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Dissertation

The effects of introducing market principles into the city gas industry in Japan

Graduate School of Commerce and Management
Management and Marketing Course
Satoru Hashimoto

Contents

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In chapter 2, I made this presentation at Hosei University (Japan Association for Planning Administration) in March 2008. After I modified the contents of this presentation, I was published in Ikkyo Syougaku Ronso. I thank the editor and two anonymous referees for their helpful comments in revising the original version of the paper.

When 59th Annual National Conference of Japan Society of Public Utility Economics was held at Kyoto University in Jun 2009, then, I made a presentation about chapter 3. My debater, Prof. Tomohito Yamane(Osaka University of Commerce), made a valuable comment on my presentation. I am grateful for the helpful comment. This contents was published the journal of public utility economics(Koueki Jigyo Kenkyu) in 2009. I thank the editor and two anonymous referees for their helpful comments.

The contents of chapter 4 were created based on some comments on the gas business in the future. Nobuyuki Uekusa(Japan Gas Association) gave me beneficial advice from practical perspective. I am also grateful for the helpful advice.

Chapter 5 is the contents when I made a presentation at the 1st Kanto section in Japan Society of Utility Economics in 2011. My debater, Prof. Toshio Uemura(Asia University), gave me a useful comment. I would like to thank him for the comment.

Finally, Will McCormick(English conversation school teacher) checked my awkward English carefully and sincerely. I cannot also thank him enough.

Of course, I am solely responsible for any remaining errors.

Framework

Deregulation(Introducing market principles) started in 1995.

(Chapter 2)

Estimate whether the management efficiency was improved by deregulation

(The target of this estimation is only the group of large scale incumbents.)

(The management efficiency of large scale incumbents is significantly improved.)

Extend to small and middle utilities.

(There are two types of organizational forms.)

(The one holds both a manufacturing and a sales sector, and the other holds only a sales sector).

(Chapter 3)

Analyze the reason why two types of organizational forms exist.

The retail price differential between two types of utilities exists.

(Chapter 4)

Analyze the factor of retail price differential.

(The price differential cannot vanish by the utility efforts.)

(Utilities can provide gas cheaper through pipelines.)

Utilities should make pipeline investments.

(Chapter 5)

Consider the way to increase pipeline investments.

("Subsidiary" increases the amount of trunk pipeline investments.)

Chapter 1

Purpose and viewpoints

(Summary)

The city gas industry has been deregulated and introduced market principles since 1995, and 15 years have passed since then. Before considering the effects of introducing market principles into the city gas industry, this chapter notes the purpose, viewpoints, and composition.

1-1 Purpose

With the rise of recent environmental problems, the importance of management efficiency of energy industries such as power generation and natural gas has increased more and more. This paper focuses on the city gas industry, and analyzes the effects on the introduction of market principles by the government.

The city gas industry has been deregulated and urged implement more competitive policies by the government since 1995. In the first reform of 1995, the government instituted a policy that allowed customers who consume 2,000,000 m^3 or more are able to choose utilities, and the city gas utilities could slide the market price as to circumstance such as the fluctuation of price index. In the reform of 1999, the government extended the range of liberalization to 1,000,000 m^3 or more, and instituted consignment supply(Takuso-kyokyu) as legislative system[1]. In addition, the government mitigated regulations of the market price(from authorization price{Ninka kakaku} to reported price{Todokede kakaku}). In the reform of 2003, the government enlarged the range of liberalization to 500,000m^3 or more permitted companies to establish the utility of possessing pipelines, and pursued fairness and transparency by means of obliging all utilities to consignment supply. In the final reform of 2007, the range of liberalization was extended to 100,000m^3 or more. This range includes gyms with a pool, family restaurants, and Economy hotels(business hotels). As 15 years have been passed since the deregulation started, the time to consider the effects of deregulation has come. Therefore, this paper evaluates the effects on the deregulation and competitive policies.

With regard to the analysis, this paper examines not only the direct effects but also the future impact. The introduction of market principles by the government improves management efficiency as the direct effects, and the improvement of management efficiency would lead to a decline in the retail price. In particular, large companies generally appear the direct effects by the deregulation more strongly than small ones. Hence, I will select the data on the large companies which provide gas for 150,000 or more customers, and estimate the change of the management efficiency before and after the deregulation.

However, in the long run, because all of the incumbents cannot improve their management performance due to the difference in locations, customs, and climates(cold, warm, etc.), I need to consider the future impact of the deregulation by adding this difference. That means this paper analyzes what will happen to the whole industry including incumbents in this industry after the direct and short term effects have been continuing for a long time. In the case where the effects of introducing market principles have continued for a long time, the difference in the organizational forms of utilities might give the different effects to the gas retail price and cost structures. Consequently, for the reason above, this paper will classify into two kinds of organizational forms, and then evaluate the future impact of the deregulation.

This paper examines the effects by means of econometric methodologies. Although there have been a lot of papers dealing with the deregulation and competitive policies in the city gas industrial

[1] And legally instituted consignment supply.

fields, the objective of those papers is to evaluate only the group of large utilities insofar as I know. Hence, this paper treats of not only large utility data but also small utility data.

When this paper tries using both small and large gas utility data, two serious problems occur in econometric methodologies. The first problem is that we cannot obtain the detailed data on small utilities. We can gain the large gas utility data from Financial Statements being published by Securities Exchange in Japan. However, we cannot obtain the small gas utility data from its statements. Even if we could derive the detailed data of small utilities from others statements, the differential(variance) between the largest utility(more than 10 million customers) and the smallest utility(approximately 1000 customers) is so large that we cannot guarantee the accuracy of the estimation results. These are two of the serious problems in the city gas industry in Japan.

To solve the problem that we cannot obtain the detailed data of small utilities, this paper attempts to use macro data such as average wages. As regards the great differential between large and small utilities, this paper estimates by categorizing all utilities into several groups. Contrary to my expectation, the great differential, as a result, led to accurate estimations. More detailed discussion will be described in chapter 4.

The second problem is that two kinds of organizational forms involved in small utilities are substantially existed. The one possesses both a manufacturing and sales sector, and the other possesses only a sales sector. This means it is necessary to categorize all gas utilities into at least two types in the case of practicing the estimation. The detailed discussion such as the reason why utilities divide into two organizational forms is described in Chapter 3.

According to yardstick regulation, which categorizes all gas utilities into seven kinds of utilities, chapter 4, where the estimations of scale economies and cost structure by econometric methodologies are practiced, classifies the seven kinds of utilities in the yardstick regulation into three kinds of utilities. The discussion is expanded upon in chapter 4.

Finally, despite the importance of industrial organization theory in recent years, studies focusing on the organizational forms have not yet been seen in the city gas industry. This paper attempts to practice the analysis of the city gas industry from the view of industrial organization theory.

1-2 Viewpoints

This paper has four viewpoints.

To begin with, it is essential to divide into a manufacturing and a sales sector because the organizational structures in gas utilities are greatly different. The city gas industry in Japan has been protected by regulations for a long time. There is basically no difference in a sales sector due to the regulations. Meanwhile, each utility chooses either purchasing natural gas from wholesalers or transforming LNG(liquefied natural gas) into natural gas by using its own facility because there are no regulations in a manufacturing sector. As a result, there are two kinds of organizational forms excluding large utilities which have 150,000 or more customers in their own area such as Tokyo Gas, Osaka Gas, Toho Gas and Saibu Gas. Therefore, this paper will practice the estimation focusing on these two types, which are a utility purchasing natural gas from wholesalers and a utility transforming LNG into natural gas by using its own facility.

The second point is to demonstrate what should be the variables of input and output in the econometric analysis. Because there are not a lot of studies about the analysis in the city gas industry, a consensus has not been reached about the appropriate variables of inputs and outputs. By deregulation and consignment supply, the competitive situation has changed greatly. In particular, the nature of pipelines has been changing from private goods to public goods through popularizing of consignment supply. That is to say, it seems to be profitable to reconsider appropriate variables of inputs and outputs under the new circumstance.

The third point aims to focus on the organizational forms in the city gas utilities. No one has studied about the organizational forms in city gas utilities as long as I know. This paper discusses what the best organizational form to increase the amount of pipeline investments is. This discussion is expanded upon in chapter 5.

The final point that I consider is whether the city gas industry is a universal service or not. If we think of the whole gas industry including the community gas and the LP gas industry, the whole gas industry should be regarded as a universal service. Because the city gas industry might not be a universal service due to the change of the competitive situation in recent years, I hope to obtain several beneficial implications about this industry through the whole paper. A more detailed discussion is developed in chapter 6.

1-3 Components

The sentence shows the composition in this paper.

Chapter 2 is to verify whether the management efficiency of the city gas utilities was improved by deregulation. First, the deregulation started from customers who use 2,000,000m^3 or more, and gradually trickled down small quantity customers. By and large, the effects of the deregulation might improve the managerial performance of the large utilities more strongly than that of the small utilities. Therefore, this paper chooses the nine largest utilities and then estimates the effects by means of DEA(Data Envelopment Analysis) methodology, and examines whether the managerial performance was significantly improved after the deregulation started.

Chapter 3 aims to consider why there are two kinds of organizational forms in the city gas utilities. Although the supply sector in the city gas industry has been protected by regulations for a long time, the manufacturing sector has not been controlled by the government. Hence, each supplier chooses either purchasing natural gas from wholesalers or transforming LNG into natural gas by using its own facilities. This paper examines the reason why each gas utility chooses either purchasing natural gas or transforming LNG into natural gas under no regulations of a manufacturing sector by means of the theoretical framework of transaction cost economics.

The purpose of chapter 4 is to consider price differential. City gas utilities are classified into two types of gas utilities; the utilities which purchase natural gas through pipelines and the utilities which transform LNG into natural gas. Although deregulation such as liberalization and consignment supply has been increasing the intensity of competition radically which might influence the former kind of utilities more strongly than the latter kind. As a result, price differential between two types of utilities might be much larger by popularizing of market principles. This price differential is examined in this chapter and chapter 6.

Based on the results of chapter 4, chapter 5 considers the organizational forms which increase the amount of pipeline investments. Due to the lack of government strategies, natural gas digging companies have been making pipeline investments for a long time. Recently, both natural gas digging companies and distribution utilities adopt the organizational forms of subsidiary, and then the subsidiary makes pipeline investments in the real world. Hence, this chapter considers what the organizational form to increase pipeline investment is.

Finally, conclusions are described in chapter 6.

Chapter 2

A study of management efficiency of the city gas distribution utilities by means of DEA

(Summary)

The city gas industry in Japan needs to eliminate price differential between foreign and Japanese products. The regulations have been gradually mitigated since 1995. As a result of regulation reform of city gas utilities, a competitive principle has been spread, and a city gas utility is now able to supply gas in the monopoly area of another city gas utility.

The purpose of this paper is to analyze whether city gas utilities could improve performance of management or not. This chapter uses Data Envelopment Analysis (Window models) methodology which is a nonparametrical analysis. This chapter puts three models, and the factors of outputs are the volume of sales, the length of pipelines, and the number of customers, and the factors of inputs are LNG purchase costs, the value of assets, and the number of employees. In conclusion, I have supported that the performance of management of city gas utilities is significantly improved.

2-1 Introduction

The gas industry in Japan is classified into three forms, which are city gas distribution utilities, community gas utilities, and LP gas utilities. The purpose of this chapter is to evaluate the effect of the deregulation of city gas utilities.

In the city gas industry, deregulation started in 1995, and liberalization has been taking place gradually. In the reform of 1995, the government instituted a policy that allowed customers who consume 2,000,000 m^3 or more are able to choose utilities, and the city gas utilities could slide the market price as to circumstance such as the fluctuation of price index. In the reform of 1999, the government extended the range of liberalization to 1,000,000 m^3 or more, and instituted consignment supply(Takuso-kyokyu) as legislative system[1]. In addition, the government mitigated regulations of the market price (from authorization price{Ninka kakaku} to reported price{Todokede kakaku}). In the reform of 2003, the government enlarged the range of liberalization to 500,000m^3 or more, permitted companies to establish the utility of possessing pipelines, and pursued fairness and transparency by means of obliging all utilities to consignment supply. In the reform of 2007, the range of liberalization was extended to 100,000m^3 or more. This range included gyms with a pool, family restaurants, and Economy hotels(Business hotels).

Table 2-1 The transition of liberalization

Schedule	Liberalization range(par year)	Sample customers
March 1995	2,000,000m^3 or more	University hospital, Massive plant, Large scale facility
November 1999	1,000,000m^3 or more	Shopping mall, Factory
April 2004	500,000 m^3 or more	Large hospital, Standard hotel(City hotel), Chemical factory, Metal factory
April 2007	100,000 m^3 or more	Heated swimming pool, Economy hotel(Business hotel), Textile factory, Mechanical factory

[1] And legally instituted consignment supply.

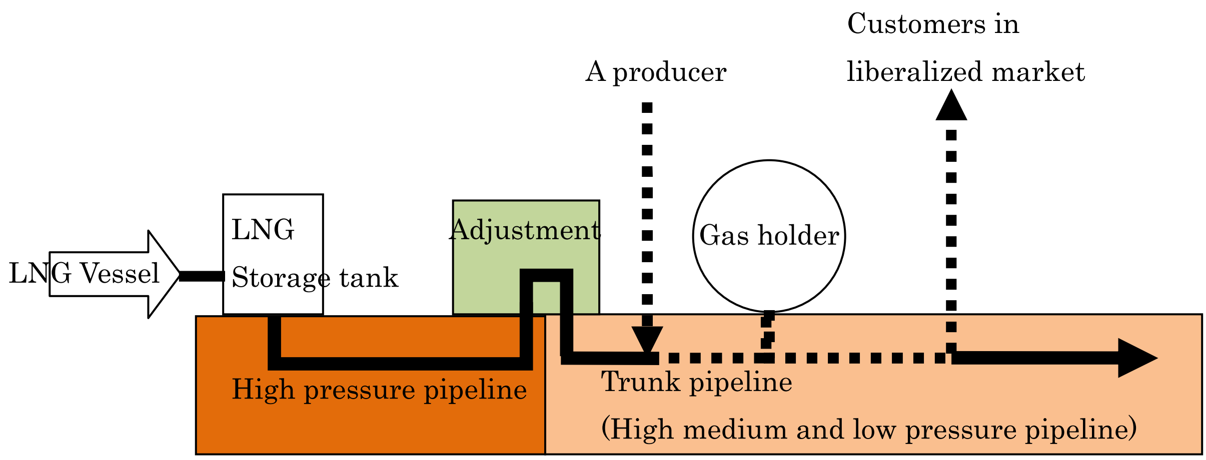

Figure 2-1 The system of consignment supply(The case which a firm supplies gas to a big customer)

By this liberalization, a producer can supply gas in the area of a particular utility by means of consignment supply. The system of consignment supply is shown in Figure 2-1. If a firm pays the consignment supply fee, the firm can use the pipeline, and the firm may provide gas to large customers in liberalized markets.[2] City gas utilities, gas producers, and power companies make use of consignment supply.

It seems that we can estimate whether the liberalization improved management efficiency of incumbents because 15 years have passed since the liberalization started. However, we have never estimated whether to improve the management efficiency of incumbents. This chapter analyzes whether the management efficiency of incumbents was improved after the liberalization started.[3]

Before estimating the management performance, let me denote the management situations of city gas utilities. The organizational forms of city gas utilities are complicated. The utilities purchase LNG by tank trucks or natural gas through pipelines. In the case where neighboring utilities are joined by pipelines, the utilities choose purchasing natural gas through the pipelines rather than purchasing LNG. In the regions such as Niigata and Chiba prefecture, there are several wells spouting out natural gas, therefore, the utilities in these regions purchase domestic natural gas, and provide the gas to customers in their own areas.[4]

There is quite a large difference between the largest utility and the smallest utility. The largest utility is Tokyo-Gas, which has more than 10,000,000s' of customers. Meanwhile, one of the smallest utilities, which is in the rural areas, has only 1,000s' of customers. Moreover, the property

[2] There is definitely not the discrimination between a pipeline and a conduit in Japan. This paper defines trunk pipelines as pipelines, and low pressured pipelines as conduits.

[3] For example, Tokyo-gas supplies gas to the customers in areas of Shin-Nihon-gas and Otaki-gas. Furthermore, Tokyo-gas also supplies gas to the 38 customers out of the areas of the city gas distribution utilities. The pipeline utilities such as INPEX Corporations and TEPCO(Tokyo Electric Power Company), supply gas to the customers in liberalized markets. The detail is written in the site of Agency for Natural Resources and Energy.
http://www.enecho.meti.go.jp/gasHP/genjo/jiyuka/kyokyu/besshi/190201ohguchi-besshi.pdf

[4] According to "An indicator of optimal gas trade(Agency for Natural Resources and Energy)", the distribution utilities obtain four measures.

(1) Purchases natural gas from the big utilities or the domestic gas utility through pipelines
(2) Purchases low calorie gas from a refinery, a petrochemical company and a steel industry
(3) Purchases LNG from the big utility or the domestic gas utility through pipelines
(4) Purchases LPG or naphtha from the wholesalers

rights of utilities are not only private but also public(municipalities). The number of private utilities is 176, and the number of public utilities is 33 at the end of 2007 fiscal year.

The effects of the liberalization should strongly appear in large utilities. Therefore, this chapter estimates the performance of utilities which have the customers of more than 150,000.[5]

2-2. DEA methodology

Here, the management efficiency of city gas utilities can be examined by means of Data Envelopment Analysis(henceforth DEA) methodology. DEA consists in the identification of a nonparametric piecewise linear frontier representing the best practice in the transformation of a bundle of inputs into final outputs. The simplest model is one input and one output shown in Figure 2-2. The method of the transformation process can be based on the hypothesis of constant returns to scale(CCR) and variable returns to scale(BCC).[6] The former is shown in Figure 2-2, and assumes constant returns to scale technology, therefore, in the case of one input and one output, the frontier line is drawn from the origin through the decision making the most efficient DMU(Decision Making Unit). Meanwhile, the latter assumes variable returns to scale, and the frontier line is drawn between the most efficient DMUs in respective output levels.

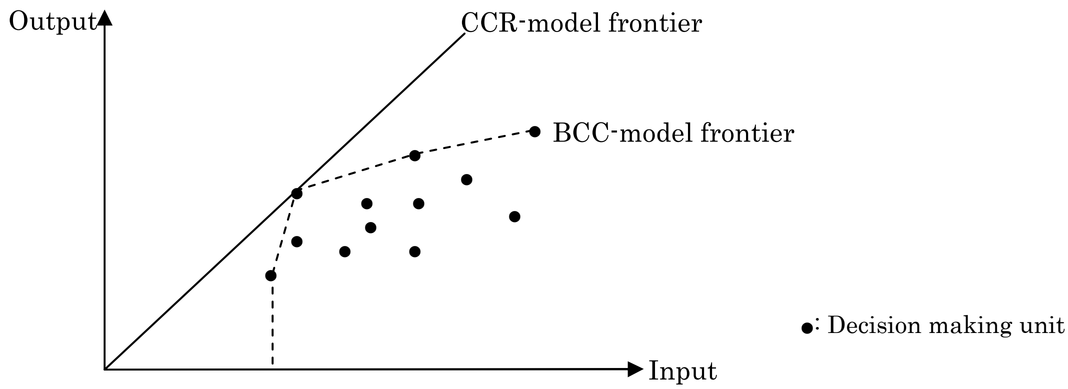

Figure 2-2 The frontier line in DEA methodology

In DEA methodology, the most efficient DMU is set at "1", and inefficient DMU is set at a score of less than 1. An alternative occurs in the identification of inefficiency. It is feasible to minimize

[5] There are seven classifications in yardstick regulations in city gas industry. In this classifications, the number of utilities more than 150,000 customers are 10, which are Hokkaido-gas, Tokyo-gas, Keiyo-gas, Hokuriku-gas, Shizuoka-gas, Toho-gas, Osaka-gas, Hiroshima-gas, Saibu-gas, and Nihon-gas. Actually, although other utilities, such as Sendai-gas, have more than 150,000 customers, the utilities are classified into other groups because of the difference of organizational forms.

[6] BCC-model, which is named by getting an initial of Banker, Charnes, and Cooper, is that it is not supposed returns to scale. It is sometimes expressed VRS model (variable returns to scale). CCR model(CRS model), which is named by getting an initial of Charnes, Cooper, and Rhodes, is that it is supposed constant returns to scale.

the use of inputs given the outputs or to maximize the constant outputs given the constant inputs. Regarding public utility services, such as the city gas industry, the output is apt to be linked to the local demand. Therefore, this chapter would analyze the efficiency conditions using an input-oriented projection model and variable returns to scale.

