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Empirical analysis of Japanese households' switching behaviour for energy after the deregulation of electricity and gas retail sales

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Empirical analysis of Japanese households' switching behaviour for energy after the deregulation of electricity and gas retail sales

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Abstract

The deregulation of electricity retail sales for general households started in April 2016, and the deregulation of gas retail sales started in April 2017. Every household can choose their preferred electric power and gas company among all suppliers. In the electricity retailsales, urban gas companies and telecommunication companies start to sell electricity, and in the gas retail sales, electric power companies start to sell gas. In my questionnaire, in February 2018, the switching rate of electricity was 19%, and that of gas was only 5.6% out of 1000 households in Kanto and Kansai area. New entrants in the gas sales are very few compared with electricity sales.

I analyze households' switching of a supplier or their choice of an energy source after the deregulation. Moreover, I analyze the future conditions that households will change a supplier or choose an energy source by a conjoint analysis. As conditions, a monthly total electricity and gas bill, CO_2 emissions, the use of nuclear power, the ratio of renewable energy, optional energy-saving appliances and additional security services are considered.

After the deregulation, some suppliers provide both electricity and gas. We need to analyze the whole energy market including both electricity and gas. Under some conditions, some households might use either of electricity or gas intensively. For example, when some suppliers provide electricity generated by renewable energy as their main energy source, households who prefer renewable energy purchase only electricity generated by renewable energy. Other households who object to nuclear power won't purchase electricity from suppliers which use nuclear power and they may purchase gas as a main energy. Through the deregulation, the substitution between electricity and gas might be promoted. I estimate the preferences for suppliers among Japanese households. I used a random parameter logit model for estimation.

From the estimation results, we obtain some policy implications. Firstly, from the negative and significant coefficient of a monthly total electricity and gas bill, households choose a supplier and an energy which provides lower bull. Lower bills are the key to be chosen by households. From the negative and significant coefficient of CO_2 emissions, households prefer a supplier and an energy which reduces CO_2 emissions. However, energy sources both nuclear power and renewable energy which suppliers use as energy sources for generation don't affect households' switching. The result is different from my hypothesis. Households don't choose an alternative with optional appliances because their prices are too expensive. On the other hand, households need security services.

The notable point of this paper is to evaluate the deregulation in the comprehensive energy market including electricity and gas. The result proposes the desirable energy supply system including alliances, elimination and consolidation after the deregulation. The result is related with the energy composition including reoperation of nuclear power plants and prevalence of renewable energy sources.

Key words: the deregulation of retail electricity and gas sales; renewable energy; the substitution between electricity and gas

JEL Classification Code:C25, L51, L94, L95, Q28

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Empirical analysis of Japanese households' switching behaviour for energy after the deregulation of electricity and gas retail sales[2]

1. Introduction

The deregulation of electricity retail sales for general households started in April 2016, and the deregulation of gas retail sales for general households started in April 2017. Every household is free to choose an electric power company and a gas company among all suppliers. In the electricity retail sales, gas companies and telecommunication companies start to sell electricity, and in the gas retail sales, electric power companies start to sell gas to households. Households are also free to choose a bill plan except conventional regulated bill plans as well as suppliers.

In March 2017, after the deregulation in electricity retail sales, the number of households who switched a supplier from an existing major electric power company in their area to a new entrant was about 2,950,000 in the whole of country, and the switching rate was only 4.7% on average in the whole of country[3]. The rate was 7.1% in the Tokyo electric power company area and 6.1% in the Kansai electric power company area. In other areas, the rate was only about 1%. Even though households can choose a new bill plan freely as well as conventionalregulated bill plans, the number of household who switched a bill plan in the existing major electric power companyin their areawas 2,580,000 (4.1%) in the whole of country in March 2017. On the other hand, the number of households who switched a gas bill plan was only 270,000 in the whole of country in June 2017. New entrants in gas retail sales are very few compared with electricity retail sales. In electricity retail sales, an electric power exchange is operated, and new entrants sell their generated electricity in the exchange and distribute electricity through the power distribution grid system of existing major electric power companies to households. However, in gas retail sales, new entrances are limited in the area where gas pipes are laid. In gas retail sales, there is no exchange. New entrants are limited to the companies which treat gas and companies which can provide gas are limited to the existing major electric power companies which have thermal power plants and generate electricity by natural gas, LP gas companies, oil companies which import gas. The operation areas of urban gas are limited to urban areas.

In this paper, I analyze that households switch their supplier after the deregulation in electricity and gas retail sales and the future conditions that households will switch their supplier. Some studies analyze the preferences for suppliers after the deregulation in electricity retail sales. However, many studies discuss the deregulation in electricity retail sales limited. After the deregulation in electricity and gas retail sales, many suppliers provide both electricity and gas. We need to analyze the whole energy including both electricity and gas. Through the substitution of electricity and gas and under some conditions, households may use either of electricity or gas intensively. As an example, households who prefer renewable energy purchase only electricity generated by renewable energy sources. Other households who object to nuclear power avoid electricity generated by nuclear power and may purchase only gas. We will discuss the substitution and competition of suppliers and, in addition, of electricity and gas.

I make researches whether households switched an electric power or gas company after the deregulation or not. I analyze the attributes of households and the reasons to switch their supplier by a probit model through collected data, and analyze what supplier and energy are preferred among households in the future through a conjoint analysis which is one of the stated preference methods. I use a random parameter logit model for estimation.

One of the notable points is to evaluate the deregulation in the comprehensive energy retail sales including both electricity and gas. The results will propose the desirable energy supply

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[3]This is from the survey of the Agency for Natural Resources and Energy in the Ministry of Economy, Trade and Industry.

system including alliances, elimination and consolidation of suppliers after the deregulation. The results will be related with the energy composition. The discussion of the restart of nuclear power plants and the prevalence of renewable energy are needed.

This paper consists of the following section. In section 2, the history of the deregulation in electricity and gas retail sales in Japan is illustrated. In section 3, the related literature is discussed. In section 4, I illustrate the survey and a conjoint analysis. In section 5, I illustrate the results of the survey. In section 6, econometric models are explained. In section 7, the estimation results are discussed. In section 8, subsample analysis is conducted. In section 9, the revealed preference method is conducted. In section 10, we discuss the conclusions and policy implications.

