Do Larger Brokerage Firms Enjoy Larger Economies of Scale and Scope?

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This study examined whether firm size determines the economies of scale and scope of securities firms. Results showed that the firms broadly achieved economies of scale and substantially benefitted from the economies of scope in the Korean brokerage sector. In particular, greater economies of scale were present in large firms. Overall, a great possibility and necessity of industrial restructuring through M&A among brokerage firms exist in the Korean brokerage sector.

Keywords: Brokerage firm, Economies of scale, Economies of scope, Cost function

JEL Classification: G2

I. Introduction

This paper examines whether firm size determines the economies of scale and scope in the brokerage sector and, if so, how substantial they are. Quantile regression is used to perform more specific analysis. The findings of this work are expected to contribute to predicting sectoral changes and to guiding financial policies about Systemically Important Financial Institutions. This research can also serve as a useful reference for future research on competitiveness in other industries or countries.

Certain prior studies are remotely related to the concern of the present research and have estimated the cost functions of Korean securities firms (*e.g.*, Lee 1992; Park1994; Chung *et al.* 2000; Kook *et al.* 2007;

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Park *et al.* 2009), which tend to use the translog cost functions and rely on the records about brokerage, prop-trading, and underwriting. These firms, however, do not consider commission fees by service types. The earlier studies agree that brokerage firms in Korea attain the economies of scale.

Nevertheless, previous studies are characterized by several limitations. First, these works did not estimate the cost functions for all brokerage firms. Translog cost function can account for a U-shaped cost function and generalizes the Cobb-Douglas function. This kind of cost function, however, is inapplicable to small-sized brokerage houses with limited brokerage operations. By comparison, Cobb-Douglas specification can be used to estimate the cost functions of all securities firms based on total assets and total costs. Therefore, previous studies generalized the Cobb-Douglas function, while sacrificing the scope of analysis.[1] Meanwhile, the quadratic cost function used in the current study is sufficiently general, which allowed small securities firms to be analyzed.

Second, the estimate cost functions of previous studies assumes that securities firms charge the same commission fee for the same service. In fact, brokerage firms in Korea charge considerably different commission fees even for similar services. Thus, estimating the cost functions based on the profits of brokerage services is more reasonable compared with basing it on the amount of brokerage transactions because cost function is based on cost and profit, not on cost and transaction alone.

II. Previous Research and Model

The extent of economies of scale and scope can be measured via different means. The most widely used specifications are the Cobb-Douglas, translog, and quadratic cost functions. The Cobb-Douglas function has been extensively used to estimate cost functions and to examine the economies of scale and scope (Benston 1965; Bell and Murphy 1968). Cobb-Douglas production is derived as the solution for the following minimization problem:

$$C(w, r, y) = \min_{\{L,K\}} wL + rK$$
$$s.t.\ \ L^{\alpha}K^{1-\alpha} = y$$

[1] Kook *et al.* (2007) applied the spline function in the analysis. Spline function overcomes the limitations of the translog function, as specified in this paper.

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Cost function then becomes

$$C(w, r, y) = \theta w^{\alpha} r^{1-\alpha} y$$
$$\theta \equiv \alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)} .$$

By taking log, an empirical specification can be acquired as follows:

$$\ln C = \alpha_0 + \alpha_1 \ln y + \alpha_2 \ln w + \alpha_3 \ln r + \varepsilon.$$

α_1 indicates the economy of scale. If α_1 is less than 1, the economy of scale exists. w signifies variable cost and r connotes the cost to fixed capital. When y is 0, cost function is not well defined. This problem can be addressed by setting the below expression.

$$C(w, r, y) = \kappa + \theta w^{\alpha} r^{1-\alpha} y, \ \ \kappa \cong 0.$$

By taking log and conducting Taylor series expansion around $\kappa=0$, the following formulas are obtained:

$$\ln C(w, r, y) = \ln\left(\kappa + \theta w^{\alpha} r^{1-\alpha} y\right)$$
$$\approx \ln\left(\kappa_0 + \theta w^{\alpha} r^{1-\alpha} y\right) + \frac{1}{\kappa_0 + \theta w^{\alpha} r^{1-\alpha} y}\left(\kappa - \kappa_0\right) \approx \ln\left(\theta w^{\alpha} r^{1-\alpha} y\right).$$

Subsequently, the same empirical specification is maintained with y as a nonzero value. However, the Cobb-Douglas production function precludes the U-shaped cost function. This limitation is overcome by studies, which have undertaken on the multi-product translog cost function (Benston 1965; Benston, Hanweck, and Humphrey 1982). Translog function includes the quadratic terms of the log of Cobb-Douglas functions. Mester (1992) used a hybrid translog cost function in estimating economies of scale and scope. This kind of cost function is different from the translog function in the sense that the estimate can be realized at the zero production level. The output is converted to Box-Cox format. Specific equations are presented below.

$$\ln C = a_0 + \sum_i b_i \ln w_i + \frac{1}{2}\sum_i \sum_j s_{ij} \left(\frac{y_i^\lambda - 1}{\lambda}\right)\left(\frac{y_j^\lambda - 1}{\lambda}\right)$$
$$+ \frac{1}{2}\sum_i \sum_j s_{ij} \ln w_i \ln w_k + \sum_i \sum_j d_{ij} \left(\frac{y_i^\lambda - 1}{\lambda}\right) \ln w_j + \varepsilon.$$

When $\lambda = 0$, $(y^\lambda - 1)/\lambda = \log y$. Using this cost function, Mester (1992) derived the economy of scale as follows:

$$\text{For all products: } S(y) = \frac{c(y)}{\sum_i y_i \left(\partial c(y) / \partial y_i\right)},$$
$$\text{For product } i\text{: } S_i(y) = \frac{c(y) - c(y_{-i})}{y_i \left(\partial c(y) / \partial y_i\right)}.$$

