CPRC Discussion Paper Series

Competition Policy Research Center
Japan Fair Trade Commission

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CPDP-48-E January 2011

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Territorial Restrictions and Consumer Welfare in a Mixed Oligopoly: The Japanese Gas Supply Market*

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January 2011

*I have benefited from comments by Hiroyuki Odagiri, Hiroshi Ohashi, Yosuke Okada, and seminar participants at the JEA Autumn Meeting and the Competition Policy Research Center. The views expressed herein are those of the author and do not necessarily reflect those of the Fair Trade Commission of Japan (JFTC).

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Abstract

This paper assesses the consumer welfare effect of territorial restrictions in the Japanese gas supply market between 1998 and 2005. Territorial restrictions virtually prohibit the expansion of town-gas service areas in response to demand. Estimation reveals that characteristics of gas services play a significant role in demand substitution between town-gas and propane-gas. Simulation exercises indicate that if town-gas service expands to areas where town-gas pipelines have not been laid, some households switch to town-gas. In a static Cournot competition between propane-gas suppliers, this switch triggers a decline in the price of propane-gas, and it improves consumer welfare.

Keywords: consumer welfare, propane-gas, simulation analysis, territorial restriction, town-gas

JEL Classification: L43, L95

1 Introduction

Many recent studies focus on a mixed oligopoly market where a public firm cohabits with a private firm. Such a market includes financial and education markets. In mixed oligopoly markets, public firms are usually assumed to maximize welfare. However, counterintuitive results are often obtained in many theoretical literatures including De Fraja and Delbono (1989) and Cremer et al. (1991). Empirical literatures (for example, Dewenter and Malatesta; 2001) support the theoretical perspective. Till date, the role of public firms in these markets has been discussed.

The Japanese gas market is a mixed oligopoly market. In this market, propane-gas suppliers can be considered private firms because their prices and service areas have not been regulated. Although propane-gas is substitutable with which town-gas, town-gas suppliers can be considered public firms because their prices and service areas have been regulated. Since town-gas suppliers are considered to be natural monopolists, the Japanese government has regulated town-gas prices and service areas to maximize welfare. However, previous literatures cannot adequately ascertain whether regulations for town-gas suppliers can maximize welfare[1].

This study focuses on territorial restrictions of town-gas service. The Gas Business Act stipulates that town-gas suppliers provide gas services only within their predetermined service areas. The Japanese government also stipulates an agreement with propane-gas suppliers for expanding town-gas service areas. However, the Japan Fair Trade Commission (1999) reports that no consensus has been reached over such an agreement. In fact, town-gas service areas have rarely been expanded, and territorial restrictions virtually prohibit the expan-

[1] Previous literatures often focus on productivity and regulated price of town-gas suppliers (for example, Uekusa; 1994, Kaino; 2007, Takenaka; 2009). However, few literatures regard the Japanese gas market as a mixed oligopoly market.

sion of town-gas service areas in response to demand. Although the territorial restrictions can prevent conflicts between propane-gas suppliers and town-gas suppliers, it is still not obvious whether they can maximize welfare[2].

This study explores counterfactual scenarios that could arise if town-gas service expands to areas where town-gas pipelines have not been laid. First, I estimate a demand model using Japanese gas market data between 1998 and 2005. This demand model has a nested logit structure to describe consumer decision making. Similar to Berry (1994) and many other literatures, I derive a linear regression model from the demand model and estimate it with a two-stage least squared (2SLS) method. The estimation reveals that the characteristics of gas services play a significant role in demand substitution between town-gas and propane-gas.

Furthermore, this study simulates a counterfactual expansion of town-gas service to 16 areas where town-gas pipelines have not been laid. In these counterfactual scenarios, some households switch from propane-gas to town-gas. In a static Cournot competition between propane-gas suppliers, this switch triggers intense competition among propane-gas suppliers, and decreases propane-gas prices (5.2%); this improves consumer welfare (10.8%). The simulation result indicates that frequent readjustments regarding town-gas service areas should improve consumer welfare. In other words, this result suggests that maintaining territorial restriction for town-gas suppliers softens competition among propane-gas suppliers.

