ECONOMETRIC TEST OF COST SUBADDITIVITY IN U.S. ELECTRIC INDUSTRY

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ABSTRACT

There have been several studies of market power and existence of cost subadditivity in case of U.S cigarette industry and various utility industries. But there is dearth of similar studies in U.S. electric industry. This study attempts to fill that gap. We apply Evans and Heckman's test in the case of cost subadditivity in U.S. electric industry because the electric utility industry in the United States is often cited as an example of a less than perfectly competitive industry. The necessary and sufficient conditions of the test require that the firms chosen for the study have the output at least twice the minimum output observed in the sample. We chose 19 firms that met the conditions. The output quantity for each of the firms was split into the minimum observed quantity and the residual quantity as required by the test. Using a Cobb-Douglas production function the total cost of production for both components of total output (i.e. the minimum quantity and the residual quantity) for each firm were computed and compared with the actual cost of production of the entire quantity by each firm. We found that the sum of the cost of production of the minimum quantity and that of the residual quantity was greater than the cost of production of entire quantity for each firm. Thus, all 19 firms in our sample were found to exhibit cost subadditivity and thereby a natural monopoly.

JEL Classification: L1
Key Words: natural monopoly, cost superadditive, cost subadditive, cost additive

INTRODUCTION

The adherents of deregulation maintain that an increased competition in the markets invariably enhances efficiency in production and distribution. The underlying logic is that efficiency in allocation is achieved as firms after deregulation tend to attain the output level where marginal cost equals price. In so doing, the firms also tend to achieve production efficiency by choosing the input combination that produces a given level of output with a given level of technology at the least costs. But the opponents of deregulation question whether a competitive market always brings about production and allocative efficiency. A situation where the average cost of producing the total demand quantity by a single firm is lower than the average cost of producing the same quantity by two or more firms creates opportunity for a natural monopoly. If that occurs, the cost of producing the total demand quantity would be minimized by allowing one firm to produce all quantity, that is, by restricting other firms to enter the market.

There have been several studies of market power and existence of cost subadditivity in case of U.S cigarette industry and various utility industries. But there is dearth of similar studies in U.S. electric industry. This is surprising in view of the important position of electric industry in GDP and the lives of millions of people and thousands of other industries affected by their cost/price increase. This study attempts to fill that gap because the electric utility industry in the United States is often cited as an example of a less than perfectly competitive industry. The findings of this study would be important to the Electric Industry companies, its millions of residential and commercial consumers and the Policy makers involved in regulating utility companies.

REVIEW OF UNDERLYING MICROECONOMIC THEORY

A firm, operating in the short run, finds it impossible to vary the quantities of all the inputs it uses in the production, due to its inability to constantly adjust its production capacity to match the ever changing demand for its product. If the capacity of production cannot be adjusted (changed) according to each incremental unit of production then such a situation gives rise to an average cost curve that slopes downward until the capacity is fully exhausted. This situation persists as long as the firm fails to fully adjust its production capacity to every marginal increment in the production. This phenomenon is also referred to as the "economy of scale." To see how the economy of scale gives rise to a downward slopping average cost curve, we differentiate the average cost (AC = C/Y) with respect to the output (Y) as follows:

$$\partial AC/\partial Y = \partial(C/Y) / \partial Y = (Y\partial C/\partial Y - C.\partial Y/\partial Y) / Y^2 = (Y.MC - C) / Y^2 =$$
$$(Y. MC/Y - C/Y) / Y = (MC - AC) / Y \qquad (1)$$

where, C is the total cost; and MC is the marginal cost.

As output (Y) can never be negative, this implies that the AC curve slopes downward in the output range where the marginal cost (MC) is smaller than the average cost (AC), a situation called the positive economy of scale. Thus, the AC curve slopes downward so long as a positive economy of scale exists. Conversely, the AC curve slopes upward so long as a negative economy of scale exists, a situation where $AC < MC$ and $\partial AC/\partial Y > 0$.

