The Effects of Exogenous Shocks on Technical Efficiency of Industry by Size in Korea

Mi-Kyung Pai

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KOREA INSTITUTE FOR INDUSTRIAL
ECONOMICS & TRADE(KIET)

Mi－Kyung　Pai,　Associate Research Fellow
(mkpai@kiet.re.kr, 82－2－3299－3083)
Korea Institute for Industrial Economics and Trade (KIET)

Korea Institute for Industrial Economics and Trade (KIET)
206－9, Cheongnyangni－Dong, Dongdaemun－Gu, Seoul, Korea
TEL : (82) (2) 3299－3114
FAX : (82) (2) 963－8540
http://www.kiet.re.kr

Contents

Table Contents

Figure Contents

Ⅰ. Introduction

The role of government in the "Big−Push Heavy Machinery and Chemical Industries (HCI) policy" from 1973 up to late 1979 in Korea was excessively directive, with the goal of fostering HCI[1)] for export promotion. A broad range of incentive schemes[2)] including fiscal, monetary and trade policies were implemented to urge the big business groups in Korea to join the HCI Projects[3)], all of which resulted in a size distribution substantially skewed toward large firms. Then came growing concerns on the issue of the size distribution of manufacturing firms.[4)] The gaps in the distribution of size between the Large Establishments (LEs) and the Small and Medium−sized Establishments (SMEs) of Korea

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1) Lee S. C (1991) characterized the HCI strategy as follows.

...The eventual consequence of these efforts was the transformation of a privately led market economy into a government−controlled one, in which the market mechanism was largely replaced by an imperative plan for the promotion of HCI....

2) The most powerful element in the new incentive regime was surely its financial policy, including credit rationing. According to J. Lee (1986), "credit rationing is an important form of market distortion and a probable determinant of technical efficiency in the Korean economy" (J. Lee(1986), p. 86).

3) The HCI policies can be characterized by the extensive capital subsidies toward HCI as part of a import−substitution program in the 1970s, which led to overinvestment in these industries.

4) See Piore and Sabel (1984) and Loveman and Sengenberger (1990).

had grown conspicuous by the mid-1970s, in contrast to other East Asia countries such as Hong Kong, Taiwan, and Japan[5], where income inequality and the percentage share of the LEs are proved to be inversely related via empirical analysis.[6] The above literature indicates clearly that the size distribution of manufacturing firms has recently become a prominent issue around the world in relation to technical efficiency. Also in Korea, the technical efficiency of different size-classes of firms has been a contentious issue for a long time.

The HCI promotion policy can be seen in the context of a major economic destabilizing event, with measurable effects on technical efficiency. The Asian financial crisis of 1997, which deeply impacted the Korean economy, was another kind of strong exogenous shock. Though the strength and direction of impact of the unpredictable financial crisis of 1997 was different from the anticipated HCI Drive Policy on production units, both were major disturbances to the essentially free-market economy.

Therefore, based on the proposition that the government's industrial policy as well as exogenous shocks to an economy affect the technical efficiency of individual establishments, this study analyzes the technical efficiency of three basic industrial groupings, further differentiated by size, with particular attention to just prior to and just after the 1997 Asian financial crisis.

5) See Rhee (1987), Levy and Kuo (1987), and Levy (1990). Nugent (1989) pointed out the reversal of the trend toward LEs in Korea since 1976.

6) See Nugent (1989).

One of the main objectives of this paper is to verify whether the technical efficiency of LEs is superior to that of SMEs, as generally agreed, and how diversely the technical efficiency levels of LEs and SMEs have varied intertemporally.

Section 2 presents a brief literature survey, and Section 3 explains the computation methodology. Section 4 describes the data set applied. The empirical results are provided in Section 5 and concluding remarks are presented in Section 6. All of the empirical results and statistics are presented in detail in the Appendix.

Ⅱ. Brief Literature Survey

The relevant literature shows interesting facts on the technical efficiency of firms based on size.