This paper is organized as follows. Section 2 gives a brief overview of the Japanese gas market. Section 3 explains a demand model, our dataset, variable definitions, and demand estimation results. Section 4 conducts simulations re-

[2]Theoretical and empirical literatures concerning territorial restrictions usually assume simple oligopoly markets (for example, Kelin and Murphy; 1988, Culbertson; 1991, Rey; 1995). To my knowledge, no study focuses on territorial restrictions in mixed oligopoly markets. This paper aims to provide the first assessment of consumer welfare effects of territorial restrictions in mixed oligopoly markets.

Table 1: The Japanese gas market in 2005

	Propane-gas	Town-gas
Number of suppliers	21780	212
Market concentration	Small	High
Supply system	Canisters	Pipelines
Number of consumers	25 million	23 million
Service areas	Unregulated	Predetermined
Prices	Unregulated	Full-cost pricing rule

Note: The number of consumers, an approximate value, is defined as the number of households.
Data Sources: *Yellow Pages* and *Town-Gas Annual Report*.

garding an expansion of town-gas service areas. Section 5 concludes this paper.

2 Overview of the Japanese Gas Market

Table 1 summarizes the Japanese gas market.

2.1 Propane-gas

Propane-gas is supplied to homes by about twenty-two thousand firms. Approximately 58% of the propane-gas suppliers are firms with three or fewer employees. Many propane-gas suppliers are small and tiny companies (Okada and Hayashi; 2009). They usually fill their canisters with liquefied petroleum gas at gas stations. Thereafter, they carry their canisters and connect them to the gas rubber hoses of individual households.

Approximately twenty-five million households used propane-gas in 2005. With canisters and portable grills, propane-gas can be used efficiently at any location. Propane-gas consumers live not only in urban regions but also in rural regions. Therefore, propane-gas could be supplied from all over Japan.

2.2 Town-gas

Town-gas was supplied to homes by 212 firms in 2005. Town-gas suppliers are regional monopolists in a certain area. However, there exists a great difference in the size of their firms. The three-firm concentration ratio is 77%, with the market share of Tokyo gas, Osaka gas, and Toho gas at 36.2%, 30.1%, and 10.7%, respectively. The top three town-gas firms provide gas services in Tokyo, Osaka, Nagoya, and their environs.

Approximately twenty-three million households used town-gas in 2005[3]. Town-gas is supplied through pipelines to individual households. However, as most town-gas pipelines are not laid from all over Japan but from urban regions, few areas can benefit from piped town-gas. Only 5% of the land in Japan has town-gas service areas.

The Japanese government regulates not propane-gas prices but town-gas prices. Town-gas prices are set on the full-cost pricing rule. They have been maintained much lower than propane-gas prices. Furthermore, town-gas suppliers need to obtain permission from the government when they change their prices. Town-gas price setting is not left to the discretion of town-gas suppliers.

2.3 Territorial restrictions on town-gas service areas

The Gas Business Act stipulates that town-gas suppliers provide their gas services only within their predetermined service areas. It also states that town-gas suppliers should apply to the Ministry of Economics, Trade and Industry (METI) for permission to change their service areas[4].

Furthermore, METI has stipulated an agreement with propane-gas suppliers

[3] Of around fifty million households in Japan, most use propane-gas or town-gas. Around one million households who use neither propane-gas nor town-gas are about one million. They use community gas or do not use gas at all.

[4] Propane-gas service areas are not stipulated in the Gas Business Act. Determining propane-gas service areas is left to the discretion of propane-gas suppliers.

when town-gas suppliers expand their service areas. This can prevent conflicts between propane-gas and town-gas suppliers (Management and Coordination Agency; 1993). However, by expanding town-gas service areas, the propane-gas suppliers would lose their consumers to town-gas suppliers and suffer a decrease in profits. They thus have no incentive to agree on the expansion. Therefore, the territorial restrictions virtually prohibit the expansion of town-gas service areas in response to demand. In fact, current town-gas service areas are similar to previous areas.