Given *n-th* DMUs (*j=1,...,n*) producing *y* outputs (*r=1,...,s*) using *x* inputs (*i=1,...,m*), the efficiency DEA score for a DMU_k under BCC(VRS) and input-oriented hypotheses can be estimated by solving the following linear programming problem:

$$Min \quad \vartheta_k$$

s.t.

$$\sum_{j=1}^{n} \lambda_j y_{rj} - y_{rk} \geq 0 \quad r = 1, \cdots, s$$

$$\vartheta_k x_{ik} - \sum_{J-1}^{n} \lambda_j x_{ij} \geq 0 \quad i = 1, \cdots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, j = 1, \cdots, n, \quad \vartheta_k : free.$$

Here, ϑ_k is composed between 0 and 1, and if $\vartheta_k = 1$, it indicates full efficiency. The first line of the constraints functions shows the limitation of production, the second line shows the limitation of resources, and the third line shows limitation of returns to scale(limitation of technology). The DEA program above is rewritten in the deal programme:

$$\underset{u_r, v_r, u_0}{Max} \ Z = \sum_{r=1}^{s} u_r y_{rk} + u_0$$

s.t.

$$-\sum_{i=1}^{m} v_i x_{ij} + \sum_{r=1}^{s} u_r y_{rj} + u_0 \leq 0 \qquad (j=1,2\ldots n)$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$v_r \geq 0 (i = 1,2, \cdots, m), u_r \geq 0 (r = 1,2, \cdots, s), \quad u_0 : free.$$

The methodology consists in the inspection of the sign of the shadow price u_0. Given the inequality constraints and the objective function above, it derives that u_0 has an upper bound of 1 and no lower bound. With inefficient DMUs the shadow price u_0 is unique and the nature of returns to scale well-defined. This occurs because the radial projections are interior points of the supporting hyperplanes of the VRS boundary. Therefore, a radial projection point exhibits increasing returns to scale if $u_0>0$, decreasing returns to scale if $u_0<0$, and constant returns to scale if $u_0=0$.

The method adopted in this chapter is based on DEA-Window-model(BCC), which is the methodology that pools the time series data into observations of a couple of terms, and this method estimates each firm's average and every terms' efficiency of a firm by sliding the starting year for each observation. This methodology is used in cases where the effect of performance of management strategy appears after several terms passed.

2-3 Related literature

I have never seen the literature of analyses by means of DEA methodology in the city gas industry in Japan. In overseas literature, Fabrisio et al.(2008) estimates the management performance of gas distribution utilities in Italy. The Italian gas distribution industry presents a high degree of fragmentation (752firms in 1999). This paper supports that local distributors have undertaken a process of scale enlargement. This raises the question of characteristics of returns to scale for such operators as well as the optimal scale at which they should operate. The scale economies are analyzed by DEA methodology. The result shows that the output space in which DMUs attain a high level of scale efficiency is widespread.

In the United States, Daniel et al.(2002) examines the Natural Gas Policy Act of 1978 and Federal Energy Regulatory Commission (FERC) policies that culminated in Order 636 in 1992. They examine the economic efficiency of gas distributors during 1975-94 by using DEA methodology. Federal policy led to a reduction of scale economies due to restructuring and more competition. However, the reduction of scale economies has not altered the economic efficiency of the utilities.

Moreover, one of the main studies using the DEA-Window model is Thompson et al.(1992), which states that the productive efficiencies of 45 randomly sampled oil/gas independent firms were analyzed year-by-year by application of DEA methods for a 7 year period from 1980-1986. The result exhibited significantly different levels and increases more in the 1980-1982 period than in the 1983-1986 period.

2-4 Empirical model and data source

There are 10 utilities which have 150,000 or more customers in Japan. The analysis in this chapter is removed Nihon-Gas because the company is not listed in the first or second section of the stock market. Therefore, this chapter estimated using an available sample of 9 companies observed data. The 9 companies are Tokyo-Gas, Osaka-Gas, Toho-Gas, Saibu-Gas, Hokkaido-Gas, Hiroshima-Gas, Keiyo-Gas, Hokuriku-Gas, and Shizuoka-Gas respectively. The period is 1988-2005. Capital assets might not be accomplished optimal performance of year by year. Hence, this problem is solved by using DEA-Window model, which analyzes the DMU's efficiency by calculating the average of several years. Therefore, I estimate the management performance of utilities at the sight of average of three years.[7] In addition, this analysis is used BCC model because there seems to be scale economy in city gas utilities.

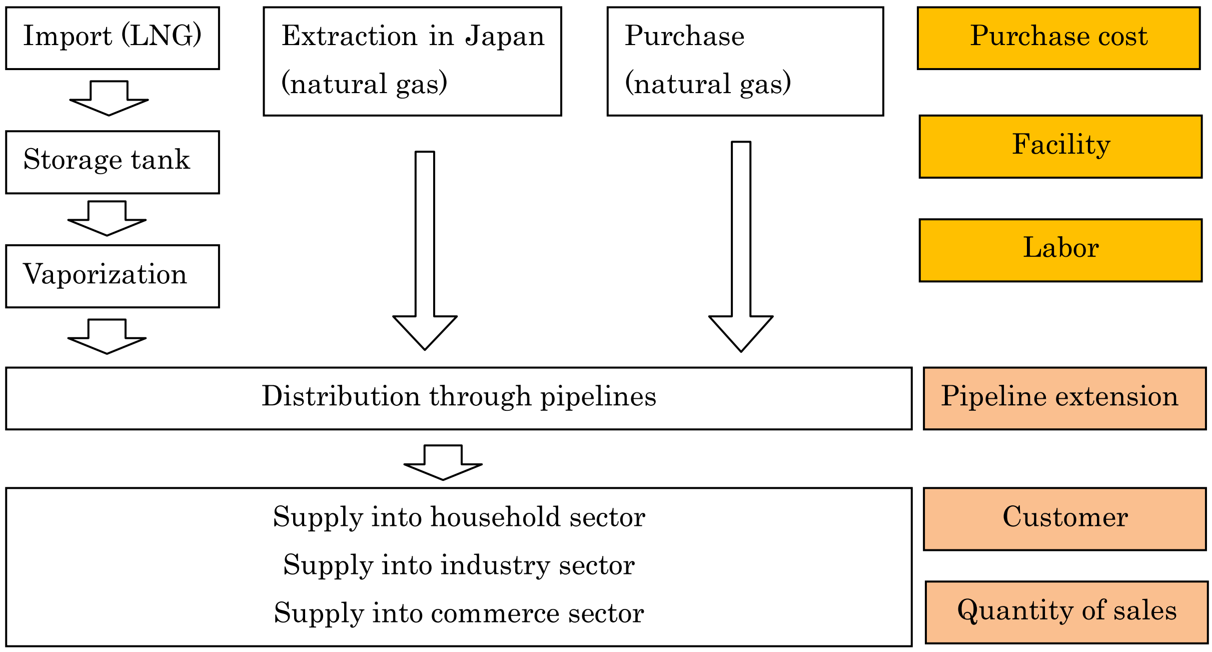

Figure 2-3 The service procedure and the factors of input and output

This model adopts raw material costs, the value of capital assets, and the number of labor as inputs based on related literature. According to the related literature, because a unified view about outputs is not seen, this chapter puts three kinds of models which are shown in Table 2-2, 2-3 and 2-4. These output variables are the amount of sales, the length of pipeline and the number of customers. The reason why the three outputs are used is as follows. First, the amount of sales is proxy for production of utilities. Second, the reason why I used the number of customers and the length of pipeline is that the two variables are able to be proxy for outputs because distribution utilities provide gas to customers through pipelines.

Table 2-2 Input and output at model 1

Inputs	Raw materials cost	The number of labor	The value of capital assets
Outputs	The amount of sales	The number of customers	-

[7] Fabrizio et al.(2008) has defined the capital cost as the average of capital cost for three years, therefore, this analysis has been also defined the capital cost by same procedure.

Table 2-3 Input and Output at model 2

Inputs	Raw materials cost	The number of labor	The value of capital assets
Outputs	The amount of sales	The length of pipeline	-

Table 2-4 Input and output at model 3

Inputs	Raw materials cost	The number of labor	The value of assets
Outputs	The amount of sales	The length of pipeline	The number of customers

Table 2-5 Descriptive statistics (S.D.: Standard deviation)

	Raw materials cost	The number of labor	The value of assets	The amount of sales	The length of pipeline	The number of customers
(Unit)	Million yen	people	Million yen	1000MJ	m	Households
(Average)	47764	3476	286652	87587264	14511118	2074347
(S.D)	61001	4216	368782	130098630	16118816	2749315
(min)	4469	378	22149	5606251	1802564	176870
(max)	234832	12970	1285594	549531736	50568132	9557213

The detail of data is described as follows.

(Inputs)

Raw materials cost= raw materials costs + power / fuel / water service costs + （The amount of beginning of a period product / commodity inventory + purchases of merchandises for the term - end of a term product / article inventory

The number of employees = end of a term number of employees + outside order / trust costs / The labor price of year concerned[8]

Fixed assets = fixed assets total

(Outputs)

The number of customers = consumer's meters （at the end of December）

The amount of sales= the gas sales amount that I appropriated in the settlement of accounts

The length of pipeline = the total extension of branch pipelines (at the end of calendar year)

The data of the number of customers, the amount of sales, and the length of pipeline are quotation from "Annual report of city gas distribution utilities (Gas Jigyou Nenpo)". The data of raw

[8] The labor price of year concerned is the value of total labor cost divided the number of employee at the end of fiscal year. The labor cost is that "Labor cost/Welfare expense(Manufacturing costs)＋Outsource/conversion costs(Manufacturing costs)＋Packing, Transportation, Reserve expense(Manufacturing costs) + Packing, Transportation, Reserve expense(General and administrative costs)＋Labor, welfare costs(General and administrative costs)" .

materials cost, the number of labor, and the value of capital assets are quotation from "The securities report". Raw materials cost and the value of assets have been modified by price index(Based on 2000-year-yen). The software is DEA-SOLVER-PRO.

2-5 Estimation results

The terms of Window which was adopted in this analysis is 3 years. "Before liberalization" is defined as the observation until 1995, and "after liberalization" is defined as the observation after 1995.[9] Furthermore, this chapter examines null hypothesis that the average before liberalization and the average after liberalization are equal. The results are shown in Table 2-6,2-7,and 2-8.[10]

Table 2-6 Estimation result (Model 1)

(Deregulation)	Before	After
Average	0.938	0.975
S.D.	0.067	0.031
t-value	-4.923	
5%significant	1.667	

S.D.: Standard deviation

Table 2-7 Estimation result (model 2)

(Deregulation)	Before	After
Average	0.951	0.960
S.D.	0.067	0.049
t-value	-0.948	
5%significant	1.667	

Table 2-8 Estimation result (model 3)

(Deregulation)	Before	After
Average	0.971	0.983
S.D.	0.050	0.023
t-value	-1.965	
5%significant	1.667	

Model 1(Table 2-6) and model 3(Table 2-8) rejected null hypotheses significantly at 5%. As a result, this chapter verified that the management performance of city gas utilities was improved

[9] The DEA methodology cannot examine the change of economic fabric of society. DEA analysis has to decide the turning point in the transformation in advance.
[10] The dispersion of the values which was estimated by DEA might be normal distribution. The number of observations is 144 and the number is sufficient to act t-test.

clearly. Although model 2(Table 2-7) did not rejected null hypothesis, the average value of management efficiency has improved. The model 2 shows that the length of pipelines might be inappropriate as the variable of output. It is one of the reason that model 2 was not rejected null hypothesis. The city gas utilities generally have three kinds of pipelines, which are high pressure pipelines, middle pressure pipelines, and low pressure pipelines. This chapter did not consider the sorts of pipelines. If this chapter would have considered the sorts of pipelines, the result of this analysis could have been changed significantly.[11]

The purpose of this chapter is to verify whether the management performance is improved or not. The most important policy of deregulation since 1995 is consignment supply. If the consignment supply would be generalized, it could be feasible for utilities to use the pipelines which are owned by a particular utility. The government has decided to the deregulation scheme that a utility can use pipelines owned by other companies, and the utility can use the pipelines whenever it wants to use these pipelines as long as it pays the consignment supply fee. Consequently, the length of pipelines might be inappropriate as output if the consignment supply is popularized in the future.[12]

Next, the values of standard deviation after liberalization are smaller than that of before liberalization in all models. This means the deregulation improved the performance of utilities. Furthermore, the value of each utility performance tends to concentrate into approximately 1. The reason is that, in addition to the intensification of competition among gas utilities, the other competition between the city gas industry and the power generation industry such as the provision of cogeneration system by gas companies and fully electrified homes(fully electric homes) by power companies might be happened after the liberalization started. In short, both the competition among gas utilities and another competition between gas utilities and power companies could improve the management performance of incumbents.[13]

2-6 Conclusions

This chapter has supposed that the deregulation and introduction of market principles improved the management efficiency of city gas utilities. However, DEA methodology has a fault which is affected by an extraordinary value strongly compared to ordinary least square. In fact, although there are several utilities which are performing calorie conversion from petroleum gas to natural gas, these utilities value(DMU) might be estimated too small because this analysis could not

[11] Although one of the outputs in the model 2 is the length of pipeline, judging from estimation results, it seems that the amount of gas flowing in pipelines is more suitable than the length of pipeline. However, this analysis has been used the length of pipeline because we cannot measure the amount of gas flowing in pipelines.

[12] The whole amount of consignment supply is 96,482658(1000MJ). It is 6.17% out of the whole amount(1,562,551,643(1000MJ)) in 2008.

[13] The restrictions of administration both power generation and city gas distribution has been abolished in 1999. The reason is to promote market competition in energy industry. As a result, the competition between gas and electricity has been improved dramatically. It is possible to approve that this improvement might be the influence on liberalizations.

exclude the influence of calorie conversion.[14] On the other hand, I need to explore appropriate inputs and outputs in the city gas industry.

[14] Toho-gas and Keiyo-gas are applicable. The period of the calorie conversion from start to finish is as follows.

(Utility)	Start	Finish
Tokyo-gas	1972	1988
Osaka-gas	1975	1990
Toho-gas	1978	1993
Saibu-gas	1989	2005
Hokkaido-gas	1996	2009
Keiyo-gas	1993	1996
Hokuriku-gas	2008	2011
Shizuoka-gas	1994	2002
Hiroshima-gas	1995	2002

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Appendix(The detail of DEA estimation results)

(Model 1) The value of DEA estimation results

Before liberalization	1988-1990	1989-1991	1990-1992	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	Average
Tokyo gas	1	1	1	1	0.998482	1	0.997677	1	0.99952
Osaka gas	0.878339	0.938758	0.995683	0.99959	0.987879	0.977803	0.983341	0.99489	0.969535
Toho gas	0.822112	0.829337	0.838799	0.833723	0.842566	0.848848	0.847105	0.857676	0.840021
Saibu gas	0.869654	0.871342	0.825474	0.894106	0.859242	0.90463	0.879168	0.948917	0.881567
Hokkaido gas	1	1	1	0.999741	0.995723	0.994451	1	0.997963	0.998485
Hiroshima gas	0.815711	0.814353	0.844291	0.81881	0.794718	0.891065	0.936687	0.999642	0.86441
Keiyo gas	0.90833	0.92591	0.915068	0.899532	0.911264	0.964343	0.9948	0.98975	0.938625
Hokuriku gas	1	1	1	1	1	0.997661	1	1	0.999707
Shizuoka gas	0.98588	0.948713	0.939184	0.963418	0.943077	0.990945	0.950269	0.903201	0.953086

After liberalization	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	Average
Tokyo gas	1	0.995642	0.995642	1	1	1	0.994534	0.95988	0.993212
Osaka gas	1	1	1	1	0.999681	0.998776	0.972163	0.961893	0.991564
Toho gas	0.877668	0.927997	0.899228	0.948805	0.971302	0.989703	0.951701	0.872411	0.929852
Saibu gas	0.953693	0.947042	0.937236	0.967902	0.994201	0.976804	0.97418	0.921708	0.959096
Hokkaido gas	0.987622	0.97258	0.975893	0.98094	0.990003	1	0.995852	0.947897	0.981348
Hiroshima gas	0.980292	0.982612	0.986424	1	0.998476	1	0.987584	0.938997	0.984298
Keiyo gas	1	0.976534	0.990413	0.973448	0.972418	0.99506	1	1	0.988484
Hokuriku gas	1	0.998055	1	1	1	1	1	0.991567	0.998703
Shizuoka gas	0.865514	0.96225	0.981587	0.96228	0.953465	0.943908	0.970455	0.967681	0.950892

(Model 2)

Before liberalization	1988-1990	1989-1991	1990-1992	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	Average
Tokyo gas	1	1	1	1	0.997691	1	0.998982	0.983893	0.997571
Osaka gas	0.969569	0.992444	1	1	0.997027	0.989123	0.988847	0.992449	0.991182
Toho gas	1	1	0.99958	1	0.99903	1	1	1	0.999826
Saibu gas	0.93453	0.942316	0.887929	0.931019	0.906069	0.869853	0.8286	0.887533	0.898481
Hokkaido gas	1	0.981385	0.95224	0.964486	0.963731	0.986899	0.994914	0.975228	0.97736
Hiroshima gas	0.80689	0.787276	0.763747	0.763247	0.783831	0.891065	0.932381	0.999692	0.841016
Keiyo gas	0.97139	0.973123	0.943918	0.922498	0.895768	0.866988	0.814438	0.815638	0.90047
Hokuriku gas	1	1	1	1	1	0.997661	1	1	0.999707
Shizuoka gas	0.98588	0.948713	0.939184	0.963866	0.945618	0.990946	0.950269	0.903201	0.95346

After liberalization	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	Average
Tokyo gas	1	0.990136	0.975883	0.989612	1	1	0.987449	0.938907	0.985248
Osaka gas	1	1	1	1	0.999681	1	0.972705	0.960904	0.991661
Toho gas	1	1	1	1	0.996345	1	0.953592	0.940285	0.986278
Saibu gas	0.891251	0.890801	0.886679	0.933951	0.978787	0.979816	0.958997	0.879168	0.924931
Hokkaido gas	0.930754	0.884687	0.862024	0.887088	0.898282	0.887765	0.860866	0.810526	0.877749
Hiroshima gas	0.981547	0.97791	0.979257	0.996043	0.999163	1	0.987045	0.932855	0.981727
Keiyo gas	0.837157	0.893596	0.92068	0.954744	0.97798	0.996547	1	0.990204	0.946363
Hokuriku gas	1	0.997879	1	1	1	1	1	0.992185	0.998758
Shizuoka gas	0.865514	0.96225	0.981587	0.96228	0.953465	0.943908	0.970455	0.967681	0.950892

(Model 3)

Before liberalization	1988-1990	1989-1991	1990-1992	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	Average
Tokyo gas	1	1	1	1	0.998482	1	0.998982	1	0.999683
Osaka gas	0.969569	0.992444	1	1	0.997055	0.989123	0.99148	0.99489	0.99182
Toho gas	1	1	0.99958	1	0.99903	1	1	1	0.999826
Saibu gas	0.951888	0.958229	0.918018	0.95089	0.931638	0.934308	0.903055	0.965312	0.939167
Hokkaido gas	1	1	1	0.999741	0.997896	0.996083	1	0.997963	0.99896
Hiroshima gas	0.815711	0.814353	0.844291	0.81881	0.794718	0.891065	0.936688	1	0.864454
Keiyo gas	0.979344	0.996891	0.997406	0.986049	0.967793	0.984099	0.996872	0.992667	0.98764
Hokuriku gas	1	1	1	1	1	0.997661	1	1	0.999707
Shizuoka gas	0.98588	0.948713	0.939184	0.963866	0.945618	0.990946	0.950269	0.903201	0.95346

After liberalization	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	Average
Tokyo gas	1	0.995642	0.995642	1	1	1	0.994534	0.95988	0.993212
Osaka gas	1	1	1	1	0.999681	1	0.974228	0.961918	0.991978
Toho gas	1	1	1	1	0.996375	1	0.953592	0.940285	0.986281
Saibu gas	0.974014	0.976058	0.956152	0.977015	1	0.986918	0.97874	0.92633	0.971904
Hokkaido gas	0.987622	0.977847	0.975893	0.98094	0.990003	1	0.995852	0.947897	0.982007
Hiroshima gas	0.982538	0.982612	0.986424	1	0.999163	1	0.987584	0.938997	0.984665
Keiyo gas	1	0.976534	0.990413	0.974026	0.97798	0.996547	1	1	0.989437
Hokuriku gas	1	0.998055	1	1	1	1	1	0.992185	0.99878
Shizuoka gas	0.865514	0.96225	0.981587	0.96228	0.953465	0.943908	0.970455	0.967681	0.950892

Chapter 3

A study of vertical integration between a manufacturing and a sales sector

(Summary)

The purpose of this chapter is to analyze vertical integration seen in city gas distribution utilities(the general gas suppliers) in Japan. In the real world, there are two types of organizational forms in the city gas utilities: One has only a sales sector, and the other has both a manufacturing sector and a sales sector. The former type purchases natural gas from wholesalers, and provides the gas to its own service area concerned, while the latter type holds vaporizing facilities to transform LNG into natural gas, and provides the gas in its own service area. Each gas distribution utilities select whether to integrate a manufacturing sector or not, based on the market situation and economic activities.