The economy of scale occurs when both $S(y)$ and $S_i(y)$ are greater than 1. The economy of scope is similarly defined. Let $\vec{y}$ be the vector of project, $\vec{y}_i$ be the vector in which i's element in the vector is not zero, and $\vec{y}_T$ and $\vec{y}_{N-T}$ be the vector with subset T as nonzero and with subset T as zero, respectively. The measures for the economy of scope are subsequently altered, as shown below, with $SC_T(y)$ as the economy of scope in a subset T.

$$SC(y) = \frac{\sum_i c(\vec{y}_i) - c(\vec{y})}{c(\vec{y})},$$
$$SC_T(y) = \frac{c\left(\vec{y}_T + c(\vec{y}_{N-T}) - c(\vec{y})\right)}{c(\vec{y})}.$$

Meanwhile, Goldberg *et al.* (1991) and Jagtiani *et al.* (1995) defined a translog cost function based on the research of Christensen *et al.* (1973).

$$\ln C = a_0 + \sum_i a_i \ln y_i + \sum_i b_i \ln w_i + \frac{1}{2}\sum_i \sum_j s_{ij} \ln y_i \ln y_j$$
$$+ \frac{1}{2}\sum_i \sum_j g_{ij} \ln w_i \ln w_j + \sum_i \sum_j d_{ij} \ln y_i \ln w_j + \varepsilon.$$

The economy of scope ($S(\bullet)$) and cost complementarity ($COMP$) are depicted below.

$$S(y) = \sum_i \frac{\partial \ln C}{\partial \ln y_i} = \sum_i \left(a_i + \sum_j s_{ij} \ln y_j + \sum_j d_{ij} \ln w_j \right),$$

$$COMP_{ik} = \frac{\partial^2 C}{\partial y_i \partial y_k} = \frac{C}{y_i y_k} \left(\frac{\partial^2 \ln C}{\partial \ln y_i \partial \ln y_k} + \frac{\partial \ln C}{\partial \ln y_i} \frac{\partial \ln C}{\partial \ln y_k} \right), \ i \neq k$$

$$\propto s_{ik} + \left(a_i + \sum_j s_{ij} \ln y_j + \sum_j d_{ij} \ln w_j \right) \left(a_k + \sum_j s_{kj} \ln y_j + \sum_j d_{kj} \ln w_j \right).$$

$S(y) < 1$ indicates that the economy of scale exists. $COMP_{ik} < 0$ implies the cost complementarity that the production of k reduces the cost of producing i. Estimating the economies of scale based on cost complementarity can overcome the limitations of Mester's methodology. Jagtiani *et al.* (1995) attested that the method of Mester (1992) can be problematic because it requires the estimation of $c(0, 0, \ldots, y_i, \ldots, 0)$. That is, assumptions should be made to compare the financial institutions that produce a single product with those that produce multiple ones (*i.e.*, the assumptions that ensure both types of firms have the same structure, so that their cost functions are comparable).

Schmiedel *et al.* (2006) characterized a translog cost function based on the research of Berndt and Hansson (1991) and considered that economies of scale can vary with production scale and time.

$$\ln C = a_0 + \sum_i a_i \ln y_i + \sum_i b_i \ln w_i + \frac{1}{2} \sum_i \sum_j s_{ij} \ln y_i \ln y_j$$
$$+ \frac{1}{2} \sum_i \sum_j g_{ij} \ln w_i \ln w_j + \sum_i \sum_j d_{ij} \ln y_i \ln w_j + \tau T + \varepsilon.$$

Toivanen (1997) underlined that the translog cost function of Christensen *et al.* (1973) had the limitation of not allowing zero production level in the subset of products. Toivanen also proposed a quadratic specification cost function expressed as follows:

$$C = \alpha + \beta_i x_i + \sum_i \gamma_{ii} x_i^2 + \sum_{i \neq i} \gamma_{ij} x_i x_j + \varepsilon.$$

Here, the economies of scale and scope can be identified with the below equations.

$$S_N = \frac{C(x)}{\sum x_i C_i}, \; C_i = \frac{\partial C}{\partial x_i}$$

$$S_E = \frac{C(x_{N-i}) + C(x_i) - C(x_N)}{C(x_N)}$$

In the above formula, S_N, S_E indicate the economies of scale and scope, respectively.

III. Estimation

A. Description of Data Sets

All securities firms in Korea were analyzed in this study. In particular, large firms were construed as those whose market share of commission fee is 4.0% or greater. These firms included Samsung, Goodmorning Shinhan, Daeshin, Daewoo, Tong Yang, Mirae Asset, Woori, Korea, and Hyundai. The remaining companies (17) were categorized as small firms. The analysis period of this study spanned from Q2 2000 to Q1 2007 to examine the dramatic changes that occurred in the financial market after the Asian financial crisis.

Commission revenue (y) was determined by multiplying the commission rates with the total service amount for different service types. Commission revenues were gathered from brokerage, underwriting, sales of brokerage commissions and hybrid securities, and wealth management. Prior literature employed the reports about brokerage, prop-trading, and underwriting (Lee 1992; Park 1994; Chung *et al.* 2000). In comparison, this study compared the sales of brokerage commissions and hybrid securities, and wealth management, which are fast growing and increasingly more important than brokerage and underwriting that used to be the main activities of securities firms.

Table 1 compares the asset magnitude of large- and small-sized Korean brokerage firms. The result of the investigation specified that the average volume of the assets of large firms is about four times greater than that of small firms; the former has assets worth KRW 3.5 trillion, which is approximately 3.6 times greater than that of small firms (asset amount of KRW 0.97 trillion). Meanwhile, the average assets of domestic banks amounting to KRW 80 trillion is 34 times higher than that of all brokerage firms at KRW 2.4 trillion. This discrepancy in asset volume should be considered in analyzing the economies of scale of brokerage firms.

