A Literature Study on Simulation Methods With Respect to Denuclearization

Jinyoung Lee*
Korea Institute of Nuclear Nonproliferation and Control, 1534, Yuseong-daero, Yuseong-gu, Daejeon, Republic of Korea
*jylee86@kinac.re.kr

1. Introduction

Since the PyeongChang Olympics in 2018, the situation around the Korean Peninsula has rapidly changed from decades-long strained relations. Based on these environments, the ROK government launched a new R&D program to develop ROK’s technical capability which can be applied in DPRK’s denuclearization process.

One of the subjects in the program is development of physical model of DPRK’s nuclear facilities. In this paper, for proceeding this research on the prediction methods of unknown variables based on limited information, several literatures which were studied on general simulation researches, and its applications in nuclear non-proliferations were reviewed.

2. Main Subjects

2.1 Simulation Methods in General

In terms of utilized simulation methods in technical and political researches, there are well-known three kinds of techniques as follows; Agent Based Modeling (ABM), System Dynamics (SD) [1], and Bayesian Network (BN).

In a chronological point of view, the BN (or Bayes probability concept) was first developed by Thomas Bayes. The Bayes theorem is known as a theory which can provides a mathematical framework for inference using probability. Secondly, the SD is a widely used for simulation method in the field of factory design, political simulation, decision making, marketing and so on. Basically it is a kind of network analysis among nodes and variables. Thirdly, the ABM, somewhat opposing to top-down mechanism of SD methodology, is a bottom-up methodology which gathers all the phenomena from agent(an agent is defined as a smallest behavioral actor of the subject system). These three techniques are very useful to analyze the unknown phenomena or to find out an unclear mechanism with limited information.

2.2 Precedent Simulation Research in Nuclear Nonproliferation

The first research was conducted by Dr. Hacker’s team [2]. John E. Bistline et al. suggest several parts which are critical to make the centrifuge are restricted by China’s black market situation. The probability was given to the stockpile of the parts and a Monte Carlo sampling was carried out to optimize the centrifuges for the enrichment [2].

The second one was studied by G.A. Coles, which shows the BN technique that how to evaluate a state level proliferation resistance. The variables are in a very abstract level such as technical factors, international security factors, domestic politics factors, and national identify & Psychology factors [3].

The third one was conducted by C.R. Freeman, which is focused on material acquisition path. He
composed the pathways of each nuclear facilities in an entire nuclear cycle from a U enrichment to a recycling process by BN method, and then combined them all to a state level pathway [4].

The fourth one was studied by R.A. Elmore, which was started from G.A. Cole’s previous study [4] to his own research topics. He suggested a multidisciplinary methodology combining the BN and the ABM. In his work, a nation is playing a role of agent as a player of a game theory.

3. Conclusion

Based on the review of previous literatures, several research topics and questions were derived as follows. Firstly, which way of simulation can provide the most confident inference on the total amount of DPRK’s nuclear materials? Secondly, how can we evaluate the performance of each methodology? As shown in this paper, there have been many simulation methodologies including the already mentioned the BN, the ABM and the SD. Thus before we select a specific method, it is necessary to find a way of evaluation on those methods very carefully. In the near future, not only the validity of these simulation methods and their combination but also the answer of these questions are necessary to be studied in more detail.

REFERENCES


