Economies of vertical integration in the Japanese water supply industry

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[Abstract] The merging of some water utilities in Japan has become possible since the 2000 Outline of Administrative Reform and the 2001 Water Act Revision. There are two avenues to merge water utilities, horizontal consolidation and vertical integration. Horizontal consolidation enables water distributors, such as the large water supply systems, to merge into one. Vertical integration enables water distributors and water wholesalers, such as the bulk water supply systems, to merge into one. However, these wide area consolidations or integrations haven't been promoted at local government level due to an absence of authority. Further, promotion has also been hindered by the lack of previous studies to support the economies of wide area consolidations or integrations.

This paper focuses specifically on vertical integration between the water intake-purification and water distribution stages. To investigate economies of vertical integration, I estimate the translog cost function in the Japanese water supply industry and calculate economies of vertical integration between water intake-purification and water distribution stages directly following the separability assumptions. Furthermore, we also take into account the purchased water ratio in calculating economies of vertical integration. The results show that the economies of vertical integration exist between the water intake-purification and water distribution stages, especially in the case of the lower purchased water ratio. Therefore, water supply systems that need to purchase high percentages of purified water would receive benefits of cost efficiency from the improvement of lower capacity utilization of purification plants.

[JEL Classification] L95, L11

[Key Words] water supply systems, translog cost function, economies of vertical integration

1. Introduction

Since the first modern water supply system was constructed in Yokohama in 1887, water supply systems have basically been owned by local governments such as city, town, and village. This is mainly due to the opinion that local governments were considered to play an important role in avoiding waterborne infectious disease as well as prevent fire expansions. (Fire expansions resulted from the popularity of wooden houses being built in Japan at that time) Therefore, a large number of small water supply systems have been operating in Japan. Although the Japanese government has been aware of the possibility of inefficiency due to the existence of a large number of small water supply systems, the wide area consolidations or integrations among already operated water supply systems hasn't been promoted due to an absence of authority, except for some areas where water intake and water purification activities have been jointly operated among some local governments.

However, recently in 2000, the Japanese water industry reached a crossroad due to discussions relating to administrative reforms. Since the 2000 Outline of Administrative Reform supported by the Koizumi Cabinet, many local governments merged. This became known as the Great Heisei Era Consolidation (3,232 in 1999 to 1,840 in 2006). Subsequently, many water supply systems have been inevitably consolidated or integrated. However, the consolidations or integrations of water supply systems have been promoted for political purposes rather than economic purposes. Actually, nobody really knows whether or not these consolidations or integrations lead to cost efficiency.

Another turning point was the Water Act revision in 2001 whereby many water utilities acquired options that allowed them to operate by themselves, or outsource whole or some parts of water supply systems, to other water utilities or new entrant water companies. Water suppliers became aware of the importance to discuss the possibility of reducing the cost in order to operate jointly with other suppliers or outsource some, or whole parts of water supply systems.

This paper focuses specifically on the vertical integration between the water intake-purification and water distribution stages. To investigate economies of vertical integration, I estimate the translog cost function of the Japanese water supply industry and test separability hypotheses among the water intake, purification and distribution stages. Therefore, this article is organized in the following manner: Section 1 as outlined above.

Section 2 describes an overview of the Japanese water industry. Section 3 presents the method of our analysis. Section 4 presents the results of our analysis. The concluding remarks are summarized in Section 5.

2. An overview of the Japanese water industry

The water supply systems in Japan are categorized into four types by the Water Act. Table 1 shows the number and definitions of each type of water supply system. There are a large amount of water supply systems in Japan, however the majority of them are very small, especially in the area of the small water supply and the small private water supply systems. It is worth mentioning that almost all of the water supply systems are owned by local governments, or by water authorities that are owned by some local governments. Further ten are owned by privately owned companies in the large water supply category. In contrary to the US or Europe where many private companies have a major role in the water industry, the ten private companies in Japan are very small and are owned by local developers. In addition, all of them receive a request to supply water from their local government, therefore they don't have any competitive power against the public water supply organizations.