TABLE 1

AVERAGE ASSET OF BROKERAGE FIRMS AND BANKS

Large firms include Samsung, Goodmorning Shinhan, Daeshin, Daewoo, Tong Yang, Mirae Asset, Woori, Korea, and Hyundai. The market shares of these firms for commission fee are greater than 4%. The firms classified in this study as small are the remaining 17 brokerage firms. Banks include Woori, Standard Chartered, Hana, KEB, Citi, Kookmin, Shinhan, KDB, and IBK.

	Average Asset (KRW mil)	Relative Scale to Large Brokerage Firms
Large Firms	3,498,790	1
Small Firms	973,332	1/3.59
All Brokerage Firms	2,350,854	1/1.49
Banks	78,917,765	22.56/1

Source: Financial Supervisory Service.

B. Estimation Results

The estimates drawn from Cobb-Douglas based on cost function demonstrate that both large and small brokerage firms attain the economies of scale. See Table 2 for the results.

If only the operating cost was included in the cost, large-sized securities firms realized greater economies of scale. However, when interest payments were also considered, small-sized firms showed greater economies of scale. When only the operating cost was included in the total cost, the estimates of total cost elasticity to total asset was 0.222 and 0.398 for large- and small-sized firms, respectively, based on the random effect model. Here, elasticity was computed as $\varepsilon = \partial \log(TC) / \partial \log(TA) = TA\Delta TC / TC\Delta TA = MC/AC$, in which TA and TC are the total asset and total cost and MC and AC are the marginal and average costs, respectively.

Thus, among large brokerage firms, the marginal cost was merely 22% of the average cost ($MC = 22\%\ AC$), whereas the ratio increased to 38% for small firms. In other words, large-sized securities firms attained relatively greater economies of scale. However, if the total costs also included interest payment, the elasticity of large and small firms became 0.491 and 0.481, respectively. That is, small firms attained slightly greater economies of scale. For comparison, the same indicator for banks was 0.690 when considering only the operating cost and sharply increased to 0.923 if interest payment was also included.

TABLE 2

ESTIMATE RESULTS OF COBB-DOUGLAS FUNCTION

TC implies the total cost, *w* denotes the sales and general administrative costs per person, *R* signifies the interest rate costs, *PLS*_log(*TC*) is the panel *OLS* analysis on log *TC*, Fixed_log(*TC*) specifies the fixed effect regression on log *TC*, and Random_log(*TC*) indicates the random effect regression on log *TC*. The first column lists dependent variable (*TC*) with various specifications. The second to fourth columns cite the independent variables. The last column displays the values of R squared.

	Constant	log(*TA*)	log(*w*)	log(*r*)	R^2
Large brokerage firms: Total cost = Sales cost + Administrative cost					
PLS_log(*TC*)	0.385 (1.42)	0.472 (24.45)	0.969 (17.44)	0.116 (7.13)	0.829
Fixed_log(*TC*)	4.388 (15.12)	0.204 (9.99)	0.972 (29.8)	0.055 (4.65)	0.952
Random_log(*TC*)	4.134 (14.3)	0.222 (11.13)	0.968 (29.71)	0.061 (5.19)	0.803
Small brokerage firms: Total cost = Sales cost + Administrative cost					
PLS_log(*TC*)	−2.762 (−5.81)	0.798 (26.28)	0.499 (6.58)	0.198 (7.27)	0.735
Fixed_log(*TC*)	2.248 (5.40)	0.382 (12.38)	0.685 (12.26)	0.113 (7.66)	0.945
Random_log(*TC*)	2.075 (4.80)	0.398 (13.06)	0.676 (12.18)	0.116 (7.89)	0.602
Banks: Total cost = Sales cost + Administrative cost					
PLS_log(*TC*)	−2.623 (−2.55)	0.760 (12.73)	0.305 (2.52)	−0.526 (−4.58)	0.557
Fixed_log(*TC*)	−3.222 (−5.10)	0.690 (17.69)	0.829 (21.26)	0.175 (4.89)	0.973
Random_log(*TC*)	−3.236 (−5.16)	0.692 (18.06)	0.824 (21.26)	0.170 (4.77)	0.908
Large brokerage firms: Total cost = Sales cost + Administrative cost + Interest					
PLS_log(*TC*)	−0.457 (−2.27)	0.588 (41.05)	0.798 (19.37)	0.146 (12.05)	0.913
Fixed_log(*TC*)	1.374 (4.17)	0.451 (19.37)	0.857 (23.11)	0.129 (9.51)	0.943
Random_log(*TC*)	0.821 (2.83)	0.491 (24.01)	0.845 (23.00)	0.139 (10.94)	0.832

(Continued Table 2)

TABLE 2
(CONTINUED)

	Constant	log(*TA*)	log(*w*)	log(*r*)	R^2
Small brokerage firms: Total cost = Sales cost + Administrative cost + Interest					
PLS_log(*TC*)	−3.168	0.850	0.458	0.208	0.768
	(−6.90)	(28.97)	(6.24)	(7.89)	
Fixed_log(*TC*)	1.367	0.468	0.648	0.129	0.953
	(3.42)	(15.78)	(12.09)	(9.13)	
Random_log(*TC*)	1.215	0.481	0.640	0.132	0.661
	(2.92)	(16.46)	(12.01)	(9.35)	
Banks: Total cost = Sales cost + Administrative cost + Interest					
PLS_log(*TC*)	−3.499	0.936	0.063	0.659	0.925
	(−11.64)	(53.56)	(1.77)	(19.64)	
Fixed_log(*TC*)	−3.771	0.922	0.206	0.854	0.989
	(−13.34)	(52.89)	(11.80)	(53.44)	
Random_log(*TC*)	−3.770	0.923	0.203	0.851	0.954
	(−13.79)	(54.99)	(11.80)	(53.77)	
PLS_log(*TC*)	−3.168	0.850	0.458	0.208	0.768
	(−6.90)	(28.97)	(6.24)	(7.89)	
Fixed_log(*TC*)	1.367	0.468	0.648	0.129	0.953
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Random_log(*TC*)	−3.770	0.923	0.203	0.851	0.954
	(−13.79)	(54.99)	(11.80)	(53.77)	