2. Overview of the deregulation in the electricity and gas retail sales in Japan[4]

The deregulation of electricity retail sales started in 1995. As the first stage, Independent Power Producers (IIP) could provide wholesale electricity to electric power companies as new entrants. In 2000, Power Producer and Suppliers (PPS) as new entrants started to provide electricity. The targets were limited to large scale consumers such as factories, office buildings, and commercial facilities. In 2004 and 2005, the target consumers were expanded to smaller scale consumers. High-pressure consumers such as small and medium-sized buildings and factories became the targets. The deregulation for general households and private shops was to be discussed in 2007 but it was postponed. Since April 2016 the deregulation for general households has started. Now households purchase electricity from all electric power companies including new entrants and the major electric power companies in other areas.

The deregulation of urban gas started at the same time in electricity retail sales. In 1995 large scale consumers whose annual contract was over two million m^3 became the target of the deregulation. In 1999 the target is expanded to consumers whose annual contract is over one million m^3. The transportation service was introduced, and the price regulation was changed from the approval system to the notification system. In 2004 the gas conducting pipe project was established. The transportation service charge system was enhanced, and the obligation of the transportation service were expanded to all general gas suppliers and gas conducting pipe suppliers. The fairness and transparency were aimed in the transportation service. The transportation service makes any gas suppliers possible to provide gas to large scale consumers even in areas of other general gas suppliers. Under the transportation service, any large-scale suppliers provide gas to large scale consumers through the gas conducting pipe of urban gas companies. In 2007 the target of the deregulation was expanded to consumers whose annual contract is over 100 thousand m^3. The target includes gyms with a hot pool, large scale restaurants and commercial hotels. Since April 2017, all consumers including general households have become the target of the deregulation. They can purchase gas from new entrants as well as existing major urban gas suppliers.

3. Related literature

There are very few related studies about the deregulation of electricity and gas retail sales for general households in Japan because only two years have passed. We discuss the previous studies about this. My study focuses on the two points. First one is what supplier households prefer. Second point is what energy households prefer. After the deregulation, various kinds of suppliers provide electricity and gas. Some suppliers may provide electricity generated by only renewable energy. Some suppliers will provide energy-saving appliances with electricity and

[4] The illustration about the deregulation of electricity and gas retail sales by the Agency for Natural Resources and Energy in the Ministry of Economy, Trade and Industry is referred.

gas. In addition, I analyze the substitution between electricity and gas. Under some condition, some households use only electricity and some households use only gas. For example, households who support renewable energy use only electricity generated by only renewable energy.

Nakajima, Ida and Kinoshita (2005) analyzed the competition between electricity and gas by a conjoint analysis. In 2005 before the deregulation of electricity retail sales for general households, the competition between electricity and gas was very heated. The deregulation of electricity retail sales for general households was planned to start to be discussed in 2007. An all-electric service was promoted by electric power companies, and the competition between electric power companies and gas companies was very heated. They estimated the preferences for advanced electric and gas appliances. Their aim is like my paper, and I refer their profiles of a conjoint analysis. In Nakajima, Ida and Kinoshita (2005), households faced the following three alternatives: 1. They use both electricity and gas 2. They use electricity intensively. 3. They use gas intensively. In alternative 1, households use electricity and gas in a conventional way, while in alternative 2 and 3, they use advanced appliances such as a fuel battery. I refer these alternatives. From the results of Nakajima, Ida and Kinoshita (2005), in 2005 the preferences for an all-electric service and a fuel battery were different across areas and ages. Advanced appliances were needed among the limited households such as elders. My survey was conducted in February 2018. Households have enough information about the deregulation through TV commercial or sales and marketing of electric power and gas companies. We hope to gain different results from those in 2005.

Ida and Murakami (2016) analyzed households' choices for suppliers in January 2016 before the deregulation of electricity retail sales. They estimated the preferences for new coming electric power companies and new bill plans by a conjoint analysis. The bill plans were regulated before the deregulation, and households could not choose only conventional electric light fees. We hope that the time-of-day rate system to reduce electricity consumption at the peak will be provided after the deregulation. However, sometimes we observe the status-quo bias that consumers hesitate to switch to a new supplier and a new bill plan due to their psychological burdens. From the results, though the status-quo bias is observed, households have their motivation to switch to the time-of-day rate system which is one of the new bill plans. The attributes of alternatives were bill plans, the ratio of renewable energy, the ratio of nuclear power and a monthly electricity bill. They analyzed only the deregulation of electricity retail sales, but I analyze and evaluate both the deregulation of electricity and gas.

Goto (2017) examined the switching behavior of households after the deregulation of electricity retail sales in Japan. This paper surveyed the switching behavior of households for suppliers in February 2016, before the deregulation, and December 2016, after the deregulation. They analyzed the reasons to switch a supplier or to consider switching a supplier by a logit model. They considered the benefit from switching such as a reduction of bill and the cost from switching such as a hesitation of switching from uncertainty of new suppliers, new bill plans, stable electricity supply and the management of new suppliers as the reasons. And the customer loyalty is the key reason that households don't switch their supplier because they are not dissatisfied with their current supplier. From the estimation results, the cost of switching is large, and the customer loyalty is observed. However, they discuss only the deregulation of electricity retail sales, but the deregulation of gas is outside the scope of the investigation.

There are some studies in foreign countries. Goett, Hudson and Train (2000) analyzed the households' choice behavior for electric power companies in U.S by a conjoint analysis. The attributes are the characteristics of suppliers such as their operation area and their name recognition, bills and the ratio of renewable energy. Giulietti, Price and Waterson (2005) analyzed the consumers' switching behavior for suppliers in a U.K home natural gas market. In the switching of a supplier, firstly consumers' mind changes, next they search suppliers and bill plans, and lastly, they decide to switch their supplier or not. They use a bivariate probit model for estimation. They observe the search cost and the switching cost. Both intrinsic and external factors affect their mind and switching. Hortacsu, Madanizadeh and Puller (2016) analyzed the switching behavior of households for suppliers and bill plans in the electricity market in Texas U.S. They point out the possibility that households don't switch their supplier and bill plan due to the consumer's habit even if they choose a supplier freely. The reasons are the burdens of search, unconcern, brand superiority. They found that the lower cost information intervention increased the consumer surplus.

4. Outline of the survey

I analyzed whether households switched an electric power or a gas company after the deregulation in electricity retail sales in April 2016 and in gas retail sales in April 2017. In addition, I surveyed the reasons they switched or didn't switch their supplier. I asked the supplier's name when they switched. Moreover, I asked that they switched a new bill plan from a regulated one even though they didn't switch their supplier. As other questions, I asked the electricity and gas expenditure in January 2018, their interest in energy-efficiency appliances such as a storage battery and a private power generation fuel cell (gas cogeneration system), their dwelling type, the number of family members living in the same house, household income, the most preferred energy source etc. I analyzed how these factors cause to switch an electric power or gas company by a probit model through the collected data.