This chapter examines the case from the perspective of transaction cost economics. In this theory, as transaction costs grow, the utilities integrate both the manufacturing and sales sector into their operations. This chapter defines the size of the company and the sales growth rate as the variable of long term uncertainty, the inventory and sales variance as the variable of short term uncertainty, and site specificity known as the variable of asset specificity.

This chapter concludes that gas utilities tend to integrate a manufacturing sector if short term uncertainty rises and site specificity declines. This means they tend to purchase their gas from outside suppliers and engage only in retail sales because they are able to be lower transaction costs effectively when gas retailers gather in the same vicinity.

3-1. Introduction

With regard to the management of a manufacturing and a sales sector, this chapter examines which is better, the method of purchasing natural gas from wholesalers through pipelines or the method of transforming LNG(liquefied natural gas) into natural gas by using its own facility. In terms of this point, this chapter will consider the issue from the perspective of transaction cost economics.

As of March 2008, there were 212 city gas utilities throughout Japan. 180 out of 212 are administered by private and 32 are administered by public(municipalities). The kinds of supply gas are natural gas and petroleum gas[1].

The natural gas transport systems of Japanese distribution utilities differ due to the diversity of historical and geographical characteristics. Figure 3-1 illustrates the flow of production and sales procedures. As can be seen Figure 3-1, this chapter defines the procedure of the importation to transformation of natural gas as belonging to the manufacturing sector, and defines the procedure from adjustment to supply as belonging to the sales sector.

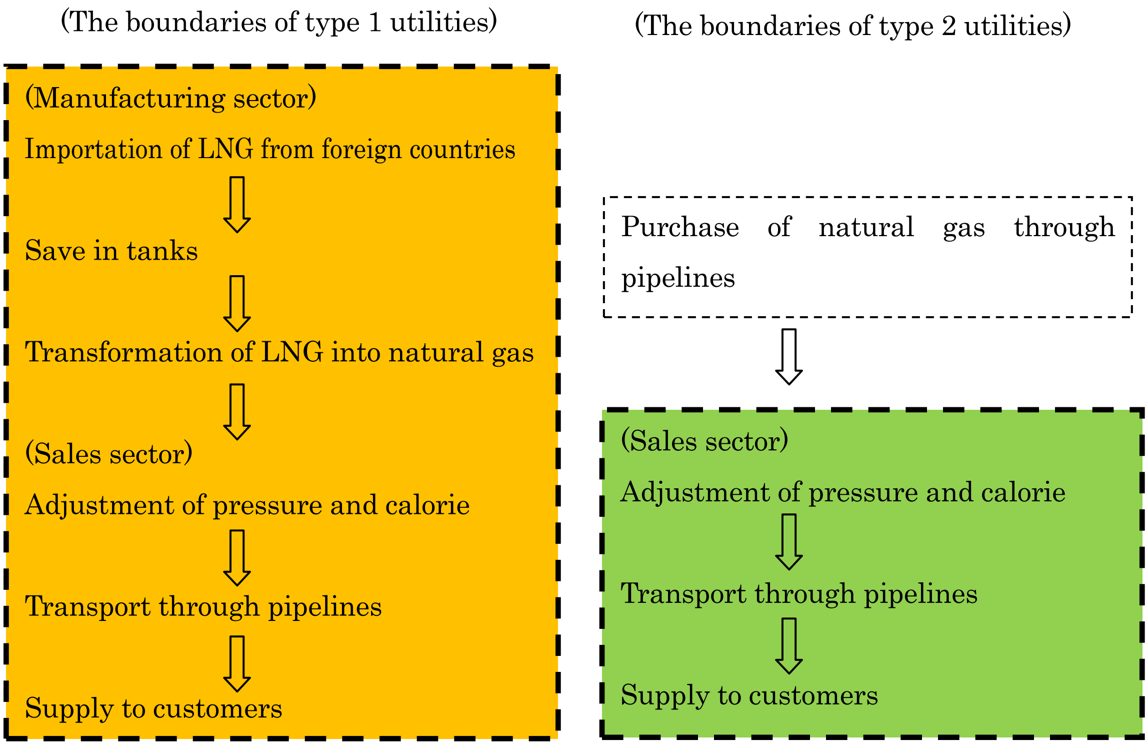


Figure 3-1 Service procedure and the boundaries of two utilities

[1] At the end of March 2011, almost all utilities provide only natural gas.

3-2. Market structure and regulations

The government licenses city gas utilities, thus grating them permission to sell natural gas based on the principle of natural monopoly. Although the utilities are obliged by the government to provide natural gas to customers in their own area, there are no regulations in a manufacturing sector. Hence, several utilities possess both a manufacturing and a sales sector, while other utilities possess only a sales sector. The flows of both sectors are illustrated in Figure 3-1. A utility which holds a manufacturing sector transforms LNG imported into natural gas by using its own facility, and then the utility supplies natural gas to customers in its own area. On the other hand, the other utilities do not possess a manufacturing sector. Those utilities provide natural gas which was purchased from other gas utilities or wholesalers through pipelines. Consequently, there are two kinds of utilities in the city gas industry due to no regulations related to a manufacturing sector.

Figure 3-2 shows the locations of utilities which do not possess a manufacturing sector. The utilities purchase the whole amount of natural gas to provide through pipelines. According to Figure 3-2, a lot of utilities tend to be close to the large utilities such as Tokyo-gas or near the regions in which natural gas is gathered such as Niigata, Akita, and Chiba prefecture.

Simultaneously, Figure 3-3 shows the locations of utilities which hold both a manufacturing and a sales sector. Compared to the locations in Figure 3-2, the utilities tend to exist widely throughout Japan and there are a lot of utilities in the districts where they cannot purchase natural gas from wholesalers.

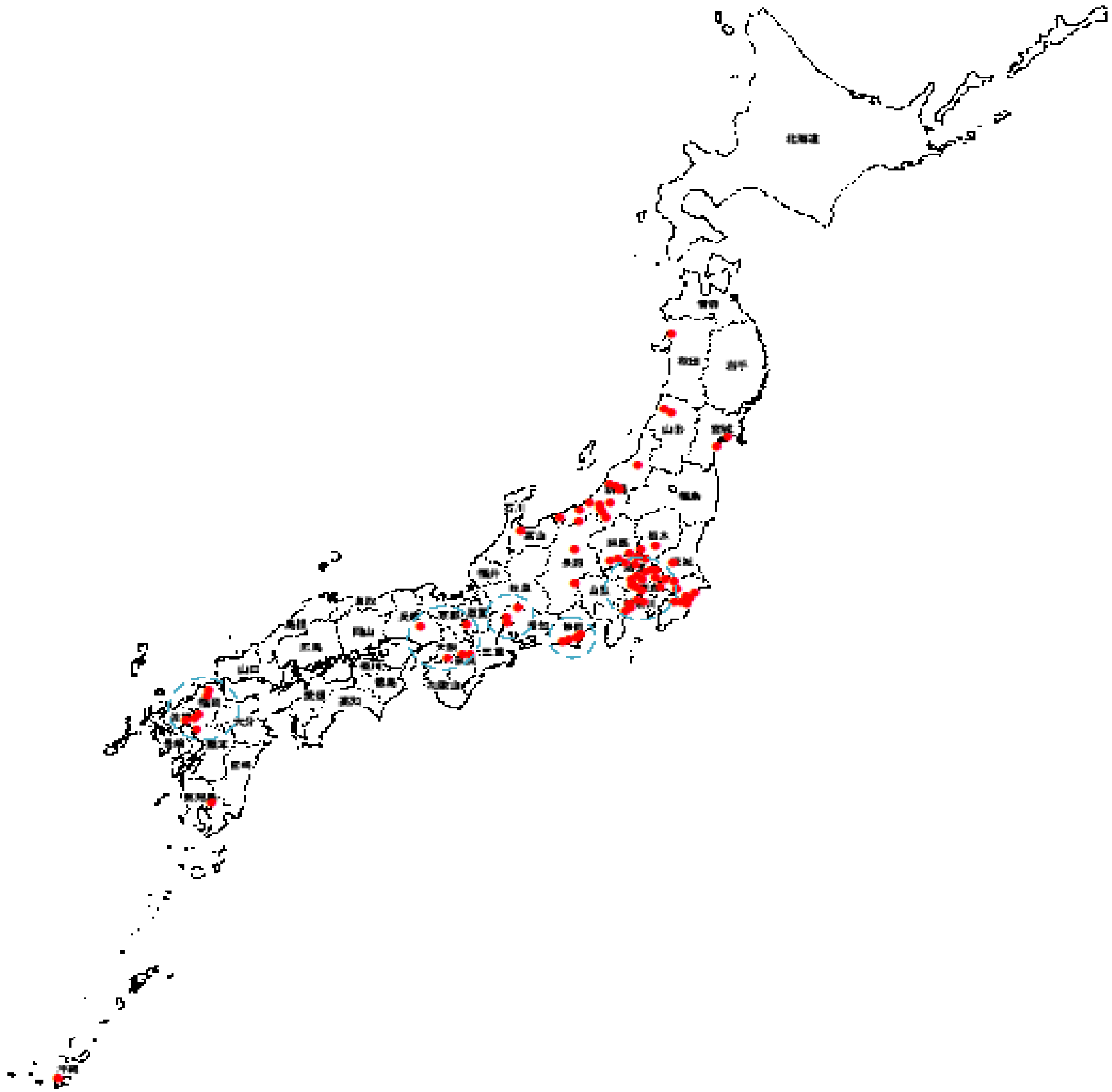
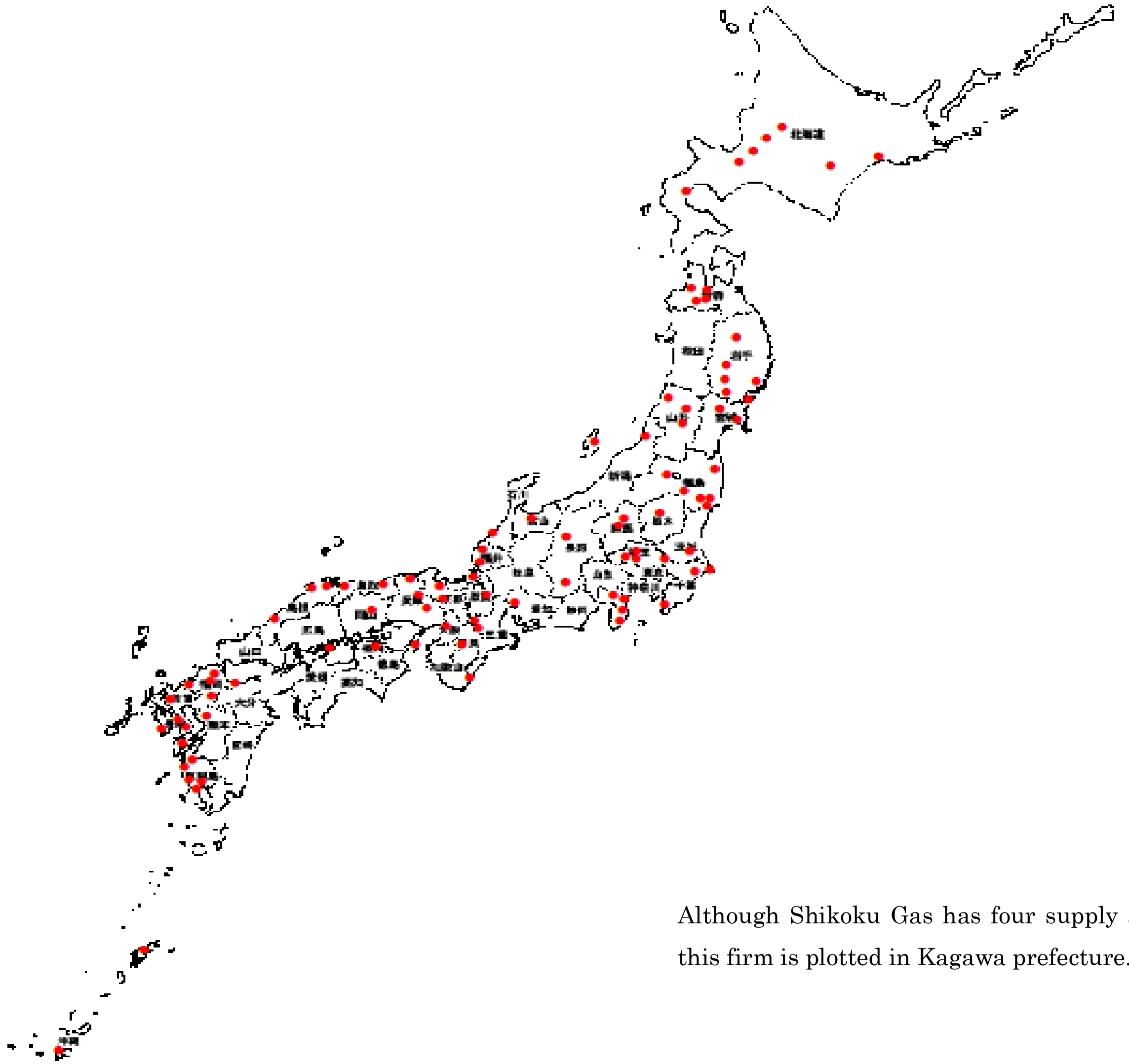


Figure 3-2 Locations of utilities without a manufacturing sector



Although Shikoku Gas has four supply areas, this firm is plotted in Kagawa prefecture.

Figure 3-3 Locations of utilities with both a manufacturing and a sales sector

Figure 3-4 illustrates the relationship between utility scale and production ratio. The horizontal axis is the number of customers in the utility, which is used as the proxy of the scale. The amount of the vertical axis is its own production ratio of supply out of the whole supply. The value of "0" means that the whole amount of supply in the utility is purchased from wholesalers. The value of "1" means that the whole amount of supply is gas produced by using its own facility. Although there is a tendency to concentrate on both sides of 0 and 1, several utilities provide not only gas purchased from wholesalers but also gas produced by their own facilities. Moreover, a remarkable correlation does not seem to be existed between the number of customers and the determinants in the choice of holding a manufacturing sector.

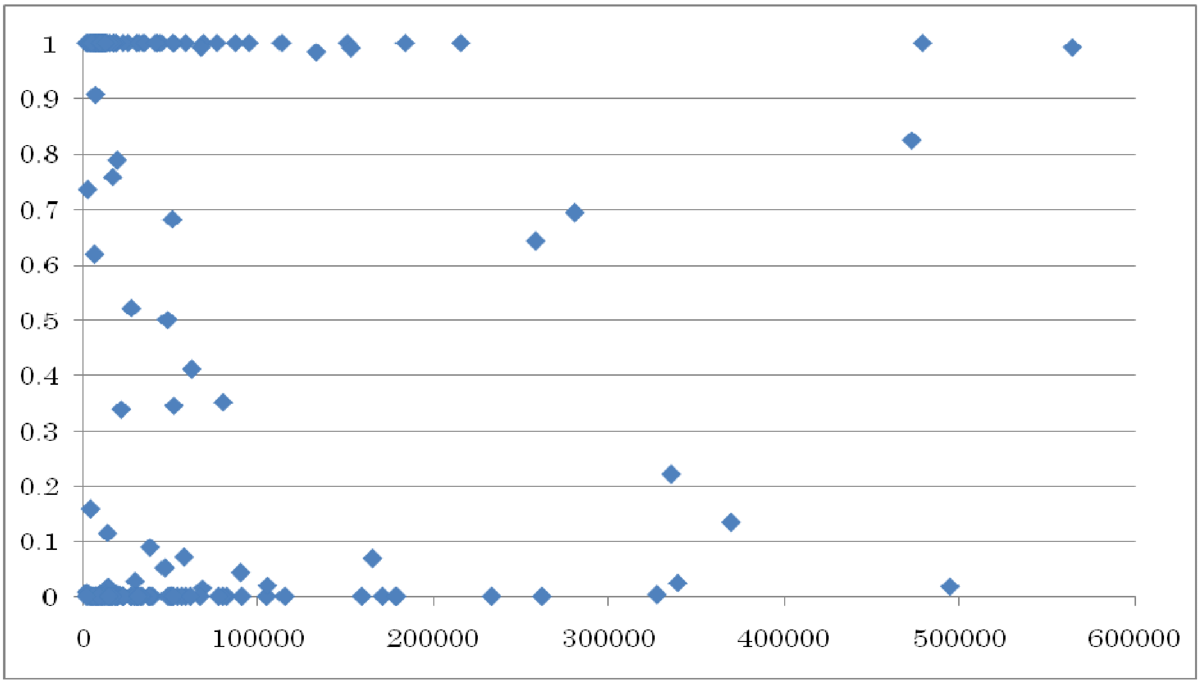


Figure 3-4 Its own production ratio of supply out of the whole supply ("big6" not shown)[2]

The determinant of the choice whether to own a manufacturing sector or not is one of the most important factors when a utility tries to improve the management performance. However, the choice tends to be decided by historical circumstance. In particular, Integrated Gas Family 21 plan(IGF21), issued by Ministry of International Trade and Industry in 1990, impacts considerably on the determinant of the choice of holding manufacturing sector.

This plan is that the Japan Gas Association, the Japan Industrial Association of Gas and Kerosene Appliances made concrete plans for integration of the city gas groups into the high-calorie groups by 2010. This plan was implemented in three ways. First, a firm should purchase natural gas through pipelines from wholesalers in the vicinity if the wholesalers have already performed transforming from petroleum gas into natural gas. Second, in the case where a firm cannot purchase natural gas from wholesalers, the firm should construct a vaporization facility to transform LNG into natural gas, and provide the gas to customers. Third, if a firm

[2] This figure used the data of the city gas utilities(213 utilities, 2008). Big6 (0.97;Tokyo Gas, 1;Osaka Gas, 1;Toho Gas, 0.59; Saibu Gas, 0.09; Hokkaido Gas, 0.003; Keiyo Gas) are not shown in this figure.

cannot neither purchase through pipelines nor construct its own facility, the utility should provides SNG(substitute natural gas) which blends liquefied petroleum gas, naphtha, and coke oven gas or propane air dilute gas which decreases its calories by means of injecting air. Most of the city gas utilities performed gas calorific conversion(adding calorie) by selecting one out of these three means.[3]

Meanwhile, uncertainty would also influence the choice of the vertical integration. Stable procurement is indispensable for all utilities because they bear the liability for public utilities. Nevertheless, it might be difficult to continue the stable procurement due to uncertainty, and all utilities provide gas under difficult conditions. To decrease the uncertainty, the gas utilities purchase natural gas from two different wholesalers, and set up several storage tanks(Gas Holders) in its own area in order to save natural gas.

3-3. Transaction Cost Economics(TCE)

Here, let me denote the context of Transaction Cost Economics(TCE) because we are able to prove the determinant whether a firm owns a manufacturing sector or not in terms of the theory of boundaries in a firm.

There are invisible costs between separate firms and also invisible costs between divisions within the same company. TCE can be explained as how the method when an entrepreneur makes a decision regarding the vertical integration of two companies. When a firm does business with a particular firm, if invisible costs are too expensive, the firm has an incentive to integrate with another firm, and if the invisible cost between the two firms is not overly expensive, the firm will not integrate with a different firm, however, it will continue to do business with a second firm. Invisible costs were first identified by Coase(1937)[4] .

The idea of invisible costs identified by Coase(1937) was developed as transaction costs economics by Williamson(1975,1985,1995). He charged the term to invisible costs "transaction costs", and explained the rise of transaction costs by several factors. According to the literature of Williamson(1985), there are three factors which give rise to transaction costs between two firms.

1. Uncertainty

When a specific firm(firm A) trades with another firm(firm B), a certain level of uncertainty regarding the trade is invariably present in firm A. There is no guarantee that the trade with firm B will proceed according to plan. This uncertainty is likely decreased by a merger with firm B.

2. Relationship specific assets

When firm A trades with firm B, firm A or firm B occasionally makes investments which can be used only between the two firms. If a firm holds such assets, they are called relationship

[3] The "Integrated Gas Family 21 Plan" was proposed by Agency of Natural Resources and Energy, Ministry of International Trade and Industry, in January 1990. In response, the Japan Gas Association and the Japan Industrial Association of Gas and Kerosene Appliances made concrete plans for integration of the gas groups of city gas into the high-calorie groups by 2010.

[4] Coase(1937) has not used the word of "Transaction Costs".

specific assets. When the relationship specific assets which a firm owns increase, the transaction costs also rise.

Relationship specific assets are classified into four kinds of specificities, these are referred to as: site specificity, physical asset specificity, human asset specificity, and dedicated assets.