The asset volume of large brokerage firms, small firms, and banks significantly vary. Hence, their estimated parameters should be interpreted accordingly. In particular, the volume of average assets of large securities firms was 3.6 times larger than that of small firms, whereas banks averagely owned 23 and 81 times more assets than large and small brokerage firms, respectively. Assuming cost included only the

TABLE 3

QUANTILE ESTIMATE RESULTS OF COBB-DOUGLAS FUNCTION

This table shows the result of quantile regression on all brokerage firms. Variable definitions are similar to those presented in Table 2.

Panel A: Total cost = Sales cost + Administrative cost

	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
10% quantile regression	log(TA)	.7862383	.0193777	40.57	0.000	.7482203	.8242562
	log(w)	.3810733	.128003	2.98	0.003	.1299388	.6322078
	log(r)	.2458684	.0534596	4.60	0.000	.1409836	.3507531
	Constant	−1.95672	.431639	−4.53	0.000	−2.803571	−1.109869
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
20% quantile regression	log(TA)	.7243778	.0131978	54.89	0.000	.6984845	.7502711
	log(w)	.3281428	.0709698	4.62	0.000	.1889042	.4673814
	log(r)	.1991954	.0249438	7.99	0.000	.150257	.2481337
	Constant	−.7911889	.2519912	−3.14	0.002	−1.285581	−.2967966
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
30% quantile regression	log(TA)	.6921871	.0132344	52.30	0.000	.666222	.7181521
	log(w)	.1892772	.0616704	3.07	0.002	.0682834	.3102709
	log(r)	.177648	.0206232	8.61	0.000	.1371864	.2181095
	Constant	.2475249	.2350498	1.05	0.293	−.2136292	.7086791
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
40% quantile regression	log(TA)	.677987	.0142534	47.57	0.000	.6500227	.7059513
	log(w)	.1117964	.06365	1.76	0.079	−.0130812	.236674
	log(r)	.151491	.0206069	7.35	0.000	.1110614	.1919207
	Constant	.7461045	.2472007	3.02	0.003	.2611109	1.231098
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
50% quantile regression	log(TA)	.680432	.009081	74.93	0.000	.6626157	.6982483
	log(w)	.0484527	.041098	1.18	0.239	−.0321792	.1290847
	log(r)	.1624932	.0129366	12.56	0.000	.1371123	.1878741
	Constant	1.082521	.1594669	6.79	0.000	.7696562	1.395386
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
60% quantile regression	log(TA)	.6688929	.0100002	66.89	0.000	.6492731	.6885126
	log(w)	.0648928	.0468006	1.39	0.166	−.0269274	.156713
	log(r)	.1784554	.0144544	12.35	0.000	.1500967	.2068141
	Constant	1.346726	.1815046	7.42	0.000	.9906248	1.702828
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
70% quantile regression	log(TA)	.6543292	.0073025	89.60	0.000	.6400022	.6686563
	log(w)	.1450047	.036329	3.99	0.000	.0737292	.2162801
	log(r)	.1756871	.0109907	15.99	0.000	.1541239	.1972503
	Constant	1.351429	.1359581	9.94	0.000	1.084687	1.618171

(Continued Table 3)

TABLE 3
(CONTINUED)

	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
80% quantile regression	log(TA)	.648216	.0073837	87.79	0.000	.6337296	.6627025
	log(w)	.1692891	.0399694	4.24	0.000	.0908715	.2477067
	log(r)	.1690557	.0118612	14.25	0.000	.1457848	.1923267
	Constant	1.410486	.1424382	9.90	0.000	1.131031	1.689942
	log_tc1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
90% quantile regression	log(TA)	.6551016	.0068269	95.96	0.000	.6417077	.6684956
	log(w)	.4696567	.049441	9.50	0.000	.3726562	.5666571
	log(r)	.1938895	.0131032	14.80	0.000	.1681817	.2195972
	Constant	.5094555	.163478	3.12	0.002	.1887211	.8301899

Panel B: Total cost = Sales cost + Administrative cost + Interest

	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
10% quantile regression	log(TA)	.9468113	.0141121	67.09	0.000	.9191242	.9744985
	log(w)	.1565335	.0975687	1.60	0.109	−.0348908	.3479578
	log(r)	.2573221	.0444187	5.79	0.000	.1701752	.344469
	Constant	−3.113198	.3475173	−8.96	0.000	−3.795007	−2.431388
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
20% quantile regression	log(TA)	.8408017	.0122974	68.37	0.000	.8166749	.8649284
	log(w)	.0778096	.0685839	1.13	0.257	−.056748	.2123673
	log(r)	.2264595	.0248272	9.12	0.000	.1777499	.2751691
	Constant	−1.131847	.2433068	−4.65	0.000	−1.609201	−.6544925
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
30% quantile regression	log(TA)	.8006231	.0121475	65.91	0.000	.7767903	.8244558
	log(w)	.0388009	.0582661	0.67	0.506	−.0755139	.1531157
	log(r)	.1904555	.0198549	9.59	0.000	.1515013	.2294096
	Constant	−.4139724	.2215671	−1.87	0.062	−.8486744	.0207297
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
40% quantile regression	log(TA)	.7798266	.0088061	88.56	0.000	.7625496	.7971035
	log(w)	.0237553	.0396661	0.60	0.549	−.0540674	.101578
	log(r)	.1671193	.0128988	12.96	0.000	.1418126	.1924259
	Constant	−.0561305	.1555403	−0.36	0.718	−.3612916	.2490307
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
50% quantile regression	log(TA)	.7640903	.0084106	90.85	0.000	.7475892	.7805913
	log(w)	.0129258	.0379184	0.34	0.733	−.0614679	.0873195
	log(r)	.1805251	.0119527	15.10	0.000	.1570747	.2039755
	Constant	.3497505	.1476406	2.37	0.018	.060088	.639413
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
60% quantile regression	log(TA)	.7524144	.0076665	98.14	0.000	.7373732	.7674556
	log(w)	.0759667	.0353815	2.15	0.032	.0065502	.1453831
	log(r)	.1935133	.0107784	17.95	0.000	.1723667	.2146599
	Constant	.4167634	.1374255	3.03	0.002	.1471425	.6863843

