



Original Article

The role of tolerance and self-sufficiency in a nation's adoption of nuclear power generation: A search for a quick and simple indicator

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ABSTRACT

Nuclear energy remains one of the world's major energy sources, making up over 10% of global electricity generation in 2017. Public acceptance of nuclear energy is essential for its adoption. From a practical perspective, it is beneficial to have a simple indicator that can predict the actual adoption of nuclear energy. Based on practical experience, the authors suggest tolerance and self-sufficiency as potential indicators that may predict the adoption of nuclear energy. By evaluating the cross-sectional data of 18 countries in 2013, this research assesses the actual impact of tolerance and self-sufficiency on public acceptance in order to identify the validity of the two variables. The results indicate that the two variables are statistically significant, while public acceptance is insignificant in explaining national adoption of nuclear energy. This may be because tolerance reflects national willingness to accept potential risk, while self-sufficiency explains a government's likelihood of developing non-carbon energy sources.

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1. Introduction

Despite the 2011 Fukushima disaster, nuclear energy remains a major source of energy [1]. It generates over 10% of the global electricity in 2017. It also remains an important energy source for developed nations, accounting for over 30% (Republic of Korea), over 70% (France), and approximately 20% (North America) of national electricity generation [2].

As part of a country's successful adoption of nuclear energy, the public's acceptance of nuclear energy is extremely important, because nuclear power plants and waste repositories require significant investment to build, and nuclear catastrophes cause significant, long-lasting environmental damage and health problems [3]. This factor has become more important in developed nations, as democracy and transparent processes often require the acceptance of a majority of stakeholders if not all [4,5].

While public acceptance is important, it is difficult to measure public acceptance in practice since there are many variables that affect public acceptance, including subjective ones [6]. Furthermore, while public acceptance is an important determinant of nuclear uptake, the direct effects of public acceptance on a nation's

nuclear uptake is often overlooked. In practice, it is important to ensure simplicity of measurement when it comes to encouraging nuclear uptake. This research, therefore, will explore two variables that are regularly measured and made available by the OECD, and have been proven with practical experience to be effective.

This paper is structured as follows. The subsequent section reviews public acceptance literature and identifies gaps. The next section describes the research model and methodology used in our research. Next, the data used and the results are described. Finally, the paper concludes with a discussion of the results and suggests future topics for study.

2. Literature review

Since public opinion is important in nuclear policymaking, there have been a considerable number of studies in the area of aspects of public acceptance and nuclear policy. This section will review existing literature and identify potential gaps to be filled.

From the overall perspective of public acceptance, Van der Pligt et al. qualitatively identified the risks associated with nuclear technology that determine attitudes toward nuclear energy [7]. Visschers et al. tested the validity of a public acceptance model, where trust and affect were the basic variables that affected public acceptance, with two items in between: Risk perception and

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benefit perception (climate mitigation/energy supply) [8]. While research has provided good comprehensive public acceptance frameworks, it is neither simple to derive public acceptance based on these frameworks nor to measure the impact of public acceptance on a nation's nuclear electricity generation adoption.

A number of studies have focused on the aspects of affect and values of the public as determinants of public acceptance. Finucane et al. studied affect heuristics in judgments of risks and benefits [9]. Siegrist and Visschers found that public acceptance change was moderate after Fukushima, and that prior beliefs and attitudes around nuclear energy were important determinants [10]. Such research provides a good understanding of where different perceptions of the same benefit/risk come from, but such research neither provides a simple method for measurement of nor the effect of public acceptance of nuclear energy.

Some studies have focused on the aspect of trust in public acceptance. Siegrist and Cvetkovich determined that there is a correlation between social trust and judged risks/benefits for people who did not possess much knowledge of a hazard [11]. Visschers and Siegrist also deduced that the Fukushima accident reduced public acceptance of and trust in nuclear energy, where trust affected perceived benefits and risks significantly [10]. As in the case of research on affect and values, literature on trust shows a good understanding of the role of trust, but is unable to provide either a simple method for measuring public acceptance of nuclear energy, or measuring the effect of public acceptance of nuclear energy on nuclear energy adoption.

There are studies that focus on the perceived risk of public acceptance. Sun and Zhu found that people who received comprehensive information had less risk perception than those without it [12]. Literature focusing on risk perception also demonstrates a good understanding of this area, but it is unable to provide either a simple method for measurement of or the effect of public acceptance of nuclear energy on its adoption.

Some literature has focused on the benefit perception aspect of a public acceptance framework. Pidgeon et al. showed that the perception of nuclear energy's benefits leads to better acceptance [13,14]. Siegrist et al. showed that changes in attitudes in a Swiss sample after the Fukushima accident were mostly due to changes in benefit perception rather than changes in risk perception [15]. Literature focusing on benefit perception also demonstrates a good understanding of this area, but it is similarly unable to provide either a simple method for the measurement of or the effect of public acceptance of nuclear energy on nuclear energy adoption [16].

A vast amount of research has already studied public acceptance frameworks in detail. Such frameworks themselves often stand firm empirically and theoretically. However, the gaps that this paper attempts to answer, namely, simplicity in measurement and quantification of actual effect on the national share of nuclear electricity generation, are not covered by existing literature.

3. Research model and methodology

This research proposes two factors, which can be relatively simply measured, to identify a nation's acceptance of nuclear electricity generation uptake.

The first factor is tolerance, which is defined by the OECD as “the ratio of the people who respond yes to the question of whether the city or area where they live is a good place to live or not for ethnic minorities, migrants, or gay or lesbian people to all people contacted.” This factor measures the cultural aspects of a nation, in particular whether its citizens are willing to embrace unfamiliar and/or potentially risky factors. Since this factor is measured and published regularly by the OECD, it is considered to be a variable

relatively simple to measure.

