in M .P .Fry, N. P. Keatinge and J. Rotblat (eds.), *Nuclear Non-Proliferation and the Non-Proliferation Treaty* (Berlin : Springer-Verlag, 1990), p.49.

23) Harald Muller, "The Challenge for West European Diplomacy," in Harald Muller (ed.), *A European Non-proliferation Policy : Prospects and Problems* (Oxford : Clarendon Press, 1987), p.104.

self-sufficient, or if a state is self-sufficient in the basic technology needed for making bombs, it will not depend on nuclear transfers which export controls are imposed on. As Janne E. Nolan points out, export controls can slow, but not stop, technical diffusion.[24] When export controls do not work because of indigenous technology or facilities, diversion controls or punitive sanctions should be reinforced to compensate for the weaknesses of export controls.

Judging from the mentioned above, this paper suggests some alternatives to improve the effectiveness of the global nuclear nonproliferation regime.

First, it is desirable to adopt discriminatory export controls on nuclear transfers.[25] Export controls should be imposed discriminatorily case by case, according to the level of the *de facto* compliance of nuclear recipients with international safeguards. In other words, the more likely a nuclear recipient is to develop nuclear weapons program, the more severely export controls should be imposed on that recipient. In this sense, it is urgent for the NPT regime to strengthen its information gathering capability related to nuclear trades. It is impossible to discriminatorily impose export controls without sufficient, precise, and prompt information on nclear transfers.

Second, it is necessary to enhance the international norms that nuclear nonproliferation should take precedence over any particular or national interests of the nuclear suppliers. In the absence of their strong

---

24) Janne E. Nolan, "Proliferation and Int*ernational Security: An Overview," in* W. Thomas Wander and Eric H. Arnet (eds.), *The Proliferation of Advanced Weaponry: Technology, Motivations, and Responses* (Washington D.C.: The American Association for the Advancement of Science, 1993), p.9.

25) For example, Gary K. Bertsch and Richard T. Cupitt categorize proliferant states into coordinating states, collaborating states, sensitive states, threatening states, peripheral states. Thereafter, against each type of the proliferant state, they suggest a different combination of export control options such as harmonization, liberalization, safeguards, assistance, conditional aid, and denial. See, Gary K. Bertsch and Richard T. Cupitt, "Nonproliferation in the 1990s: Enhancing International Cooperation on Export Controls," *The Washington Quarterly*, Vol.6, No.4 (Autumn 1993), pp.58-60..

committement to global security, the nuclear suppliers are more likely to close their eyes on the loopholes of export controls. It is desirable to reinforce the international cooperation among the nuclear suppliers facing the problem of oversupply in the nuclear markets.

Third, it is required to delay the indigenous development of nuclear technology in potential nuclear proliferators. Therefore it is desirable to lease rather than sell sensitive nuclear items to the recipients because the leased items can be monitored directly by the suppliers to delay technological spillover. Moreover, it is desirable that the exchanges of nuclear scientists, technicians, and students should be checked and controlled.

Ⅲ. DIVERSION CONTROLS

Diversion controls aim at preventing the use of nuclear energy for military purposes, by detecting deviant nulear activities as early as possible. Diversion controls are mainly guided by IAEA nuclear safeguards whose objective is the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices. It is evident that diversion controls are indispensable bulwarks against nuclear proliferation. However, the application of IAEA safeguards does not ensure the success of diversion controls. There can be some loopholes to diversion controls because nuclear diversion from peaceful uses into military uses can happen regardless of the presence of IAEA safeguards.

1. Clandestine diversion under full-scope safeguards

A determined proliferator can develop its nuclear weapons program secretly, taking advantage of the limitations of IAEA nuclear safeguards. Especially, the case of Iraq revealed the problems of the IAEA safeguards in preventing a clandestine nuclear weapons program.[26]

According to Article III.1 of the NPT, the NNWS party to the NPT should accept the safeguards of IAEA with a view to preventing diversion of nuclear energy from peaceful purposes to military purposes. The IAEA safeguards are supposed to be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such state, under its jurisdiction, or carried out under its control anywhere.[27]

In general, there are three main measures of the safeguards system such as material accountancy, containment, and surveillance. These measures are used by the IAEA to detect and thereby to deter diversion of nuclear materials to weapon purposes.[28] However, these measures are not absolutely reliable in terms of perfect inspection. In a sense, overexpectation is a central problem for IAEA safeguards.[29]