Within the downward slopping range of the AC curve, it is always cheaper to produce the total demand quantity by one firm than to produce the same quantity by more than one firm. This is illustrated in Figure1below. The AC of producing OQ_2 is lower than the AC of producing OQ_1 by each of the two separate firms where $2OQ_1 = OQ_2$. This situation gives rise to the so called "cost subadditivity" in production. Evans and Heckman (1984) define cost subadditivity as the following. The cost function C (q) is Sub-additive at the output level $\bar{q}$ if and only if

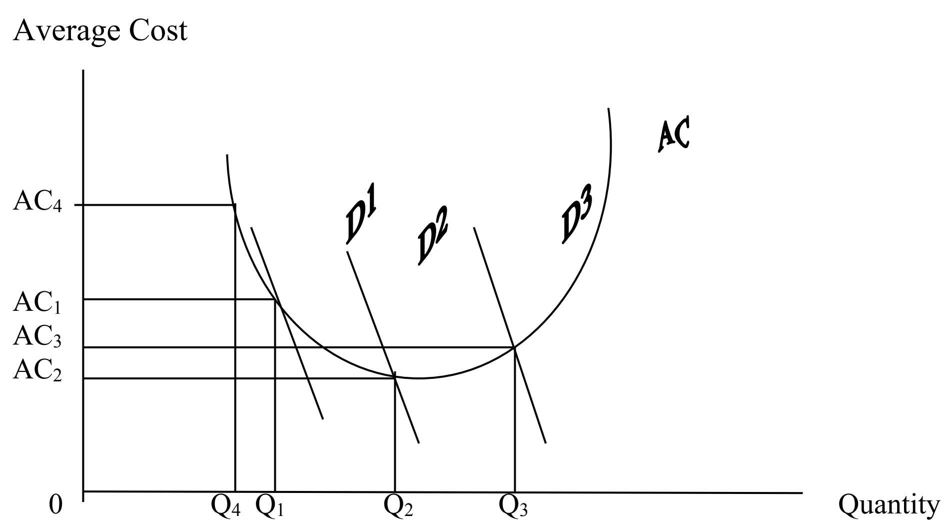
$$C(\bar{q}) < \sum_{i=1}^{n} \sum C(\bar{q}^{i}) \qquad (2)$$

where, $\sum_{i=1}^{n} \bar{q}^{i} / n = \bar{q}$, (3)

and $\bar{q}^{i} \geq 0$ with at least two non-zero vectors of $\bar{q}^{i}$. Here **n** is the number of firms. This very existence of cost subadditivity gives market power to the incumbents by preventing entry to potential entrants and thereby limiting the competition in the market.

As illustrated in Figure 1 below a positive economy of scale implies cost subadditivity. However, as Panzar (1989) argues, positive economies of scale are sufficient but not necessary for the firm's average cost curve to be declining in the single output case. Figure 1 demonstrates that situation.

Figure 1



At OQ_3 level of demand, it is cheaper to produce the total OQ_3 quantity by a single firm (at AC_3) than to produce OQ_2 quantity by one largest firm at the lowest average cost, AC_2, and the residual amount Q_2Q_3 (equal to OQ_4) by a second firm at the average cost, AC_4. Clearly, at OQ_3 level of production, there is a negative economy of scale, but there still exists the cost subadditivity. So, an economy of scale is not required for the existence of cost subadditivity, but the cost subadditivity necessarily exists if there is an economy of scale.

REVIEW OF SELECTED LITERATURE

In Tobacco Case of 1946, the major domestic (U.S.) cigarette manufacturers were accused of operating an illegal cartel (Nicholls, 1949). Although the manufacturers were convicted, but there was a general consensus that the industry behavior was not changed by the verdict. As a result, the aftermath of the case prompted several studies on market conduct and market structure of the cigarette industry.

Sumner (1981) measures the market power of U.S. cigarette industry using a price function. Sullivan (1985) estimates a similar model using a simultaneous equation system approach over the year 1955-82. A study by Adhikari (2004) measures the market power of U.S. cigarette industry using revenue elasticity approach. Furthermore, one can find several studies done on cost subadditivity in various public or private utilities companies. Studies in this group include those by Bitzan (2003), Sueyoshi (1996), Cubukcu et al (2008), Jamasb et al (2008), Everett (2008), Yudong et al (2008), Currier et al (2008), Wills-Johnson (2008), Won (2007), Fung et al (2007), Becker et al (2006), Kwoka (2006), Chang et al (2006), Ramos-Real & Javier (2005), and Gordon et al (2003). These studies cover communication and transportation except for Ramos-Real & Javier (2005). There is, however, lack of empirical study on the tests for cost subadditivity in U.S. electric industry. Most of the studies mentioned above apply a translog function for the estimation of the cost function and for the determination of cost subadditivity. However, these studies don't impose a necessary or a sufficient condition to test their hypothesis. Our study will apply Evans and Heckman's test (1984) for the test of cost subadditivity and will test the hypothesis by imposing both necessary and sufficient condition.