Only two years have passed since the deregulation in electricity retail sales started, and only one year has passed since the deregulation in gas retail sales started. Now, the switching among households has not prevailed yet. I analyze the future conditions that households switch their supplier. To analyze the future switching behavior, I use a hypothetical questionnaire. I present several hypothetical suppliers as alternatives and ask to choose the most desirable supplier for households. This research has some notable points. First one is what suppliers are preferred by households. After the deregulation, various suppliers with various services and energy sources will start their business. I estimate the preferences for various suppliers through a choice questionnaire. Another point is how the preferences for electricity and gas change after the deregulation. For example, some suppliers will provide electricity generated by renewable energy sources to avoid the global heating. Households who prefer renewable energy purchase only electricity from such a supplier and they don't purchase gas. Or, other households who object to nuclear power don't purchase electricity from suppliers which use nuclear power and may purchase only gas. I use a conjoint analysis for the hypothetical questionnaire.[5]

A conjoint analysis is one of the stated preference methods (SPM). Individual preferences can be estimated for hypothetical goods or services, each of which have several attributes. We can evaluate each attribute by willingness to pay (WTP). Households choose one alternative of the hypothetical goods or services. A conjoint analysis is used to analyze households' switching behavior for suppliers under hypothetical situations wherein a monthly electricity and gas bill changes as an example. A conjoint analysis is one of the choice experiments. In this paper, four alternatives are presented to households and they choose the most preferred one. Sometimes, the goods or services have not yet prevailed, and this method is often used in marketing research.

Contingent Valuation Method (CVM) is another popular stated preference method, but it is not a choice experiment. CVM can be used to evaluate users' valuation of non-marketable targets such as forests and beaches. CVM evaluates the value of one target and doesn't evaluate the value of each attribute.

In a conjoint analysis, the researcher presents goods or services, each of which has several attributes to households. The researcher decides the number of attributes. A profile that has few attributes is not enough to describe a good object of study, but a profile with too many attributes

[5] I refer to Louviere, Hensher and Swait (2000), Kuriyama and Shoji (2005), Tsuge, Kuriyama and Mitani (2011), and Kuriyama, Tsuge and Shoji (2013) for a conjoint analysis.

makes it difficult for participants to choose among options. In general, five or six attributes is suitable. After attributes and their levels are selected, their profiles are compiled. However, if all the combinations of attributes and levels are adopted, the patterns are too many and cause strong correlation between some attributes, i.e., multicollinearity. To avoid these problems, profiles are created by the orthogonal planning method. We need to select attributes and their levels to avoid this problem. From various cards that we get through the orthogonal planning method, and selecting cards and their combinations, profiles are made after deleting unrealistic and dominant cards. I used the Excel conjoint analysis version 2.0 (Esumi) for the orthogonal planning.

I present the following four alternatives and households choose the most desirable one.

Alternative 1: Households purchase electricity from an existing major electric power company and gas from an existing major gas company. They don't change both electric power and gas company after the deregulation. They purchase electricity and gas from the same suppliers before the deregulation.

Alternative 2: Households switch either electric power and gas company after the deregulation. They purchase electricity and gas from the same one supplier. They use both electricity and gas after the deregulation.

Alternative 3: Households switch either electric power and gas company after the deregulation. They purchase electricity and gas from the same one supplier. They use gas as a main energy.

Alternative 4: Households switch either electric power and gas company after the deregulation. They purchase electricity and gas from the same one supplier. They use electricity as a main energy.

Each alternative represents suppliers which provide electricity and gas. In alternative 1, households don't switch both electric power and gas company after the deregulation. This means that they purchase electricity and gas from the existing major electric power and gas company in their living area like before the deregulation. In alternative 2, 3, and 4, households switch either electric power and gas company after the deregulation. In alternative 2, households switch either electric power and gas company after the deregulation and purchase electricity and gas from the same one supplier. However, they use both electricity and gas. In alternative 3, households switch either electric power and gas company after the deregulation and use gas as a main energy. In alternative 4, households switch either electric power and gas company after the deregulation and use electricity as a main energy. One of the remarkable points is to find the conditions that households switch suppliers. In alternative 3 and 4, the substitution of electricity and gas after the deregulation is analyzed. In some conditions, households may use only electricity or gas.

Each supplier provides electricity and gas with several attributes. In this analysis, a total monthly electricity and gas bill, CO2 emissions, use of nuclear power, the share of renewable energy sources, optional energy-saving appliances, and security services are considered as attributes. These attributes and their levels will now be discussed in detail.

1. A total monthly electricity and gas bill

Under some conditions, a total monthly electricity and gas bill will change. When households contract electricity, gas, and telecommunication services with the same supplier, the bill will be discounted. When households use energy-saving appliances such as a storage battery and a private power generation fuel cell (gas cogeneration system), the bill will be reduced. Sometimes, the bill depends on energy sources. Using nuclear power, the bill will be lower. Using renewable energy sources, the bill will be higher. The levels are -5000 yen, -3000 yen, -2000 yen, -1000 yen, -500 yen, 0 yen (unchangeable), +1000 yen.

2. CO_2 emissions

CO_2 emissions will change in 2030 compared with 1990 which is the benchmark year of the Kyoto Protocol. The levels are -30%, -20%, -10%, 0% (unchanged), and +10%. CO_2 emissions are related with energy sources. Nuclear power might reduce CO_2 emissions. Coal and LNG might increase CO_2 emissions while renewable energy might reduce CO_2 emissions.

3. Use of nuclear power

The existing major electric power companies have nuclear power plants and can provide electricity generated by nuclear power. New coming suppliers don't have nuclear power plants. Using nuclear power realizes lower electricity bills and reduces CO_2 emissions. In an econometric analysis, dummy variables are used. For suppliers which use nuclear power, 1 is assigned and for suppliers which don't use nuclear power, 0 is assigned.

4. The share of renewable energy sources

Some new coming suppliers will provide electricity generated by renewable energy sources such as solar and wind power as a main energy source. The existing major electric power companies also provide electricity generated by renewable energy sources. The levels are 5%, 10%, 30% and 50%. In alternative 3, households use natural gas intensively as a main energy source. The levels are 5% or 10%. In alternative 1, the level is 5% because the share of renewable energy sources is around 3% before the deregulation for example in 2014.

