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Examining relationship between nuclear proliferation and civilian nuclear power development

Man-Sung Yim [a,*], Jun Li [b]

[a] Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, 291 Daehakro, Yuseong-gu, Daejon 305-701, Republic of Korea
[b] University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA

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ABSTRACT

This paper attempts to examine the relationship between nuclear weapons proliferation and civilian nuclear power development based on the history of Atoms for Peace Initiative. To investigate the relationship, a database was established by compiling information on a country's civilian nuclear power development and various national capabilities and situational factors. The results of correlation analysis indicated that the initial motivation to develop civilian nuclear power could be mostly dual purpose. However, for a civilian nuclear power program to be ultimately successful, the study finds the role of nuclear nonproliferation very important. The analysis indicated that the presence of nuclear weapons in a country and serious interest in nuclear weapons have a negative effect on the civilian nuclear power program. The study showed the importance of state level commitment to nuclear nonproliferation for the success of civilian nuclear power development. NPT ratification and IAEA safeguards were very important factors in the success of civilian nuclear power development. In addition, for a country's civilian nuclear power development to be successful, the country needs to possess strong economic capability and be well connected to the world economic market through international trade. Mature level of democracy and presence of nuclear technological capabilities were also found to be important for the success of civilian nuclear power program.

1. Introduction

Nuclear power technology features the promise of an abundant energy supply which enables rapid industrial and economic development. With the concern over global warming and the need for energy, many countries around the globe are considering nuclear power technology. The Fukushima accident is expected to slow the growth of nuclear power globally but not reverse it. According to the latest IAEA report (IAEA, 2012), the projected demand for new nuclear power capacity in 2030 is 84 GWe (under low scenario) and 374 GWe (under high scenario). Although the demand for new nuclear power plants mostly comes from the existing nuclear power nations, a number of countries are still interested in introducing nuclear power. At present, there are over 430 commercial nuclear power reactors operating in 31 countries, with about 372,000 MWe of total capacity.

The countries interested in nuclear power technology can be categorized (IAEA, 2012) as: 1) Power reactors under construction: UAE, (Iran reactor has started up and been grid-connected); 2) Contracts signed, legal and regulatory infrastructure well-developed: Lithuania, Turkey, Belarus; 3) Committed plans, legal and regulatory infrastructure developing: Vietnam, Jordan, Poland, Bangladesh; 4) Well-developed plans but commitment pending: Thailand, Indonesia, Egypt, Kazakhstan, Saudi Arabia, Chile; 5) Developing plans: Israel, Nigeria, Malaysia, Morocco; 6) Discussion as serious policy option: Namibia, Kenya, Mongolia, Philippines, Singapore, Albania, Serbia, Croatia, Estonia & Latvia, Libya, Algeria, Azerbaijan, Sri Lanka, Tunisia, Syria, Qatar, Sudan, Venezuela, and; 7) Officially not a policy option at present: Australia, New Zealand, Portugal, Norway, Ireland, Kuwait.

Current developments around the globe remind us of the question that the world's nuclear community faced during the early days of civilian nuclear technology development: "Can a peaceful use of nuclear power be expanded without affecting the world's nuclear proliferation?"

This question was qualitatively examined by Yim, comparing today's world situation with the past situation during the AFPI (2006). It has been over 50 years since the Atoms for Peace Initiative (AFPI) begun. It was a grand global vision presented by US President Eisenhower to spread the benefits of nuclear energy while locking

* Corresponding author. Tel.: +82 42 350 3836; fax: +82 42 350 3810.
E-mail addresses: msyim@kaist.ac.kr (M.-S. Yim), junli@unc.edu (J. Li).

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up the military use of the technology. Initially under the AFPI, 37 countries explored the use of civilian nuclear power technology between 1954 and 1962. The list was then expanded to 57 countries by 1973. Among these, a number of countries were also interested in nuclear weapons and pursued related developmental activities. Today, out of these 57 countries, three are known to possess nuclear weapons, and only 17 of them have operating nuclear power plant(s). Among those countries with operating nuclear power plants, the size of the country's civilian nuclear generating capacity varies significantly depending upon each country's situation.

Two questions arise in this observation: 1) "Does the interest or development in nuclear weapons have relationship with civilian nuclear power development, or vice versa ?"; 2) "Is it possible to characterize the success of civilian nuclear power development in relation to nuclear weapons proliferation or other national attributes?"

Regarding the first question, Fuhrmann (2009) investigated the relationship between civilian nuclear cooperation and nuclear weapons proliferation by using a data set compiled by Singh and Way (2004). Both the demand and the supply side of nuclear proliferation were represented in the data. Through case studies and statistical analysis of the data, he argued that all types of civilian nuclear assistance raise the risks of nuclear proliferation and that peaceful nuclear cooperation and proliferation are causally connected because of the dual-use nature of nuclear technology and know-how. But in a subsequent work, Fuhrmann (2012) indicated that the evidence does not support the argument that countries pursue civilian nuclear power to augment nuclear weapons programs.