We will present the model for the study in section 3. In section 4 we will explain the data and the methodology of the study. The empirical findings will be presented in section 5 and will summary of our results in section 6.

THE MODEL

Baumol et al. (1982) have recommended separate tests for necessary and sufficient conditions for cost subadditivity. Because, doing so will allow the researcher to reject the hypothesis of cost subadditivity if the necessary condition fails to be satisfied, and to accept it if the sufficient condition is met. However, the problem with this testing procedure, in a single product case, is that the test becomes inconclusive if the acceptance of the necessary condition occurs together with the rejection of the sufficient condition. Therefore, this study applies Evans and Heckman's test for the test of cost subadditivity. They derive the test as following.

Since an industry can be split into two or more firms in an infinite number of ways, a global test for cost subadditivity is extremely difficult. Owing to this problem, Evans and Heckman have developed a local test for cost subadditivity. By employing certain restrictions, as determined by observed data points, they have narrowed down the area over which the test could be applied. The region confined within these restrictions is called the "admissible region." For the sake of simplicity, they assume that there only exist two firms in the industry, and so, $n = 2$. Denoting the first hypothetical firm by A, and the second by B the total output can, then, be expressed as $q = q^A + q^B$. The cost of production of the total quantity, q, by the two firms is $C^A + C^B$, whereas the cost of producing the whole quantity, q, by a single firm is C. If $C < C^A + C^B$ for all two-firm configurations, then the cost function is subadditive at q, over an admissible region. They specify two constraints that define the admissible region.

The first constraint requires that no hypothetical firm be permitted to produce less of either of the two outputs than the output of the firms for which there is data. Suppose q_m is the vector of minimum output such that $q_m = (\min. q_{1t}, \min. q_{2t}) = (q_{1m}, q_{2m})$ where $\min. q_{it}$ is the minimum quantity of *i*th output. Suppose firm A and B produce as following:

$q_t^A = (\phi\ q_{1t}^* + q_{1m}\ ,\ \ w\ q_{2t}^* + q_{2m})$; and (4)
$q_t^B = [(1\text{-}\phi)\ q_{1t}^* + q_{1m}\ ,\ \ (1\text{-}w)\ q_{2t}^* + q_{2m}]$, (5)

where, q_{it}^* is the incremental quantity and q_{im} is the minimum quantity of ith output respectively. Then the industry production of output 1 and 2 can be expressed as

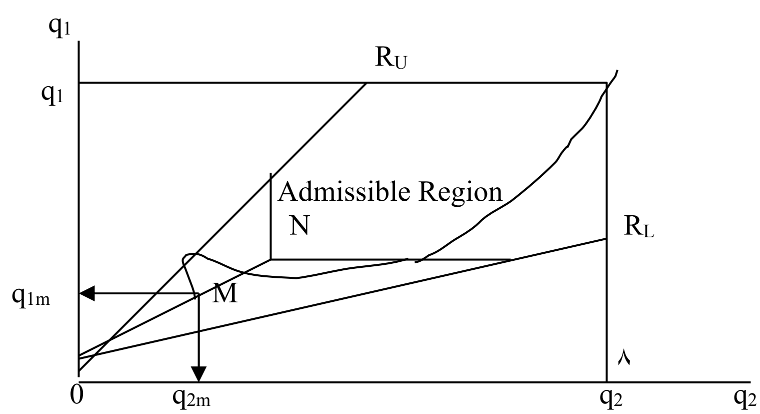
$\bar{q}_{1t} = q_{1t}^* + 2q_{1m}$ (6)
$\bar{q}_{2t} = q_{2t}^* + 2q_{2m}$ (7)

Thus the first constraint requires that the test be based on the firms for which the output of each of the two products is at least twice the output level in the sample. This constraint also holds in one product case. The second constraint requires that both firms A and B produce q_1 and q_2 in a ratio within the range of the ratios observed in the data. This implies the following inequalities.

$R_L\ <\ (\phi q_{1t}^* + q_{1m}) / (w\ q_{2t}^* + q_{2m})\ <\ R_U$ (8)
$R_L\ <\ [(1\text{-}\phi)\ q_{1t}^* + q_{1m}] / [(1\text{-}w)\ q_{2t}^* + q_{2m}]\ <\ R_U$, (9)

where R_L is min.(q_{1t}/q_{2t}) and R_U is max.(q_{1t}/q_{2t}). The admissible region can be shown as following.