3. Frequency

In the case where firm A and Firm B trade each other, transaction costs depend on the frequency. If the frequency of the trade rises the transaction costs also rise.

3-4. Related Literature

This chapter empirically examines the determinants of vertical integration focusing on the city gas industry in Japan. Since Coase's(1937) seminal work, there is a lot of literature related to transaction cost economics. However, there is no literature related to transaction cost economics in the city gas industry in Japan as far as I know.

There are several notable papers based on transaction cost views of vertical integration in the automobile industry. First, Monteverde and Teece(1982) tests a transaction cost theory of vertical integration with data from the United States automobile industry. Analyzing asset specificity of GM and Ford, they have shown that the probability of vertical integration between two firms might rise because the manufacture of parts which needs advanced technologies in automobiles tends to become relationship specific assets. Second, Masten et al(1989), extending the analysis of Monteverde and Teece(1982), categorizing specific assets into human assets and physical assets, and insist that human assets affect vertical integration more than physical assets. Third, Walker and Weber(1984,1987) show that, focusing on the uncertainty, the higher the uncertainty of getting manufacturing parts is, the higher the probability of vertical integration becomes.

As one of the literature treating large number of industries, Levy(1985) estimates the boundaries of firm by using 67firms' data (37industries) and cross section analysis, and puts asset specificity as R&D investment, and moreover puts uncertainty as variance of sales and so on.

There are several notable papers in public utility fields. Joskow(1985,1987) show that the power plant tends to construct near the mining pits, and the vertical integration between plants and pits has been widely spread. Crocker and Masten(1996) researches the organizations of public utilities in the United States.

Shelanski and Klein(1995) reviews empirical analysis of the TCE, and shows the way of methodology. David(2004) categorizes the empirical methodology of uncertainty and asset specificity.

Although it is not an approach from TCE, Masten and Crocker (1985) shows that long-term contract is made between natural gas mining companies and pipelines companies in the United States to avert the uncertainty. Besides, Whinston(2001,2003) explains property rights theory(PRT) by using a mathematical model, and discusses the difference between the nature of PRT and TCE.

3-5. Empirical Analysis

Before this chapter makes an empirical analysis with regard to the choice of holding a manufacturing sector, let me denote the application of transaction costs[5] in city gas utilities. Figure 3-5 illustrates transaction costs and internal costs in city gas utilities. Transaction costs mean the external costs between firm A and firm B, whereas internal costs mean the costs between a division and another division within a company. If transaction costs are greater than internal costs, firm B(or firm A) should consolidate or acquire firm A(or firm B)(Vertical integration). If transaction costs are smaller than internal costs, firm B(or firm A) should trade with firm A(or firm B). Although I should observe both transaction costs and internal costs directly, it would not be feasible to measure internal costs directly and accurately. Nevertheless, there is the positive correlation between the increase of transaction costs and the incentive for vertical integration, and then the incentive to integrate the manufacturing sector also rise when transaction costs grow.

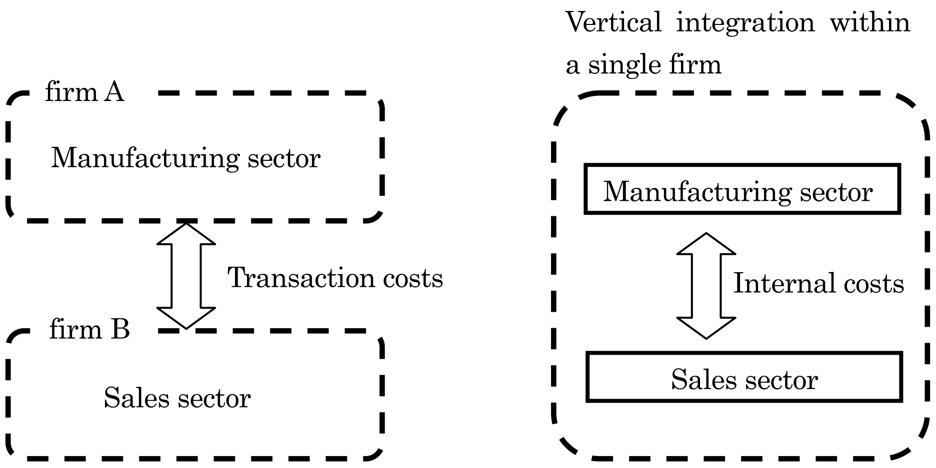


Figure 3-5 Transaction costs and internal costs

Here, this chapter examines the factors of transaction costs in the city gas industry. As shown in section 3-3, transaction costs include uncertainty, relationship specific assets, and frequency. Let me define uncertainty and relationship specific assets as transaction costs, and then estimate the costs by means of empirical models. In city gas utilities, one of the factors of uncertainty would be fluctuation in the amount of sales. If the area is large, the amount of sales is also large. If the supply area is spread or the number of customers grows larger, it would be not feasible to purchase the whole amount of sales from wholesalers. Therefore, let me define the growth rate of sales as one of the factors of long-term uncertainty.

On the other hand, the demand of gas is influenced by seasonal factors. Monthly sales variance and inventory sources also fluctuate because of changes in the demand of gas. Hence,

[5] Williamson(1985, p20) states that "transaction costs of ex ante and ex post types are usefully distinguished. The first are the costs of drafting, negotiating, and safeguarding an agreement". Based on this statement, this analysis will estimate ex ante transaction costs.

let me define monthly sales variance and inventory as sources of short-term uncertainty.

Next, relationship specific assets would be site specificity. This chapter defines site specificity as sources of relationship specific assets.

Based on the definition above, I suppose three hypotheses.

Hypothesis 1: When long-term uncertainty rises, and then transaction costs also rise.
Hypothesis 2: When short-term uncertainty rises, and then transaction costs also rise.
Hypothesis 3: When site specificity exists, and then transaction costs decline[6].

With respect to these hypotheses, I compose the following equation of integration.

$$Integration = f(LU, SU, SS)$$

LU: long-term uncertainty, *SU:* short-term uncertainty, *SS:* site specificity

Here, dependent variable "integration" is the ratio of utilities' product(ratio of the supply produced by using its own facilities out of its whole supply). Independent variables are the ratio of the firm's supply amount out of the whole supply in the city gas industry, the number of customers, average sales growth rate(absolute value), sales variance, stock dummy[7], the rate of inventory (absolute value), monthly sales variance, site specificity dummy, and the dummy which purchases gas from wholesalers excluding city gas utilities. The ratio of the firm's supply amount out of the whole supply in the city gas industry, the number of customers, and sales growth rate are the proxy for long-term uncertainty. The sales variance, Stock dummy, the rate of inventory, and the monthly sales variance are the proxy for short-term uncertainty. Site specificity dummy and the dummy which purchases gas from wholesalers except for city gas utilities are the proxy for site specificity. More detailed data are as follows.

(Dependent variable)

Variable	Definition
Own	A company's own ratio of product[8] $\left(\dfrac{A\ supplier's\ \ own\ \ ratio\ \ (\mathrm{MJ})}{A\ supplier's\ \ whole\ \ product\ \ (\mathrm{MJ})}\right)$

(Independent variable: Long-term uncertainty)

Variable	Definition
Scale	A ratio of an amount of a utility's supply out of the whole supply in the city

[6] In this analysis, site specificity will be defined as the characteristic that utilities are able to purchase natural gas from wholesalers or other utilities.
[7] The variance of stock price fluctuation is superior to the dummy variable of public companies on the stock market. However, the fluctuation of non public companies is zero. This analysis adopts a dummy variable because logarithms cannot calculate zero.
[8] In the case of dependent variable of Probit model, if the utility holds manufacturing sector, assign 1. Otherwise, 0.

	gas industry $\left(\frac{Sales \quad of \quad a \quad \sup plier(MJ)}{Whole \quad Sales \quad in \quad the \quad industry(MJ)} \right)$
Demand	The number of customers
Sgrowth	Average sales growth rate of the past 12 years(1995-2006)(Absolute value)
Salevar	Sales variance for the past 12 years

(Independent variable: Short-term uncertainty)

Variable	Definition
Inventory	The rate of inventory(absolute value) $\left(\frac{product - sales}{product} \right)$
Msalevar	Monthly sales variance
Stock	Stock dummy If a utility is listed on the stock market, assign 1. Otherwise 0.

(Independent variable: Site specificity)

Variable	Definition
Site1	Site specificity dummy If a utility borders on another utility or there are domestic gas fields[9] in its own area, assign 1. Otherwise, 0.
Site 2	Wholesalers dummy If a utility purchases gas from wholesalers(excluding city gas utilities), assign 1. Otherwise 0.

(Equation)

$$e^x = aLU_l^{b_l} SU_m^{c_m} SS_n^{d_n}$$
$$\ln e^x = \ln aLU_l^{b_l} SU_m^{c_m} SS_n^{d_n}$$
$$x = \alpha + b_l \ln LU_l + c_m \ln SU_m + d_n \ln SS_n$$

x: Transaction costs, LU_l: l-th long term uncertainty, SU_m: m-th short term uncertainty, SS_n: n-th site specificity, α: constant.

The number of observations is 208. Although the number of utilities in Japan is 212, utilities which could not obtain the detailed data were excluded in my analysis. Probit model and OLS

[9] There are 17 gas fields in Japan. For example, Yufutsu field(owned by Japan Petroleum Exploration Co.,Ltd), Yatsuhashi field(owned by INPEX Corporation), and so on.

model (Ordinary least square) are used in this chapter. I used the software of TSP5.1.

Table 3-1 Expected sign

	Scale	Demand	Sgrowth	Salevar	Inventory	Msalevar	Stock	Site1	Site2
sign	+	+	+	+	+	+	+	−	−

Table 3-2 Descriptive statistics

	Own	Scale	Demand	Sgrowth	Salevar	Inventory	Msalevar
(Unit)	-	-	(house)	-	-	-	-
Mean	0.5136	0.0048	164929.875	0.040	7.43E+13	0.0133	835.095
Variance	0.2294	0.0011	8.44405E+11	0.033	7.21E+29	0.0009	16802490
Min	0	8.6E-06	1289	-0.064	18547586	-0.1023	1.116325
Max	1	0.3826	10994225	2.575	1.2E+16	0.1607	46295.54

Table 3-3 Probit model results

Coefficient	Model 1	Model 2	Model 3	Model 4
Constant	0.263(1.102)	1.059(1.017)	1.002(1.015)	1.956**(0.810)
Scale	-0.099(0.871)			
Demand		0.030(0.092)	0.064(0.087)	
Ave growth rate	0.068(0.106)	0.032(0.108)	-0.069(0.088)	0.059(0.105)
Salevar	-0.156*(0.084)	-0.122(0.084)		-0.148*(0.083)
Household rate	-0.181(0.208)	-0.067(0.184)	-0.046(0.183)	-0.153(0.198)
Inventory	0.232***(0.084)	0.244***(0.083)	0.239***(0.083)	0.230***(0.084)
Msalevar				-0.048(0.043)
Stock	2.411***(0.683)	2.037***(0.687)	1.918***(0.678)	2.361***(0.663)
Site1	-1.263***(0.231)	-1.370***(0.217)	-1.345***(0.215)	-1.256***(0.233)
Site2	-0.297(0.352)	-0.343(0.354)	-0.308(0.350)	-0.298(0.353)
R-square	0.31	0.30	0.30	0.31
Log likelihood	-98.319	-98.918	-99.972	-98.331
Observations	208	208	208	208

(The parentheses: standard deviation t-test*significant at 1%, **5%, *10%)**

Table 3-4 OLS model results

Coefficient	Model 1	Model 2	Model 3	Model 4
Constant	0.501*(0.281)	1,020***(0.285)	1..253***(0.228)	1.284***(0.221)
Scale	-0.044*(0.023)			
Demand		-0.010(0.025)		)
Ave growth rate	-0.011(0.024)	-0.009(0.029)	-0.003(0.028)	-0.012(0.023)
Salevar		-0.007(0.024)	-0.014(0.024)	
Household rate	-0.001(0.061)	0.045(0.057)	0.001(0.060)	0.006(0.059)
Inventory	0.059**(0.023)	0.064***(0.024)	0.057**(0.024)	0.057**(0.023)
Msalevar			-0.025**(0.012)	-0.024**(0.011)
Stock	0.374***(0.144)	0.258*(0.145)	0.372***(0.139)	0.368***(0.139)
Site1	-0.388***(0.067)	-0.437***(0.063)	-0.376***(0.068)	-0.378***(0.675)
Site2	-0.194**(0.094)	-0.216**(0.096)	-0.199**(0.095)	-0.193**(0.094)
Adjusted R-square	0.29	0.27	0.29	0.29
Log likelihood	-102.250	-104.080	-101.663	-101.850
Observations	208	208	208	208

(The parentheses: standard deviation, t-test ***significant at 1%, **5%, *10%)

3-6. Conclusions

Here, let me consider three hypotheses. First, as far as the long-term uncertainty of hypothesis 1 is concerned, the coefficient of the ratio of a certain company's supply out of the whole supply in the city gas industry and the coefficient of the number of customers are not respectively satisfied significant at 5% in all models. Hence, the scale of utility such as the amount of sales and the number of customers might not influence vertical integration. I recognize that the amount of sales and the number of customers are the proxy of the scale of utility. However, we can also recognize those costs as internal costs when a utility merges with a firm. Therefore, I have to pay attention to interpreting the variables.[10]

Second, with regard to hypothesis 2, the coefficients of inventory in all models are satisfied significant at 5% respectively. In model 3 and 4(Table 3-4), monthly sales variance is also satisfied significant at 5%. Third, as far as hypothesis 3 is concerned, the coefficients of site1 are satisfied significant at 5% in all models. If site specificity for which a utility could purchase gas in the vicinity exists, transaction costs decline, and the incentive of vertical integration might also reduce.

[10] The sales share and the number of customers are representative variables of the size of the utilities. When the utility size is larger, the larger size increases not only the risk of purchasing natural gas but also the internal cost of the utility. Although the results have shown correlation between the risk and the internal cost, the increase of utility scale might have some influence in the determinant of the choice of vertical integration more strongly than the increase of internal cost. In addition, several large utilities such as Tokyo-Gas tended to make investments in manufacturing equipment because the government has enforced these utilities on the investments by IGF 21 plan(administrative advice).Therefore, these utilities needed to enlarge sales by selling gas to residential neighborhoods.

According to the estimation results, this analysis does not recognize that long-term uncertainty could impact on the determinant of the choice of vertical integration strongly. On the other hand, site specificity and short-term uncertainty might impact the determinant of the choice of vertical integration significantly.

Actually, utilities which only hold supply sector are in the urban regions or in Niigata, Akita, and Chiba prefecture. There are domestic natural gas fields in Niigata, Akita, and Chiba prefecture. It is ease for these utilities to purchase from wholesalers. Therefore, the site specificity makes transaction costs lower, and the utilities tend to purchase natural gas from wholesalers.

Finally, the concept of TCE is to minimum the cost of management, and this chapter does not pay attention to consider scale economies, the strategy of management, and externality. Those extensions need to be pursued in the future research.

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Chapter 4

A Study of Scale Economies and Price Differential

(Summary)

The purpose of this chapter is to prove price differential of the city gas industry in Japan by estimating scale economies.

There are three organizational forms in the city gas industry in Japan. In particular, the organizational forms between utilities which purchase natural gas from wholesalers and utilities which provide natural gas transformed into LNG by using its own facility are quite different. They are respectively trying to pursue their efficiency in a competitive manner. However, the results turned out to be quite different. This chapter estimates scale economies in two types of suppliers and factor analysis on the price of their suppliers, and then examines the influence which the differential of two organizational forms gave to gas price.

In conclusion, the affects of scale economy of utilities which purchase natural gas from wholesalers is larger than that of utilities which supply natural gas transformed into LNG by using its own equipment. In addition, this paper found that the prices of larger scale utilities were constant or at least not rising. This means that the city gas price has been decided under the influence of scale economies.

This paper has also found that price differential will become increasingly larger in the future. If the city gas industry is considered a universal service, the government needs to reduce this price differential. However, if this industry is considered a local service in a particular district, several utilities would lose in the competition, then stop supplying, and finally leave the market. Hence, the government needs to make a new policy as a next step after the reform of liberalization since 1995 by considering whether this industry is universal or not.

4-1. Introduction

In Japan, the natural gas(including petroleum gas) industry is classified into three business forms, which are city gas utilities, community gas utilities, and LP gas utilities. These utilities provide natural gas or petroleum gas to customers through pipelines. City gas utilities tend to be operating in large cities throughout Japan. Community gas utilities supply gas to customers in smaller areas compared to city gas utilities by using simple facilities and pipelines. These utilities generally operate in the suburbs close to large cities. LP gas utilities supply gas to customers in areas where the two kinds of utilities mentioned above cannot supply gas. LP gas utilities tend to operate in rural areas. The purpose of this chapter is to prove price differential of the city gas industry by estimating scale economies. And moreover, I verify that the price differential is caused by deregulation in the city gas industry.

The city gas industry has been deregulated gradually since 1995. In the reform of 1995, the government introduced the institution that customers who demand 2,000,000m^3 or more could purchase gas from suppliers outside of their area's supplier. The government also instituted a slight adjustment to the energy price. In the reform of 1999, the institution which customers could purchase gas from other suppliers was extended from 2,000,000 m^3 or more to 1,000,000 m^3 or more, consignment supply[1] was legislated and formally instituted. The government deregulated the retail sales price. In the reform of 2003, by legal institution the gas pipeline service company(Doukan Jigyosya) was established, and the range of liberalization was extended from 1,000,000 m^3 or more to 500,000 m^3 or more. Finally, the range of liberalization was enlarged to 100,000 m^3 or more in 2007. The purpose of the deregulation above is to decrease the gas price by means of introduction of competitive principle.[2]

To evaluate the effect of the deregulation, I classified city gas utilities as three kinds of organizational forms based on the groups of yardstick regulation.[3]

1. "Big supplier[4]" (Utilities which provide natural gas to 150,000 or more customers)

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[1] It means that every company can use the pipelines which a particular company owns. This institution is called "Open Access".

[2] The consignment supply is gradually increasing by this deregulation. The whole amount of consignment supply including wholesale and retail is 96,482,658,000MJ. The ratio of consignment supply out of the whole amount of total sales(1,562,551,643,000MJ) is 6.17% in 2008.

[3] There are seven classifications in yardstick regulation. The seven are as follows.
(1) 150,000 or more customers
(2) Purchase from wholesalers
(3) Hold facilities(LNG-satellite, LNG-air)
(4) Use a lot of materials(LNG, LPG, Naphtha etc.)
(5) Public utility(Municipal utility) and purchase from wholesalers
(6) Public utility(Municipal utility) and hold facilities(LNG-satellite, LPG-air)
(7) Public utility(Municipal utility) and use some types of material(LNG, LPG, Naphtha etc.)

In this chapter, (1) is defined as big supplier, (2) and (5) are defined as pipeline based supplier, and (3), (4), (6), and (7) are defined as Vertical integrated supplier. The utilities of big supplier are Tokyo-gas, Osaka-gas, Toho-gas, Saibu-gas, Hokkaido-gas, Keiyo-gas, Hokuriku-gas, Shizuoka-gas, Hiroshima-gas, and Nihon-gas respectively.

[4] Due to the emphasis of supply sector, I use the word of "supplier" instead of the word of "utility" in this chapter.

2. “Pipeline based supplier” (Utilities which purchases natural gas from wholesalers through pipelines)
3. “Vertical integrated supplier” (Utilities which provide natural gas by using vaporizing facilities)

Within the three kinds of gas utilities, the big supplier is the leader in the region, and holds huge manufacturing facilities. The big supplier provides natural gas not only to customers in its own area but also to city gas suppliers in the vicinity. The pipeline based supplier, which is shown on the right side of Figure 4-1, constructs trunk pipelines to other suppliers in the vicinity, and then purchases natural gas through the pipelines, and provides the gas to customers in its own area. The vertical integrated supplier, which is shown in Figure 4-1 on the left side, purchases LNG, then vaporizes the LNG into natural gas by its own facility, and provides this gas to customers in its own area. The Vertical integrated supplier has to possess vaporizing facilities because this supplier cannot tie pipelines between the area and other suppliers.[5]

I researched the authorization prices(Ninka kakaku) in the household sector. The prices are approved by government. Table 4-1 shows the average authorization prices in the three types of suppliers.