< Table 1 >

< Figure 1 >

Figure 1 shows the time trend of public and private utility rates from 1992 to 2004. As you can see the water utility rate has dramatically increased whereas other utilities have either stabilized or decreased. The water utility rate increase is due to three factors: the number of water supply systems; a lack of competition due to deregulation issues; and ownership of water supply systems. Table 1 shows the number of water supply systems with the majority being small water supply systems. In a previous study Mizutani and Urakami(2001), it was concluded that the optimal size of a water supply system should be 800,000 however these water supply systems are less than 5,000. Therefore we consider that cost inefficiency is affected by the large number of small water supply systems. In addition, the type of ownership contributes to the increase in price, for example, publicly owned water companies over estimated future demand perhaps due to the companies focus on social welfare issues rather than cost efficiency. Further, the publicly owned companies overspent on construction of water intake and purification plants that resulted in a cost burden. In contrast, the privately owned companies are focused on minimizing costs and maximizing profits.

However, the main reason for the increase is the non-deregulation of the Japanese water industry resulting in a lack of competition.

In the case of the telecommunication industry, the competition between mobile phone companies has escalated due to the popularization of mobile phones, as well as the competition between broadband companies due to the wide use of ISDN, ADSL and optical networking. Hence, the connection fees of fixed phone line networks have been dramatically decreasing. In the case of the electricity industry, new entry to electric generation has been promoted in the area of large contracts due to the deregulation of the electricity industry. Subsequently, gas and steel companies have started to generate electricity for self usage as well as for re-sale. Thus, the price of electricity has been decreasing. Increased competition in the market place is also affected by the privatization of the expressway company and the electric company's plan to supply natural gas. In contrast, deregulation of the water industry has not been promoted therefore it is impossible to create competition between water companies. As already mentioned local government owned water companies used to seek maximization of social welfare, so they often provide excess investment resulting in increased water prices.

The Cabinet Office investigated the situation of the water industry especially in relation to higher prices of water rather than other public rates. They conclude that the main reason for high priced water was the cost burden of purchased water and depreciation expense. We can easily understand from Table 2 that the average cost of purchased water is higher when the purchased water ratio is higher. Therefore, the Cabinet Office made suggestions that water companies should consolidate their plants or vertically integrate water intake-purification companies and water delivery companies in order to save costs and operate water supply systems more efficiently.

< Table 2 >

In this analysis, I focus specifically on the economies of vertical integration between water intake-purification and water delivery activity. Therefore I will explain the method of the analysis used in my study.

3. Method

As mentioned by Nemoto and Goto(2004), there are two approaches for testing economies of vertical integration. One is the subadditivity test of the multi-output cost function in which an output is specified as one output of a vertically integrated firm. Following this approach, Kaserman and Mayo(1991), Gilsdorf(1994), Kwoka(2002), Jara-Dias et al.(2004) and Nemoto and Goto(2004) find evidence for the existence of economies of vertical integration. The other approach is to test separability among the production stages. Following this approach, Lee(1995) and Hayashi et al.(1997) provided supporting results for economies of vertical integration. As far as I know, while all these previous studies were investigated in the electricity industry, there is no published paper which tests economies of vertical integration in the water industry.

I estimate cost functions for the water intake-purification stage and water delivery stage respectively under the separability assumption and also estimate cost function for whole stages of water supply systems under the integration assumption. Then I compare the estimated costs and test the economies of vertical integration. The theoretical framework will be explained in the following section.

3.1 Theoretical Framework

A cost function of integrated firms is as follows:

$$C^{VI}= C^{VI} (Q, P_L, P_K, P_C, P_P, P_O, Z) \qquad (1)$$

Where C^{VI} is a total cost of vertically integrated water supply systems, Q is delivered water, P_L, P_K, P_C, P_P and P_O are input factor prices of labor, capital, chemical, purchased water and others. Z is a control variable.

If water supply systems are separable into upward stage (water intake and water purification stage) and downward stage (water delivery stage), the above cost function will be changed as follows:

$$C^{NVI} = C^{NVI}\{C^U(X, P_L, P_K, P_C, P_O), C^D(Q, P_L, P_K, P_P, P_O, Z)\} \tag{2}$$

Where C^{NVI} is a total cost of vertically disintegrated water supply systems, X is purified water, C^U is a total cost of upward stage and C^D is a total cost of downward stage. If we assume that the intermediate goods are to be sold at a marginal production cost, the above equation would be changed as follows:

$$C^{NVI} = C^{NVI}(Q, P_L, P_K, P_P, P_J(X, P_L, P_K, P_C, P_O), P_O, Z) \tag{3}$$

Where

$$P_J = \partial C^U / \partial X \tag{4}$$

We can estimate economies of vertical integration (EVI) directly as follows:

$$EVI = C^{VI}/C^{NVI} \tag{5}$$

If EVI<1 then the vertical structure is characterized by economies of vertical integration. On the contrary, if EVI>1, there are diseconomies of vertical integration and the two separated water supply systems are more efficient. Finally, if EVI = 1, there are no economies or diseconomies of vertical integration.