5. Optional energy-saving appliances

When households choose suppliers to purchase electricity or gas, they can purchase various kinds of advanced energy-saving appliances. Whether households purchase these appliances or not is optional, and they don't need to purchase these appliances if they don't need them. If they purchase these appliances, they should pay money as an initial cost. However, purchasing these appliances reduces their monthly electricity and gas bill and contributes to the global heating problem. Households purchase a private power generation fuel cell (a gas cogeneration system) when they choose gas as a main energy, and they purchase an energy-saving water heater when they choose electricity as a main energy. The initial cost is assumed one million yen. When households use both electricity and gas, they usually switch only supplier without purchasing energy-saving appliances. When households don't switch a supplier, they don't purchase energy-saving appliances[6]. The utility level, when households choose alternative 1, sets 0.

6. Security services

Households can receive security services and maintenance services of appliances as accompanying services from electric power and gas companies. The services are assumed to be free. Households receive services to detect gas leak from gas companies and fix electricity troubles at outages from electric power companies. When households choose alternative 1, they can't receive any services for 0 utility in alternative 1. In an econometric analysis, a dummy variable is used, assigning 1 with services and 0 without services.

Table 1 is the summary of attributes' levels.

Table 1 The levels of attributes

Attributes	Levels
A total monthly bill	-5000 JPY, -3000 JPY, -2000 JPY, -1000 JPY, -500 JPY, 0 JPY (unchanged), +1000 JPY
CO_2 emissions	-30%, -20%, -10%, 0% (unchanged), +10%
Use of nuclear power	Yes (1), No (0)
The share of renewable energy sources	5%, 10%, 30%, 50%
Optional energy-saving appliances	Purchase (1million JPY), not purchase (0 JPY)
Security services	Yes (1), No (0)

[6] The fact was found in the interview for the Osaka gas corporation.

I make profiles, using the levels and combining cards created by the orthogonal planning method. Profiles are made after deleting unrealistic and dominant cards. For example, the case that CO_2 emissions increase even though nuclear power or renewable energy sources are used, and the case that monthly bill is higher even though households purchase energy-saving appliances are deleted. In alternative 4, where electricity is used intensively, it is impossible to provide cheaper electricity without using nuclear power and with the share of renewable energy sources 50%[7]. When the share of renewable energy sources is raised to 30% or 50%, nuclear power is used, or the billis higher. Table 2 represents an example of profile.

Table 2 An example of profile

	Alt. 1: No switch	Alt. 2: electricity and gas	Alt. 3: gas	Alt. 4: electricity
A total monthly electricity and gas bill	No change	-5000 JPY	-500 JPY	-1000 JPY
CO_2 emissions	No change	-30%	No change	-30%
Use of nuclear power	No	Yes	No	Yes
The share of renewable energy sources	5%	5%	10%	50%
Optional energy-saving appliances	No	No	Yes (1million JPY)	No
Security services	No	No	Yes	No

Households choose the best alternative. They answer with respect to 10 choice questions. Each question has various levels of attributes. The data were collected via a web-based questionnaire, utilizing the services of the Rakuten Research Company. The sample size is 1000 households in Kanto[8] and Kansai[9]areas. The sample is weighted by each area's population. The sample size of Kanto area is 667 and that of Kansai area is 333. Before the deregulation, households in Kanto area purchased electricity from the Tokyo electric power company (TEPCO) and gas from the Tokyo gas corporation. TEPCO has some nuclear power plants. Households in Kansai area purchased electricity from the Kansai electric power company (KEPCO) and gas from the Osaka gas corporation. KEPCO also has some nuclear power plants. Respondents' age is under 59 because we assume households use optional energy-saving appliances for a long term. Even if they purchase these appliances, they need a long term to recover the initial cost by reducing their monthly bill. Some elders don't choose the alternative with optional energy-saving appliances due to their age. Data were collected in February 2018.

5. The results of the questionnaire

In this section, we review the results of the questionnaire. We note the percentage of households who switched their electricity or gas supplier after the deregulation. Only 19 % switched their electricity supplier, and only 5.6 % switched their gas supplier. Only 4.2 % switched their electricity bill plan, and only 3.3% switched their gas bill plan.

In the questionnaire, I asked the new supplier which households switched after the deregulation. In both Kanto and Kansai area, many households choose a major gas company in the area (the Tokyo gas corporation in Kanto area and the Osaka gas corporation in Kansai area) for the purchase of electricity and choose a major electric power company in the area (the

[7] The fact was found in the interview for the Osaka gas corporation.
[8] Tokyo, Chiba, Kanagawa and Saitama prefecture
[9] Osaka, Kyoto, Hyogo, Shiga and Nara prefecture

Tokyo electric power company in Kanto area and the Kansai electric power company in Kansai area) for the purchase of gas.

The primary reason of switching was a cheaper electricity and gas bill. The major second reason was a stable electricity and gas supply, the stable management of suppliers and the public notoriety of suppliers. A set discounted bill was also one of the major reasons, but it is included in a cheaper bill. Some households switched their supplier by the recommendation of sales persons especially in gas. The main reasons that households didn't switch their supplier were that they were not dissatisfied with their current electric power and gas company and that they didn't trust new suppliers. The fact is related with the customer's loyalty as Goto (2017) pointed. Many households feel burdensome in searching bill plans and switching procedures. This is the switching costs as Goto (2017) pointed.

I asked households that their electricity and gas bill was reduced by switching after the deregulation as the effects of the deregulation. 61.2 % households reduced their electricity bill and 48.7% reduced their gas bill. However, 31% didn't reduce their electricity bill and 42.3% didn't reduce their gas bill.

More than half of households are not interested in advanced appliances such as a fuel battery[10]. We expect that to obtain their clients each supplier will develop their own energy services after the deregulation. Advanced appliances are expected to be developed and promoted, and suppliers provide long-term energy-saving appliances and comfortable life as value-added services. However, if households are interested in only reducing their bill and are not interested in long-term energy savings and value-added services, we couldn't gain the benefits from the competition and innovation.

Table 3 shows the socio-demographic attributes of the sample. Respondents who are unemployed are more observed than the population.