Meller (1976) disaggregated establishments into twenty-one industries according to their four-digit ISICs (International Standard Industrial Classification) using the Chilean Industrial Manufacturing Census of 1967 and divided them into five size-classes, with the smallest size class employing 5 or more less than 10 persons, and the largest size class employing 100 or more persons.[7] Aggregating across all industries into the five size classes, he found greater inefficiency in the smaller size classes, but also discovered that large establishments were not unambiguously more efficient than smaller ones within the same industry as calculated with Farrell's efficiency frontier approach.[8]

He summarized the results as follows.

First, approximately 75 percent of the industrial establishments had a level of technical efficiency more than 50 percent below that of the most efficient establishments in the same industry. This

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7) Five size groupings of establishments were 5 to 9, 10 to 19, 20 to 49, 50 to 99, and 100 & more persons.

8) Technical efficiency is defined as the minimal input for a given level of production.

implies that a large number of establishments can survive even using very inefficient production techniques. He concluded that competition is far from perfect, both in the commodities and factor markets.

Second, LEs are not necessarily more efficient than SMEs in the same industry, nor is size a prerequisite for efficiency. However, there is less dispersion in efficiency among LEs than among SMEs.

Third, establishments using supposedly modern techniques have neither higher nor lower technical efficiency than those using what are considered old-fashioned techniques.

Fourth, average remuneration is higher for efficient than for inefficient establishments. Also, the value-added-to-gross output ratio is greater for the efficient than for the inefficient, and the ratio of white-collar to blue-collar workers does not have any effect on the efficiency level of industrial establishments. On the contrary, the ratio is higher in inefficient than in efficient establishments.

Meeusen and van den Broeck (1977) discussed the theoretical and statistical implications of a possible relationship between technical efficiency and firm size. They computed technical efficiency for each industry as a whole as well as for separate size-classes, and compared the results. The estimation of the average technical efficiency for each ten two-digit industry sector using data from the *1962 French Census* *of Manufacturing* was carried out by means of a MLE (Maximum Likelihood Estimation) of the Cobb–Douglas frontier production model with composed error. In each industry, the sample consisted of all firms employing at least 20 workers and salaried employees. Two size–classes were distinguished in terms of yearly value added based on factor prices, labor was measured as the unweighted sum of workers, and capital was estimated as the book value of gross fixed assets. The frontier production functions and the corresponding technical efficiency levels of each different size–class for the individual industries were measured, and verified that larger firms were relatively more efficient than smaller ones in the eight out of the ten industries.

They also compared the production elasticities between the two size subsectors of individual industries, finding that the elasticity of output with respect to labor was higher for smaller firms than for larger ones in eight out of the ten industries, while six of these same eight industries showed a higher elasticity of production with respect to capital in larger firms, implying a more labor–saving bias in LEs than SMEs.

Caves and Barton (1990) divided each industry with data available on sixty or more plants into halves by size and estimated technical efficiency separately for the larger and smaller halves of plants within each industry. They also demonstrated that LEs are relatively more efficient than SMEs using a translog–production function model with composed error. They indicated the reasons for the inferior technical efficiency of the SMEs.[9)]

As Nugent (1991) noted, large firms are generally acknowledged to achieve higher technical efficiency as well as more dynamic efficiency through vigorous R&D activities and easier access to new technologies than small and medium firms, although small and medium firms are more flexible, hence better able to adopt new technologies and to respond to fluctuating market situations.

However, Mills and Schmann (1985) emphasized the strengths of small firms by noting that small firms, with their superior responsiveness to cyclical or random swings in demand,[10)] can compete successfully with large firms with their greater technical efficiency by absorbing a disproportionate share of industry−wide output fluctuations in the context of generalized competitive equilibrium.

Milgrom and Roberts (1990) also highlighted the observed pattern of modern manufacturing as “a flexible multiproduct firm that emphasizes quality and speedy response to market conditions

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9) One of the reasons is that newer units should show relatively high variance in their performance and are also disadvantageously affected by factors that increase the hazards to business units overall (such as the prevalence of innovation). Another is related to the probability of a fringe of unskilled entrepreneurs with high probability of failure who would be filtered out (by the financial markets or other monitors) of activities that require a large scale of operation. Measurement errors may also be involved. Expected technical efficiency is indeed lower in the small−plant sectors (Caves and Barton (1990), p. 128).

