

## **Exploring Quantitative Framework to Evaluate Nuclear Transparency**

Jee-Min Ha<sup>1</sup>, Hyeon Seok Park<sup>2</sup>, and Man-Sung Yim<sup>1\*</sup>

<sup>1</sup>Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Korea

<sup>2</sup>Department of Humanities and Social Sciences, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Korea

\*Corresponding author: *msyim@kaist.ac.kr*

### **1. Introduction**

This work is our initial attempt to develop a quantitative method to evaluate nuclear transparency of a state. Although the literature stresses its importance, the concept of nuclear transparency is still vague and complicated in its application. In this work, a definition of nuclear transparency is elaborated and ways to represent a country's nuclear transparency are examined.

### **2. Methods and Results**

In this section, a definition of nuclear transparency and major elements for defining nuclear transparency are described. Using publicly available data, two different measures for nuclear transparency at the state level is developed here. To construct new measures, IAEA safeguards classification and Nuclear Threat Initiative (NTI) security index data were used.

#### *2.1. Definition of nuclear transparency*

Nuclear Transparency has been defined in various ways. In the 1990s, it was defined simply as "openness" (Stiglitz, 1990) and "permitted knowledge" (CSIS, 1999). It has also been said to mean being "free from pretence or deceit", "readily understood", and "clear, frank, and obvious" (Drew, 2001; Winkler, n.d.) [5]. Some studies defined it as process; the process of allowing the unilateral, isotropic, unmanaged, unconditional, free-flow of information, ideas, opinions, and knowledge (Roger G. Johnston, et al., 2008), and a cooperative process of providing information to all interested parties so that they can independently assess the safety, security, and legitimate management of nuclear materials (Carles D. Harmon, et al., 2000). Besides, it was defined as the condition in which a state's nuclear programs, activities, facilities, capabilities, and intentions are known to other members of the international community, through explicit policies and actions of the state, by reason of its general climate and culture of openness, and by independent information available on the state (James Larrimore, et al., 2006) or the flow of information and knowledge between parties (Frans Berkhout and William Walker, 1999).

While all of these definitions have merits, they should be further examined to evaluate the transparency

accurately. The transparency, therefore, is defined as the condition that shows how clearly the State's information related to nuclear proliferation is revealed to the international society. In addition, it is hypothesized that nuclear transparency is one of the confidence building measures for States to successfully develop peaceful nuclear power program.

#### *2.2. Elements for defining nuclear transparency*

For analyzing nuclear transparency, not only information of nuclear material and activities but also information seeker and seeke should be mentioned.

##### *2.2.1. Who see – Information seeker*

Information seekers are the one who want to get the information of nuclear material and activities from the suspicious States. In brief, they concern about the diversion of nuclear material and wonder whether the policy directions of suspicious States are on the same way with theirs. They could be States and Agents. [8].

##### *2.2.2. Whom do they see – Information seeke*

Information seekes are the suspicious States. If they already have nuclear weapons or weapon-usable nuclear materials, information seeker might require the information about it. In the other hand, States who don't have nuclear weapons but have techniques could be also information seekes.

##### *2.2.3. What do they see - Information*

When information seekers inquire seekes about information, there are several target information; information of nuclear material, facilities, equipment, and activities. The information about nuclear material includes the type, forms, and amounts of nuclear material. In the case of facilities and equipment, information seekers might require for the type, design feature, and purpose of facilities and equipment. And the seekers could ask for the type, purpose, plan of nuclear activities.

#### *2.3. Measures for evaluating nuclear transparency*

##### *2.3.1. IAEA safeguards*

Safeguards are measures to verify that States comply with their international obligations not to use nuclear materials for nuclear explosives. If States conclude safeguards agreements, IAEA is entitled to examine any indication of the diversion of nuclear material from peaceful nuclear activities through the reports from the States.

