

Updating the Determinants of Nuclear Proliferation Dataset: 1939-2012

Chul Min Kim ^a, Hyeon Seok Park ^b, Man-Sung Yim ^{a,*}

^a Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology

^b School of Humanities and Social Sciences, Korea Advanced Institute of Science and Technology

*Corresponding author: msyim@kaist.ac.kr

1. Introduction

Nuclear proliferation history implies that the nuclear proliferation risk of a country should be based on both current capability and motivational factors. Previous studies have attempted to analyze the relative importance of the determinants of nuclear proliferation using the historical information of the countries under consideration, or with developed nuclear weapons (Jo and Gartzke, 2007; Li et al., 2010; Meyer, 1984; Singh and Way, 2004). However, the dynamics of nuclear weapons decision-making process is still not well understood. Montgomery and Sagan (2009); Sagan (2011); and Bell (2016) analyzed and summarized the major challenges of quantitative proliferation studies. This has led to the almost disappearance of literature using quantitative approaches. As in any scientific enterprise, improving measurement must be a central goal of the proliferation literature (Sechser, 2016).

Since 2000, new proliferators such as North Korea, Syria and Iran have appeared. The importance of non-state actors emerged after the September 11, 2001 attack. The environment surrounding nuclear security and proliferation has been changed. Nevertheless, quantitative nuclear proliferation studies still cover from 1950 to 2000 as the research scope.

In this study, we re-built the dataset to help enhance the reliability of quantitative nuclear proliferation studies. The coverage of the nuclear proliferation dataset was updated from 1950-2000 to 1939-2012. Thanks to the studies updated and improved the credibility of nuclear proliferation history (Bleek, 2017) and sources used to build the independent datasets of previous studies have been updated over the years, we extended the coverage of proliferation determinants used in previous quantitative nuclear proliferation studies.

2. Previous Studies

Why do countries develop nuclear weapons even though there are technological, normative barriers and taboos? When does the state decide to initiate nuclear weapons program? Researchers tried to find the evidence of these questions countries that have considered nuclear weapons.

In the early literatures on the causes and consequences of nuclear proliferation, the focus was mainly on the motive for countries to secure national sovereignty and security against several types of

international threats. However, Sagan (1996) summarized that three factors, including domestic security and international politics, as well as international security, have been considered in the country's decision to develop nuclear weapons.

Based on this, Singh and Way (2004) constructed a dataset on nuclear proliferation with three phases of nuclear weapons development (exploration, pursuit, and acquisition) and three categories of determinants (technological, external, and internal). Table I summarizes the definitions of their proliferation history, and Table II summarizes the categories of proliferation determinants and variables from previous quantitative nuclear proliferation studies. They used multinomial logistic regression analysis and survival (event history) analysis to calculate the importance of each determinant and predict the proliferation risk of the country.

TABLE I: Four Levels of Nuclear Proliferation

Level	Name	Description
0	No interest	No proliferation attempts
1	Exploration	Country considered nuclear weapons and conducted some exploratory work
2	Pursuit	Country started a nuclear weapons development program
3	Acquisition	First explosion/assembly of nuclear weapon

TABLE II. Categories of Proliferation Determinants and Variables from Previous Studies

Category	Subcategory	Variable
Capability	Economic capacity	GDP, GDP per capita, GDP ² , log(GDP), population
	Industrial capacity	Industry indicators, electricity, Iron and steel production
	Nuclear capability	Existence of nuclear fuel cycle capacity and sensitive material
	Nuclear assistance	Sensitive nuclear assistance, civilian nuclear assistance, IAEA technological cooperation
Domestic Politics	Political System	Democracy score
	Domestic	5-year change of

	Unrest	democracy score
	Leader's Characteristics	Coup d'état experience, regime length, leader type
International Security	Rivalry	Frequency of disputes, conventional threat, nuclear threat
	Alliance	Security guarantee (defense pact), nuclear deployment, troop deployment
	Domestic Isolation	Economic openness
	Power of Nation	Major power country, regional power country
International Norm		IAEA (membership, safeguards agreement, additional protocol), NPT (signed / ratified), other nuclear-related multilateral agreements

3. Updating the Dataset

Thanks to the sources used to build the independent datasets of previous studies have been updated over the years, we were able to extend the coverage of proliferation determinants used in Singh and Way (2004) (SW hereafter), originally from 1950-2000, to 1939-2012.

First, various researchers have been developed datasets to describe the country's economic and industrial capacity. In the SW dataset, Penn World Tables (PWT) (Feenstra et al., 2015), the Maddison Project (Bolt et al., 2018), and Gleditsch (2002)'s dataset were used to obtain Gross Domestic Product (GDP), trade and population. Similarly, we imported the GDP dataset from the R package *AuthoritarianismBook::economic_data* (Marquez, 2016), which combined historical estimates of GDP from the Maddison, PWT, the World Bank (The World Bank, 2020), and Gleditsch (2002). The population dataset was also imported from *AuthoritarianismBook::population_data*, a dataset extending Gleditsch's population of independent states list (Gleditsch, 2002) with the World Development Indicators "SP.POP.TOTL" variable (The World Bank, 2020) and the World Population data assembled by Max Roser (Max Roser and Ortiz-Ospina, 2020).

Instead of using trade data of PWT and Gleditsch following SW, we used Correlates of War (COW) International Trade dataset (Barbieri et al., 2009) to calculate economic openness, considering its wider coverage. Industrial capacity variables were calculated from updated

Industrial capacity index included the data of domestic steel production, electricity-generation

capacity and energy consumption. COW National Material Capabilities v5.0 (Dutka et al., 2017), which covers from 1816-2012, provided steel production and primary energy consumption data.

International relations and domestic politics variables were calculated using updated version of datasets used in previous studies. The Militarized Interstate Disputes (MID) dataset, which was used to calculate dispute involvement of a country, were also updated to 2010 (Palmer et al., 2019). COW Formal Alliances (v4.1) dataset, which was used to indicate the security guarantee from the superpower countries, covers from 1816-2012 (Gibler, 2009). The famous rivalry dataset (Klein et al., 2006) describes the rival states were also updated to Peace scale data, which covers from 1900-2015. It is an extensive revision, updating, and extension of our original rivalry dataset to include peaceful relationships (Diehl et al., 2019). The coverage of Polity IV annual time-series dataset for democracy-related variables, were also expanded to 1800-2018 (Marshall et al., 2019).

Finally, international norms variables were updated. NPT signatory and ratification dates were assessed from the United Nations Office for Disarmament Affairs (UNODA) repository (United Nations Office for Disarmament Affairs, n.d.), and ratification dates of comprehensive safeguards agreement (CSA) and additional protocol (AP) with International Atomic Energy Agency (IAEA) were assessed from the IAEA repository (IAEA, 2019).

4. Results

New nuclear proliferation dataset had lesser missing data, compared with SW. Table III shows the status of missing data of SW and newly constructed dataset.

Table III. Missing Data Status of Datasets

Variables	SW (all)	SW (selected)	New (all)	New (selected)
GDP per capita	819	269	300	123
GDP squared	819	269	300	123
Industrial capacity	17	0	0	0
Rival states	0	0	0	0
Disputes (5-year average)	525	192	539	0
Ally with Nuclear Weapon States	67	15	0	0
Democracy Index (Polity IV)	676	50	1019	35
Economic	845	255	1120	262

Openness				
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