(Continued Table 3)

TABLE 3
(CONTINUED)

	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
70% quantile regression	log(TA)	.7470044	.0062652	119.23	0.000	.7347125	.7592964
	log(w)	.0813842	.0310802	2.62	0.009	.0204066	.1423617
	log(r)	.1938134	.0092074	21.05	0.000	.175749	.2118779
	Constant	.5410138	.1171525	4.62	0.000	.3111673	.7708603
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
80% quantile regression	log(TA)	.7262103	.0066752	108.79	0.000	.713114	.7393066
	log(w)	.1785594	.0373153	4.79	0.000	.1053488	.25177
	log(r)	.1946457	.010495	18.55	0.000	.174055	.2152364
	Constant	.5865925	.132509	4.43	0.000	.3266175	.8465675
	log_tc2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
90% quantile regression	log(TA)	.7224208	.005668	127.46	0.000	.7113006	.733541
	log(w)	.3807789	.0412814	9.22	0.000	.2997872	.4617706
	log(r)	.1966031	.0108217	18.17	0.000	.1753715	.2178347
	Constant	.0791301	.1411712	0.56	0.575	-.1978398	.3560999

operating cost, and the asset volume of small securities firms increased to the level equivalent to that of large firms. In this case, the diseconomies of scale were observed as $\varepsilon = 0.398 \times 3.59 = 1.43$. When the assets of small brokerage firms increased to the level equivalent to that of banks, the diseconomies of scale worsened as much as $\varepsilon = 0.398 \times 81 = 32.24$. Conversely, when the asset volume of banks shrank to the level equivalent to that of large securities firms, the result was $\varepsilon = 0.928 \div 23 = 0.04$. When, however, the asset volume of large securities expanded to the level equivalent to that of banks, the diseconomies of scale became $\varepsilon = 0.491 \times 23 = 11.29$. If interest payment was added to business cost, the diseconomies of scale worsened for all brokerage firms, and banks would attain the economies of scale to a lesser degree.

The results obtained from quantile estimate were similar, such that greater cost incurred lower ratio of marginal cost to average cost, that is, the economies of scale were achieved. See the results in Table 3.

Table 4 describes the estimation results with the translog cost function. In particular, these findings signify the economy of scale. Nine large brokerage firms were analyzed in this study, in which methodological issues were observed. First, this log specification allowed this study to analyze only the firms with full suite of services. Only a few large brokerage firms offer all services without a blank in any service. Second, the fee for wealth management service is zero in many cases (*i.e.*, commission free); thus, this study excluded such service in the analysis. This

TABLE 4

ESTIMATE RESULTS OF TRANSLOG FUNCTION

This table indicates the regression results on translog cost function. Samsung, Goodmorning Shinhan, Daeshin, Daewoo, Tong Yang, Mirae Asset, Woori, Korea, and Hyundai were analyzed. *OC* connotes operating cost, *BC* implies brokerage commission, *SC* represents sales commission of beneficiary certificate and hybrid securities, and *UC* denotes underwriting commission. T-values are enclosed in parenthesis.

Panel A: Parameter estimates

Variables (log)	Coef	Model 1	Model 2	Model 3	Model 4	Model 5
BC	a1	0.4712*** (12.86)	−1.6936** (−2.28)	−1.0407 (−1.34)	−1.1058 (−1.58)	−0.9499 (−1.19)
UC	a2	0.0805** (2.74)	0.0628 (0.47)	−0.3473 (−1.02)	0.1970 (0.61)	0.4275 (0.89)
SC	a3	0.2753*** (10.60)	2.1545*** (5.55)	2.9614*** (6.73)	2.0841*** (5.00)	2.4394*** (3.99)
BC×BC	s11		0.1048** (2.89)	0.1093** (2.63)	0.0878** (2.34)	0.0729 (1.65)
UC×UC	s22		−0.0014 (−0.15)	0.0015 (0.08)	−0.0120 (−0.72)	−0.0194 (−1.12)
SC×SC	s33		−0.1027*** (−4.86)	−0.0982*** (−4.24)	−0.0955*** (−4.63)	−0.0790** (−2.09)
BC×UC	s12			0.0202 (0.46)	−0.0090 (−0.22)	0.0022 (0.05)
BC×SC	s13			−0.0995*** (−3.40)	−0.0269 (−0.93)	−0.0740 (−1.20)
UC×SC	s23			0.0190 (0.58)	0.0082 (0.28)	0.0189 (0.45)
W	b1				0.4629*** (5.09)	−0.0570 (−0.03)
R	b2				0.2577*** (6.83)	−1.4959** (−1.98)
W×W	g11					−0.0624 (−0.32)
R×R	g22					0.0143 (0.30)
W×R	g12					0.2474 (1.36)

(Continued Table 4)

TABLE 4
(CONTINUED)