3 Demand Estimation

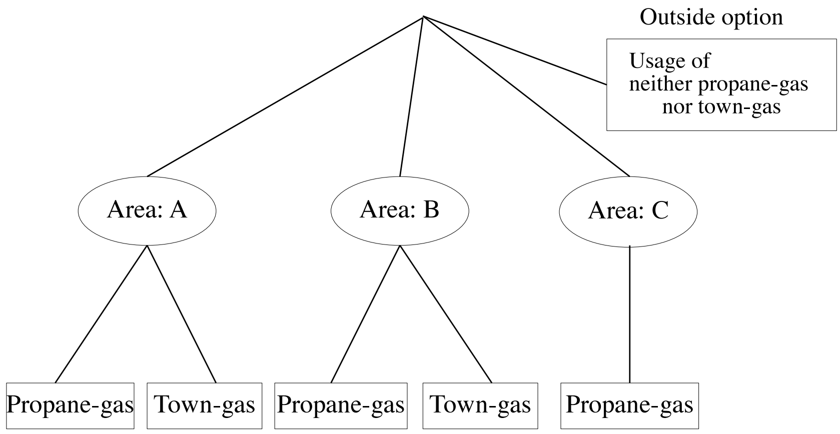
3.1 Demand model

I assume that a household uses one type of gas; that is, it uses either one type of gas or none at all. Each household is assumed to maximize the following utility function by using gas type g in area j:

$$u_{ijg} = \beta_0 + \beta_1 p_{jg} + \beta_2 MJ_{jg} + \beta_3 Temp_j + \beta_4 Density_j + \xi_{jg} + \epsilon_{ijg},$$

where u_{ijg} is household i's utility by using gas type g (either propane-gas or town-gas) in area j. p_{jg} is the average real price of gas g in area j (adjusted by the Consumer Price Index: 1998 = 100). MJ_{jg} is a calorific value of gas g in area j. High-calorific gas has high thermal efficiency. $Temp_j$ is the annual mean temperature in the prefecture including area j. Gas consumption should increase in cold weather. $Density_j$ is the population density in area j. Gas suppliers usually have their sales offices in densely populated areas. They reach customers through their sales offices. In areas with high population density, customer support should be enhanced. Let ξ_{jg} be the mean of consumers' valuations of unobserved qualities of gas type g in area j. Following Berry

Figure 1: Nested logit model



(1994), δ_{jg} is defined as the mean utility of using gas type g in area j:

$$\delta_{jg} := \beta_0 + \beta_1 p_{jg} + \beta_2 MJ_{jg} + \beta_3 Temp_j + \beta_4 Density_j + \xi_{jg}.$$

ϵ_{ijg} denotes the distribution of consumer preferences about this mean utility, and u_{ijg} is decomposed into δ_{jg} and ϵ_{ijg}.

I impose an assumption on ϵ_{ijg} that generates the following nested logit structure. On the first node, a household decides its area of residence. On the second node, given the choice of a dwelling area, the household decides which type of gas it uses. In certain areas where town-gas pipelines are not laid, a household should inevitably use propane-gas. An image of this nested logit model is drawn in Figure 1.

The nested logit formula for the market share of gas type g in area j is

$$s_{jg} = \frac{e^{\delta_{jg}/(1-\sigma)}}{D_j^{\sigma} \sum_{j'} D_{j'}^{1-\sigma}}, \tag{1}$$

where $D_j := \sum_{g \in \vartheta_{jg}} e^{\delta_g/(1-\sigma)}$ and the set of gas type in area j is ϑ_j. Parameter σ measures the correlation in unobserved utility from the different gas types in the same area. This parameter also provides a test of whether it is appropriate to have a second-stage choice in the model. If σ is 0, the model becomes equal to a simple logit model. The conditional market share of gas type g given the area j is

$$s_{g|j} = \frac{e^{\delta_{jg}/(1-\sigma)}}{D_j}. \tag{2}$$

Following Berry (1994), a linear regression model for this two-stage nested logit is derived as follows:

$$\begin{aligned}
&\log(s_{jg}) - \log(s_0) \\
&= \delta_{jg} + \sigma \log(s_{g|j}) - \delta_0 \\
&= \beta_0 + \beta_1 p_{jg} + \beta_2 MJ_g + \beta_3 Temp_j + \beta_4 Density_j + \xi_{jg} + \sigma \log(s_{g|j}). \quad (3)
\end{aligned}$$