Table 3 Socio-demographic attributes

		Number	%
	Total	1000	100
Occupation	Employed	714	71.4
	Unemployed	286	28.6
Household income (thousand JPY)	Less than 2,000	150	15
	2,000-3,990	189	18.9
	4,000-5,990	251	25.1
	6,000-7,990	168	16.8
	8,000-9,990	119	11.9
	More than 10,000	123	12.3
Family composition	Single	198	19.8
	Couple	269	26.9
	Three	256	25.6
	Four	200	20
	Five	49	4.9
	More than six	28	2.8
Dwelling type	Detached house (including two households house)	420	42

[10] Other advanced appliances are solar panel, home wind generator, storage battery, energy-saving water heater (electricity and gas for each), dehumidifier for the bathroom (electricity and gas for each), floor heating (electricity and gas for each).

	Collective housing (condominium, apartment, housing complex etc.)	539	53.9
	Company housing, dormitory housing etc.	41	4
Sex	Male	508	50.8
	Female	492	49.2
Age (years old)	20-29	209	20.9
	30-39	247	24.7
	40-49	310	31
	50-59	234	23.4
	Average	40.57	
	Minimum	20	
	Maximum	59	

6. Econometric model

In a choice experiment, the dependent variable is discrete. To estimate a choice model, therefore, a discrete choice econometric model should be used. A conditional logit model is a popular model in this context. However, this model assumes an Independent and Identical Distribution (IID), and this assumption derives from the Independence of Irrelevant Alternatives (IIA). This assumption is restricted and easily violated in many cases. Consequently, a random parameter logit model (mixed logit model) is used as a general discrete choice econometric model[11]. This model allows the random variation of individual preferences, unrestricted substitution patterns, and correlation among unobserved factors over time.[12]

A random parameter logit model assumes that each parameter has a specific distribution. The utility is specified as

$$U_{nj} = \alpha' x_{nj} + \beta_n' z_{nj} + \varepsilon_{nj}$$

This function specifies that individual *n* chooses alternative *j*, where α is a non-random parameter and β_n is a random parameter that represents the preference of each individual and varies among individuals. In this paper, constant terms and the parameter of a monthly bill, which is a price parameter, are non-random parameters. x_{nj} is a variable vector that includes a monthly bill. On the other hand, the parameters of CO_2 emissions, use of nuclear power, the share of renewable energy sources, optional energy-saving appliances and security services are random parameters. z_{nj} is a variable vector that includes CO_2 emissions, use of nuclear power, the share of renewable energy sources, optional energy-saving appliances and security services. ε_{nj} is a random error term and has an IID extreme value.

The probability conditional on β_n is

$$L_{ni}(\beta_n) = \frac{\exp(\beta_n' x_{ni})}{\sum_j \exp(\beta_n' x_{nj})}$$

The random parameter logit probability is

[11] I tried a nested logit model. But I couldn't obtain any reasonable results.

[12] The explanation of a random parameter logit model derives from Train (2003) and Louviere et al. (2000).

$$P_{ni} = \int \left(\frac{\exp(\beta' x_{ni})}{\sum_j \exp(\beta' x_{nj})} \right) f(\beta) d\beta$$

This probability is the unconditional choice probability calculated as the integral of $L_{ni}(\beta_n)$ over all β_n.

The distribution of β_n must be assumed. Usually, a normal, log-normal, or triangular distribution, etc., can be assumed. In this paper, normal distribution is assumed.

Simulation methods were used for estimation. The simulated probability is

$$\widetilde{P_{ni}} = \frac{1}{R} \sum_{r=1}^{R} L_{ni}(\beta^r)$$

where R is the number of draws. This simulated probability is an unbiased estimator of P_{ni}. The simulated log-likelihood (SLL) is

$$SLL = \sum_{n=1}^{N} \sum_{j=1}^{J} d_{nj} \ln \widetilde{P_{nj}}$$

where d_{nj} is an indicator. It equals 1 if an individual *n* chooses alternative *j*, or is 0 otherwise. The SLL was maximized to capture the maximum simulated likelihood estimator. In addition, 100 Halton draws were used for simulation. For estimation, *Limdep NLOGIT 5* was used.

7. Estimation results

In this section, the estimation results of a random parameter logit model are illustrated. Table 4 represents the estimation results.

Table 4 Estimation results

Variables	Coefficient	Standard Error	Z value	P value
Random parameter				
CO_2 emissions	-0.00608	0.00287	-2.12	0.0343
Nuclear power	0.0699	0.0907	0.77	0.4409
Renewable energy	-0.01132	0.00212	-5.34	0
Optional appliances	-0.02644	0.00147	-18.02	0
Security services	0.24336	0.05045	4.82	0
Non-random parameter				
Monthly bill	-0.00014	0.00001494	-9.65	0
Constant 1	-0.0644	0.11385	-0.57	0.5716
Constant 2	0.75973	0.06926	10.97	0
Constant 3	-0.44992	0.06409	-7.02	0
Standard deviation				
CO_2 emissions	0.06757	0.00277	24.4	0
Nuclear power	1.71012	0.06928	24.68	0
Renewable energy	0.04199	0.00174	24.16	0
Optional appliances	0.03332	0.00146	22.75	0
Security services	0.09792	0.15937	0.61	0.5389
McFadden R^2	0.315645			

Log likelihood	-9487.17			

The coefficient of a monthly bill is negative and significant at 1% significance level. A lower monthly bill increases the probability for the alternative. Households choose a supplier which provides a lower bill. The coefficient of CO_2 emissions is negative and significant at 5% significance level. If CO_2 emissions are reduced, the probability for the alternative increases. Households prefer a supplier which provides energies to reduce CO_2 emissions. The coefficient of use of nuclear power isn't significant, while the coefficient of the share of renewable energy sources is negative and significant at 1% significance level. This means that households don't choose a supplier which provides electricity generated by renewable energy sources and the use of nuclear power doesn't affect households' choice for a supplier. The result is different from my hypothesis and previous researches[13].

It is impossible to realize an all-electric service with higher ratio of renewable energy sources, without nuclear power and with a lower bill. We assumed that in the profiles of an all-electric case suppliers use nuclear power when the share of renewable energy sources is 30% or 50%. Some respondents support renewable energy and don't support nuclear power. This fact may cause different results from the hypothesis and previous studies.

The coefficient of optional energy-saving appliances is negative and significant at 1% significance level. Households don't choose the alternative with optional energy-saving appliances. The price of optional energy-saving appliances is 1 million JPY, which is too expensive. Households don't purchase optional energy-saving appliances unless the price or monthly bill becomes much lower. This result means that households are not interested in such appliances. According to the previous questionnaire, more than half of households are not interested in such appliances. The estimation result is consistent with the result of questionnaire. The coefficient of security services is positive and significant at 1% significance level. Households need the services. After the deregulation, suppliers are expected to acquire their customers by providing such free services.