10) This indicates “flexibility.”

while utilizing technologically advanced equipment and new forms of organization." He generally point out that small firms are considered to have competitiveness, flexibility, and innovativeness superior to large firms.

Ⅲ. Methodology

1. Maximum Likelihood Estimation of Full Frontier Production Function[11] with Gamma Distribution

A FFPF (Full Frontier Production Function) with a gamma distribution is used as the frontier translog production function and estimated through a modified procedure of the general MLE (Maximum Likelihood Estimation) on the assumption that the error term has a gamma distribution.

The Relative Technical Efficiency (RTE) of each establishment (u) is converted from the corresponding residual (ε) as follows:

$y = F(x)\ u,\ 0 < u \leq 1,$ (3.1)

where y is gross output, and x is an input bundle.

By log transformation of the above equation, we have

$Log\, y = log\, F(x) + log\, u = log\, F(x) - \varepsilon,\ \varepsilon \geq 0$

$Log\, u = -$ and $u = e^{-\varepsilon}.$ (3.2)

As a result, the most efficient establishment must be u = 1 with $\varepsilon = 0$.

11) It is also called a Deterministic Frontier Production Function.

To maintain consistency and to validate the resulting differences in the comparisons of estimated parameter values, the most common and flexible functional form is employed as follows:

$$
\begin{aligned}
ln\,(GO/N) &= ln\,a + \beta_L\ ln\,(N) + \beta_K\ ln\,(K/N) + \beta_M\ ln\,(M/N) \\
&+ \beta_{LL}\ (ln\,N)^2 + \beta_{KK}\ (ln\,K/N)^2 + \beta_{MM}\ (ln\,M/N)^2 \\
&+ \beta_{LK}\ (ln\,N)\ (ln\,(K/N)) + \beta_{KM}\ (ln\,(K/N))\ (ln\,(M/N)) \\
&+ \beta_{ML}\ (ln\,(M/N))\ (ln\,N) - \varepsilon\ ,\ \varepsilon \geq 0, \qquad (3.3)
\end{aligned}
$$

where GO = value of gross output in million won,

N = number of employees,

K = value of tangible fixed assets in million won,

M = value of production costs including the cost of raw materials, fuel, electricity and water, contract work and repair and maintenance costs in million won.

In the above equation, ε denotes a random disturbance term which has a two-parameter gamma distribution such as

$$
F(\varepsilon) = G(\lambda, \mathrm{P}) = \frac{\lambda^{\mathrm{P}}}{\Gamma(\mathrm{P})}\ \varepsilon^{\mathrm{P}-1} exp(-\lambda\,\varepsilon),\quad \varepsilon \geq 0, \lambda > 0,\ \ \mathrm{P} > 2, \qquad (3.4)
$$

where the mean and variance of ε are $\mu = \frac{\mathrm{P}}{\lambda}$ and $\sigma^2 = \frac{\mathrm{P}}{\lambda^2}$, respectively.

The log likelihood function for the gamma density model is represented as:

$$\text{Log}\, L = T\text{P} \log \lambda - T \log \Gamma(\text{P}) + (\text{P}-1) \sum_t \log(\alpha + \beta' x_t - y_t)$$

$$- \lambda \sum_t (\alpha + \beta' x_t - y_t). \qquad (3.5)$$

To draw an utmost "frontier" of the production function in terms of current technology, all residuals must be positive as assumed in the FFPF model, *i.e.,* the intercept should be shifted upward far enough that the minimum value of the residual is zero. Since the two free parameters in the gamma distribution, P and λ, are related to the residual term, ε, such that E (ε) = P / λ and V (ε) = P $/\lambda^2$, P and λ will be obviously positive and P greater than 2 in almost all applications.

In addition, the *skewness coefficient*, represented by $2/\sqrt{\text{P}}$, is clearly positive in all FFPF models using the gamma distribution. It is noteworthy that the concept of "absolute frontier" is constructed from the FFPF since the estimation methods draws a maximum possible output frontier from the full set of observations under current technology with an assumption of a one-sided error distribution.

As Forsund *et al.* (1980) noted, deterministic frontiers are consistent with economic theory, although they are often argued to be sensitive to outliers.

Lastly, the gamma distribution is originally asymmetric. Thus, the MLE of the parameters in (3.5) is more efficient than the least squares estimation.