The option of not using either propane-gas or town-gas is represented by 0. s_0 denotes the market share of households in the usage of community-gas[5]. I assume that $\delta_0 = 0$ and estimate this model in the following subsection.

3.2 Data

The dataset ranges from 1998 to 2005 on a yearly basis, and it has four different data sources. Surveys on propane-gas prices conducted by The Oil Information Center (The Institute of Energy Economics, Japan) report retail prices for 10 cubic meter of propane-gas, including consumption taxes and basic charges. Furthermore, these prices are reported by each administrative district. These administrative districts are narrower than prefectures and wider than munici-

[5]A community-gas is supplied only for a housing estate with more than seventy households.

palities. In this study, I refer to these administrative districts as areas[6].

The number of propane-gas firms is listed in the Japanese telephone directory *Townpage*. *Townpage* lists telephone numbers and addresses classified by propane-gas suppliers. I enumerate the numbers of propane-gas firms by area.

The *Town-Gas Annual Report* by The Agency for Natural Resources and Energy (METI) provides town-gas prices, the number of town-gas meters, and financial accountings for each town-gas firm. Since town-gas supplied by different town-gas firms has different calorific values, I calculate the town-gas prices in calorific value equivalent to 10 cubic meter of propane-gas. Furthermore, I regard the number of town-gas meters as the number of households using town-gas. However, the *Town Gas Annual Report* does not always show the number of town-gas meters by each area. I supplement the number of town-gas meters using municipality surveys.

Furthermore, I complement relevant government statistics with regard to geographical characteristics by municipalities. Using the number of town-gas households and total households, I define the market shares of town-gas and propane-gas[7].

3.3 Instruments

Three explanatory variables in equation (3) are probably correlated with ξ_{jg}. Obvious variables are $\log(s_{g|j})$ and $Density_j$, since $s_{g|j}$ and $Density_j$ contain part of the explained variable s_{jg}; p_{jg} may be correlated with ξ_{jg}. If ξ_{jg} is correctly perceived by households and suppliers, a type of gas with a better image may induce higher willingness to pay. Although town-gas suppliers cannot charge higher prices according to regulations, propane-gas suppliers may be able

[6]Here, Japan is divided into 276 areas, and in 66 areas town-gas pipelines are not laid.

[7]I can obtain data on the number of households using propane-gas, not for each area but for each prefecture. Then this number of households using propane-gas in area j is defined as the difference between total households using town-gas and those using community-gas.

to charge higher prices.

To account for the endogeneity of these three variables, I use several instrument variables. I employ some instruments from the cost side. One instrument is free-on-board prices (the data are from the *Trade Statistics of Japan*). Because propane-gas and town-gas are usually made from imported components, their retail gas price would be affected by free-on-board prices. Another instrument could be kerosene prices including delivery charge. Similar to a kerosene delivery, propane-gas suppliers often carry gas canisters by using motor trucks. Furthermore, average prices in contiguous areas could be instruments. Since the major components of propane-gas and town-gas are usually imported, transportation charges on contiguous areas may be similar.

I have appropriate instruments with regard to geographical characteristics. First, I use the logarithm of road mileage and the habitable area divided by land area. In the set of instruments I also include a population and its square. These characteristics could capture population density. Furthermore, the apartment ratio of new housing could be an instrument. Town-gas is often supplied in areas with many apartment houses. The apartment ratio of new housing may be correlated with the within-area market share $\log(s_{g|j})$.

The basic statistics and variable definitions are summarized in Table 2.