By using a similar but expanded data set, a related work was performed by our research group (Li et al., 2010a). The goal of this work was to develop statistical models to project nuclear proliferation decisions of countries against the historical records from 1945 through 2000. The expanded section included the description of nuclear technological capabilities of the nations. In this work, proliferation events were considered as a continuum covering four distinct stages: 1) "no noticeable interest in nuclear weapons", 2) "explore", 3) "pursue", and 4) "acquire." The variables that affected the proliferation decisions at different stages were identified. This work showed that having research nuclear reactors and having experiences with them could contribute to the decision to "explore" or "pursue" nuclear weapons. The study also showed that "electricity generation capacity from nuclear power reactors" may work against nuclear weapons proliferation. This implies that, as the electricity generation capacity of nuclear power increases, the motivation for nuclear weapons proliferation may decrease. According to this result, it is expected that a country with a large established infrastructure of civilian nuclear power program would abstain from nuclear proliferation decisions.

In relation to the second question, Nelson and Sprecher (Nelson and Sprecher, 2000) made an attempt to characterize the importance of various factors in the development of nuclear energy. It was based on statistical analysis of 86 nuclear candidate states by using stepwise regression applied to a set of fourteen candidate independent variables as predictors of the percentage of electrical power that a state derives from nuclear energy (so called, nuclear reliance, in the paper). In this analysis, the unit of analysis is the state with variables represented by the most recently available data. Five independent variables were found to be significant in affecting a country's nuclear reliance. The study found that three variables, international commercialization, level of democracy, and being unable to provide nuclear materials and technology domestically, each contributed to increase the nuclear reliance of a country. Two other variables, indigenous coal reserve and presence of fuel cycle production plants, were found to have potentially negative effect on nuclear reliance. The findings seem reasonable although the observation that presence of fuel cycle production plants had a negative effect on nuclear reliance can be argued. The study did not include the examination of the effect of nuclear weapons interest in the analysis.

By expanding previous work, the current study aims at furthering the investigation on the relationship between civilian nuclear power and nuclear weapons proliferation, focusing on the history of Atoms for Peace. A correlation analysis was used for the investigation with the use of STATA software. To support the investigation, the database used in previous work (Li et al., 2010b) was modified. The new database was compiled from the collected information of security environment, political situation, and economic development status by Singh and Way (2004) and Jo and Gartzke (2007) based on the use of the Correlates of War database (Correlates of War Project, 2003) and the EU Gene database (EU Gene). The data for nuclear technological capability were obtained mainly from the IAEA INFCIS, IAEA PRIS, and IAEA RRDB database along with information from Jo and Gartzke's work (2007). The database includes 66 predictor variables representing the status of world's countries from 1945 to 1992 or 2000. With the aim of delineating the impact of a country's decision to acquire nuclear technology at various stages on its civilian nuclear power development, historical proliferation events, and civilian nuclear power developmental events were also utilized in the database.

2. Examination of nuclear developments under atoms for peace

To investigate the relationship between civilian nuclear power and nuclear weapons proliferation through the AFPI history, the countries that received assistance from the IAEA under the AFPI were selected (Schiff, 1983). Between 1954 and 1962, there were 37 countries that received IAEA assistance under the AFPI. These are called Group I countries in the study. The list grew by 1973 to 57 countries. These countries are called Group II countries.. There were 22 among the 37 Group I countries and 40 out of the 57 Group II countries without an operating nuclear power unit as of February 1, 2010. (The countries with no operating nuclear power plant as of February 1, 2010 are marked with an asterisk.). The order of the listed countries follows the rank of cumulative IAEA assistance as of 1981.

- Group I: 37 countries. These are the countries with initial interests in civilian nuclear power technology (between 1954 and 1962). The group includes Brazil, India, Argentina, Pakistan, Chile*, Philippines*, Yugoslavia, Turkey*, Egypt*, Thailand*, Peru*, Romania, Korea (ROK), Greece*, Indonesia*, Colombia*, Mexico, Israel*, Uruguay*, Ecuador*, Taiwan, Costa Rica*, Venezuela*, Lebanon*, Afghanistan*, Portugal*, Iceland*, Spain, Japan, Guatemala*, Austria*, Italy, Denmark*, Federal Republic of Germany, Netherlands, New Zealand*, Sweden.
- Group II: 57 countries. These are the countries with interests in civilian nuclear power technology (between 1954 and 1973). This group includes Brazil, India, Argentina, Pakistan, Chile*, Philippines*, Yugoslavia, Turkey*, Egypt*, Thailand*, Peru*, Romania, Korea (ROK), Greece*, Indonesia*, Colombia*, Mexico, Israel*, Uruguay*, Ecuador*, Taiwan, Costa Rica*, Venezuela*, Lebanon*, Afghanistan*, Portugal*, Iceland*, Spain, Japan, Guatemala*, Austria*, Italy, Denmark*, Federal Republic of Germany, Netherlands, New Zealand*, Sweden, Hungary, Ghana*, Morocco*, Cuba*, Sri Lanka*, Iraq*, Poland*, Bulgaria, Nigeria*, Sudan*, Madagascar*, Burma*, Malaysia*, Bangladesh*, Zaire*, Iran*, Bolivia*, Zambia*, Tunisia*, Kenya*.

The current nuclear electricity generation capacity in the world as of Feb. 1, 2010 is shown in Table 1. The total generating capacity,