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Original Article

Big Data Analysis of Public Acceptance of Nuclear Power in Korea

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ABSTRACT

Public acceptance of nuclear power is important for the government, the major stakeholder of the industry, because consensus is required to drive actions. It is therefore no coincidence that the governments of nations operating nuclear reactors are endeavoring to enhance public acceptance of nuclear power, as better acceptance allows stable power generation and peaceful processing of nuclear wastes produced from nuclear reactors. Past research, however, has been limited to epistemological measurements using methods such as the Likert scale. In this research, we propose big data analysis as an attractive alternative and attempt to identify the attitudes of the public on nuclear power. Specifically, we used common big data analyses to analyze consumer opinions via SNS (Social Networking Services), using keyword analysis and opinion analysis. The keyword analysis identified the attitudes of the public toward nuclear power. The public felt positive toward nuclear power when Korea successfully exported nuclear reactors to the United Arab Emirates. With the Fukushima accident in 2011 and certain supplier scandals in 2012, however, the image of nuclear power was degraded and the negative image continues. It is recommended that the government focus on developing useful businesses and use cases of nuclear power in order to improve public acceptance.

1. Introduction

Nuclear power, despite its various benefits, has critical drawbacks such as the possibility of a nuclear meltdown, as was seen in Fukushima [1,2]. Public acceptance of nuclear power is important for the government, the major stakeholder of the industry, because a consensus is necessary to drive government actions [3]. It is therefore no coincidence that the governments of nations operating nuclear reactors are endeavoring to enhance public acceptance of nuclear power: better acceptance allows stable power generation and peaceful processing of nuclear waste produced from nuclear reactors. In this context, public acceptance is critical for sustaining nuclear power, and researchers have devised various methods to measure that acceptance. The existing literature suggests that rationality, emotion, knowledge of

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nuclear technology, trust, policy executor, and risk perception variables affect public acceptance. Recent attempts at evaluation of degree of public acceptance of nuclear power, however, have been limited to epistemological measurements using methods such as the Likert scale [4,5]. Because such methods are standardized, it is difficult for them to reflect the emotions latent in individuals within the public. Moreover, surveys can be conducted only with participants in a specific region and time interval, and it may be misleading to generalize these results to represent the overall attitude of the public. To measure public acceptance of nuclear technology precisely, one must devise a methodology that can collect a massive amount of data from large samples and analyze this "big" data. This is because big data methods are based on unstructured data, which contain live experiences/opinions, and because big data are collected virtually in real time with almost no delay between the events of concern and the data collection [6]. In this research, we propose big data analysis as a solution to these problems and attempt to identify the attitudes of the public toward nuclear power using big data analysis.

2. Literature review

2.1. *Public acceptance*

To measure the public acceptance of nuclear power, scholars from many fields have suggested and used various methodologies. It has usually been the fields of sociology and public administration that have investigated the public acceptance of nuclear technology; survey results have been analyzed using several methodologies. The results indicate that trust, knowledge, and economic benefit are required to enhance public acceptance of nuclear technology. Such analysis, despite convincing results, has four limitations [7]. First, the data analyzed do not necessarily represent the opinions of the entire population because, owing to various constraints, researchers have analyzed citizens in limited geographical regions. Second, because anonymity has to be guaranteed in a survey, it is difficult to identify opinion leaders in networks of people. Third, a real-time analysis is almost impossible because of the time taken to acquire and process data. Surveys and face-to-face interviews require significant time to complete and may not be suitable for situations that require fast decision making. Lastly, as traditional methodologies are structured, it may be difficult to induce unstructured opinions from the respondents. As described above, the traditional methodologies of surveys and face-to-face interviews have various limitations. This research proposes big data analysis as an alternative.

2.2. *Big data*

Big data is a concept that encompasses "large-scale data" and, initially, the definition of big data consisted of attributes such as a large volume, high velocity (speed of data creation and distribution), and variety of data. The value of big data from social networks (e.g., Twitter and Facebook) is growing because the data can be used to overcome the limitations of traditional methodologies (e.g., surveys). Social data can be used not only to overcome the constraints of space and time, but also to reflect various opinions in unstructured forms and to identify networks among people. Such characteristics make social big data suitable for analyzing public acceptance of nuclear power, in which a diversity of opinions across regions exists and opinions are susceptible to rapid changes. To overcome the limitations of traditional methodologies and to view the public from a new perspective, this research analyzed the Korean public using social big data analysis.

3. Methodology and data

As noted in the previous section, using big data analysis, we were able to identify the emotional state of the public and, furthermore, the process of diffusion. This allows a quick detection/visualization of major issues and is thus very effective at measuring public acceptance of nuclear technology, an issue that is directly related to civil safety and welfare. This analysis reduces the distortion of parameters by allowing researchers to analyze the opinion of the overall population rather than that of a small sample. In addition, the analysis allows discovery of new relationships among variables and real-time analysis. In this context, we used common big data analyses to analyze consumer opinions in SNS (Social Networking Services) via keyword analysis.