3.4 Demand estimation results

Table 3 shows four estimation results of a gas demand. The first specification (3.1) presents the ordinary least squared (OLS) estimates without regard for the endogeneity. From (3.2) to (3.4), I use a 2SLS method to control for the endogeneity in p_{jg}, $\log(s_{g|j})$, and $Density_j$. In the specification (3.2), I use the instruments introduced in the above subsection for equation (3). Specifi-

Table 2: Basic statistics and variable definitions

Variable	Mean	S.D.	Definition
$\log(s)$	-6.82	1.29	Logarithm of market shares
$\log(s_0)$	-2.49	0.02	Logarithm of outside market share
p	5076	950	CPI-Deflated retail gas price (in 1998 yen)
MJ	74.19	31.36	Calorific value (Mega Joule)
$Temp$	15.45	2.41	Average temperature (Celsius)
$Density$	1.82	2.38	Population density (thousand people/km^2)
$\log(s_{g\|j})$	-0.86	1.01	Logarithm of within-area j market share
FOB	29551	6687	Propane free-on-board price (yen/t)
KP	953	126	Kerosene prices including delivery charge (yen/18ℓ)
Road	4744	24707	Road mileage (km)
Area	1303	1626	Land area (km^2)
H area	431	457	Habitable area (km^2)
Housing	0.47	0.12	Ratio of apartment houses to new housing starts

Notes: The CPI-deflated retail town-gas prices are calculated in calorific value equivalent to 10 cubic meter of propane-gas.

cation (3.3) adds year dummies to explanatory variables in the equation (3)[8]. Specification (3.4) excludes kerosene prices, including delivery charge from instruments. The three results using 2SLS methods give virtually similar results. Hereafter, I have discussed and used the result in specification (3.2).

It should be noted that 2SLS estimators could be biased if instruments are weak. Therefore I have checked the explanatory power of instruments, conditional on the included exogenous variables in the first stage of the 2SLS method. I calculate first stage F-statistics for each endogenous variable. Table 3 also reports the average F-statistics. The F-statistics indicate that all instruments are not weak.

I obtained several significant coefficients. First, the coefficient of *price*, β_1, is significantly negative. This indicates that prices have a negative impact on utility. Second, the coefficient of MJ is positive and significant, and households

[8] Although I have added year dummies to explanatory variables in equation (3), year dummies are not significant.

Table 3: Demand estimation results

	(3.1) OLS	(3.2) 2SLS	(3.3) 2SLS	(3.4) 2SLS
const.	-3.2213^{***}	-3.1675^{**}	-3.1502^{**}	-3.0996^{**}
	(0.0877)	(0.2156)	(0.2107)	(0.2191)
p	0.0000^{*}	-0.0001^{***}	-0.0001^{***}	-0.0002^{***}
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
$\log(s_{g\|j})$	1.0417^{***}	0.7316^{***}	0.7505^{***}	0.7142^{***}
	(0.0109)	(0.0436)	(0.0426)	(0.0443)
MJ	-0.0039^{***}	0.0053^{***}	0.0048^{***}	0.0062^{***}
	(0.0005)	(0.0019)	(0.0019)	(0.0020)
$Temp$	-0.0334^{***}	-0.0526^{***}	-0.0521^{***}	-0.0536^{***}
	(0.0040)	(0.0046)	(0.0046)	(0.0047)
$Density$	0.2678^{***}	0.3288^{***}	0.3250^{***}	0.3294^{***}
	(0.0049)	(0.0086)	(0.0084)	(0.0087)
year dummy	No	No	Yes	No
F-statistics		791^{***}	544^{***}	846^{***}
adjusted R^2	0.7936	0.7372	0.7436	0.7302

Notes: The first specification (3.1) presents the OLS estimates without regard for the endogeneity. From specification (3.2) to (3.4), I use 2SLS methods. In the specification (3.2), I use the instruments introduced in the above subsection for equation (3). Specification (3.3) adds year dummies to explanatory variables in equation (3). Specification (3.4) excludes kerosene prices including delivery charge from instruments. F-statistics are the average first stage F-statistics, which provide the average explanatory power of instruments, conditional on the included exogenous variables. ***, **, and * denote significance at 0.01, 0.05, and 0.10 levels respectively. Standard errors are in parentheses. The number of observations is 3895.