Figure 2



At point M, both outputs are at their observed minimum levels, whereas, at point N, both output quantities are double their observed minimum levels. Therefore, any point to the right of point N will satisfy the first constraint. Since R_U and R_L are maximum ratio of output 1 to output 2 in observed data, any point to the right of OR_U line but to the left of OR_L line satisfies the second constraint. Since q_1 and q_2 are the maximum levels of outputs observed in the data, the admissible region satisfies all the constraints. So, the test of sub-addativity has to be limited within the admissible region. In one product case the second constraint reduces to the following inequalities

$$\min.\ q_t \le \phi\ q_t^* + q_m = \bar{q}_t^A \le \max.\ q_t \qquad (10)$$

$$\min.\ q_t \le (1-\phi)\ q_t^* + q_m = q_t^B \le \max.\ q_t \qquad (11)$$

It means that none of the hypothetical firms be permitted to produce lower than the observed minimum quantity and higher than the observed maximum quantity. In one product case the second constraint is satisfied by all the observations. Therefore, in one product case, the observations considered for the test of sub-addativity have to satisfy the first constraint only. As such, only those observations can be taken for the test, which have output quantity twice as much as the minimum observed quantity.

Let $\bar{C}(\bar{q}_t^A)$, $\bar{C}(q_t^B)$ and $\bar{C}(\bar{q}_t^A + \bar{q}_t^B)$ be the cost of producing $\bar{q}_t^A$ and $\bar{q}_t^B$ by firm A and firm B and the cost of producing $\bar{q}_t^A + \bar{q}_t^B$ by a single firm respectively. Then the degree of cost subadditivity is measured by:

$$SUB = [\bar{C}(\bar{q}_t^A + \bar{q}_t^B) - \bar{C}(\bar{q}_t^A) - \bar{C}(\bar{q}_t^B)] / \bar{C}(\bar{q}_t^A + \bar{q}_t^B) \qquad (12)$$

If SUB is less than zero the cost function is Sub-additive; if it is zero the cost function is additive; and if it is greater than zero, then the cost function is super-additive.

THE DATA AND METHODOLOGY

The data on all the variables (e.g. input costs and output) for the U.S. electric industry have been obtained from the United Nations Industrial Development Organization (UNIDO) website: http://www.unido.org. Only those firms have been chosen for the study for which the output is at least double of the minimum quantity observed in the sample in order to satisfy the constraints defined in our model. The relevant data set on all the firms is given in Appendix A.

The costs of producing total output have been estimated using the Cobb-Douglas cost function as shown in the appendix-A. To test for cost subadditivity, we need to split each firm's output into two or more parts. A firm's output quantity can be split into two parts in infinite number of ways without violating the constraint. However, to economize on time, output in each observation has been split into the minimum observed quantity, which is 0.248 million kilowatt hours, and the residual quantity. Then using the estimated cost function, the cost for each of the two components has been estimated for each firm. Based on the above estimates, the degrees of subadditivity have been estimated for each of the admissible firm using equation (12). Values less than zero for the variable SUB imply cost subadditivity; zero implies cost additivity and values greater than zero for the variable SUB_t imply super-additivity.

EMPIRICAL FINDINGS

Based on the data on 19 firms, we estimated the following Cobb-Douglas cost function:

LNCOST = -0.329753698+0.774837428LNPL–0.421208228LNPK + 0.840977191 LNY
(-0.7786451) (3.057291524) (-1.58613098) (17.36975228)
R^2 = 0.9583, F-statistic = 114.8199, p-value associated with the F-value = 0.000

The value LNCOST is the log of the long run total cost for the generation and transmission of electric power expressed in millions of dollars, LNPL is the log of the average annual payment per worker expressed in thousands of dollars, LNPK is the log of the estimated user cost of capital expressed in thousands of dollars, and LNY is the log of the total generation and transmission of electric power expressed in millions of kilowatt-hours. The data on these variables are given in the appendix. The figures in the parentheses are the associated t-values. The coefficients associated with LNPL and LNY are significant at 1 percent level whereas that associated with the variable LNPK is not significant even at 10 percent level. A high R^2 value indicates that the model fits the data well and the p-value associated with the F-statistic indicates that the Coefficient of Determination is highly significant. Therefore, we use this model to estimate the total long-run cost of producing the total quantity as well as the cost of producing both the minimum quantity ((0.248 millions of kilowatt-hours), and the residual quantity for each firm. We, compute the average cost of production of the total quantity, the minimum quantity, and the residual quantity as the following:

Log of average cost of production = LNCOST – LNY (13)

The average cost of production for the total and for each quantity for each firm is, then, estimated by taking the exponent of the log of the average cost of production, which is shown in Appendix-B. The average cost of producing the minimum quantity and that of the residual quantity are added together. Finally, the sum was subtracted from the average cost of producing the total quantity for each firm. The result is the measure of cost-additivity (the result is shown in column COSTADD in Table 1 below. A negative entry indicates that the sum of the average cost of producing the minimum quantity and that of the residual quantity is greater than the average cost of producing the whole quantity, exhibiting thereby the cost subadditivity. The results in Table 1 show that the average cost of production of each firm is sub-additive.

Table 1

Subadditivity Estimates for 19 Private U.S. Electric Utility Firms

Firm	ECOST	ECOST1	ECOST2	COSTADD	SUB
1	2.284075	2.656892	0.199748	-0.57256485	Sub-additive
2	2.33695	2.795377	0.171976	-0.6304033	Sub-additive
3	2.508023	2.823898	0.252225	-0.56810021	Sub-additive
4	2.114484	2.755656	0.196873	-0.83804574	Sub-additive
5	2.362858	2.937729	0.215758	-0.79062906	Sub-additive
6	2.54975	2.796534	0.26923	-0.5160153	Sub-additive
7	2.230965	2.819163	0.190253	-0.77845152	Sub-additive
8	2.281219	2.91201	0.175835	-0.80662636	Sub-additive
9	2.208226	2.609671	0.256217	-0.65766195	Sub-additive
10	2.4956	2.94253	0.198923	-0.64585272	Sub-additive
11	2.238234	2.790404	0.165291	-0.71746078	Sub-additive
12	2.052351	2.893871	0.149038	-0.99055829	Sub-additive
13	2.081873	2.541041	0.141839	-0.60100668	Sub-additive
14	1.872957	2.601372	0.145678	-0.8740938	Sub-additive
15	2.03678	2.663727	0.231515	-0.85846204	Sub-additive
16	1.920776	2.665863	0.163748	-0.90883421	Sub-additive
17	2.256829	2.816801	0.177496	-0.73746772	Sub-additive
18	2.190043	2.788608	0.164746	-0.76331088	Sub-additive
19	2.561288	2.960528	0.21376	-0.61300022	Sub-additive

ECOST = Exponent of **LNCOSTY** = Long-run average cost for the entire quantity for the firm

ECOST1 = Exponent of **LNCOST1Y** = Long-run average cost for the minimum quantity for the firm

ECOST2 = Exponent of **LNCOST2Y** = Long-run average cost for the residual quantity for the firm

COSTADD = **ECOST - (ECOST1 + ECOST2)** = Long-run average cost for the entire quantity minus sum of the average cost for the minimum quantity and the average cost for the residual quantity

SUB = A measure of cost-subadditivity (If **COSTADD** is less than zero, the firms average cost is sub-additive).

SUMMARY OF RESULTS

If the average cost of producing the whole demand quantity by a single firm is lower than that of producing the same quantity by two or more firms combined, then such situation gives rise to a natural monopoly. In this situation the cost of producing the whole demand quantity is minimized by allowing one firm to produce all quantity. The electric utility industry in the United States is often cited as an example of a natural monopoly. Our study applies Evans and Heckman's test for the test of cost subadditivity on U.S. electric industry. The necessary and sufficient conditions of the test require that the firms chosen for the study have the output at least twice the minimum output observed in the sample. We chose 19 firms that met the conditions. Then the output quantity for each of the firms was split into the minimum observed quantity and the residual quantity as required by the test. Using a Cobb-Douglas production function the total cost of production for each of the quantities (i.e. the minimum quantity and the residual quantity) for each of the firms were computed and compared with the actual cost of production of the entire quantity by each firm. We found that the sum of the cost of production of the minimum quantity and that of the residual quantity was greater than the cost of production of entire quantity for each firm. Thus, each of the firms in our sample was found to exhibit cost subadditivity and thereby a natural monopoly. In simple words it is more cost effective to let the existing industries grow to fulfill the growing demand compared to entry of new companies. This finding is important for millions of consumers, the existing electric companies and the policy makers because it provides strong basis for regulating entries into this industry.

