Economies of scale and scope in the Japanese water industry

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Introduction

In the past decades, the effectiveness of privatization and deregulation in the area of public utility industries such as electricity, gas, water, telecommunication, and transportation have been significant interests of researchers worldwide. At the same time, quite a lot of empirical studies have been conducted in different industries in different regions. One of the major focusing points of these studies is to find the existence of natural monopoly because if it doesn't exist, monopolistic supply should be no longer allowed and then the market should be divided as well as competitively supplied by at least two or more companies.

Natural monopoly tends to disappear due to the technology development which not only decreases average production cost but also reduces minimum efficient scale of production. As is well known by practitioners and researchers, the technology of water industry has not been progressed as compared to electricity, gas, telecommunication, and transportation industries where privatization or deregulation policies have been adopted in many countries. Furthermore, the water industry has specific characteristics, such as essential commodities of life, lack of substitute goods, necessities of maintaining high-qualities of purified water and so on. Therefore, water supply services have traditionally been provided by state- or municipally-owned water utilities and then unmoved to public-turned-private organizations. In fact, Van Ginneken and Kingdom (2008) reported that the major transition of water utilities in the 1990s had not been from public to private operation, but from centralized to decentralized public provision.

As far as we know, quite a lot of empirical studies have been conducted worldwide in the water industry. Most of them have been focusing whether economies of scale and/or economies of scope does exist in the industry because, as mentioned above, the common interests of regulators and managers of water utilities are in the most efficient scale (scope) of operations, not in the ownership changes or other drastic regulatory reforms.

In this study, we try to investigate effectiveness of scale expansion of Japanese water utilities. The benefits of using data in the Japanese water industry is that almost all of water utilities in Japan are owned and operated by local governments (99.4% in 2005) and many of them have been consolidated since 2000 (total number of water utilities changed from 1,964 in 2000 to 1,572 in 2006), so that we can conduct before- and after-consolidation analysis about really consolidated water utilities. Furthermore, we can use in-depth operating and accounting data provided online by The Ministry of Internal Affairs and Communications (http://www.soumu.go.jp/c-zaisei/kouei.html) which enables us to investigate whether or not economies of scale and/or economies of scope exist in the Japanese water industry.

The structure of the paper is as follows after the introduction. In the first section, we will give an overview of the water industry in Japan, some background to aid in understanding the reasons of high cost structures and the brief history of WSSs' consolidation. In the second section, the methodology for the cost models will be explained. In this section, we address some modifications of the cost function models. Third, we will show estimation results and analyze what factors have been affected from consolidations. Finally, we will summarize our results in a conclusion.

The Japanese Water Industry

The Number of Water Supply Systems

Since the first modern water supply system (WSS) was constructed in Yokohama in 1887, WSSs have been expanded throughout of Japan. WSSs are categorized into four types by the Water Act: Large Water Supply (LWS); Small Water Supply (SWS); Small Private Water Supply (SPW); and Bulk Water Supply (BWS). LWS is defined as the system wherein water is to be supplied to an estimated population of over 5,001, whereas SWS is defined as the system in which water is to be supplied to an estimated population between 101 and 5,000. SPW refers to the water supply system in buildings that are equipped with holding water tanks that have a capacity of more than $10m^3$ and can receive portable water from large/small water supply systems. On the contrary, BWS is defined as the water supply systems that supply portable water to large/small water supply systems and not to the end user[1].

It is worth mentioning that water services have been supplied by a large number of small WSSs. Even in the case of LWSs, the average number of water supplied population is only 73,526. The reason is that WSSs have generally been owned by the local governments of cities, towns and villages. This is mainly because the local governments are considered to play an important role in the prevention of water-borne infectious diseases and fire expansions (fire expansions are the result of the popularity of wooden houses being built in Japan) which were thought as big disasters at the time when modern water supply systems became to be required.

Water Supply Cost

The price index of water and sewerage services has increased dramatically in recent years.

[1] In our later analysis, we sample the observations from LWSs because only LWSs provide potable water under the regulation of independent accounting systems. Therefore, when we use the word 'water utilities' in this paper, it means LWSs.

Urakami (2007) pointed out that the reason of this dramatic increase of water utility rate was due to three factors – the type of ownership of water utilities, a lack of competition due to deregulation issues, and the number of water utilities. As mentioned above, almost all of Japanese water utilities are owned and operated by local governments. Generally, publicly-owned water utilities tend to over-estimate future demands, perhaps due to the utilities' focus on social welfare issues rather than cost-efficiency. To make matters worse, recent decline of water demand due to the development of water-saving technologies (e.g. water-saving toilet systems, water-saving washing machines, etc.) as well as change of life style (e.g. eating out more often, taking a shower instead of taking a bath, etc.) led to the reduction of water revenue – resulting in increased water prices.

