The Effect of Competitive Pressure from the Electric Utilities on Gas Prices in Japan

Toru Hattori*
Socio-economic Research Center
Central Research Institute of Electric Power Industry
2-11-1 Iwado Kita, Komae-shi, Tokyo 201-8511 JAPAN

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Abstract

This paper investigates the effect of inter-energy competition (competition between two different forms of energy, electricity and gas) on average gas prices in Japan to determine whether competitive pressure from the electric utilities has an effect on pricing behavior of the gas utilities. We estimated the regression equation for average unit price of gas as a function of average cost of gas supply and factors that possibly affect their pricing behavior, using panel data for about 200 small and medium size gas utilities from 1995-2006. We use the share of newly-built houses based on the total number of households in the service area of the gas utility as a proxy for the competitive pressure from the electric utility, since all-electric homes, competitive threats to the gas utilities, are more likely to be adopted for newly-built houses. Our instrumental variable estimation results indicate the followings: the unit gas price relative to the unit cost of gas supply has been decreased as the share of newly-built houses in the service area is increased, perhaps as a result of competitive threats from the diffusion of all-electric homes. However, that impact is smaller among the gas utilities with a larger share of regulated residential customers.

Key Words: Gas Utilities, Inter-energy Competition, Regulated Prices, Competitive Pressure

JEL Classification: L95, L59

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1. INTRODUCTION

In Japan, the retail electricity market and the gas market had long been served separately by distinct utility companies, namely, electric utilities and gas utilities. Although residential electricity and gas markets are still regulated (the markets for commercial customers and industrial customers are liberalized in both the electricity and gas industries), electric utilities and gas utilities have long been competing for various types of residential energy demand (so called inter-energy competition, a type of inter-modal competition). Competition between different forms of energy, or, what we call inter-energy competition, in the residential sector has been intensified in recent years due to some technological advances. The electric utilities are actively promoting all-electric homes equipped with induction heating cookers and CO_2 refrigerant heat pumps, inducing the customers to substitute their demand for gas with that for electricity. It is considered that the residential demand for natural gas has become stable in recent years because of not only the declining population but also increasing number of all-electric homes. Against the spread of all-electric homes, gas utilities are promoting the efficient water heating system and glass-top stoves as well as gas cogeneration system for residential use.

It is considered that this inter-energy competition, if effective, has some impact on pricing behavior of the utilities. Such an impact would be more significant for gas utilities, as most of them are smaller than the competing local electric utility, and with all-electric homes, they lose their customers. While the residential sector is still regulated, it is not clear whether inter-energy competition can improve efficiency of the industry without its market liberalization. In fact, we still observe large price differential among the gas utilities. Yet, there have been few empirical studies to measure the impact of this type of competition.

This paper investigates the effect of inter-energy competition on average gas prices in Japan. The purpose of our research is to determine whether competitive pressure from the electric utilities has an effect of lowering the gas price. We also examine if the degree of competitive pressure is dependent on the share of residential customers who are still under regulation. The paper is organized as follows: The next section provides some background of the inter-energy competition between gas and electricity in Japan. The third section presents our empirical model to examine the effect of competitive pressure from the electric utility on average unit price of gas, and explains our data set as well as estimation method. The forth section discusses our empirical results. The final section concludes our analysis and points out some topics for future research.

2. BACKGROUND

In Japan, the retail electricity market and gas market had long been served separately by distinct utility companies, namely, electric utilities and gas utilities. To be precise, gas utilities here are the so-called “city gas utilities,” who supply natural gas using pipeline networks in designated

supply areas. In Japan, most of the natural gas (about 90%) has been imported in the form of liquefied natural gas (LNG). The supply areas of city gas are limited to serving about 40% of residential customers in the country. The rest of the customers are mostly served by LP gas companies who supply propane gas[1]. The electricity retail market has been dominated by 10 vertically integrated electric utilities. In contrast, there have been more than 200 gas utilities in Japan, although the four largest utilities account for about 75% of the market share. All of the electric utilities and the majority of gas utilities are privately owned, but 32 gas utilities are municipally owned[2].

By 2000, both gas and electricity retail markets were partially liberalized for industrial and commercial customers: these customers are now able to choose their supplier of gas and electricity. As a consequence, electric utilities and gas utilities are now competing in each of the liberalized markets. While the market share of new entrants has been fairly small in both markets, these utilities play an important role as major competitors in each other's market[3]. Large gas utilities entered the electricity market through subsidiaries as competitive power suppliers (known as Power Producers and Suppliers, PPS). Some electric utilities entered the retail and wholesale gas markets. In fact, electric utilities account for the largest share among the new entrants in the liberalized gas market.