evaluate high thermal efficiency. Third, the coefficient of $Temp$ is significantly negative. This is consistent with the fact that gas consumption should increase in cold weather. Fourth, the coefficient of $Density$ is significantly positive. Households should expect enhanced customer support would be enhanced in densely populated areas . Finally, parameter σ, the coefficient of $\log(s_{g|j})$, is significantly different from zero, that is, 0.73. This parameter tests whether it is appropriate to have a second-stage choice in the model. Therefore, a simple logit structure can be rejected. Using estimated parameters β_1 and σ, I will calculate demand elasticity in the following subsection.

3.5 Demand elasticity

In this model, I can calculate demand elasticity using estimated parameters. From the market share definition (1) and the within-group market share definition (2), own-and-cross price elasticity of demand in the nested logit model are derived as:

$$\eta_{hg}^{j} = \begin{cases} \dfrac{\beta_1}{1-\sigma} p_{jg}(1 - \sigma s_{g|j} - (1-\sigma)s_{jg}) & \text{if} \quad h = g, \\ -\dfrac{\beta_1}{1-\sigma} p_{jh}(\sigma s_{h|j} + (1-\sigma)s_{jh}) & \text{if} \quad h \neq g \end{cases} .$$

Using the estimated parameters σ and β_1 as reported in the specification (3.2) of Table 3, I calculate own and cross elasticity in 2005. I have chosen this year because it is in the last year of my dataset, and I will use the estimated elasticity in the following section.

Elasticity is evaluated with respect to each area. Table 4 reports the mean estimated elasticity in areas where town-gas pipelines are laid. While the own elasticity for propane-gas is -1.47, the own elasticity for town-gas is -1.58. This result indicates that the demand for town-gas is more elastic. This is because the switch from town-gas to propane-gas is quicker. Owning gas canisters and portable grills for propane-gas enables the efficient of propane-gas at any location. However, to use town-gas, it is essential to be connected to town-gas pipelines.

I find that the calculated cross elasticities are asymmetric. While the cross elasticity of town-gas demand is 1.33, that of propane-gas demand is 0.50. This asymmetric cross elasticity could be induced by a wide discrepancy in prices between propane-gas and town-gas. Town-gas prices have been maintained much lower than propane-gas prices. If town-gas prices increase slightly, households that use town-gas will not switch from town-gas to propane-gas.

Furthermore, I compute the own elasticity for propane-gas in areas where

Table 4: Elasticities in areas where town-gas pipelines are laid down

	Propane-gas price	Town-gas price
Propane-gas demand	−1.47 (0.013)	0.50 (0.009)
Town-gas demand	1.33 (0.015)	−1.58 (0.014)

Notes: Using the estimated parameters σ and β_1, as reported in the specification (3.2) of Table 3, I calculate own and cross elasticities in 2005. Standard deviations are in parentheses.

town-gas pipelines are not laid. The elasticity is estimated at -0.77 on average. The demand for propane-gas in these areas is less elastic than that in areas where town-gas pipelines are laid. This is consistent with evidence that a household should inevitably use propane-gas.

4 Expanding Town-gas Service Areas

4.1 Supply model

This study explores counterfactual scenarios if town-gas service expands to areas where town-gas pipelines have not been laid. Calculating equilibrium under counterfactual scenarios requires a supply model describing the behaviors of town-gas and propane-gas suppliers. By regulation, town-gas service areas are predetermined. Let the town-gas service area in area j be $(1 - k_j)Q_j$, where Q_j is the total number of households in area j, $0 \leq k_j \leq 1$. Town-gas suppliers in area j supply their gas services only inside $(1 - k_j)Q_j$. Moreover, town-gas prices are set on the full-cost pricing rule.