Drastic regulatory reforms have been undertaken in public utility industries in Japan, such as electricity and gas (liberalization of market entry), transportation (deregulation of supply-and-demand balancing), and telecommunication (breakup and privatization). On the contrary, in the case of the Japanese water industry, such kinds of deregulations have not been promoted. That is because, as mentioned above, water industry has specific characteristics, such as essential commodities of life, lack of substitute goods, necessities of maintaining high-qualities of purified water and so on. As a result, natural monopoly has remained in the water industry so that competition has not been promoted.

Not only researchers but also practitioners have recognized that the scale disadvantages do exist in the Japanese water industry. KIIS (2006) conducted a questionnaire survey analysis and concluded that the main reasons of high cost structure of Japanese water industry were high percentage of purchased water cost and depreciation cost. Therefore KIIS suggested that water utilities should consolidate their plants or vertically integrate water intake-purification only companies and water-delivery only companies in order to save costs and operate water supply systems more efficiently. On the other hand, Mizutani and Urakami (2001) concluded that the optimal size of a water supply system should be 766,000 consumers; which is more than ten times larger than the average size of LWSs (73,526). However, the percentage of number of water utilities whose size of water supplied population is more than 500 thousands, is only 1.5%. This indicates that there must be so many cost-ineffective water utilities in Japan.

Methodology

Composite Cost Function

Traditional functional forms such as Cobb-Douglas and Translog have been used to estimate economies of scale and/or economies of scope. However, if some parts of observations include zero outputs; these functional forms would be inadequate because they have log-quadratic structures for output variables. To tackle this problem, researchers have applied a Box-Cox transformation to the Translog model (which is well known as Generalized

Translog); however question does arise even in this case: whether zero should be treated the same as nonzero data or whether zero represents a discrete corporate decision from other variations in the variable levels. (Greene 2008, pp.296-297) Therefore, in this study, a Composite cost function is selected as a cost model of water utilities. (*the details were omitted in this resume version*)

Data

All of the data used in the analysis was collected from the Annual Statistics of Local Public Corporations, (*Chihou Kouei Kigyo Nenkan*, in Japanese) edited by the Research Association of Local Public Firm Management (*Chihou Kouei Kigyou Keiei Kenkyu Kai*, in Japanese), and the Statistics of Water Works (*Suido* Tokei, in Japanese) edited by the Japan Water Works Association (*Nihon Suidou Kyokai*, in Japanese).

(Variables used in this analysis were omitted in this resume version)

Estimation Results

The estimation methods are the SUR (Seemingly Unrelated Regression) for a total cost function with input share equations. Before estimation, all variables except for time trend and dummy variables are normalized by sample means. The estimation results are shown in Table 3. The goodness-of-fit is acceptably high and the first-order coefficients of output and input factor prices show the correct signs and are statistically significant at 1% level.

The estimated coefficients of time trend shows negative sign and is statistically significant at 1% level. On the other hand, the estimated coefficients of cross term of consolidation dummy variable with time trend shows negative sign and is statistically significant at 1% level. Our result also shows water utilities' consolidation has a negative impact on cost reduction during sample periods, however it is quite small

Furthermore, the estimated coefficient of a type of water utilities dummy variable shows negative sign and is statistically significant at 1% level; however the extend is surprisingly small. It suggests that consolidated water utilities are 2.0% more cost effective than non-consolidated water utilities.

As for the estimation results of economies of scale and economies of scope are also shown in Table 3. The estimation results overall economies of scale show 1.020, indicating that there are economies of scale for Japanese water utilities, evaluated at sample mean points. In addition, estimation results of economies of scope show 0.534 for consolidated water utilities after water utilities' consolidation and 0.530 for non-consolidated water utilities. This indicates that, in both cases, there are economies of scope for water delivery and water purification so that Japanese water utilities could achieve cost savings from vertical integration.

Conclusion

The primary purpose of this study has been to investigate the existence of economies of scale and economies of scope in the Japanese water industry. This analysis relates world-wide interest about the optimal scale of water supply systems and optimal scope of services that water utilities provide.

The obtained results from our analysis are that there exist overall economies of scale for Japanese water utilities, as well as Japanese water utilities could achieve cost savings from joint operation between water delivery and water purification. These indicate that not only horizontal but also vertical scale expansion could lead to cost savings.