2. Technical Efficiency by Size

Since the most efficient establishment in this model must have u = 1 due to the technical inefficiency term ε = 0, the *ex post* observed production points of individual establishments should lie beneath the production frontier F(x). As a result, there must be at least one best practice firm with u = 1. The tables below from Table 2 to Table 14 show the summarized statistics of u for each establishment in percentage terms, where u = 0.9999(99.99 %) implies the most efficient production unit in the sample under study. In the Appendix, Mean(u), Max(u), Min(u), Var(u), and sc(u) indicate sample mean, sample maximum value, sample minimum value, sample variance, and sample skewness coefficient, respectively.

Ⅳ. Data Description

The *1978 Census of Manufacturing Establishments of Korea* was used as reference for the pre−1980 period, while the *1983* and *1988 Census of Manufacturing Establishments of Korea* and the *1992, 1996, 1999, 2000, and 2001 Survey of Manufacturing Establishments* were used as reference for the post−1980 period to estimate the technical efficiency of firms during each event.

In particular, the years 1992 and 1996 were selected for the pre − IMF supervision[12)] era and 1999, 2000 and 2001 were selected for the post − IMF supervision era as reference points to detect trends in the technical efficiency of establishments by size caused by industrial structural adjustments under the IMF supervision.

The main contribution of this study is the use of annual micro−level establishment data to analyze the technical efficiency of Non−HCI, HCI, and IT manufacturing industries.

The industries selected are the key industries that have driven the sustained economic growth of Korea, and were divided into three categories, HCI, Non−HCI, and IT Manufacturing:

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12) IMF supervision was triggered by the 1997 Asian financial crisis.

Non-HCI (Heavy Machinery and Chemical industries)

KSIC 17 *Textiles, Except Sewn Wearing Apparel*
KSIC 181 *Sewn Wearing Apparel, Except Fur Apparel*

HCI (Heavy Machinery and Chemical industries)

KSIC 241 *Manufacture of Basic Chemicals*
KSIC 271 *Manufacture of Basic Iron and Steel*
KSIC 291 *Manufacturing of General Purpose Machinery*
KSIC 34 Motor Vehicles & Trailers Manufacturing
KSIC 343 *Parts for Motor Vehicles and Engines Manufacturing*
KSIC 3511 *Building of Ships*

IT (Information and Communication Technology) Manufacturing

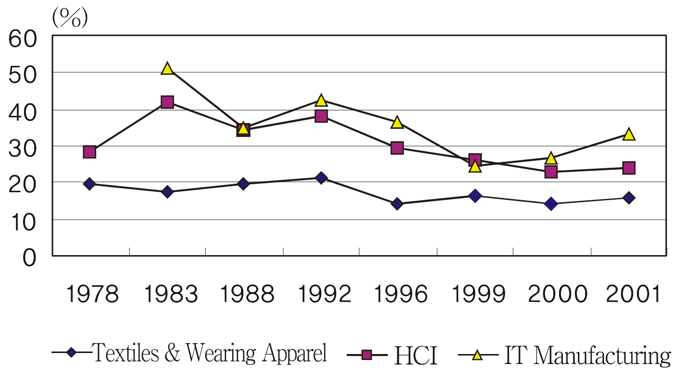
KSIC 3001 *Computers and Peripheral Equipment*
KSIC 30013 *Input / Output Units and Peripheral Equipment*
KSIC 321 *Semiconductor and Other Components*
KSIC 32202 *Communication Apparatuses*
KSIC 323 *Television and Radio Receivers*

Ⅴ. Empirical Results

1. Relative Technical Efficiency by Industry Group and Size

Figure 1 presents the technical efficiency of the 13 selected industries divided into the three industrial groups of Textiles & Wearing Apparel (Non-HCI), HCI, and IT Manufacturing.