3.1. *Keyword analysis*

Keyword analysis identifies sentences with keywords of concern and extracts nouns from the sentences. The ratio of nouns determines the overall consumer opinion. To conduct the analysis, we collected data by crawling the Web, Twitter, and Naver.com, for approximately 1.2 million sets of data from January 1, 2009 to July 31, 2014. The gathered data were decomposed by the word class, such as nouns and adjectives, to extract SNS user emotions, and the nouns of the decomposed data were visualized following the building of a "word cloud."

3.2. *Comparison of nuclear power awareness: Seoul and Kori*

We compared the awareness of nuclear power for two different groups of people: people living far from a nuclear reactor (Seoul) and people living in the proximity of a nuclear reactor (Kori). This is because nuclear reactors are subject to "Not In My Backyard" objections, and the awareness of nuclear reactors is expected to decrease as the distance from a nuclear reactor increases. To analyze this, we collected data by crawling Twitter with the keywords "nuclear," "nuclear power plant," and "smart nuclear reactor" Tweets from January 1, 2015 to April 30, 2015 with location information (both longitude and latitude) were filtered. Among the filtered data, we selected tweets written in a 10-km radius of Seoul City Hall and tweets written in a 20-km radius of the Kori Nuclear Reactor as samples of these two groups of people.

4. Results

4.1. *Keyword analysis*

The results indicate that SNSs were dominated by positive terms such as "success," "growth engine," and "beneficiary" when Korea established an export contract with the United Arab Emirates (UAE) in 2009 (Fig. 1).

However, just a year after the Fukushima accident, in 2012, the Korea Hydro & Nuclear Power fabricated documents regarding parts in its nuclear reactors. The results followed the situation and showed that SNSs were dominated by negative terms such as "Fukushima," "death," "conceal," "danger," and "radioactivity" (Fig. 2).

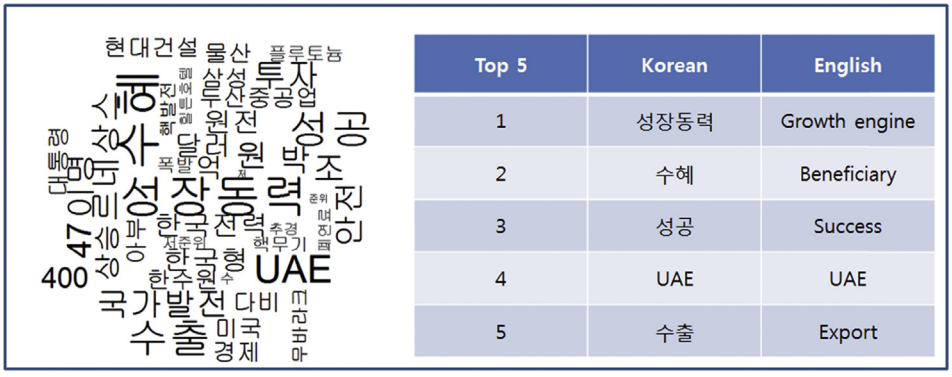
SNS analysis on data for the year 2014 indicated that Korean society is still highly aware of critical issues of nuclear technology such as safety and the potential for leakage. Moreover, one can observe that controversies such as nuclear fuel reprocessing, the Korea–United States nuclear cooperation agreement, and concerns about the Kori reactor and the Wolsong reactor, are attracting public interest (Fig. 3).

4.2. *Comparison of nuclear power awareness: Seoul and Kori*

The analysis indicates that Kori generated 153 times more tweets with keywords "smart nuclear reactor," "nuclear power," and "nuclear power plant" than did Seoul. The data from Kori also indicated that there were two times more tweets about nuclear power plants than there were tweets about nuclear power. The number of tweets in Seoul was very small and did not show any statistically significant difference. In any case, there were a small numbers of tweets on the topic "smart nuclear reactor." The results also indicate the domination of twitter opinions by a few opinion leaders. The top 0.3% of users (19 out of 6,203 users) generated 24.8% of the tweets (4,811 out of 19,345 tweets). In other words, only a few users generated a large number of tweets and led opinion on SNS. It is worth noting that the top 19 users were all living in Kori, which indicates that it is difficult to find people living in Seoul who are interested in issues related to nuclear power. These results demonstrate that people distant from a nuclear reactor (Seoul) are not aware of nuclear issues and that it is people/organizations living in the proximity of a nuclear reactor that lead opinion on nuclear power and nuclear power plants.