One another result we obtained from our analysis is that water utilities' consolidation has had beneficial impacts on cost effectiveness, but that is quite restricted. Almost eight years have passed since the beginning of local governments' consolidation, however large part of CWUs have been consolidated only for two or three years. It is easily thought that the effectiveness of consolidation in short time periods would be restrictive, so that we think we should continue to analyze the effectiveness of consolidations in the future.

Figure 1 *Number of Water Supply Systems*

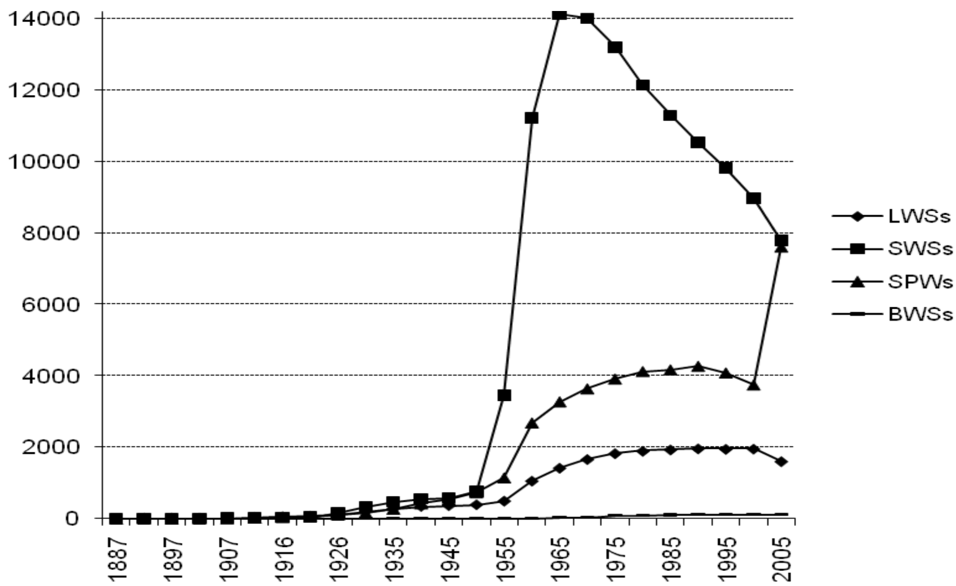

Table 3 *Estimation Results*

Variable	Estimate	SE	Variable	Estimate	SE
Constant	0.017	0.001	$w_L \times w_O$	-0.067	0.004
y_{DEL}	0.762	0.015	$w_K \times w_E$	-0.001	0.002
y_{PUR}	0.161	0.014	$w_K \times w_E$	-0.047	0.006
$y_{DEL} \times y_{DEL}$	0.032	0.005	$w_E \times w_O$	0.006	0.002
$y_{PUR} \times y_{PUR}$	0.031	0.006	Z_{POPNET}	-0.134	0.008
$y_{DEL} \times y_{PUR}$	-0.033	0.006	Z_{CAPUTL}	-0.356	0.026
$y_{DEL} \times w_L$	-0.082	0.003	Z_{COVRAT}	-0.087	0.022
$y_{DEL} \times w_K$	-0.091	0.016	Z_{DAYWAT}	-0.541	0.014
$y_{DEL} \times w_E$	0.000	0.009	Z_{UNDWAT}	-0.116	0.009
$y_{DEL} \times w_O$	0.172	0.020	Z_{PURWAT}	0.614	0.024
$y_{PUR} \times w_L$	0.045	0.001	Z_{HIGHPU}	0.104	0.011
$y_{PUR} \times w_K$	-0.119	0.014	t	-0.014	0.002
$y_{PUR} \times w_E$	0.026	0.009	tD_{Con}	0.011	0.002
$y_{PUR} \times w_O$	0.047	0.017	D_{Type}	-0.020	0.007
w_L	0.206	0.003	SE_{DEL}	0.811	0.015
w_K	0.482	0.004	SE_{PUR}	0.170	0.015
w_E	0.083	0.003	SE	1.020	0.001
w_O	0.229	0.010	*SC* with dummy	0.534	0.006
$w_L \times w_L$	0.109	0.004	*SC* without dummy	0.530	0.005
$w_K \times w_K$	0.086	0.005	R square (total cost)		0.938
$w_E \times w_E$	0.000	0.001	R square (labor cost)		0.279
$w_O \times w_O$	0.108	0.009	R square (capital cost)		0.373
$w_L \times w_K$	-0.038	0.003	R square (enegy cost)		0.294
$w_L \times w_E$	-0.005	0.001			