Figure 1 Technical Efficiency by Industry Group



unit : %

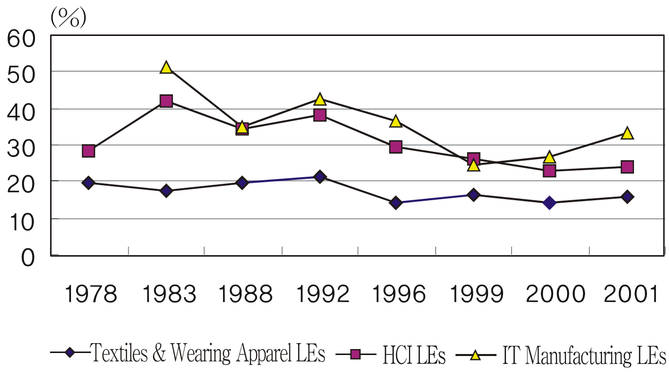
Year	1978	1983	1988	1992	1996	1999	2000	2001
Textiles & Wearing Apparel	19.78	17.215	19.61	21.205	14.11	16.355	14.41	15.76
HCI	28.45	41.975	34.158	38.346	29.343	26.213	22.858	23.923
IT Manufacturing		51.1	34.875	42.32	36.72	24.656	26.6	33.288

Figures 2 and 3 show the trends in technical efficiency of the LEs and SMEs in each industry group.

The figures clearly show the following facts on the basis of one-tailed hypotheses tests at the 95% significance level:

First, patterns in variation of technical efficiency for industry groups as well as both SMEs and LEs for each industry group were similar in all periods, *i.e.* IT manufacturing marked the greatest technical efficiency, HCI second, and Textiles & Wearing

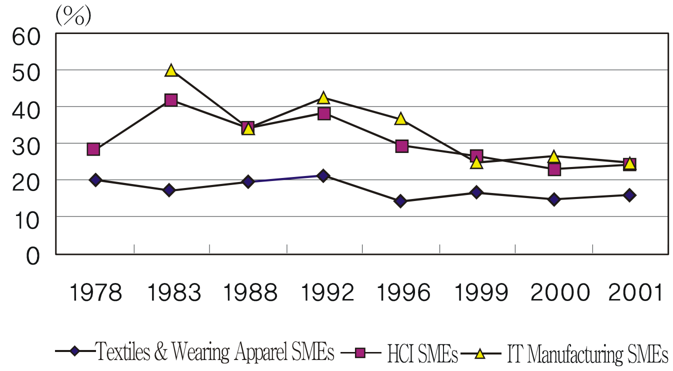
Figure 2 Technical Efficiency of LEs by Industry Group



unit : %

Year	1978	1983	1988	1992	1996	1999	2000	2001
Textiles & Wearing Apparel	19.42	16.83	19.84	21.73	14.51	18.91	15.22	16.46
HCI	33.21	45.39	42.28	40.89	30.2	26.83	27.26	24.60
IT Manufacturing		55.15	41.01	47.16	38.44	22.87	26.8	36.12

Figure 3 Technical Efficiency of SMEs by Industry Group



unit : %

Year	1978	1983	1988	1992	1996	1999	2000	2001
Textiles & Wearing Apparel	19.82	17.11	19.6	21.19	14.11	16.34	14.45	15.76
HCI	28.12	41.71	34.08	38.23	29.3	26.19	22.83	23.90
IT Manufacturing		50.28	34.07	42.22	36.62	24.71	26.43	24.65

Apparel (Non-HCI) was lowest except in 1999. The ranking of technical efficiency levels among the industrial groups and size-classes varied for the first time in the year 1999, when the HCI ranked first and the IT manufacturing dropped to second, with the Non-HCI still last. In particular among the LEs, HCI rated the highest, IT manufacturing second, and Textiles & Wearing Apparel (Non-HCI) still last in 2000.

Second, the variation of technical efficiency for LEs was greater than that of SMEs.

Compared to the results in 1992, LEs in both HCI and IT manufacturing experienced drops in efficiency of 10.7% and 8.7%, respectively, worse than for SMEs', 9% and 6%, respectively in 1996 just before the financial crisis of 1997. However, loss of efficiency in the same period was around 7 % for both size groups in the Textiles & Wearing Apparel (Non-HCI).

Third, the industrial structural adjustments triggered by the financial crisis weakened the technical efficiency of the LEs more than that of the SMEs. In particular, compared to the results in 1996, the deterioration of technical efficiency in LEs was more rapid by 3 % than in SMEs in IT manufacturing in 1999, *i.e.,* the deterioration of technical efficiency in LEs marked approximately 16 % while that of the SMEs did 12%.