First of all, the IAEA suffers from the lack of coercive enforcement authority, since all safeguards are based on an agreement between the IAEA and the target state of nuclear inspection. The consent of a target state is indispensable in the process of nuclear inspection. The routine inspection of the IAEA is applied only to the materials or facilities reported by a target state. Although the special inspection can be applied to unreported and suspected sites, it can be carried out only under the consent of a target state. For example, the IAEA tried to conduct a special inspection against North Korea, but it finally failed to do so in the absence of North Korea's consent.[30] Moreover, when the IAEA tries to conduct nuclear inspections, a

---

26) Anthony Fainberg, *Strengthening IAEA Safeguards: Lessons from Iraq* (Stanford, California: Center for International Security and Arms Control, 1993). Lawrence Scheinman, "Lessons from Post-War Iraq for the International Full-Scope Safeguards Regime," *Arms Control Today* (April 1993), pp.3-6.

27) Zozef Goldblat (1990), op. cit., p.66.

28) SIPRI, *The NPT : The Main Political Barrier to Nuclear Weapon Proliferation* (New York : Creane, Russak & Company, Inc., 1980), p.20. The surveillance and containment equipment include sealing systems, photographic surveillance, television surveillance, bundle counter, underwater surveillance instruments, and radiation dosimeters.

29) Lawrence Scheinman, op. cit., p.43.

target state may resist against the IAEA to earn time for hiding some materials or facilities, by delaying the designation of inspectors. In the case of plutonium or highly enriched uranium, it may require only several days for diverted nuclear material to be transformed into an explosive.[31] Hence IAEA safeguards for diversion controls are unlikely to be successful without the goodwill of a target state for nuclear nonproliferation.

It is difficult for the IAEA to detect nuclear diversion for military purposes when a nuclear proliferator misuses some nuclear materials by regularly submitting slightly distorted figures in each accounting system. A margin of error in material accountancy, especially in large civilian nuclear programs, may result in 'significant' quantities of fissionable material usable for nuclear weapons program. It is rarely possible to fully monitor large bulk-handling facilities such as reprocessing or enrichment plants which provide direct access to weapons-usable material.[32]

Iraq's secret nuclear weapons program, detected by UN Special Commission inspection team after the Persian Gulf War, warns that a determined proliferator can exploit the status of the NPT member while accepting full-scope IAEA safeguards.[33] Iraq cheated on its treaty commitments, and the NPT did not inhibit Iraq's ability to go forward with a dedicated nuclear weapon program.[34] The case of Iraq apparently shows that a nuclear

30) For the issues of IAEA special nuclear inspection in the case of North Korea, see Jeongwon Yoon, *Bargaining under Uncertainty : To Resolve the North Korean Nuclear Dispute* (Unknown: The University of Georgia, Ph.D. Dissertation, 1996), pp.206-345. Michael J. Mazarr, *North Korea and the Bomb : A Case Study in Nonproliferation* (New York: St. Martin's Press, 1995), pp.79-180.

31) SIPRI, op. cit., p.21.

32) For example, the gross measurement uncertainty in reprocessing is likely to be of 1 percent. A large plant reprocessing 500 tons of spent fuel a year can produce 4,500 kg of plutonium, and 1 percent or 45 kilograms of this amount is roughly enough for 6 or 8 nuclear warheads. See, David Fischer (1992), op. cit., p.159.

33) Hans Blix, "Verification of Nuclear Nonproliferation: The Lesson of Iraq," *The Washington Quarterly*, Vol.15, No.4 (Autumn, 1992), pp.57-65.

34) Paul L. Leventhal, "Nuclear Export Controls : Can We Plug the Leaks ?," in Jean-Francois Rioux (ed.) *Limiting the Proliferation of Weapons : The Role of Supply-Side Strategies* (Ottawa : Carleton University Press, 1992), pp.43-44.

proliferator can develop its nuclear weapons program clandestinely even under full-scope IAEA safeguards.

As David Fisher points out, IAEA safeguards face problems such as limited authority, inability to compel acceptance of inspection, limited access of inspectors, no say over the scope of national programs.[35]

To cope with the threats of clandestine nuclear diversion under full-scope safeguards, it is necessary to strengthen IAEA safeguards toward more tight and frequent inspections. In doing so, it is inevitable to reinforce the authority of the IAEA over national nuclear energy program. It may be desirable to internationalize the most pro-proliferation parts of the nuclear cycle with a view to placing sensitive nuclear materials and facilities under the authority of an international agency.