5. Discussion

The keyword analysis identified the attitudes of the public toward nuclear power. The public was positive toward nuclear power when Korea successfully exported nuclear reactors to the UAE. With the Fukushima accident in 2011 and supplier scandals in 2012, however, the image of nuclear power was degraded; that negative image continues. It should be noted that there were relatively few tweets with the keyword "Smart nuclear reactor" because Korea's export to the UAE was announced in March 2011. However, this is not an issue

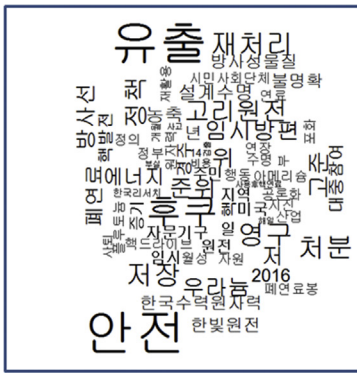


Top 5	Korean	English
1	성장동력	Growth engine
2	수혜	Beneficiary
3	성공	Success
4	UAE	UAE
5	수출	Export

Fig. 1 – Word cloud of tweets in 2009. UAE, United Arab Emirates.

Top 5	Korean	English
1	후쿠시마	Fukushima
2	사망	Death
3	은폐	Conceal
4	위험	Danger
5	방사능	Radioactivity

Fig. 2 – Word cloud of tweets in 2012.



Top 5	Korean	English
1	안전	Safety
2	유출	Leakage
3	후쿠시마	Fukushima
4	재처리	Reprocessing
5	처분	Disposal

Fig. 3 – Word cloud of tweets in 2014.

because the tweets were present for a short period and were not generated further. This indicates that concepts such as "growth engine," "national pride," and "export" do not significantly affect public opinion. Although it is true that a "smart nuclear reactor" could reinforce the image of nuclear power in a positive way, the related concepts (growth engine, national pride, and export) are only superficial in forming public opinion.

A direct comparison of tweets in Seoul and Kori showed that people living in Seoul are less affected by nuclear reactors than people living in Kori, owing to differences in physical distance from a nuclear reactor. It is worth noting that only 0.3% of Twitter users generated 24.8% of tweets, and that the majority of these users are related to nongovernmental organizations and political organizations. The nuclear industry should actively interact with these opinion leaders by providing necessary information and engaging them in public discussions.

Overall, the negative image of nuclear power and nuclear power plants has persisted since 2011, and people/organizations living in the proximity of nuclear reactors are hostile toward nuclear power. This is reflected in the recent (June 2015) rejection of the extension of the Kori nuclear reactor operation because of strong objections from local citizens and political organizations. Despite the reactors' excellent performance and safety certification by a government-accredited organization, extension of operation was denied. This recent event shows that the sustainability of nuclear power is mostly determined by the acceptance, the image, and public feelings toward nuclear power, rather than by technological excellence or economic feasibility.

6. Conclusion and research limitations

To conclude, big data is a useful tool to efficiently measure public acceptance of nuclear technology (i.e., the use of big data saves cost, time, and effort in measurement and analysis); this research was able to provide a case for using big data to analyze public acceptance of nuclear technology. In addition, the analysis identified opinion leaders, which should allow target marketing when policy is executed. In particular, the trends and opinions of opinion leaders on SNSs should be monitored and responded to in real time. As demonstrated by the rejection of the extension of the Kori nuclear power plant, image and feelings are more important than the performance of the safety technology in the operation of a nuclear power plant. Because Korea has many aging reactors, evaluation of projects to extend the operation of old reactors and to build new reactors will have to take place in the near future. In this context, it is crucial to collect and analyze data regarding the image of nuclear power. Big data analysis will allow the nuclear industry and the government to proactively respond to the public, which will lead to rational decisions and interaction with the public. Evaluation and prediction of nuclear policies will be made more reliable by using big data methodologies and the results of this research. However, there are certain limitations. First, this research did not analyze individuals directly, but rather their groups on SNS. Applying the results to individuals directly may create an ecological fallacy. Second, using only Twitter data could limit the scope of this research. Nevertheless, the research assembled an ample dataset for the analysis, and the overall trend of opinions is not expected to differ even in other SNSs. Lastly, there were very small numbers of tweets generated from Seoul. However, the concentration of data in a specific region could be a plus for analyzing public acceptance of nuclear power as local residents' acceptance is the most important determinant. In the past, Korea experienced significant challenges in hosting nuclear facilities owing to opposition of local residents, which makes the locally concentrated data and the big data analysis presented in this paper very effective. In addition, real-time big data analysis will accelerate responses by the central government to local opinions. In the process, the opinion leaders may distort the data if they purposely attempt to influence the opinion. This, however, could be prevented by using Bayesian statistics-based machine learning analysis of user information (also collected when big data is collected) to distinguish actual residents from opinion leaders [8, 9]. In other words, intentional distortion of opinion can be filtered and accommodated by using machine learning technology [10]. For the case in which a national sample is desired, it is suggested that big data analysis be used with appropriate sampling methods (e.g., considering regional population) or that a conventional survey method used.

Conflicts of interest

There are no conflict.

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