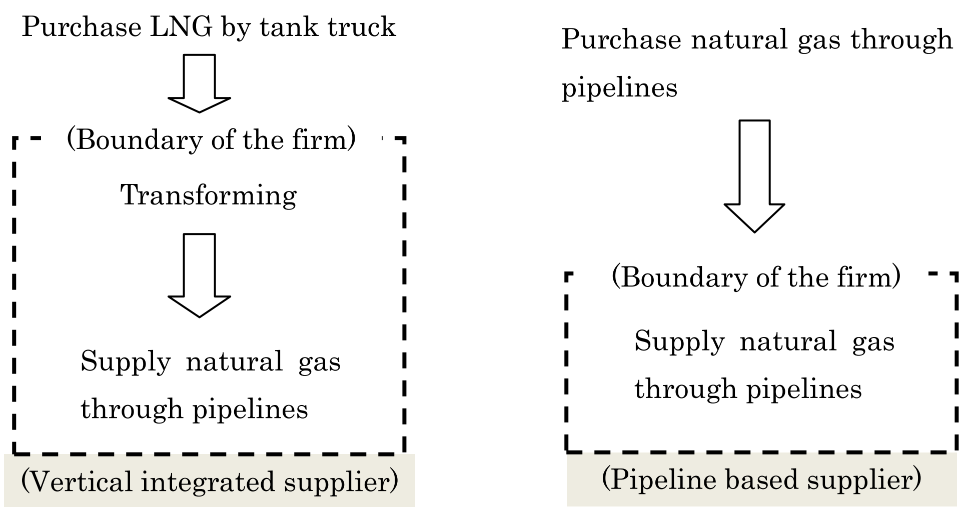

Figure 4-1 The organizational forms

[5] Because the city gas supplier is assigned the supply area by the government, the supplier is basically a monopoly against household customers. Meanwhile, the government does not regulate the means of purchase of raw materials. Hence, some suppliers purchase LNG, and then transform LNG into natural gas by using vaporizing facilities. The other suppliers purchase natural gas from wholesalers through pipelines.

Table 4-1 The authorization prices of the three types of suppliers (Unit: yen)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
(Big supplier)	115.6	118.6	132.7	141.4	141.1	139.3	144.90	150.8	157.8	163.7
(Pipeline based supplier)	108.3	109.6	115.9	130.0	125.8	131.6	132.3	135.3	140.7	147.4
(Vertical integrated supplier)	151.4	155.4	161.8	162.1	173.5	194.1	205.2	211.1	225.2	238.2

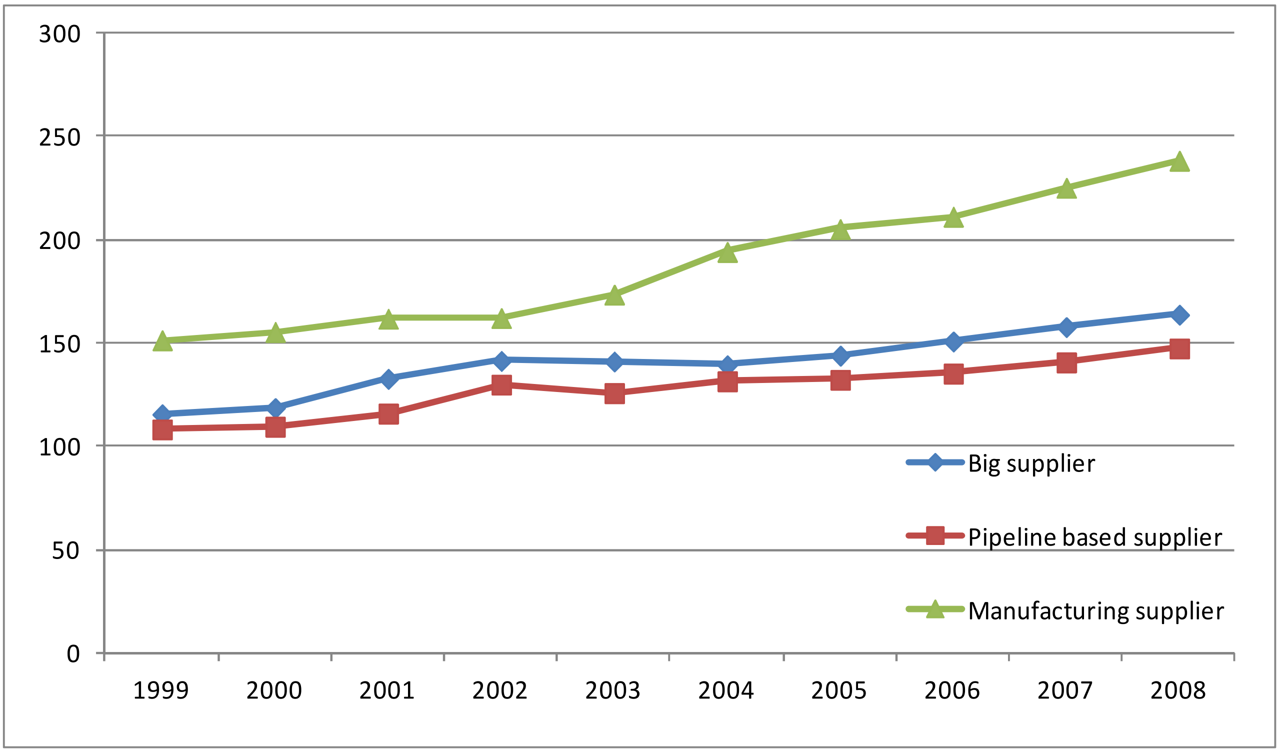

Figure 4-2 The authorization prices of the three types of suppliers (Vertical axis: price, Unit: yen)

The price differential between big suppliers and pipeline based suppliers is not obvious. However, it seems that the price differential between big supplier and vertical integrated suppliers definitely exists, and the price differential between pipeline based suppliers and vertical integrated suppliers also significantly exists.[6] The authorization price of city gas suppliers is basically decided by the cost price method which adds up the whole costs to produce natural gas. Therefore, we can interpret this price differential as cost differential between those suppliers. The price of pipeline based suppliers is the lowest out of the three types of suppliers because several pipeline based suppliers can purchase domestic natural gas. The domestic natural gas is cheaper than imported LNG. The reason is that the transportation cost of domestic natural gas is cheaper compared to that of imported LNG, and moreover, domestic natural gas is unaffected by the fluctuation of the

[6] The average price included the suppliers which are practicing calorie conversion. The number of suppliers which are changing gas calorie is approximately 30, and the number of suppliers which amortize pipelines' facilities costs is approximately 30 at the end of 2009 fiscal year. While many pipeline based suppliers practiced calorie conversion at the beginning of 2000s, many vertical integrated suppliers practiced calorie conversion at the end of 2000s. Therefore, the influence of calorie conversion could have appeared in this figure.

exchange rate.

Although deregulation enables a lot of suppliers to make consignment supply, the effects of deregulation penetrates into the management of big suppliers and pipeline based suppliers more strongly than that of vertical integrated suppliers. Hence, the effects of deregulation might be different among these suppliers.

4-2. The purpose of this chapter

This chapter deals with pipeline based suppliers and vertical integrated suppliers, and considers what influence the difference of management forms gives their costs. I have three steps for methodology. First, I estimate the scale economies of two forms by supposing cost functions. Next, to verify whether the scale of each supplier gives gas price some influence, I practice the factor analysis by putting the gas price as the dependent variable. Finally, based on my estimation results, I consider the price differential between pipeline based suppliers and vertical integrated suppliers.

4-3. Related literature

There is a little related literature in this industry.

First, Aivazian et al.(1987) estimates scale economies by using translog cost function and data from 1953 to 1979. According to this literature, there are scale economies in the U.S. natural gas transmission industry, and they found that the growth rate of productivity depended on scale economy.

In Japan, there is little literature in price differential between city gas suppliers. Kaino(2004) researched the factor of this price differential, and the productivity of labor and capital influenced this differential as the results.

Takenaka and Urano(1994) estimated scale economies using Translog cost function. And they verified that there are scale economies in the city gas industry. Kinugasa(2002) also estimated scale economies using Translog cost function. Although the purpose of his chapter is to consider the Averch-Johnson effect, he found this industry existed scale economies.

4-4. Empirical analysis

Here, I verified scale economies of two types of suppliers, which are pipeline based suppliers and vertical integrated suppliers, by estimating cost functions.

In order to test scale economies(returns to scale), a general model of energy company costs with two outputs and three inputs types is specified as follows.

Long-term Cost function $C = (p_i, Q, Z)$ $i = k, l, m$ k: Capital, l: Labor, m: Energy

C: Total cost

Q: The level of output

Z: The additional output

p_i: The price of i-th input($i=k,l.m$)

The most widely used functional form is the translog function, which is flexible in the sense that it provides a second order approximation to an unknown function at any given point. The translog function is specified in the following form:

$$\ln TC = \alpha_0 + \sum_{i=k,l,m} \alpha_i \ln p_i + \alpha_q \ln Q + \alpha_z \ln Z + \frac{1}{2}\sum_{i=k,l,m}\sum_{j=k,l,m} \beta_{ij} \ln p_i \ln p_j + \frac{1}{2}\beta_{qq}(\ln Q)^2 + \frac{1}{2}\beta_{zz}(\ln Z)^2$$
$$+ \frac{1}{2}\sum_{i=k,l,m} \gamma_{qi} \ln p_i \ln Q + \frac{1}{2}\sum_{i=k,l,m} \gamma z_i \ln p_i \ln Z.$$

In order to estimate more accurately, I impose the restriction on input factor prices such that

$$\sum_{i=k,l,m} \alpha i = 1 \qquad \sum_{i=k,l,m} \beta ij = \sum_{i=k,l,m} \gamma qi = \sum_{i=k,l,m} \gamma zi = 0 \ .$$

Furthermore, I apply Shephard's Lemma on the total cost function, and then obtain the input share equations as follows:

$$SHLi = \frac{\partial \ln TC}{\partial \ln pi} = \frac{\partial TC}{\partial pi} \cdot \frac{pi}{TC} = \frac{Xi \cdot pi}{TC} = \alpha i + \sum_{i=k,l,m} \beta ij \ln pj + \gamma qi \ln Q + \gamma zi \ln Z,$$

SHLi: Cost share function.

As for the estimation technique, I apply the SUR(seemingly unrelated regression) by Zellner(1962) for the total cost function and the input share equations. And moreover, it is worth noting that I normalize the observation on each variable by dividing by its sample mean, before making the natural logarithmic transformation.

I could use the pooled data from 2002 until 2007 excluding big 10 suppliers[7]. The observations of pipeline based suppliers are 447, and the observations of vertical integrated suppliers are 811. I excluded the data which I cannot obtain exactly. The detail of data is as follows.

(Data)

Source: Annual report of city gas distribution utilities (Gas Jigyou Nenpo), Corporate goods price

[7] The big 10 suppliers are Tokyo-gas, Osaka-gas, Toho-gas, Saibu-gas, Hokkaido-gas, Keiyo-gas, Hokuriku-gas, Shizuoka-gas, Hiroshima-gas, and Nihon-gas.

index(The Bank of Japan), GDP Data Base (Cabinet Office, Government of Japan)

Total cost: Energy cost + Labor cost + Capital cost

Energy costs(m): The amount of LNG×LNG-price + The amount of LPG×LPG-price + (The amount of natural gas + volatile oil + others gas + wholesalers)×natural gas-price (Corporate goods price index 2000 base)

Labor costs(l): The number of employee×The wage of each prefecture(more than 30people×12(GDP deflator 2000 base)

Capital costs(k): Depreciation expense + (The real assets × Government bonds(10years)) (Corporate goods price index 2000 base)

Energy price(P_m): Energy costs/the amount of sales

Labor price(P_l): The wage of each prefecture (more than 30people)

Capital price(P_k): Capital price index×(depreciation expense/real assets + the rate of government bonds(10years)

Sales(Q): The whole amount of sales for a year (1000MJ)

Additional revenue(Z): The incidental business earning and miscellaneous revenue of sales

Public dummy(d_1): The public utility(1), The private utility(0)

LNG dummy(d_2): Supply only natural gas(1), otherwise(0)

The descriptive statistics are shown in Table4-2 and 4-3. Then, the average costs of the two types of suppliers are also shown in Figure4-4 and 4-5. The vertical axis is average cost(unit yen), and the horizontal axis is the whole amount of sales for each supplier (unit 1000MJ). The average value of vertical integrated supplier is 2.31, and that of pipeline based supplier is 1.76.

Table 4-2 Descriptive statistics (Vertical integrated supplier)

	Total Cost	Quantity	Additional	Capital	Labor	Energy
Unit	1000yen	1000MJ	1000yen	1000yen	1000yen	1000yen
Average	1210911	797563	6006794	0.104	361621	0.562
S.D.	2385999	1728790	58652831	0.043	33183	0.136
Min	35830	13046	3415	0.010	295294	0.235
Max	16351723	12386950	949019845	0.939	520876	1.100

S.D.: Standard deviation

Table 4-3 Descriptive statistics (Pipeline based supplier)

	Total Cost	Quantity	Additional	Capital	Labor	Energy
Unit	1000yen	1000MJ	1000yen	1000yen	1000yen	1000yen
Average	1253951	1271306	2208073	0.107	381071	0.586
S.D.	84762	122440	743318	0.002	1842	0.012

Min	13106	2038	183113057	0.013	309899	0.179
Max	14470261	28015405	987008633	0.319	532773	1.223

S.D.: Standard deviation

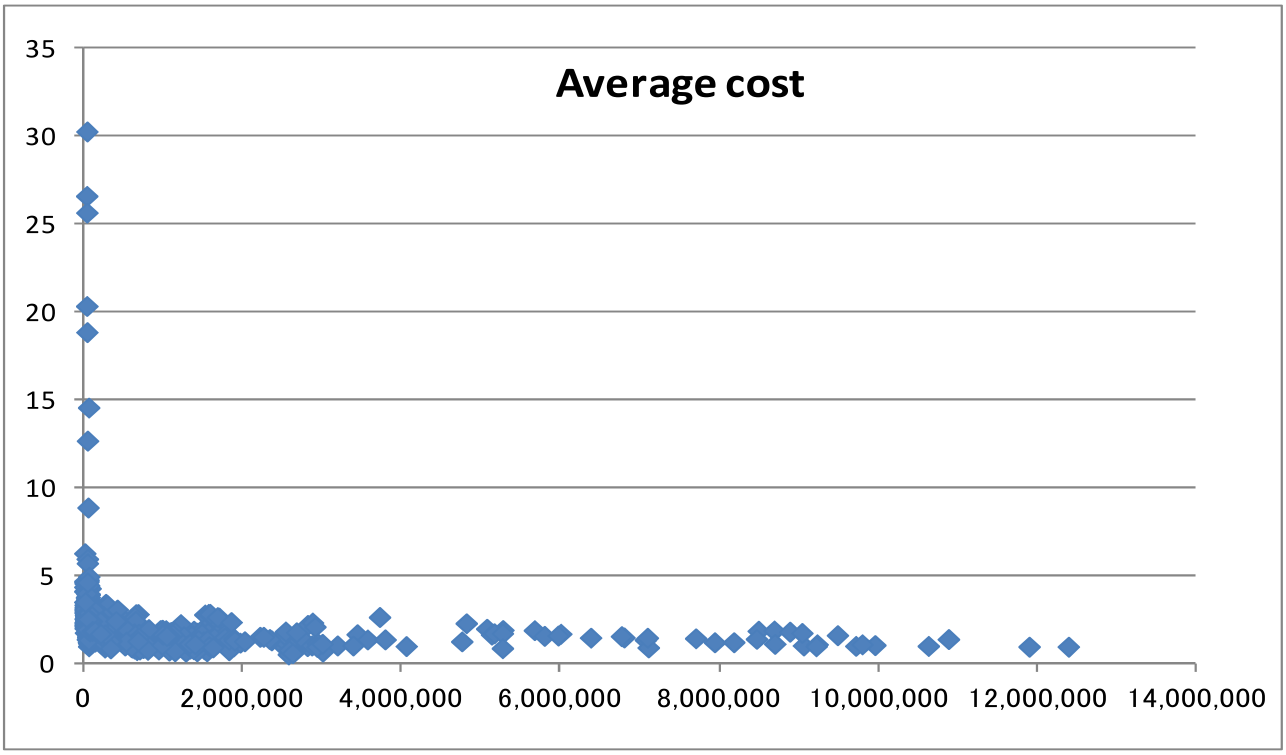

Figure 4-4 The average costs of vertical integrated suppliers

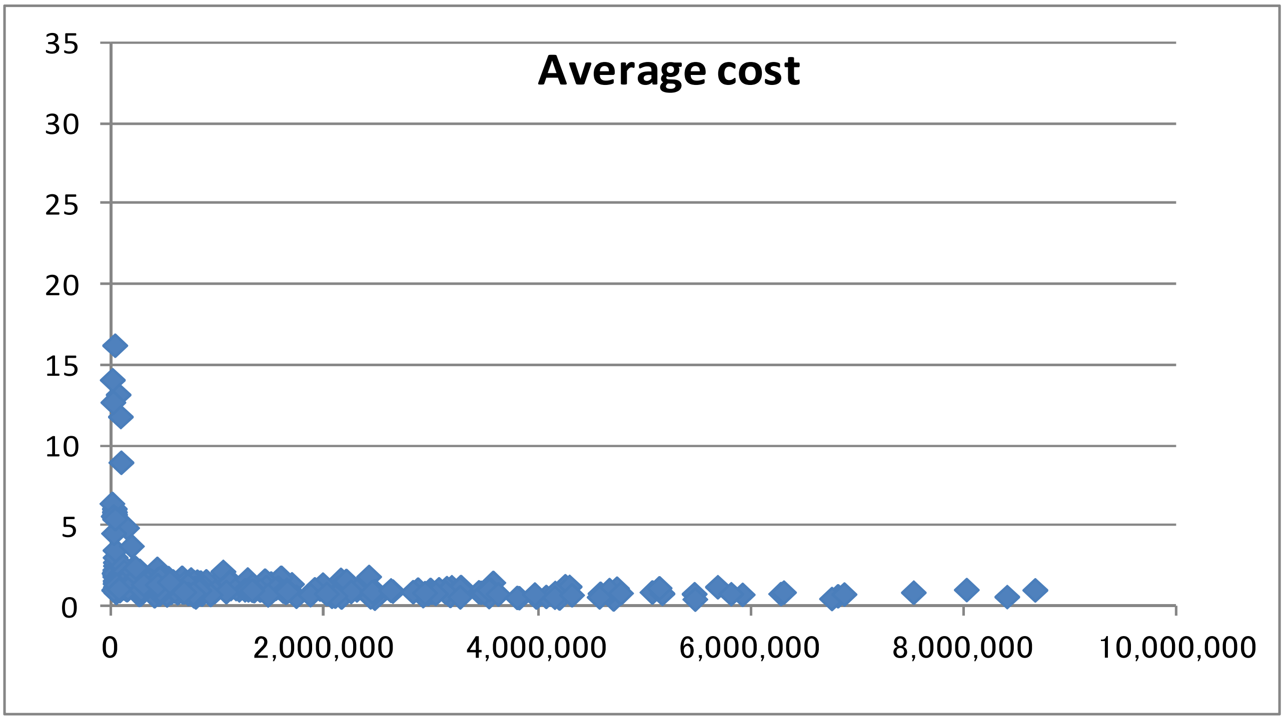

Figure 4-5 The average costs of pipeline based suppliers

4-5. Estimation results

Although the value of R-square of labor cost function is a little small, the performance of my estimation results is robust.