Variables (log)	Coef	Model 1	Model 2	Model 3	Model 4	Model 5
BC×W	d11					−0.0267 (−0.18)
UC×W	d21					−0.2081 (−1.54)
SC×W	d31					0.0479 (0.29)
BC×R	d12					0.0622 (0.97)
UC×R	d22					0.0415 (0.91)
SC×R	d32					−0.0410 (−0.62)
C		3.7621 (10.75)	6.6076 (1.77)	1.0636 (0.27)	0.5993 (0.17)	6.5895 (1.18)
R^2		0.7338	0.7612	0.7748	0.8225	0.8337

Panel B: Estimates on the economy of scale

	Model 1	Model 2	Model 3	Model 4	Model 5
$\frac{\partial LN(OC)}{\partial LN(BC)}$	0.47117	0.510554	0.513046	0.429786	0.427095
$\frac{\partial LN(OC)}{\partial LN(UC)}$	0.08045	0.042101	0.058993	−0.004520	−0.02549
$\frac{\partial LN(OC)}{\partial LN(SC)}$	0.27531	0.305547	0.290425	0.144389	0.165971
Sum (*i.e.*, economy of scale)	0.72693	0.858202	0.862424	0.569555	0.59017

(Contined Table 4)

TABLE 4
(CONTINUED)

Panel C: Estimates on the economy of scope

	Model 1	Model 2	Model 3	Model 4	Model 5
$\frac{\partial^2(OC)}{\partial(BC)\partial(UC)}$	0.0379	0.0207	–0.0747	–0.0173	–0.0141
$\frac{\partial^2(OC)}{\partial(BC)\partial(SC)}$	0.1297	0.1303	0.0235	0.0197	–0.0188
$\frac{\partial^2(OC)}{\partial(UC)\partial(SC)}$	0.0221	0.0134	0.3322	0.0112	0.0148
Sum (*i.e.*, economy of scope)	0.1897	0.14644	0.2810	0.0126	–0.0181

undertaking might underestimate the marginal cost relative to average cost.

Panel B in Table 4 demonstrates the existence of the economy of scale in all specifications, and Panel C suggests that the economy of scope was observed only in some models contrary to the economy of scale. In Models 3 to 5, the economy of scale existed between underwriting and brokerage commission. In Model 5, such scale particularly existed between underwriting and sales commission for beneficiary certificates and hybrid securities. In other models and service combinations, the opposite occurred; diversification engendered the diseconomy of scope.

Unlike the translog function, quadratic cost function is applicable to all securities firms. Translog function can hardly model business divisions with zero production or firms without full range of operations. The estimate results from quadratic cost function are shown in Table 5. The economies of scale are most evident in Panel B of Table 5. Cost complementarity was not observed in all six cases of combining four service types; it was observed only in three cases, including the combinations of {brokerage, underwriting, and underwriting} or {wealth management, brokerage, sales of hybrid securities}. According to Panel C of Table 5, the economy of scale existed for all specifications. Table 6 separately displays the estimation results for the quadratic cost functions of small and large brokerage firms.

As a robustness check, this study estimated the quadratic functions using sales (Table 7). The results of this verification were qualitatively similar to Table 5 and Table 6.

TABLE 5

ESTIMATE RESULTS OF QUADRATIC COST FUNCTION

This table demonstrates the regression results on quadratic cost function. In this case, all brokerage firms were explored. OC implies operating cost, BC signifies brokerage commission, SC exemplifies the sales commission of beneficiary certificate and hybrid securities, and UC indicates underwriting commission. T-values are enclosed in parenthesis.

Panel A: Parameter Estimates

Variable (log)	Panel OLS	Fixed Effect (Cross section, Period)	Fixed Effect (Cross section)	Two way random Effect
BC	2.8959 (10.60)	2.2957 (4.97)	2.3117 (5.67)	2.7230 (9.10)
MC	5.7879 (0.96)	−2.7202 (−0.44)	6.0218 (1.05)	2.1864 (0.37)
SC	2.2481 (6.48)	4.0568 (5.39)	4.6361 (6.39)	2.3255 (5.43)
UC	5.4813 (2.35)	3.4358 (1.39)	3.7629 (1.58)	4.5827 (1.94)
BC×BC	−1.42E-05 (−4.42)	−1.00E-05 (−2.92)	−1.19E-05 (−3.58)	−1.25E-05 (−3.97)
MC×MC	0.000230 (0.37)	−0.0003 (−0.50)	−0.0010 (−1.76)	7.92E-06 (0.01)
SC×SC	−9.99E-06 (−2.32)	−2.34E-05 (−3.95)	−2.78E-05 (−4.77)	−1.14E-05 (−2.58)
UC×UC	−7.10E-05 (−0.42)	0.000311 (1.92)	0.0003 (2.02)	0.0001 (0.71)
BC×MC	0.0007 (8.23)	0.0007 (8.09)	0.0007 (7.84)	0.0007 (8.24)
BC×SC	2.31E-07 (0.03)	2.97E-05 (3.23)	3.14E-05 (3.37)	1.42E-05 (1.61)
BC×UC	−0.0001 (−0.99)	−0.0002 (−3.17)	−0.0002 (−3.30)	−0.0001 (−2.15)
MC×SC	−0.0013 (−7.51)	−0.0010 (−6.38)	−0.0010 (−6.47)	−0.0011 (−6.91)
MC×UC	−0.001991 (−1.95)	−2.27E-05 (−0.02)	−0.0002 (−0.19)	−0.0012 (−1.22)
SC×UC	0.0004 (3.59)	0.0003 (3.14)	0.0003 (3.14)	0.0004 (3.74)
C	2512.2 (0.66)	2040.4 (0.22)	−1940.1 (−0.24)	4891.7 (0.87)
R^2	0.714917	0.804567	0.785095	0.707886

(Continued Table 5)

TABLE 5

(CONTINUED)