2. Opaque diversion under partial safeguards

Opaque diversion means the concealment of a nuclear weapons program behind the veil of R & D to avoid hostile scrutiny by critics. The proliferators of opaque diversion neither admit nor deny its nuclear weapons program. The characteristics of opaque diversion are no test, denial of possession, no direct nuclear threats, no military doctrine, no military deployment, no open debate, and organization insulation.[36]

For example, Israel, India, Pakistan, and South Africa have pursued opaque nuclear diversion under partial safeguards, because a deliberately cultivated uncertainty as to their nuclear intentions or capabilities (or both) can make it possible to take advantage of the nuclear weapons option without facing strong criticism. Israel is considered a typical case of an opaque diversion.[37] Israel maintaines an ambiguous nuclear posture and tries to divert nuclear

35) David Fischer (1992), op. cit., pp.124-128.

36) Avner Cohen & Benjamin Frankel, "Opaq Nuclear Proliferation," in Benjamin Frankel (ed.), *Opaq Nuclear Proliferation* (London: Frank Cass, 1991), p.22.

37) Yair Evron, "Opaq Proliferation: The Israeli Case," in Benjamin Frankel (ed.), *Opaque Nuclear Proliferation* (London: Frank Cass, 1991), pp.45-63.

energy into nuclear weapons. The Indian policy of maintaining a nuclear-weapon option is perceived to be a middle strategic ground between the extremes of inaction and action. India has followed a policy of strategic ambiguity by maintaining its nuclear weapon option.[38] Pakistan also keeps nuclear ambiguity and uncertainty, and tries to divert nuclear energy into nuclear warheads.[39]

The proliferators of opaque diversion tend to reject the full-scope safeguards of the IAEA. Instead, they make some agreements with the IAEA in connection only with nuclear items transferred in order to smoothe nuclear imports.[40] They maintain unsafeguarded sensitive nuclear facilities such as uranium enrichment plants, plutonium reprocessing plants, or heavy water plants.[41]

To cope with opaque diversion, it is necessary to enforce non-NPT NNWs under partial safeguards to accept full-scope IAEA safeguards. The full-scope safeguards can work to increase the nuclear transparency of the proliferators of opaque diversion. However, the NPT regime lacks the power to press the proliferators of opaque diversion to accept the NPT and subsequently compy with full-scope IAEA nuclear safeguards. In the case of

---

38) Raju G.C. Thomas, "Should India Sign the NPT ?," in Joseph F. Pilat and Robert E. Pendley, *Beyond 1995 : The Future of the NPT Regime* (New York and London: Plenun Press, 1990), pp.135-139.

39) Neil Joeck, "Tacit Bargaining and Stable Proliferation in South Asia," in Benjamin Frankel (ed.), *Opaq Nuclear Proliferation* (London: Frank Cass, 1991), pp.77-91.

40) "Most European countries have decided to keep open the option of continuing nuclear trade with countries which have not accepted full-scope safeguards. They believed that any non-proliferation policy which could be perceived as discriminating against the nuclear energy programs would only lead to strong reactions and an unavoidable trend towards nuclear autarky." See, Bertrand Goldschmidt, op. cit., p.28.

41) Jozef Goldblat & Peter Lomas, "The Threshold Countries and the Future of the Nuclear Non-Proliferation Regime," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), pp.25-27.

opaque diversion, the intrinsic problem of IAEA safeguards is political as well as technical. Therefore, the political approach should be implemented to complement the technical approach in preventing nuclear proliferation.[42]

3. Visible diversion

Visible diversion can be referred to as the open pursuit of nuclear weapons program. No NNWSs pursue the visible diversion which can bring about severe criticisms and sanctions at the global level. Only some NWSs such as Britain, France, and China pursued visible diversion before the nuclear nonproliferation regime was established. As far as the international norms of nuclear nonproliferation prevail over the world and physical sanctions against nuclear proliferation are expected, a nuclear proliferator is unlikely to follow the option of visible diversion.