The second factor is self-sufficiency, which is defined as the ratio of energy consumption that is produced by the resources produced within the nation. This factor indirectly measures a government's willingness to establish energy security. This measure is also regularly measured and made available by the OECD.

To evaluate the two factors' effects on public acceptance, our research model also incorporates a public acceptance measure, as measured by the IAEA. In addition, to avoid mere exposure effects, where “mere repeated exposure of the individual to a stimulus object enhances his attitude towards it,” as defined in Zajon [17], the number of years a country has been operating nuclear energy is added as a control variable.

This research employs multiple linear regression analysis to determine the impact of the four independent variables described above on the dependent variable: The share of electricity generated by nuclear energy. The equation to which the data were fitted is:

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \varepsilon \quad (1)$$

where,

y is the dependent variable: Share of electricity generated by nuclear energy

x_i are the four independent variables (where $i = 1, 2, 3, 4$)

β_i are the regression coefficients of x_i , respectively, (where $i = 1, 2, 3, 4$) and ε is the error term

4. Data and results

For the data used, the nuclear-related statistics (share of electricity generated by nuclear energy, public acceptance measure, and number of years the country has been generating nuclear energy) are provided by the IAEA, while tolerance and self-sufficiency are provided by the OECD [18]. Table 1 provides the actual data values.

The results of the analysis (Table 2) indicate that at 10% significance level, both tolerance and self-sufficiency are statistically significant predictors of the share of electricity produced by nuclear energy. The insignificance of public acceptance and years of nuclear energy generation suggest that the two factors have greater influence on the nuclear energy uptake than public acceptance, while there is a very limited mere exposure effect involved.

5. Discussion and implications

As the results indicate, the presence of tolerance and self-sufficiency make public acceptance statistically insignificant to a nation's uptake of nuclear energy. In fact, the limited mere exposure effect contributed more to the uptake of nuclear energy than public acceptance did in the presence of the two variables.

While tolerance and self-sufficiency are not readily studied variables in academia, the definition of these variables provides some hint of their statistical significance. Firstly, tolerance is a society's readiness to accept unfamiliar and/or different values. The coexistence of different values and not merely opposing specific values enables a nation to discuss important issues such as nuclear energy, while low tolerance and an inclination toward anti-nuclear sentiment could prevent a nation from having a discussion. Therefore, while the public's opinion is formed by affect, trust, and values that individuals possess, tolerance indirectly measures the extent to which the public is willing to embrace nuclear adoption.

Self-sufficiency, on the other hand, predicts a government's energy policy direction. The lower self-sufficiency is, the more

Table 1
Data used for analysis.

Country	Nuclear share	Public acceptance	Operation start year	Tolerance	Self-sufficiency
Belgium	52	45	1962	82.08	0.27
Canada	16	69.6	1962	89.18	1.55
Czech	35.9	61	1985	60.69	0.74
Finland	33.3	45	1977	74.00	0.48
France	73.3	58	1959	79.80	0.51
Germany	15.4	69.5	1962	78.99	0.39
Hungary	50.7	75	1983	68.12	0.43
Japan	1.7	37.7	1965	57.48	0.19
Korea	27.6	64	1978	50.07	0.18
Mexico	4.6	60.5	1990	58.90	1.28
Netherlands	2.8	—	1969	85.63	0.84
Slovak	51.7	—	1972	53.63	0.36
Slovenia	33.6	—	1983	53.45	0.50
Spain	19.7	—	1969	84.43	0.26
Sweden	42.7	50	1964	87.59	0.64
Switzerland	36.4	40	1969	73.39	0.48
United Kingdom	18.3	40	1956	85.89	0.73
United States	19.4	62	1958	79.53	0.78

Table 2
Result of the analysis.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	−23.752	40.264		−.590	.570		
Tolerance	1.525	.688	.948	2.217	.054	.337	2.971
Public Acceptance	.295	.439	.184	.671	.519	.822	1.217
Years of operation	−1.112	.746	−.623	−1.491	.170	.352	2.839
Self-sufficiency	−37.029	15.507	−.729	−2.388	.041	.661	1.513

inclined a government will be toward non-carbon energy sources such as nuclear energy and renewable energy. The focus will surely be on nuclear energy if the geographic context of a nation does not promise the economic feasibility of renewable energy. Self-sufficiency explains the willingness of a government to adopt nuclear energy.

This means that, on top of enhancing public acceptance, the nuclear industry and governments interested in promoting nuclear energy should focus on enhancing the tolerance of society in general. Countries with low levels of national tolerance often face extreme conflicts when an issue arises. In the process, the governments of those countries become reluctant to openly address it, and people's discontent increases. Therefore, countries that are planning to operate or introduce a nuclear industry need to consider their cultural tolerance.

In conclusion, while enhancing public acceptance of nuclear energy will enhance the adoption of nuclear energy, the more important factor would be the cultural and national willingness to embrace the unfamiliar. Furthermore, tolerance and self-sufficiency can be used to quickly predict a society's readiness and ability to accept nuclear energy uptake.

6. Limitations and topics for further study

While this research was prompted by practical experience, most of the content in the discussion is subject to further proof and research. These naturally lead to the topics for further study. Firstly, the determinants of tolerance should be identified to correctly assess the effects of tolerance and to effectively enhance it. Secondly, self-sufficiency describes the inclination of a government, which may be that a government has already gone through measures to enhance the image of nuclear energy. Therefore, the impact

of self-sufficiency on the government's public relations activities related to nuclear energy should be investigated. Lastly, standardized public acceptance indices that are easy to measure and obtain for use in practice are necessary.

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