In the previous estimation, we obtain the different results from our hypothesis, which use of nuclear power isn't significant and the share of renewable energy sources has a negative impact on households' choice and is significant. The results could be caused because we assume that suppliers use nuclear power when the share of renewable energy sources is higher in making profiles. That is why a cross term of use of nuclear power and the share of renewable energy sources is added in the regression equation to analyze households' preferences for both use of nuclear power and higher ratio of renewable energy sources. The expected sign is positive. Table 5 shows the estimation results. The cross term is positive but isn't significant. Households don't prefer electricity which is generated by nuclear power and higher share of renewable energy sources.

Table 5 Estimation results (with a cross term of use of nuclear power and the share of renewable energy sources)

Variables	Coefficient	Standard Error	Z value	P value
Random parameter				
CO_2 emissions	-0.00587	0.00276	-2.13	0.0335
Nuclear power	0.06692	0.12146	0.55	0.5817
Renewable energy	-0.01386	0.00329	-4.22	0
Optional appliances	-0.03015	0.00153	-19.75	0
Security services	0.24049	0.05339	4.5	0

[13]Morita and Managi (2013) and Murakami, Ida, Tanaka and Friedman (2015) find that households show negative evaluation for nuclear power and positive evaluation for renewable energy.

Cross term (nuclear power and renewable energy sources)	0.00047	0.00303	0.16	0.8757
Non-random parameter				
Monthly bill	-0.00014	0.00001491	-9.36	0
Constant 1	-0.04367	0.1151	-0.38	0.7044
Constant 2	0.75504	0.07042	10.72	0
Constant 3	-0.50228	0.08553	-5.87	0
Standard deviation				
CO_2 emissions	0.07103	0.00288	24.64	0
Nuclear power	1.73663	0.07401	23.46	0
Renewable energy	0.04302	0.00186	23.09	0
Optional appliances	0.03312	0.00137	24.11	0
Security services	0.25843	0.20197	1.28	0.2007
Cross term (nuclear power and renewable energy sources)	0.00575	0.0022	2.62	0.0089
McFadden R^2	0.314399			
Log likelihood	-9504.45			

The monthly bill of an all-electric service with higher share of renewable energy sources and without nuclear power would become higher. To analyze that households prefer electricity generated with higher ratio of renewable energy sources even if the bill is higher, a cross term with a monthly bill and the ratio of renewable energy sources is added to the regression equation. Table 6 shows the estimation results. The coefficient of the cross term is positive and significant at 1% significance level. Households tend to choose a supplier which provides electricity generated with higher ratio of renewable energy sources even if the bill is higher.

Table 6 Estimation results (with a cross term of a monthly bill and the share of renewable energy sources)

Variables	Coefficient	Standard Error	Z value	P value
Random parameter				
CO_2 emissions	-0.00632	0.00276	-2.29	0.0219
Nuclear power	0.10032	0.09116	1.1	0.2711
Renewable energy	-0.00913	0.0025	-3.65	0.0003
Optional appliances	-0.02979	0.00161	-18.51	0
Security services	0.29176	0.05288	5.52	0
Non-random parameter				
Monthly bill	-0.00019	0.00002119	-8.92	0
Cross term (monthly bill and renewable energy)	0.0000026436	0.0000008101	3.26	0.0011
Constant 1	0.0376	0.11461	0.33	0.7429
Constant 2	0.73344	0.07029	10.43	0
Constant 3	-0.50658	0.06538	-7.75	0
Standard deviation				
CO_2 emissions	0.07186	0.00297	24.2	0
Nuclear power	1.74169	0.07677	22.69	0
Renewable energy	0.04377	0.00185	23.64	0
Optional appliances	0.03245	0.00131	24.79	0
Security services	0.13292	0.21982	0.6	0.5454

McFadden R^2	0.314552			
Log likelihood	-9502.33			

8. Subsample analysis

In the questionnaire, I investigate households' socio-demographic attributes such as household income and the number of family members and their consciousness about energy problems such as electricity and gas bills and renewable energy. I divide into some subsamples for example higher and lower income group. The differences of preferences for suppliers between subsamples are analyzed. I use a random parameter logit model for estimation.

Table 7 shows the estimation results of lower income (less than 6 million JPY) and higher income group (more than 6 million JPY). In the higher income group, the coefficient of nuclear power is not significant, but in the lower income group, it is positive and significant at 10% significant level. Lower income group accepts nuclear power compared with higher income group.

Table 7 Lower income vs higher income

	Lower income		Higher income	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2 emissions	-0.00814	**	-0.01515	***
Nuclear power	0.20332	*	-0.11532	
Renewable energy	-0.01216	***	-0.01088	***
Optional appliances	-0.0279	***	-0.02449	***
Security services	0.24424	***	0.24411	***
Non-random parameter				
Monthly bill	-0.00012	***	-0.00017	***
Constant 1	-0.13316		0.03813	
Constant 2	0.72134	***	0.84996	***
Constant 3	-0.50758	***	-0.42612	***
McFadden R^2	0.316435		0.318131	
Log likelihood	-5590.97		-3875.61	
Sample size	5900		4100	

Note) *** 1%, ** 5%, *10% significant level

Table 8 shows the estimation results of younger (less than 39 years old) and elder (more than 40 years old) group. In the elder group, the coefficient of CO_2 emissions is not significant, but in the younger group, it is negative and significant at 10% level. Younger group chooses a supplier which provides energy that contributes to the global heating problem.

Table 8 Younger vs elder households

	Younger		Elder	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2 emissions	-0.00675	**	-0.000096197	
Nuclear power	0.08913		0.0115	
Renewable energy	-0.00984	***	-0.01656	***
Optional appliances	-0.03107	***	-0.02553	***
Security services	0.18869	**	0.32288	***
Non-random parameter				

Monthly bill	-0.00017	***	-0.00011	***
Constant 1	-0.34684	**	0.15141	
Constant 2	0.43765	***	1.08602	***
Constant 3	-0.66169	***	-0.26493	***
McFadden R^2	0.300639		0.333196	
Log likelihood	-4421.01		-5028.66	
Sample size	4560		5440	

Note) *** 1%, ** 5%, *10% significant level

Table 9 shows the estimation results of households who live in a detached house and households who live in a collective housing. Collective housing includes company and dormitory housing. But we don't find notable differences between two subsamples.