In addition to the direct competition in each of the markets after liberalization, electric utilities and gas utilities have long been competing for various types of energy demand. Figure 1 shows how gas utilities are competing with the electricity industry in residential sector. This is a type of inter-modal competition and has been taking place regardless of liberalization[4]. It is noteworthy that this is occurring in the residential sector that is still under regulation in both electricity and gas industries[5]. In fact, inter-energy competition in the residential sector has been intensified in recent years due to some technological advances. The electric utilities are actively promoting all-electric homes equipped with induction heating cookers and CO_2 refrigerant heat pumps, totally eliminating the demand for gas. Such all-electric homes have been growing in number, accelerated by technological progress. Figure 2 shows the cumulative number of all-electric homes in Japan. The share of all-electric home in newly-built houses is estimated to be about 24% in 2010, while it was only about 0.9% in 2001. It was after the CO_2 refrigerant heat pumps were commercialized that the all-electric home was disseminated. Since these heat pumps uses electricity during off peak period,

[1] The market for LP gas is liberalized and there is no price regulation.
[2] In recent years, several municipal utilities have been privatized and the number of municipal utilities has been decreased.
[3] However, there have been few instances of direct competition between electric utilities in the liberalized electricity retail market, and between gas utilities in the liberalized gas market.
[4] This type of competition existed in the United States during the 1970s. See Weiss (1975). In recent years, it is also observed in the U.S. that electric-to-gas substitution from electricity to natural gas by households. See Costello (2009).
[5] Both industries are regulated by the Agency for Natural Resources and Energy in the Ministry of Economy, Trade, and Industry.

they contribute to higher load factor[6]. Induction heating cooker was commercialized in 1990 and has grown in performance in recent years to contribute to the diffusion of all-electric home. The all-electric homes appeal to elderly households, as they are considered to be safe. Figure 3 shows the development of the demand for electricity and gas in residential sector. It is considered that the residential demand for natural gas has become stable in recent years because of the declining population and increasing number of all-electric homes (Toichi, 2008)[7].

Against the spread of all-electric homes, gas utilities are promoting highly efficient water heater and glass-top stove as well as the gas cogeneration system for residential use[8]. At this moment, most of the cogeneration systems are sold by Osaka Gas, the second largest gas utility in the country, accounting for about three quarters[9]. However, many other gas utilities started to sell it, and the number of such utilities is also increasing. While the total demand for electricity replaced by such systems is still fairly small relative to the total electricity demand, this technology has made electric utilities conscious of inter-energy competition. The diffusion of the household gas cogeneration system may well be threatening the electric utilities in the future, depending on the technological progress. In recent years, the major gas utilities started to sell fuel-cell cogeneration system called "Ene-farm", and photovoltaic generation system[10].

There have been few empirical studies to date to analyze this kind of competition between the two different forms of energies for residential customers. Although we have some evidences that electricity and gas are substitutes, there has been no analysis of the actual impact of inter-energy competition in residential sector on the performance of the utilities. In addition, while the residential sector is still regulated, it is not clear whether inter-energy competition can improve efficiency of the industry without its market liberalization.

In this paper, we focus on the effect of inter-energy competition on gas prices of small-to-medium size gas utilities[11]. As mentioned, there are about 200 gas utilities in Japan and most gas utilities are smaller in size relative to the competing electric utility (one that supplies electricity in their service area). Thus, the economic impact of inter-energy competition would be greater for gas utilities. Another reason we focus on gas prices is that there have been a large price differential among the small and medium size gas utilities. Price differentials among the utilities are larger in gas utility industry (¥75-¥240/cubic meter) than in electricity industry (¥19-¥24/kWh). That

[6] Typically, time-of-use tariff is offered to the customer with all-electric homes with the heat pump.
[7] Industrial demand for gas has been increased in recent years, due to the switch from oil.
[8] This cogeneration system generates 1 kW of electricity with a small gas engine and is being sold under the brand name of "Eco-will" since 2003. In this system, water is heated by exhaust heat recovered from the engine and stored in a water tank. The stored hot water is used not only for hot water supply but also for space heating, thereby helping conserve energy.
[9] The largest gas utility, Tokyo Gas, had focused on marketing a fuel cell cogeneration system; however, in 2006, it changed the strategy to shift to promoting Eco-will.
[10] This strategy is driven by the feed-in-tariff for photovoltaic generation by households introduced in 2009.
[11] Many electric utilities use LNG as fuel in power generation (about 25% of total generation). There are some cases that the major electric utility and gas utility jointly import LNG.

is, there seems to be a potential for efficiency gains through competition with electric utilities. Although the electricity and gas prices for residential customers are still regulated, the utilities are allowed to lower the price only with prior notification to the Minister (prior approval or rate case is not necessary). Many gas utility managers think that lowering the gas price is important for them to compete with all electric homes.