REFERENCES

Adhikari, Deergha (2004). Measuring Market Power of U.S. Cigarette Industry. *Applied Economics Letters*, 11(15), 957-59.

Baumol, W. J.; J. C. Panzar and Robert D. Willig (1982). Contestable Markets and the Theory of Industry Structure, San Diego: Harcourt, Brace, Jovanvich.

Becker, Klaus G., Von Ende, Eleanor T. (2006). Sub-Game Perfect Equilibria in Natural Monopoly Markets. *Atlantic Economic Journal*, 34(3), 365-366.

Berndt, Ernst R. (1991). The Practice of Econometrics: Classic and Contemporary.Addison-Wesley Publishing Company, Inc.

Bitzan, John D. (2003). Railroad Costs and Competition. *Journal of Transport Economics & Policy,* 37(2), 201-225.

Chang, Hsihui, Mashruwala, Raj (2006). Was the bell system a natural monopoly***?*** An application of data envelopment analysis. *Annals of Operations Research*, 145(1), 251-263.

Cubukcu, K. Mert, Guldmann, Jean-Michel (2008). Geography and the costs of local telephone networks. *Annals of Regional Science*, 42(4), 821-842.

Currier, Kevin M., Jackson, Brian K (2008). A Pedagogical Note on the Superiority of Price-Cap Regulation to Rate-of –Return Regulation. *Journal of Economic Education*, 39(3), 261-268.

Evans, David S. and Heckman, James J. (1984). A Test for Subadditivity of the Cost Function with an Application to the Bell System. *American Economic Review*, 74, 615-623.

Everett, Sophia (2008). Public sector deregulation: a paradigm in conflict.*Maritime Policy & Management*, 35(4), 341-351.

Fung, K. K., Kolar, Sri Harsha, Karnam, Pavan (2007) " Regulating Natural Monopoly—Flash Animation," Journal of Economic Education; 38(2), 255-255.

Gordon, D.V., Gunsch, K., Pawluk, C.V. (2003). A natural monopoly in natural gas Transmission. *Energy Economics*, 25(5), 473.

Gujarati, Damodar N. (1995), Basic Econometrics, McGraw Hill, Inc.

Jamasb, Tooraj, Pollitt, Michael (2008). Security of Supply and Regulation of Energy Networks. *Energy Policy*, 36(12), 4584-4589.

Kwoka, John E. (2006) "The Role of Competition in Natural Monopoly: Costs, Public Ownership, and Regulation. *Review of Industrial Organization*, 29(1/2), 127-147.

Kristin Boose (1991). An Analysis of Subadditivity of Costs as Applied to the Deutsche Bundespost. (Unpublished).

Nicholls, William H. (May 1949). The Tobacco Case of 1946. *American Economic Review: Papers and Proc*.39(3), 284-296.

Panzar, John C., 1989. Technological determinants of firm and industry structure. In Handbook of Industrial Organization, R. Schmalensee & R. Willig (ed.), ed. 1, vol.1, ch. 1, 3-59, Elsevier.

Ramos-Real, Francisco Javier (2005). Cost functions and the electric utility industry. A contribution to the debate on deregulation. *Energy Policy*, 33(1), 69-87.

Sullivan, Daniel (1985). Testing hypothesis About Firm Behavior in the Cigarette Industry. *Journal of Political Economy*, 93(1-3), 586-598.

Sumner, Daniel A. (1981). Measurement of Monopoly behavior: An Application to the Cigarette Industry. *Journal of Political Economy*, 89(4), 1010-1019.

Sueyoshi, Toshiyuki (1996). Divestiture of Nippon Telegraph and Telephone. *Management Science*, 42(9), 1326-1351.

Won, Gu-Hwan (2007). Electric power industry restructuring and ROE: The case of Korea Electric Power Corporation. *Energy Policy*, 35(10), 5080-5090.

Wills-Johnson, Nick (2008). Separability and Subadditivity in Australian Railways.*Economic Record*, 84(264), 95-108.

Yudong Qi, Xuexin Liu, Zhili Wang (2008). Governance Model Reform in Natural Monopoly Industries. *Chinese Economy,* 4(4), 5-22.