Nonetheless, we cannot overlook a possibility that some NNWS may seek visible diversion, especially in a crisis situation. When the technically less-capable NNWSs reject international diversion controls and follow the path of visible diversion, export controls and punitive sanctions may work to deter or delay such deviant nuclear diversion. However, if the technically highly-capable NNWSs go nuclear openly, export controls can rarely work to make up for the failure of diversion controls. Only punitive sanctions can function as a measure to reverse the path of visible diversion. However, it is uncertain that severe punitive sanctions can be imposed against a nuclear proliferator with sufficient nuclear capabilities which may be used to make atomic bombs in a short time.

Nowadays, German, Japan, Argentine, and Brazil are highly-capable NNWSs, although they do not show high aspirations for nuclear weapons. Nonetheless, German and Japan were not so much willing to sign the NPT because they though that the NPT primarily aimed at restraining their

42) Cannizzo Cynthia, "A Critique of the Technical Approach," in William H. Kincade and Christoph Bertram, *Nuclear Proliferation In the 1980s : Prospectives and Proposals* (New York : St. Martin's Press, 1982), pp.173-193.

options of nuclear weapons program. Argentine and Brazil had showed their high aspirations for nuclear weapons in the past. We cannot reject a possibility that these countries may want to cope with severe threats to their national interests by going nuclear openly.[43] To cope with such visible diversion, it is important to lessen the incentives to nuclear weapons and to prepare stringent export controls and punitive sanctions which can deter or correct such deviant diversion.

In sum, some NNWSs may try to carry out their options of nuclear proliferation through clandestine, opaque or visible diversion. To cope with these threats to nuclear nonproliferation, this paper can suggest some alternatives.

First, it is necessary to strengthen IAEA safeguards in technical terms. It is necessary to develop more appropriate inspection techniques and instruments, and to increase the frequency of inspection. Nuclear inspectors should be able to gather sufficient, precise, and prompt information on nuclear diversion. In this sense, it is recommended to weaken the reserved rights of a target state related to the timing and scope of nuclear inspection.

Second, it is urgent to force non-NPT members to sign the NPT and accept full-scope IAEA safeguards. However, the non-NPT members do not have any obligation to sign the NPT unless they feel the necessity to do so. Moreover, they are not required to accept full-scope IAEA safeguards unless they sign the NPT. In this sense, it is desirable to apply unfavorable treatments to nuclear proliferators which accept only partial nuclear safeguards, rejecting the NPT membership. Or, it is necessary to reduce the

---

43) For example, Japanese commitment against nuclear arms is not irrevocable. Strategic circumstances may require a reassessment of the nuclear factor in Japanese external relations. There is a possibility that the choice between a nonnuclear Japan and one armed with offensive nuclear weapons may be broadened. Kapur Ashok, *International Nuclear Proliferation : Multilateral Diplomacy and Regional Aspects* (New York : Praeger Publishers, 1979), pp. 325-327. Motoya Kitamura, "Japan's Plutonium Program: A Proliferation Threat?," *The Nonproliferation Review*, Vol.3, No.2 (Witer 1996), pp.1-16.

nuclear aspirations of the non-NPT members through bilateral or multilateral security guarantee, the establishment of the nuclear-free zone, economic compensation, and so on.

Ⅳ. PUNITIVE SANCTIONS

The objective of punitive sanctions is to deter, delay, or rectify deviant nuclear activities which violate the regulations of export controls or diversion controls. However, the efficacy of sanctions can be influenced by the precise information and the severity, certainty, promptness, and equity of penalties. Hence it cannot be expected that punitive sanctions can necessarily solve the threatss of nuclear proliferation.

A determined proliferator is likely to hide its violations of export controls or diversion controls in order to avoid punitive sanctions. In the absence of credible information on nuclear violations, it is difficult to impose punitive sanctions against the suspected proliferator. However, in reality, IAEA safeguards are not sufficient to timely detect the violations of nuclear nonproliferation undertakings. Although Iraq, Israel, India, Pakistan, and South Africa committed some violations of export controls or diversion controls, most of such violations were not detected timely. It is difficult for the NPT regime to gain prompt and precise information on nuclear violations as far as nuclear proliferators impede or reject the conduct of full-scope nuclear safeguards. The lack of prompt and precise information must be an essential problem of punitive sanctions.

Moreover, punitive sanctions are not always expected to be severe enough to threaten nuclear violators. According to the Article XII.7 of the Statute of the IAEA, there are some sanction measures as follows:[44]

- o Notifications: (a) of member states; (b) of United Nations organs
- o Curtailment of nuclear assistance: (a) by the Agency; (b) by member states; (c) withdrawal of materials and equipment already provided.