3. MODEL, DATA AND ESTIMATION

We investigate the effect of inter-energy competition between gas and electricity on regulated gas prices in Japan by estimating the regression model for average unit price of gas. Following Kwoka (1996), we model the average unit price of gas as a function of average cost of gas supply and factors that possibly affect their pricing behavior, including competitive pressure from the electric utilities. Our model is as follows:

$$\ln P_{it} = \alpha + \beta \ln AC_{it} + \delta IEC_{it} + \sum_{k=1}^{K} \gamma_k Z_{it}^k + \sum_{i=1}^{n-1} \mu_i D_i + \varepsilon_{it} \quad (1)$$

where P is the average unit price of gas for residential customers, AC is the average cost, IEC is the proxy for the degree of competitive pressure from electric utilities, and Z^k is factor that would affect pricing behavior of the gas utilities, and D is the firm dummy variable, and ε is the error term. The subscript i represent gas utility and t represent year. If the inter-energy competition is effective, then the average unit price relative to the average cost would be lower.

One of the difficulties associated with our analysis is how to capture the degree of competitive pressure from the electric utility promoting all-electric homes. Since all-electric homes, competitive threats to the gas utilities, are more likely to be adopted for newly-built houses, we use the share of newly-built houses based on the total number of households in the service area of the gas utility as a proxy for the competitive pressure from the electric utility. Yet, it is only after the heat pumps were commercialized that the electric utilities began to promote all electric homes. We thus slightly modified the model as follows:

$$\ln P_{it} = \alpha + \beta \ln AC_{it} + \delta_1 IEC_{it} + \delta_2 IECX_{it} + \sum_{k=1}^{K} \gamma_k Z_{it}^k + \sum_{i=1}^{n-1} \mu_i D_i + \varepsilon_{it} \quad (2)$$

where $IECX$ takes the share of newly-built houses only after a particular year when all-electric homes become competitive threats to the gas utilities. The diffusion of the all-electric homes was accelerated after the government started to subsidize the heat pumps in 2002, though the heat pumps were commercialized in 2001. We will test different years between 2001 and 2003 for $IECX$ to

indicate the share of newly-built houses. If the inter-energy competition is effective, then we expect the coefficient δ_2 to be negative in the above regression model (Model 1). We also investigate whether the effect of competition depend on the share of residential demand by including the interaction term of *IECX* and the share of residential demand (Model 2).

As other factors that may affect the pricing behavior (Z^k), we control for the followings: the share of residential customers, the difference in ownership (municipal versus private), the market share within gas market (degree of competition with liquefied petroleum gas in the gas industry), and dependence on other businesses in terms of revenue. Since we use panel data, we also control for unobservable firm-specific (time-invariant) effect by including firm-specific dummy variables in our regression model.

We estimated the regression equation for average unit price of gas, using unbalanced panel data for about 200 small and medium size gas utilities from 1995-2006. We only include the utilities that existed in 2006. The data are all collected from publicly available sources. The average unit prices are obtained by dividing total revenue from gas sales by total gas sales (in MJ). The average costs are obtained by dividing total cost (the sum of the cost of sales, supply and sales expenses and general and administrative expenses, including depreciation cost). The shares of residential demand are obtained by dividing the sales for residential customers by total retail gas sales. The market shares in gas market are calculated as the number of customers divided by the total number of households in the supply territory[12]. The difference in ownership is taken into account by dummy variable for municipal utility that takes unity if the utility is municipally owned. The dependence on other businesses is taken into account by the dummy variable that takes unity if the revenue from the other businesses is greater than the total revenue from gas sales. The shares of newly-built houses are calculated as the total number of newly-built houses divided by the total number of households in the supply territory. The descriptive statistics are shown in Table 1.

Because the average cost in our regression model is considered to be endogenous variable, we use two-stage least squares (2SLS) estimation technique. The instrumental variables are the customer density (the number of customers per kilometer of the pipeline), the ratio of the production asset to total asset, the dummy variable for LNG (taking unity if the utility either produce or purchase liquefied natural gas), and calorie of the gas supplied.