Forth, the LEs of IT manufacturing beat the LEs of HCI again in terms of technical efficiency by 11.52 % finally in the year 2001.

2. Relative Technical Efficiency by Industry and Size per Year

The following presents an analysis of technical efficiency by industry group as well as by individual industry and size class (refer to appendix).

Above all, the SMEs of all industries marked both the highest and the lowest levels of technical efficiency for the eight separate years under this study.[13] Therefore, the variance of the distribution of technical efficiency was greater for SMEs than for LEs.[14] However, the technical efficiency level of the LEs dominated that of the entire industry, i.e., if LEs are efficient then the entire industry is efficient.

What follow is a analysis of technical efficiency in detail by individual industry and size class per year:

First, in 1978, in the industries *Textiles, Except Sewn Wearing Apparel* and *Sewn Wearing Apparel, except Fur Apparel*, LEs and SMEs showed similar efficiency levels. However, in industries targeted by the HCI Drive Policy like *Manufacture of Basic Chemicals*, *Manufacture of Basic Iron and Steel*, *Motor Vehicles &*

13) The LEs of KSIC 241 in 1983 marked the lowest level, but this was similar to that of the SMEs' (refer to Appendix).

14) The exceptions are KSIC 351 and KSIC 3843 in 1978, KSIC 241 in 1983, KSIC 181 in 1992, KSIC 321 and KSIC 323 in 1996, and KSIC 17, KSIC 181, KSIC 343 in 1999 (refer to Appendix).

Trailers, *Manufacturing and Building of Ships*, LEs were more efficient than SMEs.

In particular, in the industries *Motor Vehicles & Trailers Manufacturing* and *Building of Ships*, the technical efficiency gap between the two size classes is huge, which raises the entire industry's average far beyond that of the other industries.

In conclusion, the winners under the Big−Push HCI Promotion Policy in 1978, *i.e.* the favored HCI LEs, achieved higher technical efficiency levels than the less−favored LEs of the Non−HCI, *Textiles & Wearing Apparel*. Therefore, it proved that the winners of the government industrial policy gained a superior position in attaining the maximum possible output for a given level of input.

Second, in 1983, the LEs of the HCI and IT manufacturing were more efficient than the SMEs. Particularly, for the industries *Motor Vehicles & Trailers Manufacturing* and *Building of Ships* of the HCI and *Semiconductor and Other Components* and *Television and Radio Receivers* of the IT manufacturing, the technical efficiency gaps are large. Also, entire industry average efficiency was high both in the HCI and IT manufacturing.[15] In sum, the favored HCI LEs still maintained high technical efficiency and the

15) The HCI such as KSIC 241, KSIC 271, KSIC 291, KSIC 34, and KSIC 343 were more than twice as efficient as KSIC 17 and KSIC 181. In particular, KSIC 3511 was remarkably efficient. Also, in IT manufacturing, KSIC 3001 and KSIC 321 were highly efficient (refer to Appendix).

IT manufacturing LEs achieved high technical efficiency levels.

Third, in 1988, among the HCI, LEs in *Building of Ships* beat the SMEs in terms of technical efficiency.

In IT manufacturing, the LEs of *Computers and Peripheral Equipment* and *Input/Output Units and Peripheral Equipment* were far ahead of the SMEs in terms of efficiency, and the entire industry average marked the highest efficiency.

Fourth, in 1992, the LEs of the industries *Manufacture of Basic Iron and Steel, Motor Vehicles & Trailers Manufacturing, Building of Ships, Computers and Peripheral Equipment,* and *Communication Apparatuses* were more efficient than the SMEs.

In particular, the LEs of the industries *Building of Ships* and *Communication Apparatuses* were far more efficient than the SMEs.

On the other hand, the SMEs were more efficient than the LEs in the *Semiconductor and Other Components* industry. The entire industry average efficiencies of the industries *Manufacture of Basic Iron and Steel, Motor Vehicles & Trailers Manufacturing, Parts for Motor Vehicles and Engines Manufacturing,* and *Computers and Peripheral Equipment* were high, and especially those of the industries *Building of Ships* and *Communication Apparatuses* were remarkably high.