Panel B: Estimate of Economies of Scope based on Quadratic Cost Function

	Model 1 (OLS)	Model 2 (Cross section, Period Fixed Effect)	Model 3 (Cross section Fixed Effect)	Model 4 (Two way Random Effect)
$\frac{\partial^2 (OC)}{\partial (BC) \partial (MC)}$	0.00072	0.00067	0.00065	0.00069
$\frac{\partial^2 (OC)}{\partial (BC) \partial (SC)}$	2.31E-07	2.97E-05	3.14E-05	1.42E-05
$\frac{\partial^2 (OC)}{\partial (BC) \partial (UC)}$	−0.0001	−0.00017	−0.00017	−0.00011
$\frac{\partial^2 (OC)}{\partial (MC) \partial (SC)}$	−0.00126	−0.00100	−0.00103	−0.00110
$\frac{\partial^2 (OC)}{\partial (MC) \partial (UC)}$	−0.00199	−2.27E-05	−0.00018	−0.00118
$\frac{\partial^2 (OC)}{\partial (SC) \partial (UC)}$	0.00037	0.00030	0.00031	0.00036
Sum (i.e., economies of scope)	−0.00216	−0.0020	−0.00045	−0.00034

Panel C: Estimated Economies of Scale

	Model 1 (OLS)	Model 2 (Cross section, Period Fixed Effect)	Model 3 (Cross section Fixed Effect)	Model 4 (Two way Random Effect)
$\frac{\partial OC}{\partial BC} / \frac{OC}{BC}$	0.6405	0.5466	0.5251	0.6190
$\frac{\partial OC}{\partial MC} / \frac{OC}{MC}$	0.0391	0.0197	0.0525	0.0318
$\frac{\partial OC}{\partial SC} / \frac{OC}{SC}$	0.2213	0.3883	0.5023	0.2676
$\frac{\partial OC}{\partial UC} / \frac{OC}{UC}$	0.1296	0.0666	0.0702	0.1029
Economy of scale	1.0305	1.042	1.1501	1.0202

Economy of scale: $\sum_i \frac{\partial OC}{\partial y_i} / \frac{OC}{y_i} > 1$

TABLE 6

ESTIMATE RESULTS OF QUADRATIC COST FUNCTION FOR SMALL AND LARGE BROKERAGE FIRMS

This table displays the regression results on quadratic cost function. All brokerage firms were assessed for this part, but the results are separately presented for large and small brokerage firms. *OC* means operating cost, *BC* denotes brokerage commission, *SC* signifies the sales commission of beneficiary certificate and hybrid securities, and *UC* represents underwriting commission. T-values are enclosed in parenthesis.

Panel A: Parameter Estimates for Large Brokerage Firms

Variable (log)	Coefficient	Std. Error	t-Statistic	Prob.
BC	2.741175	0.589153	4.652741	0.0000
MC	8.311547	12.04741	0.689903	0.4909
SC	1.234326	1.351976	0.912980	0.3621
UC	7.022524	5.303370	1.324163	0.1866
BC×BC	−1.63E-05	5.86E-06	−2.786415	0.0057
MC×MC	8.63E-05	0.001040	0.082995	0.9339
SC×SC	−8.16E-06	2.47E-05	−0.330974	0.7409
UC×UC	−8.10E-05	0.000264	−0.306587	0.7594
BC×MC	0.000752	0.000140	5.388814	0.0000
BC×SC	1.43E-05	1.47E-05	0.973320	0.3313
BC×UC	−5.67E-05	9.28E-05	−0.611025	0.5417
MC×SC	−0.001351	0.000270	−4.998641	0.0000
MC×UC	−0.002334	0.001568	−1.488327	0.1379
SC×UC	0.000322	0.000168	1.920074	0.0559
C	26637.63	15495.61	1.719044	0.0868
R^2	0.568664			
Adjusted R^2	0.545877			

(Continued Table 6)

IV. Conclusion

This study estimated the cost functions of brokerage firms to examine whether they attain economies of scale and scope. Cobb-Douglas, hybrid translog, and quadratic cost functions were used, and the analysis was conducted for groups of large brokerage firms, small firms, and all firms put together. The brokerage firms considered large were those whose market share of commission fee is 4.0% or higher, including nine companies. The other 17 companies were categorized as small firms. The estimate based on the Cobb-Douglas function revealed that the economies of scale were attained in all brokerage firms regardless of their sizes. The quantile estimate induced identical results, indicating that the ratio

TABLE 6
(CONTINUED)

Panel B: Parameter Estimates for Small Brokerage Firms

Variable (log)	Coefficient	Std. Error	t-Statistic	Prob.
BC	0.784419	0.461460	1.699864	0.0898
MC	9.792986	9.212129	1.063054	0.2883
SC	1.994522	0.301691	6.611146	0.0000
UC	13.56614	2.925457	4.637272	0.0000
BC×BC	2.42E-05	1.55E-05	1.560714	0.1193
MC×MC	−0.001776	0.003142	−0.565301	0.5721
SC×SC	−9.23E-06	2.43E-06	−3.805461	0.0002
UC×UC	−0.001009	0.000692	−1.457116	0.1458
BC×MC	−0.000260	0.000373	−0.696209	0.4866
BC×SC	2.74E-05	2.45E-05	1.118171	0.2641
BC×UC	−0.000294	0.000153	−1.923572	0.0550
MC×SC	−0.000194	0.000436	−0.446089	0.6557
MC×UC	0.001354	0.004587	0.295240	0.7679
SC×UC	0.000543	0.000154	3.525669	0.0005
C	9451.428	2687.572	3.516716	0.0005
R^2	0.613117			
Adjusted R^2	0.601368			

of marginal cost to average cost gradually declined when the amount of cost increased. Moreover, the results of the analysis showed the presence of economies of scale, which were also observed in the estimates based on the translog cost function for large-sized firms. Translog function analyzes only large companies because it requires a firm to undertake all types of services to be analyzed. Quadratic cost function was applied to all securities firms, and the results indicated the economies of both scale and scope. When the firms were grouped by size, large firms attained greater economies of scale.