44) Jozef Goldblat (1990), p.96.

o Suspension of privileges and rights of membership.
o Cancellation of safeguards.

However, these options of punitive sanctions are unlikely to be perceived as severe enough to intimidate nuclear proliferators which may pursue their nuclear weapons program to promote core national intertests. When the penalty is rather weak compared to the gravity of the violation, a nuclear proliferator may resist rather than yield to punitive sanctions. In the past, the US and Canada suspended further nuclear supply to India to sanction Indian nuclear weapons program.[45] However, they ultimately failed to force India to give up its nuclear weapons program.

Of course, as in the case of North Korea, the IAEA may transfer the issues of nuclear violation to the UN which can consider more severe sanctions against a nuclear proliferator. However, North Korea did not yield to the threats of UN sanctions.[46] It is not expected that the severity of UN sanctions will be always sufficient because the severity can be mitigated by diverse factors as follows:

o Reliance of the targeted country on the commodity of which it is being deprived.
o Degree to which the nation(s) applying sanctions is a provider of desired or required commodities.
o Availability of alternative sources for the commodity.
o Ability of the targeted nation to retaliate, making the cost of sanctions not worth the benefit.
o Degree of commitment by the nation(s) employing sanctions.[47]

45) Joseph W. Harned, "Sanctions : Potentials and Limitations," in James A. Powers (ed.), *Executive Conference on Safeguards* (La Grange Park, Illinois : American Nuclear Society, 1977), p.335.
46) Jeongwon Yoon, op. cit., pp.255-345.
47) Kathleen C. Bailey, *Strengthening Nuclear Nonproliferation* (Boulder : Westview Press, 1993), pp.28-30.

Seemingly stringent sanctions were imposed by the UN against Iraq which secretly developed its nuclear weapons program. The UN Special Commission inspection team detected the violations of Iraq and eliminated some sensitive materials from Iraq's nuclear facilities after the Persian Gulf War. However, it is uncertain that the UN activities finally freezed the nuclear aspirations and capabilities of Iraq for nuclear weapons. Iraq retains the basic building blocks for a renewed program, including key personnel, documentation, plans, records, design infromation, and large quantities of equipment removed from nuclear sites.[48]

The certainty and promptness of penalty are also important to the efficacy of punitive sanctions. However, it is not easy for the inspectors to acquire precise and timely evidence which would be convincing enough for the IAEA to set the sanction machinery in motion. Therefore, punitive sanctions may be slow, leaving a nuclear proliferator the time needed to carry out a nuclear weapons program. For example, as the IAEA and the UN failed to gain certain information on the nuclear violations of North Korea, the imposition of punitive sanctions agaisnt North Kroea was delayed and cancelled.

Moreover, the equity of penalty is not expected to be high bacause the imposition of sanctions is determined politically rather than legally. For example, the U.S. has opposed any sanctions against the nuclear weapons program of Israel as its ally. China resisted the imposition of UN sanctions against North Korea.

Punitive sanctions can be viewed as the last resorts to prevent the spread of nuclear weapons. However, punitive sanctions face some limitations as discussed above. To cope with such limitations, this paper suggests some alternatives.

First, it is required to expand punitive sanctions over more severe options such as military options which can be more lethal than diplomatic or economic options. However, the more severe punitive sanctions are, the more likely the retaliatory actions of the target state are to be severe. Hence, it is

48) Ibid., p.35.

important to devise punitive sanctions which are cost-efficient as well as severe.

Second, it is desirable to increase the possibility of the precise and prompt detection of nuclear violations which is essential in putting sanctions into motion. In this sense, it is necessary to give up the present principle of zero-growth budget of the IAEA and allocate more budget on information activities.

Third, it is recommended to enhance the equity of punitive sanctions. Hence, the decision making process of punitive sanctions should be oriented toward legal rather than political. It is necessary to devise clearly legal guidelines of sanctions which can lessen political judgements, compromises or bargaining at the IAEA and the UN.

V. CONCLUSION

This paper analyzes the limitations of export controls, diversion controls, and punitive sanctions, which have been the main policy options of the supply-side strategy to nuclear nonproliferation at the global level. These three policy options are common in their efforts to stem the spread of nuclear weapons although they can play different roles. All of them tend to be regulatory in that their major objective is to force the NNWSs not to go nuclear. However, each of them reveals its own limitations in preventing nuclear proliferation. In this sense, the supply-side strategy cannot be considered perfect.