3.2 Empirical Model

The functional form of the cost function is specified as the translog cost model. The model of integrated firms is as follows:

$$\begin{aligned} \ln C^{VI} &= \alpha 0 + \alpha_Q(\ln Q) + \Sigma i \beta i(\ln Pi) + \gamma_{PWR}\ln Z_{PWR} \\ &+ 1/2\alpha_{QQ}(\ln Q)(\ln Q) + \Sigma i \alpha_{Q}i(\ln Q)(\ln Pi) + \alpha_{QPWR}(\ln Q)(\ln Z_{PWR}) \\ &+ 1/2\Sigma i \Sigma j\ \eta ij(\ln Pi)(\ln Pj) + \Sigma i\ \eta i_{PWR}(\ln Pi)(\ln Z_{PWR}) \\ &+ 1/2\ \gamma_{PWRPWR}(\ln Z_{PWR})(\ln Z_{PWR}) \end{aligned} \tag{6}$$

Where C^{VI}, total costs of vertically integrated water supply systems; Q, amount of water delivered(thousand square meters); Pi, input factor price(i(or j) = L(labor), K(capital), C(chemical), P(purchased water), O(other)); Z_{PWR}, purchased water ratio as a control variable.

In this model, we also impose restrictions on input factor prices such that $\Sigma i \beta i = 1$, $\Sigma i \alpha_{Q} i = 0$, $\Sigma i \eta ij = 0$, $\Sigma i\ \eta i_{PWR} = 0$. Furthermore, we apply Shepherd's Lemma from equation (6) and obtain the input share equations:

$$Si = \beta i + \lambda Qi(\ln Q) + \Sigma j\ \eta ij(\ln Pj) \tag{7}$$

Where Si, input i's share of the cost function. Since the sum of all the cost share equations is unity, one cost share equation must be deleted for estimation.

In contrast, the model of disintegrated firms is as follows:

$$\begin{aligned} \ln C^{NVI} &= \alpha 0 + \alpha_{Q}(\ln Q) + \Sigma i \beta i(\ln Pi) + \gamma_{PWR} \ln Z_{PWR} \\ &+ 1/2\alpha_{QQ}(\ln Q)(\ln Q) + \Sigma i \alpha_{Q} i(\ln Q)(\ln Pi) + \alpha_{QPWR}(\ln Q)(\ln Z_{PWR}) \\ &+ 1/2\Sigma i \Sigma j\ \eta ij(\ln Pi)(\ln Pj) + \Sigma i\ \eta i_{PWR}(\ln Pi)(\ln Z_{PWR}) \\ &+ 1/2\ \gamma_{PWRPWR}(\ln Z_{PWR})(\ln Z_{PWR}) \end{aligned} \tag{8}$$

Where C^{NVI}, total costs of vertically disintegrated water supply systems; Q, amount of water delivered(thousand square meters); Pi, input factor price(i(or j) = L(labor), K(capital), P(purchased water), J(purified water) O(other)); Z_{PWR}, purchased water ratio as a control variable.

As mentioned in section 3.1, we derived marginal production costs of the upper stage (P_J) as follows:

$$\begin{aligned} P_J &= \partial C^U / \partial X \\ &= \{C^U / X\}\{\partial \ln C^U / \partial \ln X\} \\ &= \{C^U / X\}\{\alpha_X + \alpha_{XX}(\ln X) + \Sigma i \lambda_X i\ (\ln Pi)\} \end{aligned} \tag{9}$$

Where

$$\begin{aligned} \ln C^{U} &= \alpha 0 + \alpha_{X}(\ln X) + \Sigma i \beta i(\ln Pi) \\ &\quad + 1/2\alpha_{XX}(\ln X)(\ln X) + \Sigma i \alpha_{X}i(\ln X)(\ln Pi) + 1/2\Sigma i \Sigma j\ \eta ij(\ln Pi)(\ln Pj) \qquad (10) \end{aligned}$$

Where C^{U}, total costs of upward stage (water intake and purification); X, amount of purified water (thousand square meters); Pi, input factor price (i(or j) = L(labor), K(capital), C(chemical), O(other)). In equation (8) and (9), we can impose restrictions and define cost share equations in the same way as equation (6).