However, propane-gas prices and service areas are not regulated. I assume that propane-gas firms are homogeneous. Each propane-gas supplier maximizes his profit function given the town-gas prices and service areas. Outside town-gas service areas, propane-gas suppliers compete with each other. The competition is modeled as Cournot-Nash competition. Then, the first order condition from the profit maximization problem is derived as follows:

$$\frac{p_j - MC_j}{p_j} = \frac{1}{n_j}\frac{k_j}{\eta^j}, \tag{4}$$

where MC_j is marginal cost, n_j is the number of propane-gas suppliers, and η^j is the own-price elasticity of demand[9].

4.2 Consumer surplus in counterfactual scenarios

I evaluate the changes in consumer welfare resulting from an equilibrium in counterfactual scenarios. I measure consumer welfare of households that actually use either town-gas or propane-gas. Given the nested logit assumption and linear utility formulation, the consumer welfare can be computed as

$$CW := \frac{1}{|\beta_1|}\log\left(\sum_g D_g^{1-\sigma}\right),$$

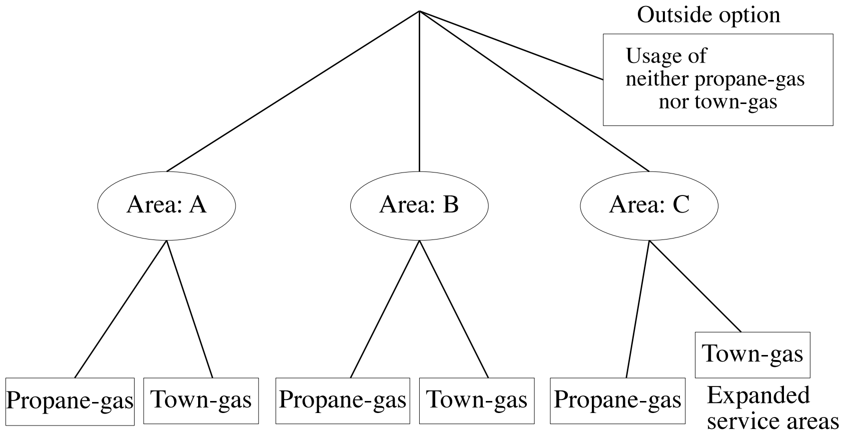
where $D_j := \sum_{g\in\vartheta_{jg}} e^{\delta_g/(1-\sigma)}$, and the set of gas type in area j is ϑ_j.

Using the estimated parameters as reported in specification (3.2) of Table 3, I can numerically compute simulated consumer welfare and change in consumer welfare under two additional assumptions. First, hypothetical town-gas prices and calorific values in expanded service areas are the average in contiguous areas. Second, propane-gas suppliers' marginal costs are constant. Given the demand estimates presented in Section 3, I recover the marginal costs of supplying propane-gas by

$$\hat{MC}_j = p_j\left(1 + \frac{1}{n_j}\frac{k_j}{\eta^j}\right).$$

[9]I have dropped subscript g to simplify notation, and g is propane-gas.

Figure 2: Counterfactual scenario



4.3 Rational expansion of town-gas service areas

This subsection discusses the potential for expansion of town-gas service areas. Counterfactual town-gas service areas expand to areas where town-gas pipelines are not laid down. Figure 2 presents a typical example. A counterfactual scenario changes Area C to one where some households are able to use town-gas.

However, if some households in Area C are able to use town-gas, town-gas supply costs might be quite high. An area with extremely few populations would provide pretty high average town-gas supply costs per household. Conversely, an area with a large population would provide low average town-gas supply costs per household, and a growing population could decrease average town-gas supply costs. Therefore, the counterfactual scenario expands to areas with relatively low average town-gas supply costs.

Then, I estimate average town-gas supply costs. Town-gas suppliers adopt full-cost pricing behavior by regulation. Following Kaino (2007), I measure average costs using financial accountings of each town-gas supplier and obtain total costs as this average costs times the number of households using town-gas. Furthermore, I regress total costs on the population density, a ratio of apartment houses to new housing starts, habitable area, and road mileage divided by the piece of land, and demand density (defined as the number of town-gas consumers divided by road mileage). Using these estimated parameters, I calculate the hypothetical town-gas costs when Area C is assumed to have some households that are able to use town-gas.