Table 9 Detached house vs collective housing

	Detached house		Collective housing	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2 emissions	0.00091		-0.00208	
Nuclear power	0.11015		0.07472	
Renewable energy	-0.00875	***	-0.01666	***
Optional appliances	-0.02334	***	-0.03014	***
Security services	0.21803	***	0.31103	***
Non-random parameter				
Monthly bill	-0.00016	***	-0.00012	***
Constant 1	-0.00032		-0.17851	
Constant 2	0.61075	***	0.83571	***
Constant 3	-0.68418	***	-0.33661	***
McFadden R^2	0.295938		0.330521	
Log likelihood	-4099.36		-5382.95	
Sample size	4200		5800	

Note) *** 1%, ** 5%, *10% significant level

Table 10 shows the estimation results of small (1-3 members) and big (4-6 more over members) family. In the small family group, the coefficient of CO_2 emissions is not significant, but in the big family group, it is negative and significant at 10% level. If the family size is bigger, households choose a supplier which provides energy that reduces CO_2 emissions.

Table 10 Small vs big family

	Small family		Big family	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2emissions	-0.00222		-0.00857	*
Nuclear power	0.15251		-0.08606	
Renewable energy	-0.01889	***	-0.0092	*
Optional appliances	-0.02955	***	-0.02884	***
Security services	0.2953	***	0.18499	*
Non-random parameter				
Monthly bill	-0.00012	***	-0.00018	***
Constant 1	-0.15319		0.0056	
Constant 2	0.7996	***	0.63004	***

Constant 3	-0.38619	***	-0.56785	***
McFadden R^2	0.324823		0.290112	
Log likelihood	-6767.24		-2725.99	
Sample size	7230		2770	

Note) *** 1%, ** 5%, *10% significant level

Table 11 shows the estimation results of households who live in Kanto and Kansai area. But we don't observe any notable differences between Kanto and Kansai area. In Kanto area, the coefficient of CO_2 emissions is significant, but in Kansai area, it is not significant.

Table 11 Kanto vs Kansai area

	Kanto		Kansai	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2 emissions	-0.00994	***	-0.00606	
Nuclear power	0.03053		0.17715	
Renewable energy	-0.01397	***	-0.0102	***
Optional appliances	-0.03344	***	-0.02523	***
Security services	0.29178	***	0.19727	**
Non-random parameter				
Monthly bill	-0.00014	***	-0.00015	***
Constant 1	-0.06716		-0.01524	
Constant 2	0.76262	***	0.74095	***
Constant 3	-0.42877	***	-0.51175	***
McFadden R^2	0.322166		0.30095	
Log likelihood	-6267.65		-3227.07	
Sample size	6670		3330	

Note) *** 1%, ** 5%, *10% significant level

In the questionnaire, I asked households the most important energy problem. Some households answered that the realization of lower electricity and gas bill is the most important. I compare their behavior between the households who answered the realization of lower bill is the most important (lower bill group) and the households who didn't answer it (not lower bill group). In the lower bill group, the coefficient of nuclear power is positive and significant at 5% level. We didn't obtain such a result in other analysis. They are permissive for nuclear power and they think nuclear power is reasonable if their bill is reduced.

Table 12 Low bill vs not low bill

	Lower bill		Not lower bill	
Variables	Coefficient		Coefficient	
Random parameter				
CO_2 emissions	0.00085		-0.01615	***
Nuclear power	0.26317	**	-0.00339	
Renewable energy	-0.0155	***	-0.00858	***
Optional appliances	-0.02603	***	-0.02742	***
Security services	0.21622	***	0.24618	***
Non-random parameter				
Monthly bill	-0.00019	***	-0.0001	***
Constant 1	0.22434		-0.42367	**
Constant 2	0.71066	***	0.75739	***

Constant 3	-0.63315	***	-0.37559	***
McFadden R^2	0.31541		0.327675	
Log likelihood	-5039.42		-4371.27	
Sample size	5310		4690	

Note) *** 1%, ** 5%, *10% significant level

9. Analysis by a revealed preference

In the questionnaire, I asked households whether they switched an electric power company and urban gas company after the deregulation. I analyze the factors that households switch their supplier. A dummy variable is used as a dependent variable where 1 is assigned when households switched their supplier and 0 is assigned when households didn't switch their supplier. Binary probit model is used for estimation because the dependent variable is discrete and has two values.

As independent variables, a monthly electricity and gas expenditure in January 2018, a detached house dummy where 1 is assigned to households who live in a detached house and 0 is assigned to households who live in a collective housing, the number of family members who live together, annual household income, male dummy, age, Kanto dummy where 1 is assigned to households who live in Kanto area and 0 is assigned to households who live in Kansai area are included. In addition, independent variables about households' preferences and perceptions are included. The preferences for renewable energy, a lower bill and a stable supply are included. I use dummy variables for the independent variables. In the preferences for renewable energy, I assign 1 for households who support renewable energy as the most desirable future energy source, and 0 for households who support non-renewable energy. Renewable energy includes solar, wind, geothermal, biomass and hydraulic power. Non-renewable energy includes nuclear, coal, oil and natural gas. In the preferences for a lower bill, I assign 1 for households who think that the realization of a lower electricity and gas bill is the most important energy problem, and 0 for households who think that other energy problems are the most important. In the preferences for a stable supply, I assign 1 for households who think a stable supply as the most important energy problem, and 0 otherwise.

The dependent variable is whether households switched their supplier or not, and whether they switched their bill plan or not in both electricity and gas.

Now, I illustrate the estimation results about the switching of an electric power company in table 13.

Table 13 Estimation results (switching of an electric power company)

Variables	Coefficient	Standard Error	Z value	P value
Electricity expenditure	0.049358	0.028067	1.76	0.079
Housing	-0.09306	0.108801	-0.86	0.392
Family members	0.068525	0.044119	1.55	0.12
Household income	0.108891	0.03155	3.45	0.001
Male	-0.05485	0.0965	-0.57	0.57
Age	0.000847	0.004735	0.18	0.858
Kanto	-0.05719	0.099975	-0.57	0.567
Renewable energy	0.016893	0.102686	0.16	0.869
Lower bill	0.273539	0.119906	2.28	0.023
Stable supply	-0.21797	0.14729	-1.48	0.139
Constant	-1.76967	0.283153	-6.25	0
McFadden R^2	0.0444			
Log likelihood	-464.647			

The coefficient of household income is positive and significant at 1% level. Households with higher income tend to switch their supplier after the deregulation. The coefficient of lower price is positive and significant at 5% level. Households who think that the realization of a lower bill is the most important tend to switch their supplier. The coefficient of electricity expenditure is positive and significant at 10% level. Households who spend more electricity expenditure tend to switch their supplier.