4. Empirical Results

4.1 Data

All of the data used in this study was collected from *The Yearbook of Public Firms,(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 *Data Handbook of Water Supply, (Suidou Toukei, in Japanese)*, edited by Japan Water Works Association. The Yearbook and Handbook report quantitative and financial data for all water utilities in Japan. The number of observations is 561 in FY2003.

The variables used for the estimation of three (whole, upward stage and downward stage) cost functions are shown in Table 3 and defined as follows: Total cost of vertically integrated water supply systems (C^{VI}) is the sum of labor, capital, chemical, purchased water and other costs, whereas total costs of vertically disintegrated water supply systems (C^{NVI}) is the sum of labor, capital, chemical, purchased water, others and total cost of upward stages. As for the output measure, we used the annual total amount of delivered water (Q) for whole and downward stages and the annual total amount of purified water (X) for upward stages. Further, we defined five kinds of input factor prices. Firstly, the labor price (P_L) defined as the average annual salary per employee. Secondly, the capital price (P_E) obtained by the multiplication of the sum of depreciation expenditure divided by depreciation assets and interest expenditure divided by the amount of corporate loans, and the deflator of capital stock assets. Thirdly, the price of chemical (P_C) defined as the expenditure for chemical per amount of purified water.

In addition, the fourth type relates to the price of purchased water (P_W) defined as the expenditure for purchased water in relation to the amount of purchased water. Finally, the price of other costs (P_O), such as outsourcing cost and tax payments, is 1 as a numeraire. The purchased water ratio (Z_{PWR}) as a control variable is defined as the amount of purchased water divided by the total amount of delivered water. We assume that these input factor prices are the same across all stages. On the contrary, we should allocate labor, capital, and other costs to each stage because we can not obtain accurate cost data of each stage. Therefore, the way we allocate three cost data is as follows: labor cost is allocated by a ratio of the number of employee in each stage. Capital and other costs are allocated by the operating expense ratio of each stage.

4.2 Estimation results

The results from the estimation of the cost function are shown in Table 4. The estimation method is the SURE (Seemingly Unrelated Regression Estimation) for the cost model with input share equations. The goodness-of-fit in these regressions are acceptably high for each model. The estimated cost models meet almost all of the required properties. Firstly, symmetry and homogeneity in input factor prices are satisfied because of the restrictions imposed on input factor prices. Further, monotonicity and concavity conditions in the cost model are satisfied at least locally. The first-order coefficients in the cost model show the correct sign.

<Table 4>

We also checked the scale economy (SE) of water supply systems. The results show slight increasing return to scale in both vertically integrated and vertically disintegrated model at the sample mean point.

Further, from the estimation results, we calculate economies of vertical integration (EVI) with respect to the different purchased water ratio. The results are shown in Table 5.

<Table 5>

We can easily understand from Table 5 that the water supply systems with higher purchased water ratio show higher economies of vertical integration. This means that the water supply systems that have to purchase purified water less than 100% of their total delivered water should own and operate a purification plant. This should result in low level capacity utilization due to the restriction of the contract of purchase responsibility of purified water with wholesaler of purified water even in the case where demand is decreasing. Therefore, the water supply systems with higher purchased water ratio receive the benefit of vertically integrated operation between the water-intake and purification activity and water delivery activity.

5. Conclusions

This paper focused on the economies of vertical integration between upward stages (water intake and purification activity) and the downward stages (water delivery activity). We analyzed whether or not vertically integrated water supply systems receive any benefit from joint operation between upward and downward stages. To analyze this, we assumed the separability condition and estimated the translog cost function for vertically integrated and disintegrated model and directly induced economies of vertical integration. Further, in calculating the economies of vertical integration (EVI), we took into account the differences of the purchased water ratio because we considered these factors affected the EVI measure.

The final results obtained from this analysis are as follows: (1) there are economies of vertical integration in the Japanese water supply industry; (2) the water supply systems that have a lower purchased water ratio can receive higher economies of vertical integration.

These results show that the water supply systems can receive cost efficiency from vertically integrated systems, especially in the case of the lower purchased water ratio. Therefore, we think water supply systems that have to purchase high percentages of purified water would receive the benefit of cost efficiency from improvement of lower capacity utilization of a purification plant.

References

Garcia,S., M.Moreaux and A.Reynaud (2004), "Measuring economies of vertical integration in network industries: an application to the water sector," presented paper in Econometric Society 2004 North American Summer Meetings, Econometric Society.

Gilsdorf,K. (1995), "Testing for subadditivity of vertically integrated electric utilities," *Southern Economic Journal*, Vol.62, No.1, pp.126-138.