Table 4-4 Estimation results

Variable	VI.	pipeline based	Variable	VI.	pipeline based
constant	0.421(11.34***)	0.330(15.80***)	ek	-0.069(-22.65***)	-0.051(-7.90***)
e(energy)	0.338(132.46***)	0.464(59.28***)	lk	-0.075(-24.67***)	0.024(2.25**)
l(labor)	0.332(133.47***)	0.161(20.95***)	qe	-0.0001(-0.07)	0.091(26.96***)
k(capital)	0.331(67.91***)	0.375(37.77***)	ql	0.001(0.57)	-0.038(-10.82***)
q(quantity)	0.729(68.35***)	0.680(65.71***)	qk	-0.001(-0.25)	-0.053(-7.90***)
f(additional)	0.206(13.39***)	0.146(12.35***)	qf	-0.007(-1.33)	-0.066(-19.60***)
ee	0.131(102.03***)	0.129(27.18***)	fe	0.00005(0.06)	-0.031(-10.63***)
ll	0.137(85.65***)	0.054(4.55***)	fl	-0.001(-0.94)	0.004(1.20)
kk	0.144(24.41***)	0.026(2.19**)	fk	0.001(0.45)	0.027(7.17***)
qq	0.010(1.78*)	0.052(20.29***)	d1(public)	0.280(8.85***)	0.073(3.69***)
ff	0.012(6.81***)	0.022(12.83***)	d2(LNG)	-0.019(-1.00)	-0.063(-3.00***)
el	-0.062(-28.95***)	-0.078(-11.55***)	observations	(811)	(447)

(parenthesis: t-value, *significant at 10%, ** 5%, *** 1%)

Vertical integrated suppliers : R^2=0.960, Labor cost: R^2=0.911, Energy cost: R^2=0.954

Pipeline based suppliers: R^2=0.963, Labor cost: R^2=0.364, Energy cost: R^2=0.742

Here, this chapter calculates scale economies by using the value of estimation results. Let me define scale economies as the growth rate of total cost when sales(Q) and additional revenue(Z) are increased at the same rate. If the value of scale economies is more than 1, scale economies exist in the industry, and in the case where the value of scale economies is larger, the effect of scale economies works strongly. In short, a rise of 1% in the sales quantity and additional revenue leads to an increase of less than 1% in the total cost if and only if there are scale economies.

$$\frac{1}{\varepsilon 1 + \varepsilon 2}$$ $\varepsilon 1$: The elasticity of sales, $\varepsilon 2$: The elasticity of additional revenue

Table 4-5 Scale economies(returns to scale)

	Returns to scale
Vertical integrated suppliers	1.07
Pipeline based suppliers	1.21

The value of scale economies is the reciprocal of elasticity of sales and additional revenue. According to the definition of scale economies(returns to scale), in the case where there are scale economies, the growth rate of total cost is smaller than that of both sales and additional revenue. This chapter used the translog function, and this function is set to assume that the amount of the inputs is minimized every year. In addition, the scale economies of vertical integrated suppliers might exist in both vaporizing facilities and the extent of pipelines in their own areas, and then the scale economies of pipeline based suppliers might only exist to the extent of their pipelines. When vertical integrated suppliers increase the amount of their sales, these suppliers have to increase both the vaporizing facilities and the length of pipelines. Meanwhile, when pipeline based suppliers increase the amount of their sales, the suppliers need only to increase the length of their pipelines(See appendix). According to my estimation results, the scale economy of vertical integrated suppliers is smaller than that of pipeline based suppliers. This means that the vertical integrated suppliers might not be able to obtain the effect of scale economies as well as pipeline based suppliers can. In other words, it would be difficult for vertical integrated suppliers to obtain scale economies compared to pipeline based suppliers because the vertical integrated suppliers generally have to use the vaporizing facilities which can only produce enough natural gas to supply in their own area.[8]

4-6. Factor analysis

The previous section illustrated that both scale economies are different. Next, this section analyzes whether scale economies influence the gas retail price. The methodology is as follows. Let me define the gas retail price as a dependent variable, and carry out factor analysis by means of ordinary least square.

Let me set the amount of sales and the number of customers as proxy of the variables of scale, and the dependent variables are set both the authorization price and 50m^3 charge[9].

---

[8] This chapter assumes long term translog functions. This means the capital costs are minimized and optimized at all times. In addition, the result of scale economies means the value of the average point because all observations are normalized by dividing by the sample mean. The average tangible asset of vertical integrated suppliers is 4,273million yen($53,421,000; $1=¥80) and that of pipeline based suppliers is 3,356million yen($41,950,000), whereas the average sales quantity of vertical integrated suppliers is 798million MJ and that of pipeline based supplier is 1,271million MJ. Although the whole tangible asset of Vertical integrated suppliers is larger than that of pipeline based suppliers, the pipeline asset of vertical integrated suppliers is smaller than that of pipeline based suppliers. Despite being in the same industry, the organizational scale and structures are quite different. This difference would appear in the distinctions between the scale economics value.

[9] The gas retail price is decided based on average costs(Sokatsu genka hoshiki). In the case of estimating the factor of price determination, average costs and the revenue and cost balance should be introduced in the model. However, I cannot estimate the average costs because the outputs in the city gas industry are two types(quantity and additional revenue). And moreover, I cannot use the revenue and cost balance as an independent variable because a negative value cannot transform a logarithm, and in fact, the revenue and cost balance of several suppliers is negative. Therefore, demand and the amount of sales are adopted as a proxy of average costs and revenue and cost balance.

(Function) Ordinary least square

$$\Pr ice = \alpha + \beta_1 * \ln Demand + \beta_2 * \ln Coverage + \beta_3 * \ln Quantity + \beta_4 * \ln Household$$
$$+ \beta_5 * \ln Wholesale + \beta_6 * \ln Public + \beta_7 * \ln HighCalori\ e$$

1. Dependent variable
   Authorization Price: The average of authorization price or reported price
   50 m^3 charge: The charge when a household consumes the amount of $50m^3$
2. Independent variable
   Customer(The number of customers): The number of customers in its own area
   Quantity(The quantity of sales): The quantity of sales at the end of fiscal year
   Coverage: the rate of customer supplying gas out of the whole customers in its own area
   Household: The rate of the quantity of household out of the whole quantity
   Wholesale(The wholesales dummy): Yes(1), No(0)
   Public(Public dummy): Public(1), Private(0)
   High-calorie(Transformed dummy): Finished (1), Otherwise(0)

Table 4-6 Descriptive statistics

	Authorization Price	50Price	Demand	Coverage	Quantity	Household
Unit	yen/m^3	yen/m^3	people	%	1000MJ	%
Average	189.1168	11105.1	136626	65.90	7657531.89	0.4177
Variance	5877.724	15842129	7.58807E+11	6870.83	2.5956E+15	0.041
Min	65.82	3974.78	483	13.9	5047	0.014
Max	639.43	24133.2	10255644	1220	611487537	1
Observations	209	209	209	209	209	209

Table 4-7 Estimation results

Variable	Model-1	Model-2	Model-3	Model-4
Constant	6.193(28.50***)	6.079(28.18***)	10.202(49.75***)	10.088(49.49***)
Customer		-0.033(-2.56**)		-0.030(-2.44**)
Quantity	-0.043(-3.57***)		-0.040(-3.54***)	
Coverage	-0.056(-1.11)	-0.071(-1.39)	-0.063(-1.32)	-0.078(-1.61)
Household	-0.023(-0.65)	0.020(0.615)	-0.075(-2.23**)	-0.034(-1.09)
Wholesale	-0.244(-5.33***)	-0.260(-5.61***)	-0.264(-6.10***)	-0.279(-6.37***)
Public	-0.282(-4.53***)	-0.279(-4.43***)	-0.323(-5.50***)	-0.320(-5.37***)
High-Calorie	-0.178(-3.68***)	-0.197(-4.40**)	-0.144(-3.14***)	-0.161(-3.51***)
(observations)	209	209	209	209
(Adjusted-R^2)	0.436	0.419	0.471	0.455

(Parenthesis: t-value, *significant at 10%, ** 5%, *** 1%)
Model 1,2: Authorization price, Model 3,4: 50 m^3 charge

Both parameter of the number of customers and the amount of sales are significantly negative. In short, when the scale of supplier is large, the gas retail price is cheap, and vice versa.

4-7. Discussion

This chapter found that the organizational form of pipeline based suppliers is significantly different from that of vertical integrated suppliers. And furthermore, if the organizational scale of pipeline based suppliers extended, the gas retail price would not rise outstandingly. The results lead to two implications.

First, if a distribution utility constructs pipelines to other suppliers in the same vicinity, and purchases natural gas from the suppliers through the pipelines, then the distribution utility could keep gas retail price at a lower level. And moreover, when two pipeline based suppliers merge with each other, the gas price could be kept at a low level. (See Figure 4-6)

Second, if several suppliers could not tie pipelines to other suppliers because of far distance from these suppliers, then, these suppliers have to construct a vaporizing facility to transform LNG into natural gas. (See Figure 4-7) As a result, these suppliers could have difficulty in obtaining the advantage of scale economies. Therefore, the retail price of these suppliers might be kept at a high level, and then the price differential between these suppliers(vertical integrated suppliers) and pipeline based suppliers would be also kept at a high level. It seems that the price differential would be extended gradually if the consignment supply is generalized.

Figure 4-6 The illustration of vertical integrated suppliers(Iwate prefecture)

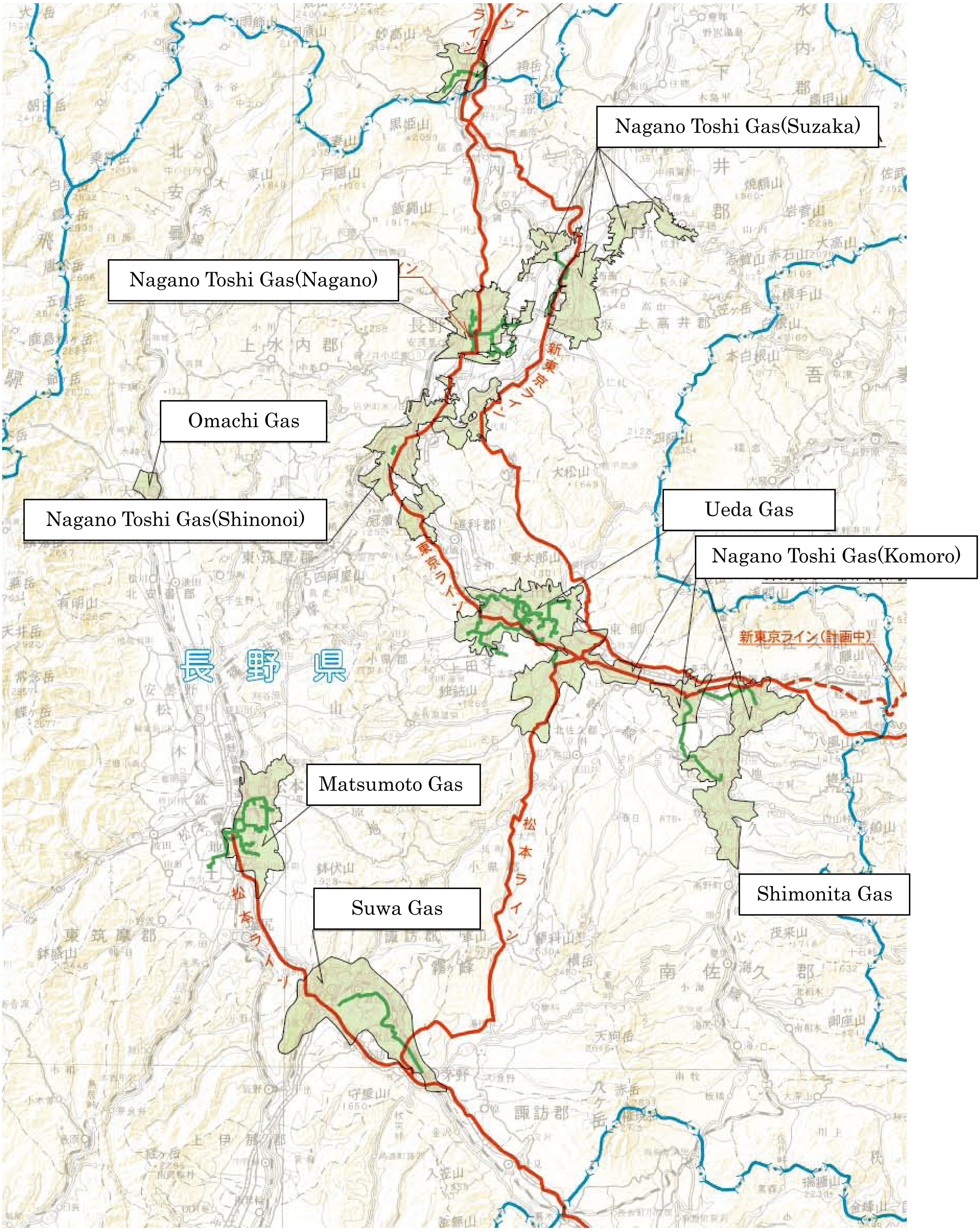

Figure 4-7 The illustration of pipeline based suppliers(Nagano prefecture)

Actually, it is natural that a supplier would take advantage of scale merit and perform his costs cut in the competitive dynamism. However, if a lot of suppliers take advantage of scale merit, the price differential between two kinds of suppliers would be expanded. It is not feasible to extinguish the differential by only exertion of each supplier because the differential depends on their location whether they would be able to construct pipelines or not.

We need to consider the significance of the city gas industry. If the city gas industry is not defined as a universal service[10] but as a gas supply service in a particular area, this price differential would be recognized as a peculiar problem in the area. In this case, the price differential is not a serious problem. In other words, when the gas price is expensive due to the location or the organizational forms, the nature of this differential is whether the consumers in this area could accept this price or not. Accordingly, the price differential would not be a serious problem if the customers accepted high prices in their own area.

On the other hand, if the city gas industry is defined as a universal service, this differential might be a serious problem. We need to extinguish this differential. However, the factor of this differential is the location or the distinction of organizational forms between pipeline based suppliers and vertical integrated suppliers. Even if several suppliers strive to reduce administration costs, it might be impossible to extinguish the price differential. In this case, we should solve this differential by political support such as a subsidy of the inside and the foundation of pipelines with public funds.

It is obvious that the liberalization since 1995 has offered management efficiency to the city gas distribution utilities. While the liberalization has been widely spread, the price differential could be larger due to dynamism of the market competition. Henceforth, we should create our next step policy and consider whether the city gas industry is universal or not.

[10] Universal services are defined as follows.
(1) Essentiality: A service is indispensable for people.
(2) Affordability: People can make use of the service by paying appropriate charge.
(3) Availability: It is feasible to use the service anywhere.
(Source: The workshop of the perspective of universal services, The Ministry of Public Management, Home Affairs, Posts and Telecommunications)

Appendix

Here, let me consider the factor of scale economies. The result of scale economies means the value of the average point because all observations are normalized by dividing by the sample mean. Despite being in the same industry, the costs structures of two types of suppliers are quite different.

Table 4-8 Descriptive statistics

	Pipeline based supplier	Vertical integrated supplier
Average total costs (Unit: 1000yen)	1,253,951	1,210,911
Average amount of sales (Unit: 1000MJ)	1,271,306	797,563
Additional revenue average(Unit: 1000yen)	2,208,073	6,006,794

According to Table 4-8, average total costs values of both suppliers are almost same. The average amount of sales of pipeline based suppliers is 1,271,306(1000MJ), and that of vertical integrated suppliers is 797,563(1000MJ). The average amount of sales of pipeline based suppliers is at least 1.5 times larger than that of vertical integrated suppliers, whereas the average additional revenue of pipeline based suppliers is approximately one third as large as that of vertical integrated suppliers.

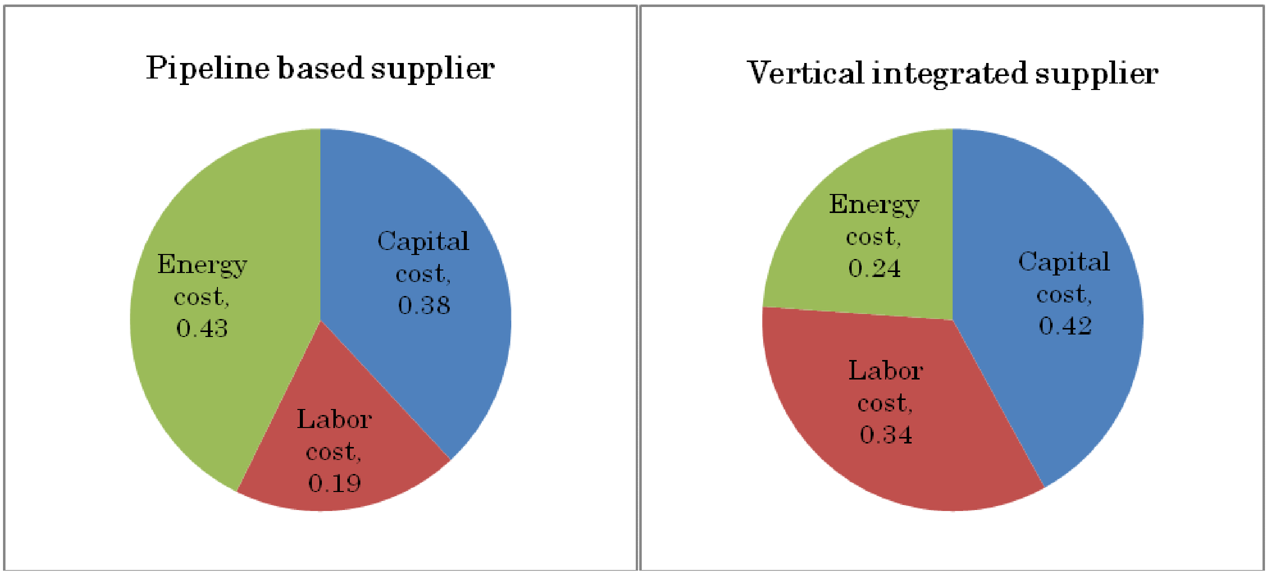

Figure 4-8 Total cost structures of both suppliers

Figure 4-8 illustrates the total cost share of both suppliers. As shown Figure 4-8, the energy cost rate of pipeline based suppliers definitely differ from that of vertical integrated suppliers, whereas the capital cost rate of pipeline based suppliers is almost same to that of vertical integrated suppliers. The difference of these cost structures might lead to the difference of scale economies.

According to the estimation results, although the capital cost rate of pipeline based suppliers is approximately same to that of vertical integrated suppliers, the scale economy of pipeline based suppliers(1.21) is larger compared to that of vertical integrated suppliers(1.07). This means that there seems to be some scale effects through the energy and labor cost. In particular, with respect to energy cost, in order that utilities can negotiate natural gas price with wholesalers under the situation of no regulations by the government, if utilities purchase natural gas large volume, unit cost of natural gas might decline. On the other hand, in the case where utilities hold vaporizing facilities, these utilities have to hire a person who can handle hazardous materials(Kikenbutsu toriatsukaisya). This employment potentially causes diseconomies of scale. And moreover, the utilities which hold vaporizing facilities, if anything, tend to be high rate of dependence on "additional revenue", and these utilities might cause diseconomies of scale.

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Chapter 5

A study of the investment in trunk pipelines using property rights theory

(Summary)

The purpose of this paper is to consider the organizational forms which increase trunk pipeline investments. In the natural gas industry in Japan, several companies adopt the organizational forms of joint ownership or subsidiary, and then make trunk pipeline investments.

In this chapter, I examine what the organizational form to increase pipeline investments is. In particular, I made a subsidiary model, and analyzed the model intensively. I utilized the model of Cai(2003) and Aghion and Bolton(1992), which are two of the famous studies of property rights theory respectively.

In conclusion, I found that the organizational form of subsidiary increases the amount of trunk pipeline investments if the investors could dominate the asset control rights.

5-1 Introduction

The purpose of this chapter is what a kind of organizational form is the best to increase the amount of natural gas pipeline investments. In Japan, both city gas utilities and natural gas digging companies generally make investments in trunk pipelines, and then these companies usually maintain and manage them without the influence of regulations.

Natural gas digging companies import almost all of the demand in Japan as LNG(Liquefied Natural Gas) because there are not large wells of natural gas in Japan. The LNG from foreign countries is stocked in the tank temporarily. After the companies vaporize the LNG into natural gas, the natural gas will be transported to several distribution utilities either through pipelines or tank trucks.

Figure 5-1 shows the recent trunk pipeline construction projects. The pipeline networks have dispersed because the pipelines radiate from LNG storage facilities (25 bases in 2004). For this reason, the lengths of the pipelines are small compared to that of the United States and Europe.

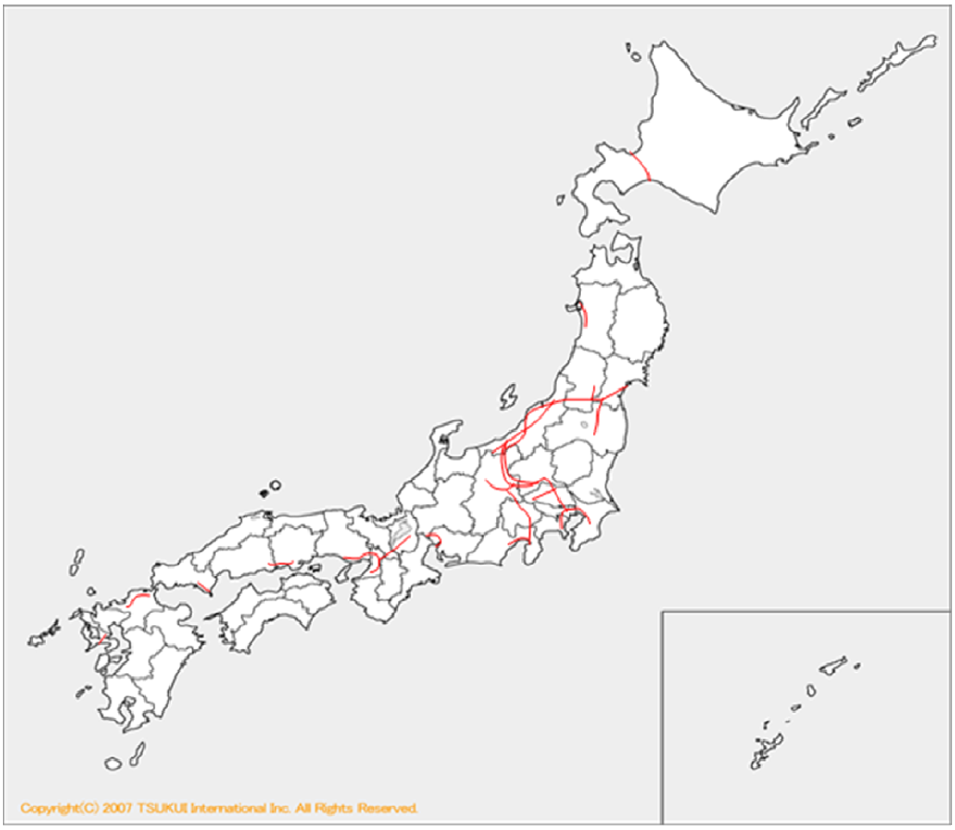

Figure 5-1 Pipelines in Japan(Based on handout of Agency for Natural Resources and Energy)

Table 5-1 illustrates several pipeline investment projects in recent years. There are three types of organizational forms involved in pipeline investments. First one is that a firm practices investment projects alone such as the Shizuoka line and the Toyama line. The second is that two or more firms adopt an organizational form of joint ownership. This organizational form can be seen in the Koriyama line and the Isewan line. The third is an organizational form of subsidiary such as the Kawasaki Gas Pipeline, the Minami Fuji Trunk Pipeline and the Setouchi pipeline.