Under the assumption that hypothetical town-gas prices in expanded service areas are average in contiguous areas, I focus on areas where the estimated average town-gas supply cost are less than the hypothetical town-gas price. There are 16 areas, including Arida-city (Wakayama Prefecture), Niihama-city (Ehime Prefecture), and Tonami-city (Toyama Prefecture). Town-gas have been supplied in these contiguous areas.

4.4 Welfare estimates

I assess welfare changes induced by the expansion of town-gas service areas. Expanding town-gas service areas could have two effects on consumer welfare. One is an effect of some households switching from propane-gas to town-gas. This improves consumer welfare because town-gas prices have been maintained much lower than propane-gas prices. Another is intensifying competition among propane-gas suppliers. Since some households switch from propane-gas to town-gas, the number of households using propane-gas decreases. In this supply model, this triggers intense competition among propane-gas suppliers and induces a steep fall in propane-gas prices.

Table 5 presents propane-gas price decreases and consumer welfare improve-

Table 5: Propane-gas price decreases and simulated welfare changes

	Ratio (%)
Propane-gas price decreases	5.2
Simulated welfare improvements	10.8

Notes: Using the estimated parameters as reported in the specification (3.2) of Table 3, I calculate propane-gas price decreases and consumer welfare improvements.

ments. The first row is the ratio of decrease in propane-gas prices. The average decrease ratio of propane-gas prices is 5.2%. The second row is the ratio of improvement in consumer welfare. The average increase ratio of the consumer welfare is 10.8% This is because propane-gas prices decrease, and some households switch from propane-gas to town-gas. The simulation result indicates that frequent readjustments regarding town-gas service areas should improve consumer welfare.

5 Concluding Remarks

This study simulates a counterfactual expansion of town-gas service to 16 areas where town-gas pipelines have not been laid. Simulation exercises indicate that some households switch from propane-gas to town-gas. In a static Cournot competition between propane-gas suppliers, this switch triggers intense competition among propane-gas suppliers and decreases propane-gas prices (5.2%). This improves consumer welfare (10.8%). The simulation result indicates that frequent readjustments regarding town-gas service areas should improve consumer welfare.

This simulation result is bound by a Japanese government requirement that stipulates an agreement with propane-gas suppliers when town-gas suppliers expand their service areas. Although this can prevent conflicts between propane-gas and town-gas suppliers, by expanding town-gas service areas propane-gas suppliers would lose their consumers to town-gas suppliers and suffer a decrease in profits. The propane-gas suppliers have no incentive to agree on the expansion. Therefore, the territorial restrictions virtually prohibit the expansion of town-gas service areas in response to demand. The demand for propane-gas remains stable, and this has softened competition among non-regulated propane-gas suppliers.

This study presents four questions for further study. First, the number of households using propane-gas is approximated. The number of households using propane-gas is defined as the difference between total households having town-gas and those having community-gas. This is because we obtain data only on the number of propane-gas meters for each prefecture. Such data for each area is not easily available.

Second, this discrete choice model suggests that the amount of gas consumption should be equal to the number of households. However, the amount of gas consumption would be different among regions. Furthermore, both propane-gas prices and town-gas prices actually consist of both fixed price and meter rate price. Therefore, the coefficient of gas price might depend on tastes and incomes of households.

Third, this study assumes homogeneous cost function among town-gas suppliers. In economic theory, the town-gas market would be a natural monopoly. The town-gas suppliers have an overwhelming cost advantage, creating a scale of economy. This consideration would require constructing a rigorous cost function model.

Finally, this study also assumes a static model. This model abstracts from dynamic issues such as households' regional settlement and suppliers' entry and exit. It would be important to characterize the dynamics of the market more precisely. Incorporating dynamic incentives of households and gas suppliers into this analysis is a direction for future research.

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