Table 14 shows the estimation results about the switching of an electricity bill plan.

Table 14 Estimation results (switching of an electricity bill plan)

Variables	Coefficient	Standard Error	Z value	P value
Electricity expenditure	-0.00296	0.042377	-0.07	0.944
Housing	-0.25515	0.174489	-1.46	0.144
Family members	0.134122	0.065657	2.04	0.041
Household income	-0.03553	0.049539	-0.72	0.473
Male	0.186584	0.15107	1.24	0.217
Age	-0.00307	0.007172	-0.43	0.669
Kanto	-0.17977	0.151233	-1.19	0.235
Renewable energy	-0.16209	0.156668	-1.03	0.301
Lower bill	-0.24629	0.178697	-1.38	0.168
Stable supply	-0.20265	0.207082	-0.98	0.328
Constant	-1.45801	0.41134	-3.54	0
McFadden R^2	0.0275			
Log likelihood	-169.454			

Only the coefficient of the number of family members is positive and significant at 5% level. Households who have more family members tend to switch their electricity bill plan.

Next, I illustrate the estimation results of the switching of a gas company in Table 15.

Table 15 Estimation results (switching of a gas company)

Variables	Coefficient	Standard Error	Z value	P value
Gas expenditure	0.015162	0.048477	0.31	0.754
Housing	0.327962	0.177141	1.85	0.064
Family members	-0.08464	0.074088	-1.14	0.253
Household income	0.090536	0.049659	1.82	0.068
Male	0.22272	0.154171	1.44	0.149
Age	-0.01709	0.007408	-2.31	0.021
Kanto	-0.52584	0.152026	-3.46	0.001
Renewable energy	-0.0567	0.158219	-0.36	0.72
Lower bill	0.269177	0.187797	1.43	0.152
Stable supply	-0.58477	0.286853	-2.04	0.041
Constant	-1.0571	0.430373	-2.46	0.014
McFadden R^2	0.1088			
Log likelihood	-168.661			

The coefficient of age is negative and significant at 5% level. Younger households tend to switch their supplier after the deregulation. The coefficient of Kanto dummy is negative and significant at 1% level. Households who live in Kanto area don’t switch their supplier. The coefficient of a stable supply is negative and significant at 5% level. Households who think a stable supply is the most important don't switch their supplier. The coefficient of a detached house dummy is positive and significant at 10% level. Households who live in a detached house switch their supplier.

Table 16 shows the estimation results about the switching of a gas bill plan.

Table 16 Estimation results (switching of a gas bill plan)

Variables	Coefficient	Standard Error	Z value	P value
Gas expenditure	0.076469	0.059759	1.28	0.201
Housing	-0.57491	0.225081	-2.55	0.011
Family members	0.088077	0.086725	1.02	0.31
Household income	0.114518	0.060198	1.9	0.057
Male	0.168455	0.180816	0.93	0.352
Age	-0.01647	0.008965	-1.84	0.066
Kanto	-0.33695	0.179036	-1.88	0.06
Renewable energy	-0.02011	0.187392	-0.11	0.915
Lower bill	0.002312	0.226112	0.01	0.992
Stable supply	0.021274	0.252075	0.08	0.933
Constant	-1.89651	0.485565	-3.91	0
McFadden R^2	0.0735			
Log likelihood	-118.178			

The coefficient of a detached house dummy is negative and significant at 5% level. Households who live in a detached house don't switch their gas bill plan. The coefficient of household income, age and Kanto dummy is positive and significant at 10% level. Younger households, households with higher income and households who live in Kanto area tend to switch their gas bill plan after the deregulation.

10. Conclusions and policy implications

In this paper, I analyzed households' choice behavior for suppliers and energy sources in Japan after the deregulation of electricity and gas retail sales in April 2016 and 2017 respectively. After the deregulation, suppliers which provide various bill plans and services will be expected to start their business. Now, very few households switch their supplier. I examined the reasons that households switched their supplier by a probit model and the future conditions that households will switch their supplier by a conjoint analysis and estimate the preferences for the attributes such as bill plans, services and energy sources which suppliers provide. On the other hand, the substitution between electricity and gas will be promoted, and as a result, some households use only electricity or gas intensively.

From the estimation results, the coefficient of a monthly bill was negative and significant. Households prefer suppliers which provide lower bill plans. The coefficient of CO_2 emissions was negative and significant. They prefer suppliers which provide eco-friendly energy to reduce CO_2 emissions. However, I couldn't obtain expected results in energy sources. The coefficient of nuclear power was not significant, and that of renewable energy sources was negative and significant. We expected that the coefficient of nuclear power was negative and significant and that of renewable energy sources was positive and significant. It is impossible to provide an all-electric service with higher ratio of renewable energy sources, without nuclear power and with a lower bill. In an all-electric service, a higher bill or use of nuclear power should be accepted. The estimation results would be caused because I make profiles considering these facts. I estimated the regression with a cross term of the ratio of renewable energy sources ratio and a monthly bill. I obtained the positive and significant coefficient. From the results, households would accept a higher bill for the higher ratio of renewable energy sources. Households need free security services. But they don't need optional advanced energy-saving appliances such as a fuel battery. This result is consistent with their respond in the questionnaire. In the questionnaire, they are not interested in such advanced appliances.

We discussed the substitution between electricity and gas. Some households may use a cheaper energy either of electricity or gas intensively. Some households who support renewable energy may use electricity generated by renewable energy intensively. However, it is impossible to provide electricity generated by renewable energy as a main energy source with a lower bill and without nuclear power. An all-electric service needs nuclear power if the bill is reduced. It is difficult to realize an all-electric service unless we resume nuclear power plants and raise the ratio of nuclear power. From the reason, the substitution between electricity and gas will not be prevailed. After the regulation, we will use both electricity and gas and purchase them from the only one supplier as the most possible scenario. On the other hand, households who object to nuclear power and support renewable energy may choose a supplier which uses renewable energy as a main energy source and may accept a higher bill.

In this paper, I analyzed the households' switching behavior for electricity and gas suppliers by both stated and revealed preference method. Now, only two years have passed since the deregulation of electricity retail sales started, and only one year has passed since the deregulation of gas retail sales started. Now, it is difficult to evaluate the deregulation including both electricity and gas. We need to evaluate the whole energy market including both electricity and gas by using real consumers' switching data.

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