We can generally divide into two kinds of regulations which are economical regulations and safety regulations. With regard to pipeline investments in the city gas industry, there are essentially no economical regulations. Hence, the trunk pipeline investors are making investments based on only market structure and competitive situations. In the real world, the investors such as natural gas digging companies and gas distribution utilities might make investments alone if they can obtain the capital stock to do so. On the other hand, unless the firm can obtain the capital stock to invest alone, the firm would adopt the organizational forms of joint ownership or a subsidiary as the next step. Table 5-1 shows the pipeline investment projects in recent years. The investors are handling pipeline investments by the organizational forms of joint ownership or a subsidiary.

Table 5-1 Pipeline investments in recent years

Pipeline's name	Organizational form (Equity rate)	Year	Distance (Bore)	Cost million dollar
Ogijima-Kawasaki	Kawasaki Gas Pipeline Co. Ltd. {Tokyo Gas: 50%, Nihon Oil: 50%}	2004	4.5 km (400～500mm)	
Shizuoka Line Showa-Gotenba	INPEX. Co. Ltd.	2006	81km (400mm)	275
Minamifuji Line Fuji-Gotenba	Minamifuji Pipeline Co. Ltd. {INPEX, Shizuoka Gas, Tokyo Gas :33% respectively}	2006	31km (500mm)	100
Setouchi Line Mizushima-Fukuyama	Setouchi Pipeline Co. Ltd. {Hiroshima Gas:80%,Fukuyama Gas:20%}	2006	40km (300mm)	75
Koriyama Line Shirroishi-Koriyama	(Joint Ownership) INPEX co.:80% ,Tohoku Electric Power:20%	2007	95km (400mm)	250
Shizuhama line Shizuoka-Hamamatsu	Shizuhama Pipeline Co. Ltd.(part of 76km) {Shizuoka Gas: 50%, Chubu Gas :50%}	2012	113km (400~500mm)	437.5
Isewan Odan Pipeline Chita,Kawagoe-Yokkaichi	(Joint Ownership) part of undersea tunnel Chubu Electric Power:50% Toho Gas :50%	2013	19km (600~700mm)	
Mie-Shiga Line Hikone-Yokkaichi	Osaka Gas(20km), Chubu Electric Power(40km)	2014	60km (600mm)	250
Himeji-Okayama	Osaka Gas Co. Ltd.	2014	85km (600mm)	
Toyama Line Itoigawa-Toyama	INPEX. Co. Ltd.	2014	102km (500mm)	

(Exchange rate: 80 dollar/yen)

The organizational forms of joint ownership and a subsidiary might strongly impact the increase of the amount of pipeline investments because there are some cases of a subsidiary and joint ownership investment in the real world. Therefore, by focusing on an organizational form of a subsidiary, this chapter assumes that the organizational form of a subsidiary enlarges the amount of pipeline investments, and then I will try to prove this assumption by using property rights theory.

5-2 Theoretical background

Although joint ownership is quite common in the real world, where examples include partnerships, cooperatives, and joint ventures, there have not been a lot of studies done in academic literature.

First, Hart(1995), which defines human capital and complementary assets, insists that the organizational form of joint ownership is suboptimal because there is a high probability that the assets will be separated in the stage of renegotiations. Hence, Hart(1995) concludes that the form of single firm ownership is superior to that of joint ownership.

Although Hart's model uses only one type of investment, the model of Cai(2003), assumes physical assets and two kinds of investments which are specific investments[1] and general investments. As a result of the analysis of Cai(2003), the organizational form of joint ownership is the most optimal form in the case of two types of investments.

Rosenkranz and Schmitz(2004) uses the model which has two investment opportunities, and they show that the organizational form of joint ownership is optimal if there are twice the investment opportunities in the real world.

In the vertical relationship between buyer and seller, Adachi(2010) proves that the organizational form of joint ownership is not optimal by improving upon the model of Hart(1995).

Furthermore, I was not able to find any literature of subsidiary model in my research.

5-3 Model

Let me denote about the model used in this chapter. The purpose of this chapter is to analyze whether the organizational form of subsidiaries is optimal, and I compose the model by adopting both the contribution of Cai(2003) and that of Aghion and Bolton(1992).

Cai(2003)'s accomplishment is as follows. In the condition of substitute between specific and general investment, when a firm makes these two types of investments, the firm increases the amount of general investment, and decreases that of specific investment in order to reduce the bargaining power between itself and other firms. The reason for the decline of bargaining power is that the firm owns the specific assets (specific investments). The best way to avert the ownership of specific assets is to admit the adoption of the organizational form of joint ownership. Because the organizational form of joint ownership can weaken the ownership of specific investments, the firm increases the incentive for specific investments.

In the model of Cai(2003), although there is only specific investments on the first best solution,

[1] The assets from specific investment mean the relationship specific assets.

the firms make both specific and general investments on the competitive equilibrium. In the city gas industry, specific investments can be defined as pipeline investments in the real world because the firms cannot use the pipelines in other situations, and general investments as tank trucks and storage tanks, which the firms can use to transport multiple firms.

Here, let M_1 denote a digging and importing company, M_2 denote a gas distribution company, and M_3 denote a subsidiary which has been established by investments from both M_1 and M_2. Although there are many kinds of subsidiaries in the real world, this chapter defines a subsidiary as follows. The subsidiary can make investments in the range of the finance(K) provided from both M_1 and M_2. That is to say, This chapter assumes that the subsidiary cannot borrow additional funds beyond capital stock(K) from several banks and other investors, and the benefit from the investment can be divided into M_1 and M_2 corresponding to the rate of their stock holdings.

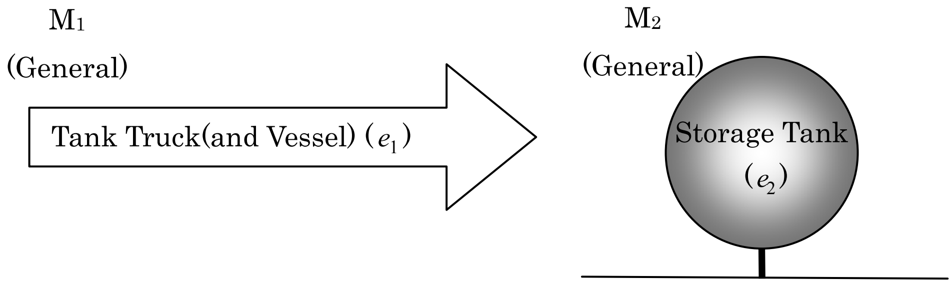

Figure 5-2 The example of general investments

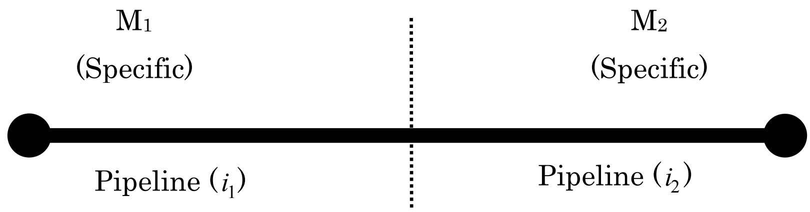

Figure 5-3 The example of specific investments

At date 0, ownership structure is chosen. At date 1, the investors(M_1 and M_2) and the manager(M_3) make investment decisions based on the methodology of profit maximizing. As shown in Figure 5-4, M_1 and M_2 can make investment decisions a_1 and a_2 respectively, and each party can make two kinds of investments(general and specific) for a_1 and a_2. Here, let i_1 denote the specific investment of M_1, i_2 denote the general investment of M_1, e_1 denote the specific investment of M_2, and e_2 denote the general investment of M_2.

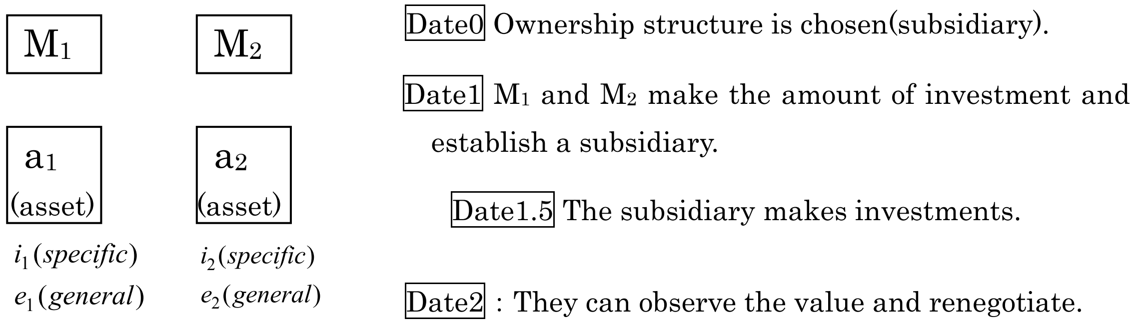

Figure 5-4 The model

At date 1.5, the subsidiary (M_3) particularly makes investments (i_1, i_2, e_1, e_2) within the range of the finance(K). Denote that the finance(K) means the monetary fund by both M_1 and M_2. At date 2, those parties can observe the surplus of the investments. In other words, it is too costly for those parties to describe and verify the benefit ex ante exactly. After this observation, those parties bargain over whether or not and how to trade with each other. In this circumstance, for simplicity, this chapter assumes there is no asymmetric information and bilateral bargaining power between those parties, and in addition, the time discount rate is 0 and M_1 and M_2 hold equal bargaining power(They split the net surplus into 50:50).

Here, let the benefit of a subsidiary $b = b(i_1, i_2, e_1, e_2)$, which is included not only in monetary returns but also intangible benefits such as reputation, specific human capital, effort, etc. And let the gross surplus of M_1, M_2, and M_3 U_1, U_2, and U_3 respectively. R and Q mean gross surplus from the specific investment, and r and q mean gross surplus from the general investment[2].

$$U_1 = \frac{R(i_1) + Q(i_2) - r(e_1) - q(e_2)}{2} + r(e_1) - C_1(i_1, e_1)$$

$$U_1 = \frac{R(i_1) + r(e_1)}{2} + \frac{Q(i_2) - q(e_2)}{2} - C_1(i_1, e_2)$$

$$U_2 = \frac{R(i_1) + Q(i_2) - r(e_1) - q(e_2)}{2} + q(e_2) - C_2(i_2, e_2)$$

$$U_2 = \frac{R(i_1) - r(e_1)}{2} + \frac{Q(i_2) + q(e_2)}{2} - C_2(i_2, e_2)$$

$$U_3 = b(i_1, i_2, e_1, e_2).$$

[2] My composition of this function is made use of the result of that of Cai(2003). In this model, when we add U_1 and U_2, then both i_2 and e_2 cancel by calculation mechanism. As a result, those companies specialize to make specific investments.

5-3-1 The maximization of the sum of net surplus of all companies

The total benefit of U_1, U_2, and U_3 is maximized, and then the benefit is as follows.

$$
\begin{aligned}
U &= \frac{R(i_1)+r(e_1)}{2}+\frac{Q(i_2)-q(e_2)}{2} \\
&\quad +\frac{R(i_1)-r(e_1)}{2}+\frac{Q(i_2)+q(e_2)}{2} \\
&\quad + b(i_1,i_2,e_1,e_2)-C_1(i_1,e_1)-C_2(i_2,e_2) \\
U &= R(i_1)+Q(i_2)-C_1(i_1,e_1)-C_2(i_2,e_2) \\
&\quad + b(i_1,i_2,e_1,e_2) \\
\frac{\partial U}{\partial i_1} &= R'(i_1^*)-C_1'(i_1^*,e_1^*)+b'(i_1^*,i_2^*,e_1^*,e_2^*)=0 \\
\frac{\partial U}{\partial e_1} &= -C_1'(i_1^*,e_1^*)+b'(i_1^*,i_2^*,e_1^*,e_2^*)=0 \qquad (1) \\
\frac{\partial U}{\partial i_2} &= Q'(i_2^*)-C_2'(i_2^*,e_2^*)+b'(i_1^*,i_2^*,e_1^*,e_2^*)=0 \\
\frac{\partial U}{\partial e_2} &= -C_2'(i_2^*,e_2^*)+b'(i_1^*,i_2^*,e_1^*,e_2^*)=0.
\end{aligned}
$$

Because the benefit of the subsidiary(M_3) is added, the result is not limited to only specific investments(i_1, i_2) where equilibrium is present[3].

5-3-2 The case that Investors(M_1, M_2) dominate control rights of the assets

Based on the idea of Aghion and Bolton(1992), this chapter assumes the control rights of asset. There are two types of unilateral control allocations, which are full control by a manager(M_3) and by investors(M_1 and M_2). This chapter does not assume contingent control allocations and partial control rights because it is quite difficult to translate these rights into theoretical framework. In this section, I consider the case in which the investors(M_1 and M_2) dominate full control over the assets. Under the full control of investors(M_1 and M_2), both investors maximize the total benefit of two firms($U_{12}=U_1 + U_2$). If the manager(M_3) could borrow more funds than K, this manager would be able to negotiate to call for any action to M_1 and M_2. However, I suppose that M_3 cannot borrow funds beyond K. In this case, the equilibrium condition is,

$$\max_{i_1,i_2,e_1,e_2} U_{12}$$

[3] Under the situation of complete contract, we can obtain a dividend in proportion to the capital. However, in the case where there are incomplete contract, equal bargaining power, and the surplus including not only monetary returns but also intangible benefit, M_1 and M_2 finally obtain a dividend in proportion to 50:50 respectively.

$$U_{12} = U_1 + U_2 = \frac{R(i_1) + r(e_1)}{2} + \frac{Q(i_2) - q(e_2)}{2} + \frac{R(i_1) - r(e_1)}{2} + \frac{Q(i_2) + q(e_2)}{2} - C_1(i_1, e_1) - C_2(i_2, e_2)$$

$$U_{12} = R(i_1) + Q(i_2) - C_1(i_1, e_1) - C_2(i_2, e_2)$$

$$\frac{\partial U_{12}}{\partial i_1} = R'(i_1{}^E) - C_1'(i_1{}^E, 0) = 0 \qquad \frac{\partial U_{12}}{\partial i_2} = Q'(i_2{}^E) - C_2'(i_2{}^E, 0) = 0. \quad (2)$$

As a result of this calculation, those parties specialize to only specific investment.

5-3-3 The case that manager(M_3) dominates control rights of the assets

Here, I consider the case in which the manager(M_3) dominates control rights of the assets. The subsidiary basically can maximize its own benefit(U_3). However, M_3 is founded by M_1 and M_2, and M_3 cannot neglect the benefits of M_1 and M_2 because both M_1 and M_2 are parent companies. If M_3 maximizes its own benefit and neglects the benefits of M_1 and M_2, the parent companies(M_1 and M_2) would dismiss the manager of M_3. In other words, because a subsidiary cannot neglect the benefits of parent companies, it has to maximize both its own benefit and parent company benefits. Hence, the maximization is as follows:

$$\underset{i_1, i_2, e_1, e_2}{Max} \quad U(= U_1 + U_2 + U_3)$$

$$U = \frac{R(i_1) + r(e_1)}{2} + \frac{Q(i_2) - q(e_2)}{2} + \frac{R(i_1) - r(e_1)}{2} + \frac{Q(i_2) + q(e_2)}{2} + b(i_1, i_2, e_1, e_2) - C_1(i_1, e_1) - C_2(i_2, e_2)$$

$$U = R(i_1) + Q(i_2) - C_1(i_1, e_1) - C_2(i_2, e_2) + b(i_1, i_2, e_1, e_2)$$

$$\frac{\partial U}{\partial i_1} = R'(i_1^*) - C_1'(i_1^*, e_1^*) + b'(i_1^*, i_2^*, e_1^*, e_2^*) = 0 \qquad \frac{\partial U}{\partial i_2} = Q'(i_2^*) - C_2'(i_2^*, e_2^*) + b'(i_1^*, i_2^*, e_1^*, e_2^*) = 0$$

$$\frac{\partial U}{\partial e_1} = -C_1'(i_1^*, e_1^*) + b'(i_1^*, i_2^*, e_1^*, e_2^*) = 0 \qquad \frac{\partial U}{\partial e_2} = -C_2'(i_2^*, e_2^*) + b'(i_1^*, i_2^*, e_1^*, e_2^*) = 0. \quad (3)$$

We can calculate these functions using Lagrangian. As a result of this calculation, the subsidiary(M_3) makes both specific and general investments where equilibrium is present.

In this situation, the manager(M_3) can renegotiate with investors(M_1 and M_2) about the contract in which the manager(M_3) compensates the investors' benefit (2) and obtains the benefit given by $U - U_{12}$.

$$U_{12} = U_{12}(i_1{}^E, 0, e_1{}^E, 0)$$

$$U_3{}^e = U_3{}^e(i_1{}^e, i_2{}^e, e_1{}^e, e_2{}^e) + U_{12}{}^e(i_1{}^e, i_2{}^e, e_1{}^e, e_2{}^e) - U_{12}{}^E(i_1{}^E, 0, i_2{}^E, 0).$$

$U_3{}^e(i_1{}^e, i_2{}^e, e_1{}^e, e_2{}^e)$ and $U_{12}{}^e(i_1{}^e, i_2{}^e, e_1{}^e, e_2{}^e)$ mean the benefit of manager(M_3) and investors(M_1 and M_2) respectively. However,

$$U_3{}^E + U_{12}{}^E - U_{12}{}^e > U_3{}^e$$
$$U_3{}^E + U_{12}{}^E > U_3{}^e + U_{12}{}^e$$
$$U_{12}{}^E - U_{12}{}^e > U_3{}^e - U_3{}^E,$$

cannot be proved. Hence, the contract is, in fact, not practiced by manager(M_3). In other words, in the case where manager(M_3) dominates control rights of the assets, even if the renegotiation would be practiced, the situation(2) in which there is specified the pipeline investments could not be achieved.

As denote above, in the case where the investors(M_1 and M_2) establish the subsidiary(M_3), the subsidiary specializes to the specific investments if and only if the investors could dominate control rights of the assets[4].

5-4 Discussion

Here, I apply the result of the model to pipeline investment in the city gas industry. First, Table 5-2 shows the surplus and costs from specific and general investments. Externality in Table 5-2 means the external effects from pipeline investments[5].

According to Table 5-2, the surplus from the pipeline investment(specific investment) is larger than that from tank trucks and storage investments(general investment). Although we should be careful because the surplus in Table 5-2 is not per unit, the pipeline construction cost is generally larger compared to that of tank trucks and storage tanks. In the case where the amount of natural gas which the distribution company purchases through pipelines is ultimately little, even if the company adds externality into the surplus of pipelines, the transportation through pipelines might be inefficient[6]. Meanwhile, if a company could try to increase factors other than sales revenue in

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[4] I show the image of subsidiary's default at Appendix.

[5] Here, I define M_1 as a gatherer which digs or imports natural gas, and M_2 as a local distribution company. Moreover, specific investments mean pipeline investments, and general investments mean tank trucks and storage tanks.

[6] Although it is difficult to estimate the profitable level of specific investments, the construction of Yamagata pipeline is one of the effective cases. Tohoku Natural Gas Co., which is a subsidiary of Tohoku Electric Power Co. and Japan petroleum Explanation Co., constructed the branch pipeline. This pipeline is 30km in total length(200mm

Table 5-2, and then increase the whole surplus of pipeline investments, these pipeline investments would be more efficient than the tank truck and storage tank investments.