Hayashi,P.M., J.Y.-J. Goo and W.C.Chamberlain (1997), "Vertical economies: the case of U.S. Electric utility industry, 1983-87," *Southern Economic Journal*, Vol.63, No.3, pp.710-725.

Jara-Dias,S., F.J.Ramos-Real and E.Martinez-Budria (2004), "Economies of integration in the Spanish electricity industry using a multistage cost function," *Energy Economics*, Vol.26, pp.995-1012.

Kaserman,D.L. and J.W.Mayo (1991), "The measurement of vertical economies and the efficient structure of the electric utility industry," *Journal of Industrial Economics*, Vol.39, No.5, pp.483-502.

Kwoka,J.E. (2002), "Vertical economies in electric power: evidence on integration and its alternatives," *International Journal of Industrial Organization*, Vol.20, pp.653-671.

Lee,B.-J. (1995), "Separability test for the electricity supply industry," *Journal of Applied Econometrics*, Vol.10, No.1 , pp.49-60.

Nemoto,J. and M.Goto (2004), "Technological externalities and economies of vertical integration in the electric utility industry," *International Journal of Industrial Organization*, Vol.27, No.1, pp.67-81.

Table 1 Number of water supply systems (FY2003)

Bulk water supply		109
Large water supply	Publicly owned	1,926
	Privately owned	10
Small water supply		8,360
Small private water supply		7,314
Total		17,719

(Source): Management indices of water utilities, FY2003.

(Note): Bulk water supply is the water supply system which supplies portable water to large/small water supply systems not to the end user. Large water supply is the system where the planned population to be supplied is more than 5,001. Small water supply is the system where the planned population supplied is between 101 and 5,000. Small private water supply is the water supply system in buildings equipped with receiving water tanks having the capacity of more than $10m^3$ and receives portable water from large/small water supply systems.

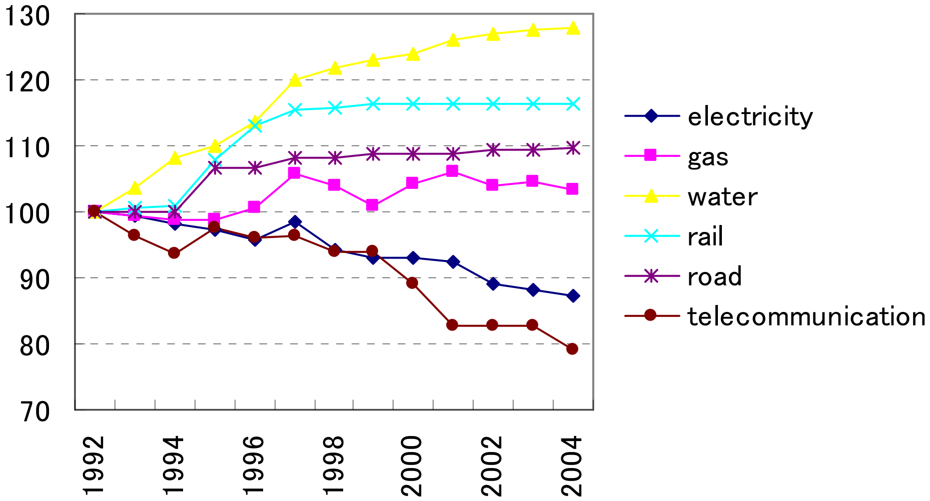

Figure 1 Price indices of public utility rates (1992=100)

(Source): Ministry of Internal Affairs and Communications

Table 2 Average cost with respect to purchased water ratio (FY2003)

	purchased water ratio	number of observation	average cost
bulk water supply	0%	85	90.9
large water supply	0%	981	179.8
	< 20%	133	189.0
	< 40%	173	206.6
	< 60%	171	223.3
	< 80%	162	207.7
	< 100%	87	238.3
	100%	161	294.6

(Source): Management indices of water utilities, FY2003.

(Note): One observation in bulk water supply and two observations in large water supply are excluded from the calculation of average cost due to data limitation. Average cost is total cost per delivered water.