Fifth, in 1996, for the industries *Manufacture of Basic Chemicals, Manufacture of Basic Iron and Steel, Motor Vehicles & Trailers Manufacturing, Parts for Motor Vehicles and Engines Manu-*

facturing, Building of Ships, Input/Output Units and Peripheral Equipment, Communication Apparatuses, and *Television and Radio Receivers*, the LEs were more efficient than the SMEs. In particular, the industries *Input/Output Units and Peripheral Equipment* and *Communication Apparatuses* showed large gaps between the two size classes.

Furthermore, the entire industry average was high in the industries *Building of Ships, Computers and Peripheral Equipment,* and *Input/Output Units and Peripheral Equipment,* and especially high in *Communication Apparatuses*.

Sixth, in 1999, the LEs of the industries *Sewn Wearing Apparel, except Fur Apparel, Manufacture of Basic Iron and Steel, Motor Vehicles & Trailers Manufacturing, Building of Ships,* and *Communication Apparatuses* were more efficient than the SMEs.

On the contrary, the SMEs of the industries *Computers and Peripheral Equipment, Input/Output Units and Peripheral Equipment, and Television and Radio Receivers* show higher efficiency than the LEs.

However, the entire industry average efficiencies of *Manufacture of Basic Chemicals and Communication Apparatuses* plunged, and even *Building of Ships*, which had maintained a high efficiency level, fell a little.

Turning to 2000, in the industries *Sewn Wearing Apparel, except Fur Apparel, Manufacture of Basic Chemicals, Manufacture of Basic Iron and Steel, Manufacturing of General Purpose Machinery, Motor*

Vehicles & Trailers Manufacturing, Parts for Motor Vehicles and Engines Manufacturing, Computers and Peripheral Equipment, I/O Units and Peripheral Equipment, and *Television and Radio Receivers,* the LEs were more efficient than the SMEs. On the contrary, in the industries, *Building of Ships and Communication Apparatuses*, the SMEs became more efficient than the LEs.

Finally, in 2001, in the industries *Sewn Wearing Apparel, except Fur Apparel, Manufacture of Basic Chemicals, Manufacture of Basic Iron and Steel, Manufacturing of General Purpose Machinery, Motor Vehicles & Trailers Manufacturing, Parts for Motor Vehicles and Engines Manufacturing, Building of Ships,* and *Television and Radio Receivers,* the LEs were slightly more efficient than the SMEs. In the industries *Computers and Peripheral Equipment* and *Input/Output Units and Peripheral Equipment*, LEs become far more efficient, by 22% and 24%, respectively, than the SMEs.

On the other hand, in the industries *Textiles, except Sewn Wearing Apparel, Semiconductor and Other Components,* and *Communication Apparatuses*, the SMEs were slightly more efficient than the LEs.

Ⅵ. Conclusion

In sum, the LEs were more efficient than the SMEs in the growing key industries in last three decades in Korea, *i.e.* large firms have generally proved themselves to achieve higher technical efficiency as well as more dynamic efficiency than small and medium-sized firms, however, the variation of technical efficiency for LEs was greater than that of SMEs by exogenous shocks in Korea.

In Particular, The LEs of the *Textiles & Wearing Apparel* industry in the 1960s and the 1970s, the *Manufacture of Basic Chemicals* industry in the 1980s, the *Motor Vehicles & Trailers Manufacturing* and *Building of Ships* industries until the latter half of the 1990s, and the *Semiconductor and Other Components* industry until 2000 and 2001 maintained the highest technical efficiency levels.

In conclusion, it proved that the winners of the government industrial policy gained *static efficiency* as well as even *dynamic efficiency* in last three decades.

Therefore, we can say that the LEs of key industries led economic growth for each economic development stage of Korea and efficient industry proved itself to be highly competitive in the world market as Caves and Barton noted (1990).

However, in 1999 when the industrial structural adjustments were being carried out the SMEs of the industries *Computers and Peripheral Equipment, Input/Output Units and Peripheral Equipment,* and *Television and Radio Receivers* show higher efficiency than the LEs as Milgrom and Roberts (1990) mentioned that small firms are competitive, flexible, and innovative superior to large firms against exogenous shocks to market.