Table 5-2 Surplus and cost from specific and general investments

	General Investment		Specific Investment	
M_1	$r(i_2)$	Sales revenue Natural storage tank (increase of asset value) Short construction term CO_2 emission, traffic jam (negative effects)	$R(i_1)$	Sales revenue Natural storage tank (increase of asset value) Stable supply (decrease of uncertainty) Increase of supply capacity (increase of the rate of LNG base operation) Decrease of transportation cost in the long run (scale economy) Saving natural gas in the pipeline Increase of reliance and confidence to partners Relationship specific assets(negative effect)
	C_1	Investment cost $C_1(i_2)$	C_1	Investment cost $C_1(i_1)$
M_2	$q(e_2)$	Sales revenue	$Q(e_1)$	Sales revenue Stable supply (decrease of uncertainty) Increase of supply capacity (increase of assets turnover) Increase of customers due to capacity Decrease of transportation cost in the long run[7] (scale economy) Saving natural gas in the pipeline Flexibility in combination with LNG terminals Increase of reliance and confidence to partners Relationship specific assets (negative effect)
	C_2	Investment cost $C_2(e_2)$	C_2	Investment cost $C_2(e_1)$
Externality		Expansion of network effects Promoting competition by network effects Widespread use of natural gas (contributing to the reduction of greenhouse gases from coal and other alternatives). Effective use of public and private land by pipeline construction		

diameter, total cost of 30 billion yen), and the diameter is smaller compared to normal pipelines(400~600mm diameter). The amount of purchase in Yamagata Gas Co. was 591,000,000MJ(2008).

[7] In fact, pipeline constructions reduce not only transportation costs but also maintenance costs and labor costs. For example, natural gas pipelines decrease maintenance costs larger than petroleum gas pipelines because natural gas is less contamination compared to petroleum gas. Moreover, in the case where distribution utilities own storage facilities, these utilities are responsibility for employing a person which has high level of knowledge about storage facilities and natural gas(Kikenbutu toriatukai sekininsya). Utilities do not need to employ the person if the utilities purchase natural gas through pipelines, and therefore, the utilities can decrease labor cost.

Next, I consider whether natural gas or not digging companies and distribution utilities should decide to adopt a subsidiary. As far as legislation in Japan is concerned since 2004, the government has permitted the establishment of companies which transports natural gas through pipelines(Doukanjigyousya). This has allowed companies to run a subsidiary for pipeline investments by making it easier than before[8]. Furthermore, there is a possibility for the subsidiary to do new business by making use of its own assets[9].

This model assumes that the investors(M_1 and M_2) commit two kinds of investments(specific and general) to the subsidiary(M_3). As a result, I found that the subsidiary makes only specific investments(pipeline investments) if and only if the investors dominate the control rights of the assets. In fact, in the case where investors establish a subsidiary cooperatively, if anything, the investors generally regulate not only a fund cap(K) but also the kinds of investments which can be made in relationship to the subsidiary. This situation seems to be the same in that investors dominate the control rights about assets. Simultaneously, if investors dominate both the control rights of assets and that of decision-making, when deciding on new investments, it would be inefficient because it takes a lot of time for several parties to make a joint decision.

Finally, this chapter explains additional comments about the rate of stock holdings. The best choice for both investors(M_1 and M_2) is that each hold a 50 percent share so as to maintain the balance of bargaining power. When we assume a situation in which the firms are not able to renegotiate and take account of only monetary benefits, the benefit from the management of M_3 is equivalent to the dividend of stock holdings. However, it is not necessary to hold more than 50 percent of the shares because the investors strive to keep the balance of bargaining power at 50:50.

5-5 Conclusions

This chapter focused on the organizational form of subsidiaries based on the evidence of the real world, and then considered whether the organizational form of subsidiaries increased the amount of pipeline investments by means of the property rights theory. Although we seem to generally have a serious problem in that theoretical models are strongly affected by assumptions, in the case where companies can make two kinds of investments(specific and general) and dominate the control rights of the assets, I found that the organizational form of subsidiaries tended to increase the amount of pipeline investments. Whereas, theoretical models, in general, are flawed in that they cannot completely account for the whole situation in the real world, and because of this, I too, was not able to solve the problem. I would need to continue studying and working to improve on this problem into the future.

[8] In Japan, pipelines are categorized four types in legislation. Four types are the city gas industry(Ippangasjigyo), Electricity(Denkijigyo), Pipeline industry, and petroleum industry(sekiyujigyo) respectively. Here, I assume as the city gas industry. This company is obliged consignment supply for effective use of pipeline network.

[9] For instance, pipeline companies in the United States provide storage services which are responsible for supplying natural gas corresponding to the fluctuation of demand.

Appendix

The objects of default are three(M_1,M_2,M_3), and the subsidiary(M_3) treats with only gas transportation between M_1 and M_2.

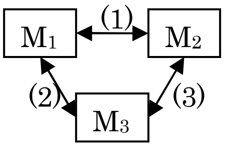

Figure 5-5 Default image

If the benefit of M_1 is $\frac{R(i_1)+Q(i_2)-[r(e_1)+q(e_2)]}{2} \leq 0$, then M_1 quits trading with M_2. M_1 stops providing natural gas to M_2, and cancels the contract of use of the pipeline. Therefore, M_1 defaults on (1) and (2). In this case, the subsidiary(M_3) is bankrupt, and the investors(M_1 and M_2) will divide the assets of M_3 into M_1 and M_2 in proportion to their stock holdings. After assets division, M_1 and M_2 continue transporting natural gas by using only general assets.

Similarly, the benefit of M_2 is $\frac{R(i_1)+Q(i_2)-[r(e_1)+q(e_2)]}{2} \leq 0$, then M_2 quits the trade with M_1. M_2 stops receiving natural gas from M_1 through the pipeline, and cancels the contract of use of the pipeline. Therefore, M_2 causes defaults against (1) and (3). In this case, the subsidiary(M_3) is bankrupt, and the investors(M_1 and M_2) will divide M_3 assets into M_1 and M_2 in proportion to their stock holdings.

As far as the subsidiary(M_3) is concerned, $b = b(i_1, i_2, e_1, e_2)$, which is included not only in monetary returns but also intangible benefits such as reputation, specific human capital, and effort, is basically $b > 0$. Even if the benefit of a subsidiary is $b < 0$, the subsidiary(M_3) cannot default on M_1 and M_2. Both M_1 and M_2 are investors and M_3 is a manager. The manager(M_3) may practice the default when the benefit of M_3 is $b < 0$. However, if the investors hope to continue in this business, the investors can continue in the business by dismissing the employer of M_3. Hence, the investors(M_1 and M_2) can veto the default of M_3, and then M_3 cannot default even if the benefit is $b < 0$.

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Japan Petroleum Explanation Co. Ltd. (JAPEX) http://www.japex.co.jp/business/japan/pipeline.html

Hokkaido Natural Gas(Hokkaido Tennengas riyosokushin kyogikai) http://www.hifa.or.jp/hng-hp/index.htm

Tohoku Natural Gas Co. http://www.tng-gas.co.jp/html/06/06_network.html

Chapter 6

Conclusions

(Summary)

This chapter, from the results of previous chapters, denotes the comprehensive conclusions. Contribution, universal services, pipeline investments and consignment supply, and future work are described.

6-1 Contribution

This paper examined the effects on the introduction of market principles into the city gas industry in Japan. The effects were, if anything, classified as the direct effects and future impact. And moreover, this paper estimated these effects by means of econometric methodologies and industrial organization theory. The research and estimation in this paper seem to be valuable because studies by the econometric methodologies and industrial organization theory have never been seen in the city gas industry.

The direct effects were considered in chapter 2. The city gas industry has been gradually mitigated the regulations since 1995 in order to eliminate the price differential between domestic and overseas by the introduction of market principles. As a result of this regulation reform, a competitive principle has been spread, and a certain city gas utility is now able to provide natural gas in the monopoly area of other gas utilities. Hence, this chapter estimated, using large utility data, whether city gas utilities could improve the management performance by means of DEA(Data Envelopment Analysis) methodology, which is a nonparametrical analysis. In the empirical analyses of public utilities, the parameter of capital assets should be treated carefully because public utilities are difficulty in optimizing capital assets and spend a lot of time to construct the plants and facilities. This chapter solved this serious problem by the use of Window Model(DEA). In conclusion, the efficiency of the management performance in the large utilities(Big9) was significantly improved.

Figure 6-1 and 6-2 show average authorization prices(Ninka Kakaku) in 1995 and 2005. Big9 companies(large utilities) are Tokyo-Gas, Osaka-Gas, Toho-Gas, Saibu-Gas, Hokkaido-Gas, Hiroshima-Gas, Keiyo-Gas, Hokuriku-Gas, and Shizuoka-Gas, which are used in chapter 2. Others denote all distribution utilities excluding Big9 utilities. Each graph shows the average authorization price in 1995 and 2005. The growth rate of Big9 from 1995 until 2005 is 29.1%, and that of other utilities is 38.6%. The growth rate of Big9 is outstandingly smaller compared to that of the other utilities. The deregulation would influence large utilities more strongly than small utilities because the government mitigated the regulation from large demand customers and gradually into smaller demand customers. Hence, the deregulation since 1995 would be useful for the city gas industry.

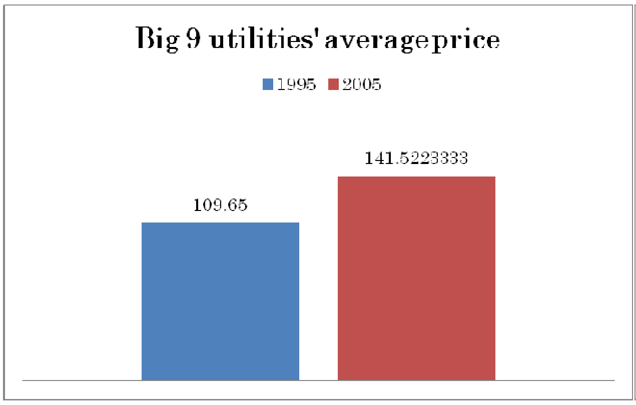

Figure 6-1 Big 9 utilities' average price

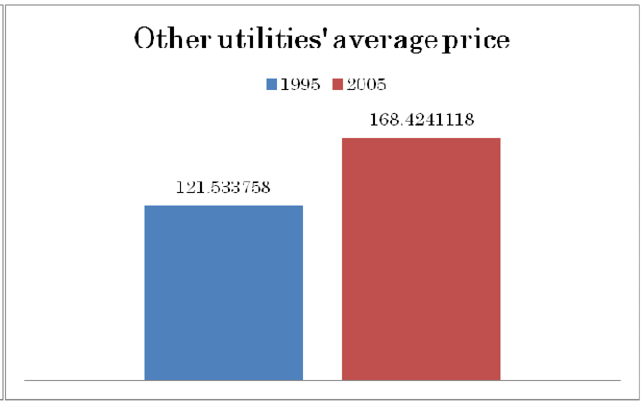

Figure 6-2 Other utilities' average price

With regard to the management of a manufacturing and a sales sector, in the real world, there are two types of city gas utilities: One which has only a sales sector, and the other with both a manufacturing sector and a sales sector. Chapter 3 considered the reason why there are two kinds of utilities by adapting the idea of industrial organization theory(transaction cost economics theory). As a result, if several utilities are existed in the same vicinity, gas retailers tend to trade with the utilities located in the same vicinity in order to purchase natural gas. In other words, when gas retailers gather in the same vicinity, they tend to buy their gas from outside suppliers and engage only in retail sales because in doing so they are able to be effectively lower the transaction costs.

City gas utilities, in general, construct pipelines when they trade with outside suppliers(utilities) in the same vicinity. If the city gas utilities constructed pipelines and tied with the utilities in the same vicinity, ex post transaction costs between gas retailers and outside suppliers rises. The increase of ex post transaction costs might cause the increase of incentive for integration between these companies.

Table 6-1 illustrates the cases of consolidation and transfer(acquisition) among gas utilities since 2000.

Table 6-1 Consolidation and transfer(acquisition)

Arrangement	Number
Consolidation	17
(Being bounded on each other)	4
(Consolidation after pipelines were constructed)	11
(Others)	5
Transfer	19
(Being bounded on each other)	8
(Consolidation after pipelines were constructed)	12
(Others)	6

(Exclude the simple transfer cases from public to private)

The retailers which were tied with utilities in the same vicinity through pipelines tend to consolidate together. This means these retailers would choose to merge in order to reduce the ex post transaction costs. With regard to ex post transaction costs and the consolidation after pipelines were constructed, they will be my future work.

Chapter 4, based on the result of chapter 3, examined the price differential in the city gas industry. This chapter reclassified city gas utilities into three organizational forms by adding the two organizational forms in chapter 3 to the utilities of holding 150,000 or more customers. In particular, the organizational forms between the firm which purchases natural gas from wholesalers and the firm which provides natural gas converted by using its own facility are quite difference. Although they are respectively trying to pursue its efficiency in a competitive manner, the results turned out to be quite different. Therefore, this chapter estimated scale economies in two types of supplier excluding the utilities of 150,000 or more customers and factor analysis on the price of their suppliers, and moreover, discussed in that the scale economies might be widen the gas price differential in the future.

Chapter 4 estimated scale economies by econometric methodology after distinguishing two types of organizational forms. As a result, the pipeline based suppliers have the nature of larger scale economies, while LNG based suppliers do not have the nature of scale economies equivalent to that of pipeline based suppliers relatively. In addition, I found that the gas retail prices of larger scale utilities were constant or at least not rising. This means that the gas retail price might be decided under the influence of scale economies. The result suggests that the rise of gas retail price of the pipeline based suppliers is not as high as that of LNG based suppliers in the case where utilities increase sales quantity. Accordingly, the result would cause price differential between pipeline based suppliers and LNG based suppliers.

The results of chapter 4 show that the utilities which purchase natural gas from wholesalers through pipelines can provide the gas to customers at a lower price, whereas the utilities which supply natural gas by transforming LNG into natural gas using their own facilities cannot provide natural gas at a lower price. If the results of chapter 4 are correct, the city gas industry should construct pipeline networks to be able to provide natural gas at a low price. Based on this idea, chapter 5 examined the organizational forms enough to increase the amount of pipeline investments.

This chapter adopted the model of subsidiary which develops the model of Cai(2003) because Cai's model supposed two types of investments and the organizational form of joint ownership. In the city gas industry, the utilities make two kinds of investments(pipelines and tank trucks), and actually adopt the organizational forms of joint ownership and a subsidiary. With respect to the relationship to investors and a subsidiary, I adapted the idea of Aghion and Bolton(1992). In conclusion, it is desirable that the utilities and digging companies should adopt the organizational forms of a subsidiary and joint ownership because pipeline investments generally, compared to tank truck investments, need a lot of construction expenditure.

6-2 Universal service

Here, I add my view about the universal service of the city gas industry[1].

The city gas industry has been one of the main energy industries for a long time, and natural gas is in constant demand throughout the year. Besides, the natural gas industry, as a rule, is well-known as a natural monopoly. Although gas distribution utilities are responsible for stable supply equal to demand, the utilities are permitted to maintain a monopolistic supply in a particular area by the government.

However, despite a lack of precise evidence, the government regulates only the supply sector because the nature of a natural monopoly might only exist in the supply sector. In this condition, the government has been gradually introducing competitive and market principles since 1995. This political resume introduction, as a result, has improved the competition not only among gas utilities but also between electric power utilities and gas distribution utilities. Cogeneration systems created by gas utilities are popularized in the industrial sector, and fully electrified homes(fully electric homes) operated by power utilities are also widespread in the household sector. The competitive dynamics after deregulation led to a transformation of the situation of energy fields, and moreover, this transformation created the serious problem of whether or not the segmentation of energy industries such as electricity, natural gas, and petroleum need to be reconstructed.

The change of situation in the area of energy fields gives us the opportunity to reconsider whether the city gas industry is a universal service or not. If we suppose that the city gas industry is a universal service, we would need to reduce the price differential among gas utilities, political subsidies for pipeline investments, and management by equal parts. On the other hand, if we suppose the city gas industry is not a universal service, and that the price differential is a regional problem, then gas distribution utility bankruptcy might occur more often, and the government would still have to do more to promote the introduction of competitive principles.

6-3 Pipeline investments and consignment supply

This paper examined the organizational forms which increase the amount of pipeline investments in chapter 5. Although I found that the organizational form of subsidiary increases the amount of pipeline investments, apart from the discussion about organizational forms, I describe about the relationship between pipeline investments and consignment supply.

Figure 6-3 illustrates the amount of all sales in the city gas industry per unit of pipeline. The values except for 2008 and 2009 are increasing constantly. This means gas distribution utilities are using pipelines effectively. Although, the average growth rate of the length of pipelines (1989-2009) is 1.6% and the growth rate of sales is 4.5%, from Figure 6-3, it is clear that the amount of pipeline investments is too little.

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[1] Universal services have the nature of essentiality, affordability, and availability(See chapter 4).

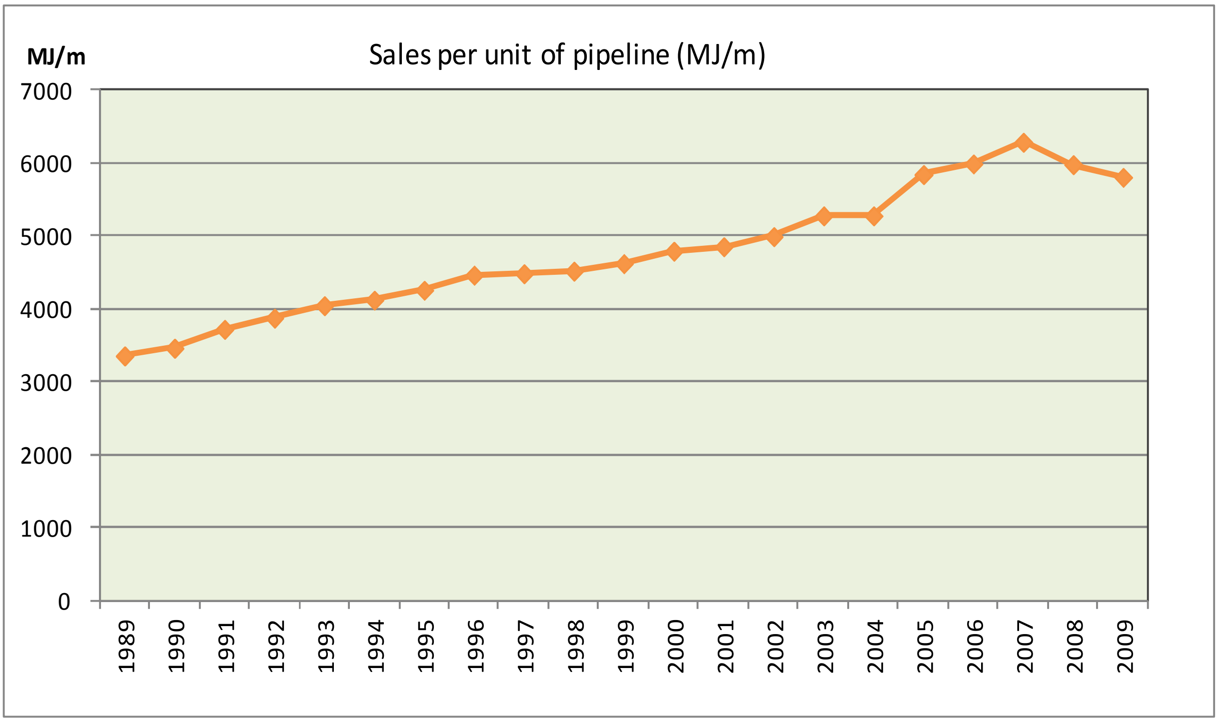

Figure 6-3 The amount of sales per unit of pipeline

The length of pipelines in Japan is small compared to the United States and European countries. Nevertheless, Japanese government has introduced consignment supply followed the deregulation in the United States. The political resume of consignment supply forces utilities owning pipelines to lend these pipelines at a reasonable price which the government has decided. Even if utilities and digging companies prefer to invest pipelines, the part of profit from the pipeline investments might be prevented by the political resume of consignment supply. This means the investors would lose the incentive of pipeline investments, and in fact, the amount of pipeline investments might not be enough compared to the amount of expected investments which investors are seeking. The source of this serious problem might be to adopt the political resume of consignment supply before the pipeline network becomes too widespread.

6-4 Future work

Finally, I denote about the studies which could not accomplish in this paper.

First, in real world, not only the competition among city gas distribution utilities but also another competition between gas distribution utilities and electric power utilities happened after deregulation. This paper explored the effects among gas utilities, and did not explore the effects between gas utilities and electric power utilities. This competition between gas and electric utilities might influence the management of the city gas utilities.

Second, cost structures and management efficiency were estimated by means of econometric methodologies, and the organizational forms were also analyzed by property rights theory. On the other hand, the consideration from the view of management strategies is not examined in this paper.

Because the importance of management strategies has been rising gradually by the spread of liberalization, it seems to be valuable to analyze management strategies.

Third, deregulation has practiced in the United States and a lot of European countries. Although it is significant for domestic utilities to research the present circumstance and deregulation schemes of natural gas market in foreign countries, this paper could not treat with these topics.

The three above will be my assignments in the future.