There are three kinds of safeguards agreements; voluntary offer agreements, comprehensive safeguards agreements, and item-specific (or limited-scope) safeguards. Five nuclear-weapon States, China, France, the Russian Federation, the United Kingdom and the United States of America, had voluntary offer agreements in force. Safeguards were applied for 171 non-nuclear-weapon States with comprehensive safeguards agreements in force. And Item-specific safeguards agreements were applied in India, Israel and Pakistan. Moreover, there are many steps after safeguards agreements were in force such as additional protocols, broader conclusion, and integrate safeguards.

Table 1: States Classification by Safeguards [7]

Group (Number)	Safeguard	Additional Protocol	Broader Conclusion	Integrate Safeguards	Total
<b>Voluntary Offer Agreement</b>					
A (5)	1	1	0	0	2
<b>Comprehensive Safeguard Agreement</b>					
B (51)	1	1	1	1	4
C (9)	1	1	1	0	3
D (54)	1	1	0	0	2
E (57)	1	0	0	0	1
F (13)	0	0	0	0	0
<b>Item-specific Safeguard Agreement</b>					
G (3)	1	0	0	0	1

For our analysis, if safeguards and protocols were in force, the case is ranked as one. And if a broader conclusion has been derived, it is scored also as one. In addition, if an integrate safeguard has been implemented, it is ranked as one. Thus, higher the total score, the greater the level of transparency, we assume.

Most of the Top 30 nuclear power capacity States are belonging to Group B. Also lots of the potential entrants are included in Group B. It shows that states who want to develop nuclear power peacefully should feature higher nuclear transparency.

### 2.3.2. Voluntary disclosure

The case of using IAEA safeguards requires information seeks to provide their information involuntarily. In contrast, information seeks could offer the information voluntarily.

Table 2 contains three measures as a way to capture this voluntary nature; published regulations and reports on nuclear security issues, public declarations and reports about nuclear materials, and invitations for review of security arrangements. "Published regulations and reports on nuclear security issues" indicates whether the State publicly released broad outlines of its nuclear

security regulations and/or an annual report on nuclear security issues or not. If the State didn't published regulations or annual reports, it is scored as zero. If the State published regulations or an annual report, it is scored as one. In case of publishing both of them, it is scored as two. "Public declarations and reports about nuclear materials" shows whether the State made any public declarations or reports about nuclear materials. Therefore, the score one in this case means that the State made public declaration or reports about nuclear materials. The last indicator "Invitations for review for security arrangements" demonstrates whether the State issued invitations for review of its security arrangements. In this case, the States were ranked as two when they issued invitations within the past five years. Again, the bigger score means greater level of transparency. Consequently, different level of transparency among the same group can be distinguished from Table 2.

Table 2: International Assurances of States with weapons-usable nuclear materials [9]

Country	Group	Published regulations and reports on nuclear security issues	Public declarations and reports about nuclear materials	Invitations for review of security arrangements
China	A	1	1	2
France	A	2	1	2
Russia	A	2	1	2
UK	A	2	1	2
USA	A	2	1	2
Australia	B	2	1	2
Belgium	B	2	0	0
Canada	B	2	0	2
Italy	B	1	0	0
Japan	B	1	1	2
Netherlands	B	1	0	2
Norway	B	1	0	1
Poland	B	1	0	2
Uzbekistan	B	1	0	2
Germany	B	1	1	2
South Africa	C	2	0	0
Kazakhstan	D	1	0	2
Switzerland	D	1	1	2
Argentina	E	2	0	2
Belarus	E	1	0	2
Iran	E	0	0	2
India	G	2	0	0
Israel	G	0	0	0
Pakistan	G	2	0	2
DPRK	-	0	0	0

### 3. Conclusion

For evaluating nuclear transparency, it is necessary to define three elements first; an information seeker who wants to see, an information seeke whom an information seeker wants to see, and information related to nuclear materials and activities. The States with high capacity of civilian nuclear power had a tendency to follow IAEA safeguards agreements well. And it means that their levels of the transparency are relatively high. Besides, the data of international assurances is one of the good indicators to confirm States' transparency. The current

study explored the use of two measures, IAEA safeguards and voluntary reporting as a way to represent nuclear transparency. Using these measures seemed to agree with the notion that nuclear transparency is important in the success of civilian nuclear power development.

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