The limitations of the supply-side strategy stem primarily from the design-problem of the NPT regime and secondly from implementation problems. As the policy options of the NPT regime were designed mainly by the nuclear superpowers or the major nuclear suppliers, they do not reflect the motivations or behaviors of potential nuclear proliferators. In other words, the policy options of the supply-side strategy were not designed to

ensure that nuclear nonproliferation would necessarily take precedence over any political, diplomatic or industrial interests. However, it is not an easy task to solve the design problem of the NPT regime in the short run, because it is difficult to draw out the overall readjustment of consensus among existing participants to the NPT regime.[49] Meanwhile, it seems easier to solve the implementation problems caused by technical or procedural limitations. Therefore it is desirable to overcome the implementation problems in the short run and rectify the design problems in the long run.

49) For Example, the amendment process specified by Article VIII of the NPT makes the Treaty extremely difficult to strengthen in any significant way. Each proposed amendment must be circulated by the Depository Governments (the U.S., the U.K., and Russia) to all NPT members, and at least one-third of the members must request a conference be convened to discuss the amendment. Before entering into force, the amendment must be approved and ratified by a majority of all parties to the Treaty including all the nuclear weapon states as well as all NPT parties that are represented on the IAEA's Board of Governors at the time the amendment is circulated. Even then, an amendment only binds those states that approve it. For the difficulty in amending the NPT regime, see Congress of the U.S., Office of Technology Assessment, *Nuclear Safeguard and the International Energy Agency* (Washington D.C.: U.S. G.P.O., 1995), pp.90-92.

< REFERENCES >

Bailey, Kathleen C., *Strengthening Nuclear Nonproliferation* (Boulder : Westview Press, 1993)

Bailey, Kathleen & Robert Rudney (eds.), *Proliferation and Export Controls* (New York : University Press of America, 1993)

Bellany, Ian, & Coit D. Blacker & Joseph Gallacher (eds.), *The Nuclear Non-Proliferation Treaty* (London : Frank Cass, 1985)

Blix, Hans, "Verification of Nuclear Nonproliferation: The Lesson of Iraq," *The Washington Quarterly*, Vol.15, No.4 (Autumn, 1992), pp.57-65

Brenner, Michael, "The Security Factor in Nuclear Proliferation," in David B. Dewitt (ed.), *Nuclear Non-Proliferation and Global Security* (New York: St. Martin's Press, 1987), pp. 49-69.

Cannizzo Cynthia, "A Critique of the Technical Approach," in William H. Kincade and Christoph Bertram, *Nuclear Proliferation In the 1980s : Prospectives and Proposals* (New York : St. Martin's Press, 1982), pp.173-193.

Congress of the U.S., Office of Technology Assessment, *Nuclear Safeguard and the International Energy Agency* (Washington D.C.: U.S. G.P.O., 1995)

Dunn, Lewis A., *Controlling the Bomb: Nuclear Proliferation in the 1980s* (New Haven and London: Yale University Press, 1982)

Fainberg, Anthony, *Strengthening IAEA Safeguards: Lessons from Iraq* (Stanford, California: Center for International Security and Arms Control, 1993)

Fischer, David, *Stopping the Spread of Nuclear Weapons* (London and New York : Routledge, 1992)

------, "The technical Basis," in Goldblat, Jozef (ed.), *Safeguading the Atom : A Critical Appraisal* (London and Philadelphia: Taylor & Francis, 1985), pp.23-34.

------, "The Role of the IAEA," in John Simpson & Anthony G. McGrew (eds.), *The International Nuclear Non-Proliferation System : Challenges and Choices* (New York :St. Martin Press, 1984), pp.55-68.

Frankel, Benjamin (ed.), *Opaque Nuclear Proliferation* (London: Frank Cass, 1991)

Goldblat, Jozef, *Twenty Years of the Non-Proliferation Treaty : Implementation and Prospects* (Oslo : PRIO, 1990)

------, "Discussion and Recommendations," in Jozef Goldblat (ed.), *Non-proliferation: The why and the wherefore* (London and Philadelphia: Taylor & Francis, 1985), pp.3-38.

Goldblat, Jozef and Lomas, Peter, "The Threshold Countries and the Future of the Nuclear Non-Proliferation Regime," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), pp.24-36.

Gummett, Philip, "Enhancing internal restraints on nuclear proliferation," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), pp.137-149.