The major contribution of this study is that it broadly examined the relationship between the size and economies of scale and scope in securities industry. Only three marginally related papers exist, but they were published more than ten years ago despite the recent dramatic development of the financial industry. In particular, the current research examined and analyzed the recent market conditions and applied various cost functions for estimates, including the Cobb-Douglas, translog, and hybrid cost functions. Linear and quantile regressions were both applied for analysis, overcoming the limitations of prior studies.

This study presents important implications in terms of policy recom-

TABLE 7

ESTIMATE RESULTS OF QUADRATIC COST FUNCTION ON SALES

This table introduces the regression results on quadratic cost function. All brokerage firms were investigated, but the results are separately cited for large and small brokerage firms. *OC* signifies operating cost, *BC* denotes brokerage commission, *SC* represents the sales commission of beneficiary certificate and hybrid securities, PI implies proprietary investment, *BR* symbolizes beneficiary requisition/trading, and *UC* stands for underwriting commission. T-values are enclosed in parenthesis.

Panel A: Parameter Estimates (dependent variable is sales)

Variable (log)	Panel OLS	Fixed Effect (Cross section, Period)	Fixed Effect (Cross section)	Two way random Effect
BR	0.001199 (6.63)	0.000384 (1.64)	0.000459 (2.00)	0.000865 (4.21)
PI	0.000555 (5.17)	0.000224 (2.27)	0.00016 (1.58)	0.000296 (2.96)
UW	−0.001781 (−0.66)	−0.008306 (−3.12)	−0.008263 (−3.12)	−0.005728 (−2.17)
BR×BR	−4.47E-12 (−4.94)	−3.99E-13 (−0.44)	−5.75E-13 (−0.63)	−2.04E-12 (−2.35)
PI×PI	−2.87E-13 (−1.16)	−2.92E-13 (−1.44)	−2.16E-13 (−1.03)	−2.68E-13 (−1.28)
UW×UW	−6.27E-11 (−0.27)	1.41E-10 (0.72)	2.23E-10 (1.12)	1.01E-10 (0.50)
BR×PI	−1.09E-12 (−0.80)	5.59E-13 (0.45)	7.32E-14 (0.06)	5.41E-16 (0.00)
BR×UW	2.26E-10 (7.63)	1.20E-10 (4.78)	1.22E-10 (4.70)	1.34E-10 (5.17)
PI×UW	−8.31E-13 (−0.03)	4.54E-11 (2.00)	4.93E-11 (2.10)	3.64E-11 (1.56)
C	13090.04 (2.32)	59722.26 (8.20)	59619.84 (8.42)	39401.1 (4.54)
R^2	0.508111	0.730220	0.691103	0.266239

(Continued Table 7)

mendations and practical applications. The profit of brokerage firms has recently declined sharply, while their business portfolios have grown extremely similar, losing diversity. This problem can be addressed by seeking policies that can restructure the industry. In doing so, cost

TABLE 7
(CONTINUED)

Panel B: Estimate of Economies of Scale based on Quadratic Cost Function and Sales

	Model 1 (OLS)	Model 2 (Cross section, Period Fixed Effect)	Model 3 (Cross section Fixed Effect)	Model 4 (Two way Random Effect)
$\frac{\partial OC}{\partial BR} / \frac{OC}{BR}$	0.5597	0.2780	0.2969	0.4356
$\frac{\partial OC}{\partial PI} / \frac{OC}{PI}$	0.2563	0.1645	0.1287	0.1827
$\frac{\partial OC}{\partial UW} / \frac{OC}{UW}$	0.1575	−0.0196	−0.0049	0.0386

Panel C: Estimate of Economies of Scope based on Quadratic Cost Function and Sales

	Model 1 (OLS)	Model 2 (Cross section, Period Fixed Effect)	Model 3 (Cross section Fixed Effect)	Model 4 (Two way Random Effect)
$\frac{\partial^2 (OC)}{\partial (BR) \partial (PI)}$	−1.09E-12	5.59E-13	7.32E-14	5.41E-16
$\frac{\partial^2 (OC)}{\partial (BR) \partial (UW)}$	2.26E-10	1.20E-10	1.22E-10	1.34E-10
$\frac{\partial^2 (OC)}{\partial (PI) \partial (UW)}$	−8.31E-13	4.54E-11	4.93E-11	3.64E-11

functions must necessarily be estimated, and the presence of economies of scale and scope must be examined. This study also provides practical implications to understanding the current conditions and future outlook of the securities sector.

For example, the presence of economies of scale is a necessary condition for M&A. A firm with economy of scale will be better off with an M&A rather than without it. This study posits that, the Korean securities industry, particularly larger securities firms, benefit from M&A due to the economy of scale. Therefore, the government should not discourage M&A in the industry. Moreover, the economy of scope also exists. The economies of scope are the cost complementarity between brokerage, sales of convertible bonds, and hybrid securities. This variable indicates where and who should try M&A. Accordingly, if M&A does not occur in the industry, the government may need to check whether any regulatory or institutional restrictions exist against M&A.

This study has limitations such that it did not include time-series data for the pre-Asian crisis period, which was unavoidable because of the structural break that transformed the financial industry before and after the crisis. Moreover, this study did not analyze data from branch offices of foreign brokerage houses, which are small and marginal players. Further study must be conducted to estimate the cost functions of other financial institutions, including banks, insurance companies, and wealth management firms, to investigate the economies of scale and scope across the financial industry in Korea. Such analysis is expected to provide an outlook on the overall financial industry.

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