4. EMPIRICAL RESULTS

Our two-stage least squares estimation results are presented in Table 2. The estimated coefficients on average cost suggest that one percent increase in average cost results in about 0.5% increase in average unit price. The estimated impact of the change in average cost may seem a bit

[12] The share in gas sales is not available.

low, but that impact seems to have been partially captured by the firm-specific effect[13].

In Model 1, when we include the share of newly built houses after 2003 as indicating competitive pressure to the gas utilities (*IECX* in equation (2)), the estimated parameter becomes statistically significantly negative, as presented in Table 2. This suggests that the unit gas price relative to the unit cost of gas supply has been decreased as the share of newly-built home in the service area is increased after 2003, perhaps as a result of competitive threats from the diffusion of all-electric homes. When we estimate the model with the share of newly-built houses after 2001 or 2002, the estimated parameter becomes negative but statistically insignificant. This might imply that competitive pressure has been in effect after the government subsidized the heat pump.

In order to investigate how that impact changes depending on the share of residential demand, we estimate Model 2. The parameter on the interaction term of the share of newly-built houses after 2003 and the share of residential demand becomes statistically significantly negative. This suggests that the impact of competitive pressure from electric utility is smaller among the gas utilities with a larger share of regulated residential demand. This might imply that liberalization of the market is important not only for its own sake but also for inter-energy competition to be effective.

Our results also suggest a couple of other things: First, the estimated parameter on the share of residential customer is statistically significantly positive in both models, indicating that utilities with a larger share of industrial and commercial customers set lower prices. This may suggests that, given the relatively lower elasticity of demand of the residential customers, the gas utilities' pricing behavior is efficient. It may also reflect some degree of competition in retail gas market, since the markets for industrial and commercial customers have been liberalized since 1995. Second, the estimated parameter on the market share in gas market is statistically significantly positive in both models, indicating that the gas utilities with higher share in gas market tend to have higher price, or the utilities faced by a higher market share of LP gas tend to set lower price. This suggests that competition between the gas utilities with pipeline network and LP gas companies without pipeline network has been also effective. Third, the estimated parameter on the dummy variable for municipal utility is statistically significantly positive in both models, indicating that municipally-owned gas utilities tend to set inefficiently higher price as compared to privately-owned utilities. This result is in favor of the recent trend of privatization. Lastly, the estimated parameter on the dummy variable for the dependence on other businesses becomes negative in both models, indicating that diversification into other businesses does not necessarily harm the consumers in gas market.

[13] If we estimate the model by excluding firm-specific dummy variables, then the estimated coefficient on average cost becomes greater than 0.85.

5. CONCLUDING REMARKS

This paper investigates the effect of inter-energy competition on average gas prices in Japan to determine whether competitive pressure from the electric utilities has an effect of lowering the price for gas. We estimated the regression equation for average unit price of gas as a function of average cost of gas supply and factors that possibly affect their pricing behavior, using panel data for about 200 small and medium size gas utilities from 1995-2006. Our estimation results indicate that the unit gas price relative to the unit cost of gas supply has been decreased as the share of newly-built houses in the service area is increased after 2003, perhaps as a result of competitive threats from the diffusion of all-electric homes. However, that impact is smaller among the gas utilities with a larger share of regulated residential customers.

Our future research need to identify other indicator of the degree of inter-energy competition. One of the possible indicator may be related to climate factor (e.g. temperature), as it may determine the relative advantages of electricity and gas.

