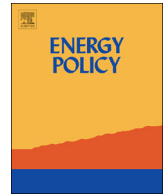




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Do people really want renewable energy? Who wants renewable energy?: Discrete choice model of reference-dependent preference in South Korea

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ABSTRACT

Renewable energy is gaining more attention than before in terms of tackling climate change and ensuring the public safety. The South Korean (hereafter, Korean) government has announced various policies to expand renewable energy sources and reduce the share of nuclear and coal-fired power. Since the energy sources are directly related to the lives of people, it is important to identify the public's acceptability of changes in the energy mix. Therefore, the purpose of this study is to analyze public preferences for changes in the shares of energy sources. For estimation of preference, this study used a mixed logit model that reflects the reference point to consider the relative shares of the energy sources and the relative level of attributes. In addition, this study used a hierarchical Bayesian logit model to examine whether the public characteristics result in any preference difference on the electricity service attributes. The results show that the Korean public's acceptability is high for renewable energy source expansion policy. Based on the analysis, this study found that the respondent's level of education had a significant effect on the preference for increase of renewable energy sources.

1. Introduction

After the adoption of the Kyoto Protocol (1997), which was mainly led by developed countries, the Paris Agreement (2015) was adopted, and interest in tackling climate change subsequently expanded globally. In particular, since the adoption of the Kyoto Protocol, developed countries have focused on transitioning to a low-carbon energy mix by expanding the shares of nuclear and renewable energy source as a policy goal.

Although the government's primary role is to set specific targets for the total power generation and each energy source, they must consider the uncertainty in the energy demand. As a result, the main energy policy is often one that deals with setting the shares of different energy sources within the overall power generation. As shown in Table 1, power generation is comprised of various energy sources, and naturally, the sum is set to 100%. In this setting, increasing the share of one particular energy source is only possible when the shares of other energy sources decrease. Thus, switching to a low-carbon energy mix requires a reduction in the share of coal-fired power plants, which naturally requires an increase in the share of other energy sources, such as nuclear and renewable energy power.

However, since the 2011 Fukushima Daiichi nuclear disaster, the public's reliability in nuclear energy has relatively decreased, while the interest in renewable energy has increased drastically (Chen et al., 2014). In June 2017 in South Korea, which previously aimed to expand the share of nuclear energy by 2040,¹ there had been many disputes about changing the direction of the energy policies (Energy Information Administration, 2016). President Moon's administration, inaugurated in 2017, has been pushing for the public debate about the installation of two new nuclear power plants that are now under construction. In addition, the Korean government has temporarily suspended the operation of eight aged coal-fired power plants for a month in June 2017.²

In the case of renewable energy sources, the Korean government previously aimed to expand the share of renewable energy source to 11% by 2020 (Ren, 2015).³ However, the new administration announced the *Renewable 3020*, which plans to increase the share of renewable energy by up to 20% by 2030. The plan also states that it will reduce the generation share of both nuclear and coal-fired power generation by 20–23.9% and 36.1%, respectively. The energy mix target proposed by the plan is described in Table 1.

Although the cost of renewable energy source is declining (International Energy Agency, 2016), it is still considerably higher than

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¹ South Korea was the only country to increase the share of nuclear power among OECD (Organization for Economic Co-operation and Development) member states.

² South Korea is a country where carbon emissions are rising at the fastest pace among other OECD member states (International Energy Administration, 2016). OECD countries' per capita carbon emissions decreased by 7.2% from 10.29 t in 1990 to 9.55 t in 2013, while South Korea's skyrocketed by 110.8% from 5.41 t to 11.39 t during the same period.

³ As of 2016, the share of renewable energy source in South Korea is 4.9%. As of 2017, the share of renewable energy sources has increased to 6.2%.

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Table 1
3020 plan's target share of energy source (Ministry of Trade, Industry and Energy, 2017).

Year	Nuclear energy	Coal-fired power	LNG	Renewable energy	Oil	Hydro power	Total
2017	30.3%	45.4%	16.9%	6.2%	0.6%	0.7%	100%
2030	23.9%	36.1%	18.8%	20.0%	0.3%	0.8%	100%

the cost of nuclear and coal-fired power generation (Energy Information Administration, 2017). In addition, the cost from expanding the share of renewable energy source, which may be imposed on the public, will further increase. In Japan, where renewable energy source is expanding fastest in Asia (International Energy Agency, 2016), people are currently paying additional 792 yen per month as renewable energy dues since 2017 (Ministry of Economy, Trade and Industry, 2017).⁴ As the Japanese directly witnessed the Fukushima Daiichi nuclear disaster, their resistance to a tax hike is relatively low. Hence, it was less challenging for the Japanese government to finance renewable energy, which allowed Japan to successfully expand solar photovoltaic (PV) and wind energy (Ministry of Economy, Trade and Industry, 2012).