Harned, Joseph W., "Sanctions : Potentials and Limitations," in James A. Powers (ed.), *Executive Conference on Safeguards* (La Grange Park, Illinois : American Nuclear Society, 1977), pp.333-343.

Husbands, Jo L., "The Prestige States," in William H. Kincade and Christoph Bertram, *Nuclear Proliferation In the 1980s : Prospectives and Proposals* (New York : St. Martin's Press, 1982), pp.112-136.

Jones, Rodney W., *Nuclear Proliferation: Islam, the Bomb, and South Asia* (London: Beverly Hills, 1981)

Kapur, Ashok, *International Nuclear Proliferation : Multilateral Diplomacy and Regional Aspects* (New York : Praeger Publishers, 1979)

Khan, Munir Ahmad, "Toward a Universal Framework of Nuclear Restraint," in M. P. Fry, N. P. Keatinge and J. Rotblat (eds.), *Nuclear Non-Proliferation and the Non-Proliferation Treaty* (Berlin : Springer-Verlag, 1990), pp.45-54.

Kitamura, Motoya, "Japan's Plutonium Program: A Proliferation Threat?," *The Nonproliferation Review*, Vol.3, No.2 (Winter 1996), pp.1-16.

Leventhal, Paul L., "Nuclear Export Controls : Can We Plug the Leaks ?," in Jean-Francois Rioux (ed.) *Limiting the Proliferation of Weapons : The Role of Supply-Side Strategies* (Ottawa : Carleton University Press, 1992), pp.39-53.

Mazarr, Michael J., *North Korea and the Bomb : A Case Study in Nonproliferation* (New York: St. Martin's Press, 1995)

Muller, Harald, "Smoothing the path to 1995 : amending the Nuclear Non-Proliferation Treaty and enhancing the regime," in John Simpson (ed.), *Nuclear Non-Proliferation: An Agenda for the 1990s* (Cambridge: Cambridge University Press, 1987), pp.123-136.

------, *A European Non-Proliferation Policy : Prospects and Problems* (Oxford: Clarendon Press, 1987)

Meyer, Stephan M., *The Dynamics of Nuclear Proliferation* (Chicago and London: The University of Chicago Press, 1984)

Nye, J. S., "Maintaining a Non-Proliferation Regime," *International Organization*, Vol. 35, No. 1 (1982), pp.15-38.

Pierre, Lellouche, "The Garrison States," in William H. Kincade and Christoph Bertram, *Nuclear Proliferation In the 1980s : Prospectives and Proposals* (New York : St. Martin's Press, 1982), pp.63-111.

Potter, William C.; *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective* (Cambridge,Massachusetts: Olegeschlager, Gunn & Hain, Publishers, Inc., 1982)

Robert, Brad, "From Nonproliferation to Antiproliferation," *International Security*, Vol.18, No.1 (Summer 1993), pp.139-173.

Scheinman, Lawrence, *The Nonproliferation Role of the International Atomic Agency : A Critical Assessment* (Washington D.C.: Resources for the Future, INc., 1985)

------, "Lessons from Post-War Iraq for the International Full-Scope Safeguards Regime," *Arms Control Today* (April 1993), pp.3-6.

Simpson, John, "Trends in Nuclear Proliferation and Supply Controls," in Jean-Francois Rioux (ed.) *Limiting the Proliferation of Weapons : The Role of Supply-Side Strategies* (Ottawa : Carleton University Press, 1992), pp.11-24.

SIPRI, *Postures for Non-Proliferation: Arms Limitation and Security Policies to Minimize Nuclear Proliferation* (London : Taylor and Francis, 1979)

------, *The NPT : The Main Political Barrier to Nuclear Weapon Proliferation* (New York : Creane, Russak & Company, Inc., 1980)

Thomas, Raju G. C., "Should India Sign the NPT ?," in Joseph F. Pilat and Robert E. Pendley, *Beyond 1995 : The Future of the NPT Regime* (New York and London: Plenun Press, 1990), pp.133-150.

Wander, W. Thomas and Eric H. Arnet (eds.), *The Proliferation of Advanced Weaponry: Technology, Motivations, and Responses* (Washington D.C.: The American Association for the Advancement of Science, 1993)

Yoon, Jeongwon, *Bargaining under Uncertainty: To Resolve the North Korean Nuclear Dispute* (Unknown: The University of Georgia, Ph.D. Dissertation, 1996)