Table 3 Definition and sample mean of variables used for the estimation of cost function

Variables	Definition	Unit	Average
TC^U	Sum of labor, capital, chemical and other costs of upward stage	thousand yen	1,338,964
TC^D	Sum of labor, capital, purchased water and other costs of downward stage	thousand yen	2,190,096
Q	Annual delivered water	thousand squared meter	22,058
X	Annual purified water	thousand squared meter	16,890
CL^U	Average annual salary of upward stage	thousand yen	324,356
CL^D	Average annual salary of downward stage	thousand yen	342,386
CK^U	Sum of depreciation costs and interest cost of upward stage	thousand yen	570,437
CK^D	Sum of depreciation costs and interest cost of downward stage	thousand yen	784,706
CC	The expenditure for chemical	thousand yen	16,688
CP	The expenditures for purchased water	thousand yen	507,525
CO^U	Other costs of upward stage	thousand yen	427,483
CO^D	Other costs of downward stage	thousand yen	555,479
P_L	Average annual salary per employee	thousand yen/employee	8,415
P_K	Sum of depreciation costs per assets and interest cost per corporate loans	-	6.536
P_C	The expenditure for chemical per amount of purified water	yen / m^3	1.160
P_P	The expenditures for purchased water per the amount of purchased water	yen / m^3	13.823
P_J	Estimated in the cost model	yen / m^3	1,279
PWR	Amount of purchased water per delivered water	-	0.248

Table 4 Estimation Results

	Vertically integrated		Vertically disintegrated			
			Upward stage		Downward stage	
Parameter	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error
α0	14.931	0.019	13.857	0.020	15.506	0.027
αQ	0.957	0.015	0.941	0.015	0.966	0.015
βL	0.152	0.004	0.204	0.009	0.121	0.012
βK	0.372	0.006	0.502	0.007	0.362	0.017
βC	0.080	0.010	0.049	0.005	-	-
βP	0.200	0.008	-	-	0.197	0.008
βJ	-	-	-	-	0.108	0.014
βO	0.196	0.013	0.246	0.008	0.212	0.023
γPWR	0.000	0.016	-	-	-0.052	0.013
αQQ	0.090	0.010	0.106	0.007	0.057	0.008
αQL	0.000	0.003	-0.029	0.005	0.001	0.003
αQK	-0.007	0.004	0.016	0.004	-0.008	0.004
αQC	-0.031	0.006	0.013	0.002	-	-
αQP	0.003	0.004	-	-	0.004	0.003
αQJ	-	-	-	-	0.008	0.004
αQO	0.035	0.008	0.001	0.004	-0.005	0.006
αQPWR	-0.006	0.005	-	-	-0.007	0.004
ηLL	0.149	0.017	0.194	0.032	0.140	0.016
ηLK	-0.056	0.012	-0.117	0.023	-0.059	0.012
ηLC	0.002	0.001	0.000	0.003	-	-
ηLP	-0.001	0.001	-	-	0.000	0.001
ηLJ	-	-	-	-	-0.012	0.004
ηLO	-0.095	0.019	-0.078	0.025	-0.068	0.018
ηLPWR	-0.004	0.001	-	-	-0.004	0.001
ηKK	0.092	0.020	0.097	0.024	0.081	0.020
ηKC	-0.001	0.002	-0.004	0.003	-	-
ηKP	-0.001	0.001	-	-	-0.003	0.001
ηKJ	-	-	-	-	-0.003	0.006
ηKO	-0.035	0.020	0.024	0.021	-0.016	0.020
ηKPWR	-0.009	0.001	-	-	-0.006	0.001
ηCC	0.013	0.001	0.007	0.001	-	-
ηCP	-0.001	0.001	-	-	-	-
ηCO	-0.012	0.003	-0.004	0.002	-	-
ηCPWR	-0.001	0.001	-	-	-	-
ηPP	0.013	0.001	-	-	0.017	0.001
ηPJ	-	-	-	-	-0.004	0.001
ηPO	-0.010	0.002	-	-	-0.010	0.002
ηPPWR	0.004	0.001	-	-	0.003	0.000
ηJJ	-	-	-	-	-0.074	0.005
ηJO	-	-	-	-	0.093	0.008
ηJPWR	-	-	-	-	-0.008	0.001

ηOO	0.152	0.030	0.058	0.033	0.001	0.030
ηOPWR	0.009	0.002	-	-	0.016	0.002
γPWRPWR	0.002	0.002	-	-	-0.002	0.002
R^2	0.946		0.875		0.972	
SE	1.045	0.016	1.062	0.016	1.035	0.016

Table 5 Economies of vertical integration with respect to purchased water ratio

Purchased water ratio	Average EVI	Number of observations
0%	0.238	279
0~20%	0.484	46
20~40%	0.524	70
40~60%	0.545	54
60~80%	0.543	64
80~99%	0.589	48
Total	0.338	561