In Europe, individuals are highly likely to accept the government's nuclear plant shutdown (or reduction of its share) and less likely to reject an electricity bill hike caused by the expansion of renewable energy source. In this context, the German government banned the construction of any new nuclear power plant after the 2011 Fukushima Daiichi nuclear disaster. Unlike Germany, there is a considerable resistance from the Koreans to an increase in electricity bill, including taxes (Kim and Kim, 2015). Accordingly, it is essential to gain the public's consent on an energy cost hike related to renewable energy source expansion for the government to successfully achieve the *Renewable 3020* plan.

Due to the Korean constitution limiting the referendum to a matter regarding national defense, diplomacy, and reunification, there has never been a referendum regarding an energy policy. As a result, a questionnaire survey has been conducted to identify the public's preferences on the changes in the shares of energy sources. The discrete choice experiment which is survey instrument was also utilized to predict the public's acceptance of the expansion of renewable energy's share and how much they are willing to pay for such a change (Train, 2009). The discrete choice model is used to analyze the data from the discrete choice experiment. Majority of the previous studies that analyzed the public preferences on electricity service and renewable energy source using the discrete choice model incorporated the share of an energy source by reflecting them in the attribute level directly in the model (as an absolute number).

However, the public does not evaluate the alternatives by considering the absolute level of attributes constituting hypothetical alternatives. Rather, they evaluate the alternatives by considering the relative difference between the current state as a reference point and the attribute level of an alternative (Tversky and Kahneman, 1991). In this regard, behavioral economics and psychographic analysis studies revealed that the relative attribute level reliant on a reference point, not the absolute attribute level of a product or service, played an essential role in determining the respondent's preferences (Dellavigna, 2009; Carson and Groves, 2007; Hardie et al., 1993; Tversky and Kahneman, 1991). Furthermore, considering consumer behavior analysis, one of the studies argues that a model reflecting a reference-dependent function is better than the standard economic model (Bateman et al., 2009).

In addition to the importance of reference-dependent preferences, changes in the share of an energy source itself are relative and affected by the share of another energy source. Nevertheless, there is almost no study that incorporates a reference point in the discrete choice model

and analyzes the public preferences for changes in the shares of energy sources. Therefore, the purpose of this study is to consider a reference point to analyze the public's preferences for relative changes in shares of energy sources using the discrete choice model based on reference-dependent preferences.

In this process, previous studies that simply consider the difference between the attribute level and the reference point in the discrete choice model can only be applied to attributes with the same preference direction. However, for attributes with a different preference direction, such as renewable energy sources, it is necessary to draw out the individual parameter of each respondent. Therefore, this study used a general mixed logit model in the first step to derive the individual heterogeneity among discrete choice models. In the second step, this study analyzed the preferences by preference direction and non-preference direction for renewable energy source using mixed logit model considering reference-dependent preferences. Additionally, this study used the hierarchical Bayesian (HB) logit model to more specifically identify whether respondents' characteristics resulted in any preference differences on the level of electricity service attributes, including the type of energy source.

The summary and results of the analysis process of the Korean consumer's preference for electricity services using various econometric models are as follows. This study found that under the current energy mix, consumers preferred to increase the share of renewable energy sources. However, the 30.7% of respondents did not prefer to increase the share of renewable energy sources. The marginal utility of respondents who preferred the expansion of renewable energy sources was 4.164, while it was -8.070 for respondents who did not prefer the expansion of renewable energy sources. Considering the number of respondents and the marginal utility of each group, this study found that Korean consumer's acceptance towards the expansion of renewable energy sources was high. Finally, this study also found that respondents who prefer the expansion of renewable energy and had higher education level were more sensitive to the expansion of renewable energy sources. On the other hand, among the respondents who did not prefer the expansion of renewable energy sources, those with higher satisfaction with the current electricity services were more sensitive to the expansion of renewable energy sources.

This study consists of the following sections. Section 2 examines the studies on government policy on the energy mix and those that analyzed the public preferences for electricity service. Section 3 introduces the general methodology on discrete choice experiment and model performed for this study. Section 4 presents the survey instrument and model specifications. Section 5 discuss the results estimated by the model. Finally, Section 6 examines this study's conclusions and implications.

2. Literature review

Many previous studies have acknowledged the government's policy as a significant factor in promoting national energy sources and determining the energy mix. Cases of employing different political instruments to change the diffusion and the growth rate of energy sources may be found in the literatures on energy system transformation (Barquin, 2014; Colli et al., 2014; Ratinen and Lund, 2014; Ciarreta, 2011). These studies analyzed the government's role in designing a new energy mix, developing energy sources, and promoting the growth of utilities. Koster and Anderies (2013) propose that a successful transition

⁴ The renewable energy dues paid by Japanese are increasing annually from about 474 yen/month in 2015 to about 675 yen/month in 2016.

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