Appendix-A

Sample Data for 20 Private U.S. Electric Utility Firms

Firm	C	Q	r	w
1	30.8923	4.612	0.06903	8.5368
2	58.5825	8.297	0.06903	9.9282
3	15.1205	1.82	0.06754	10.1116
4	32.8014	5.849	0.07919	10.2522
5	22.7768	3.145	0.06481	11.1194
6	11.9176	1.381	0.06598	9.6992
7	34.4028	5.422	0.06754	10.0613
8	47.5209	7.115	0.06565	10.9087
9	18.9136	3.052	0.10555	10.1954
10	36.0902	4.394	0.06572	11.2585
11	62.0032	9.699	0.06903	9.8758
12	74.7206	14.271	0.06789	10.9051
13	96.0053	17.743	0.06903	7.4775
14	63.4357	14.956	0.06572	7.8062
15	15.9901	3.108	0.07919	9.2689
16	42.3249	9.416	0.06565	8.3906
17	44.6781	6.857	0.06565	9.8826
18	59.252	9.745	0.0686	9.8235
19	38.7337	4.442	0.08206	12.9352

C= Total long-run cost of generation and transmission of electric power, expressed in millions of dollars

Q= Total generation and transmission of electric power, expressed in millions of kilowatt-hours.

r= Estimated user cost of capital, $r=q_k(i+\delta)$, where q_k is the unit acquisition cost of the capital stock, I is the real rate of interest and δ is the rate of depreciation.

w= Average annual payment per worker, expressed in thousands of dollars.

Source: United Nations Industrial Development Organization (UNIDO) website http://www.unido.org.

Appendix-B

Cost Estimates For 19 Private U.S. Electric Utility Firms

Firm	C	Q	r	w	LNCOST1	LNCOST2	LNCOSTY	LNCOST1Y	LNCOST2Y
1	30.8923	4.612	0.06903	8.5368	0.371609	-0.97081	0.8259609	0.9771569	-1.6106996
2	58.5825	8.297	0.06903	9.9282	0.422419	-0.85466	0.8488468	1.0279671	-1.760399
3	15.1205	1.82	0.06754	10.112	0.43257	-1.18098	0.9194948	1.0381183	-1.3774345
4	32.8014	5.849	0.07919	10.252	0.408107	-0.87693	0.7488108	1.0136556	-1.6251949
5	22.7768	3.145	0.06481	11.119	0.472089	-1.07165	0.8598721	1.0776369	-1.533597
6	11.9176	1.381	0.06598	9.6992	0.422833	-1.25796	0.9359951	1.0283809	-1.3121878
7	34.4028	5.422	0.06754	10.061	0.430892	-0.94557	0.8024343	1.0364402	-1.6593995
8	47.5209	7.115	0.06565	10.909	0.463295	-0.90144	0.8247098	1.0688436	-1.7382101
9	18.9136	3.052	0.10555	10.195	0.353676	-0.91395	0.7921897	0.9592242	-1.3617295
10	36.0902	4.394	0.06572	11.259	0.473721	-0.99721	0.9145292	1.0792697	-1.614838
11	62.0032	9.699	0.06903	9.8758	0.420638	-0.82457	0.8056871	1.0261864	-1.8000491
12	74.7206	14.27	0.06789	10.905	0.457047	-0.75671	0.7189859	1.0625950	-1.9035519
13	96.0053	17.74	0.06903	7.4775	0.327025	-0.71015	0.7332682	0.9325738	-1.953061
14	63.4357	14.96	0.06572	7.8062	0.350491	-0.7588	0.6275183	0.9560390	-1.9263536
15	15.9901	3.108	0.07919	9.2689	0.374178	-1.00675	0.7113702	0.9797264	-1.4631116
16	42.3249	9.416	0.06565	8.3906	0.374979	-0.84715	0.6527295	0.9805277	-1.8094264
17	44.6781	6.857	0.06565	9.8826	0.430053	-0.90867	0.8139605	1.0356017	-1.7288088
18	59.252	9.745	0.0686	9.8235	0.419994	-0.82577	0.7839212	1.0255426	-1.8033527
19	38.7337	4.442	0.08206	12.935	0.479819	-0.92027	0.9405104	1.0853677	-1.5428999

LNCOST1 = Log of long-run total cost estimate for the minimum quantity for the firm

LNCOST2 = Log of long-run total cost estimate for the residual quantity for the firm

LNCOSTY = Log of long-run average cost for the entire quantity for the firm

LNCOST1Y = Log of long-run average cost estimate for the minimum quantity for the firm

LNCOST2Y = Log of long-run average cost estimate for the residual quantity for the firm