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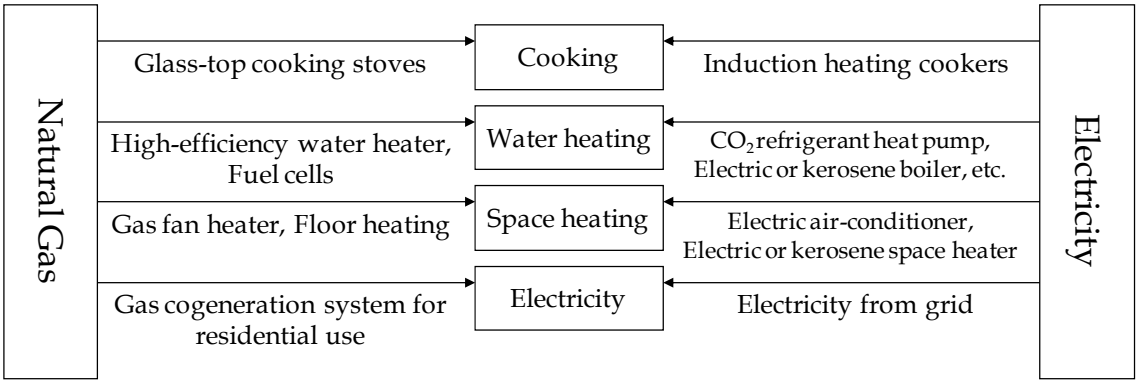
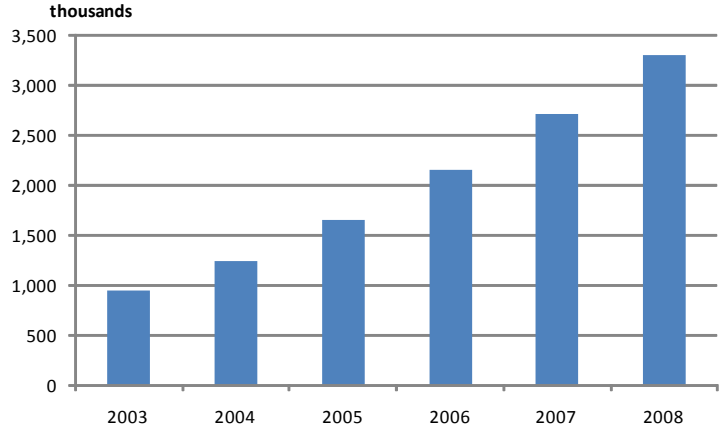


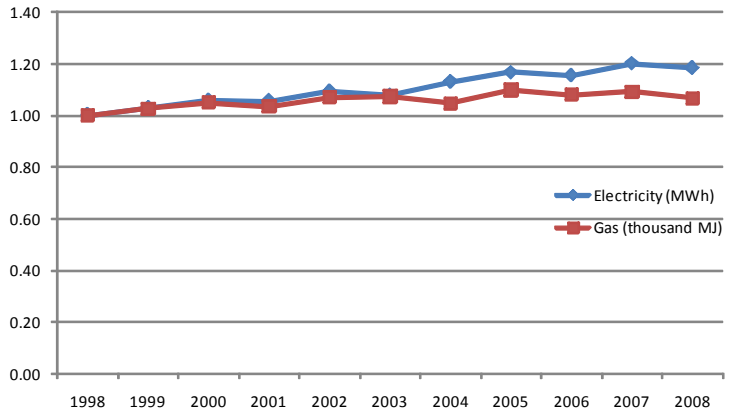
Source: Based on Japan Gas Association

Figure 1: Status of Inter-Energy Competition in Residential Sector



Source: Ministry of Economy Trade and Industry

Figure 2: The Cumulative Number of CO_2 All-Electric Homes (in thousands)



Source: Federation of Electric Power Companies and Japan Gas Association

Figure 3: Development of Demand for Electricity and Gas (1998=1)

Table 1: Descriptive Statistics

N=2228

Variable	Mean	Std. Dev.
Log of Average Unit Price	1.156	0.318
Log of Average Cost	1.128	0.527
Share of Residential Demand	0.627	0.196
Market Share within Gas Market	0.618	0.220
Dummy for Municipal Utility	0.202	0.402
Dummy for Other Businesses	0.066	0.249
Share of Newly-built Houses	0.025	0.010
Share of Newly-built Houses after 2003	0.007	0.010

Table 2: Estimation Results (t-values in parentheses)

	Model 1	Model 2
Variables		
Constant	-0.005	0.037
	(-0.065)	(0.476)
lnAC	0.541 ***	0.522 ***
(Log of Average Cost)	(13.455)	(13.193)
Z^1	0.420 ***	0.387 ***
(Share of Residential Demand)	(8.507)	(7.95)
Z^2	0.155 *	0.169 **
(Market Share within Gas Market)	(1.928)	(2.154)
Z^3	0.279 ***	0.280 ***
(Dummy for Municipal Utility)	(11.196)	(11.552)
Z^4	-0.137 ***	-0.124 ***
(Dummy for Other Businesses)	(-4.958)	(-4.593)
IEC	-0.908 ***	-0.842 ***
(Share of Newly-built Houses)	(-3.109)	(-2.958)
IECX	-0.483 *	-2.715 ***
(Share of Newly-built Houses after 2003)	(-1.874)	(-4.211)
IECX*Z^1		3.817 ***
		(3.746)
Adjusted R-squared	0.902	0.907

***, **, * indicate statistically significant at 1%, 5%, 10%.

Parameter estimates for firm-specific dummy variables are omitted.