Appendix

Table 1 shows size distribution by industry from 1978 to 2001, and Tables 2−14 present the estimation results by industry and size class of the sample used for study.

Table 1 Size Distribution by Industry (1978-2001)

unit: number of establishments, %

Year	1978			1983			1988		
KSIC	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
17	4156	3800	356	4691	4457	234	6892	6633	259
		91.43	8.56		95.01	4.98		96.24	3.75
181	2740	2481	259	3037	2819	218	4415	4225	190
		90.54	9.45		92.82	7.17		95.69	4.30
241	791	752	39	802	771	31	730	701	29
		95.06	4.93		96.13	3.86		96.02	3.97
271	498	441	57	439	397	42	649	594	55
		88.55	11.44		90.43	9.56		91.52	8.47
291				902	869	33	1516	1478	38
					96.34	3.65		97.49	2.50
34	360	334	26	595	565	30	1441	1352	89
		92.77	7.22		94.95	5.04		93.82	6.17
343				586	562	24	1399	1323	76
					95.90	4.09		94.56	5.43
3511	271	258	13	107	97	10	177	166	11
		95.20	4.79		90.65	9.34		93.78	6.21
3001				143	132	11	101	89	12
					92.30	7.69		88.11	11.88
321				191	147	44	701	636	65
					76.96	*23.03*		*90.72*	*9.27*
32202									
323				456	402	54	1355	1260	95
					88.15	*11.84*		*92.98*	*7.01*

Note : The numbers in *italics* are % shares of the SMEs and LEs in the entire sample by industry
For 1978, KSIC 321 is added to the figures for KSIC 17, KSIC 322 for KSIC 181, KSIC 351 for KSIC 241, KSIC 371 for KSIC 271, KSIC 3841 for KSIC 3511, and KSIC 3843 for KSIC 34.

Table 1 Size Distribution by Industry (1978-2001) (continued)

unit: number of establishments, %

Year	1992			1996			1999		
KSIC	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
17	7703	7510	193	8881	8762	119	8388	8314	74
		97.49	*2.50*		*98.66*	*1.33*		*99.11*	*0.88*
181	5856	5757	79	7727	7675	52	6255	6244	31
		98.64	*1.35*		*99.32*	*0.67*		*99.50*	*0.49*
241	994	947	47	994	948	46	1053	1014	39
		95.27	*4.72*		*95.37*	*4.62*		*96.29*	*3.70*
271	727	679	48	862	818	44	990	954	36
		93.39	*7.06*		*94.89*	*5.10*		*96.36*	*3.63*
291	3013	2976	37	4863	4807	56	4254	4216	38
		98.77	*1.22*		*98.84*	*1.15*		*99.10*	*0.89*
34	2320	2215	105	3180	3054	126	2812	2716	96
		95.47	*4.52*		*96.03*	*3.96*		*96.58*	*3.41*
343	2217	2126	91	3057	2946	111	2670	2587	83
		95.89	*4.10*		*96.36*	*3.63*		*96.89*	*3.10*
3511	301	290	11	460	447	13	431	420	11
		96.34	3.65		97.17	2.82		97.44	2.55
3001	283	265	18	397	381	16	459	443	16
		93.63	6.36		95.96	4.03		96.51	3.48
321	921	854	67	1336	1259	77	1241	1155	86
		92.72	7.27		94.23	5.76		93.07	6.92
32202	177	169	8	279	267	12	560	541	19
		95.48	4.51		95.69	4.30		96.60	3.39
323	1489	1434	55	1320	1282	38	851	825	26
		96.30	3.69		97.12	2.87		96.94	3.05

Table 1 Size Distribution by Industry (1978-2001) (continued)

unit : number of establishments, %

Year	2000			2001		
KSIC	Whole	SMEs	LEs	Whole	SMEs	LEs
17	8877	8797	80	9161	9099	62
		99.10	*0.90*		*99.33*	*0.68*
181	7757	7721	36	7991	7964	27
		99.54	*0.46*		*99.66*	*0.34*
241	1090	1055	35	1209	1174	35
		96.79	*3.21*		*97.11*	*2.89*
271	995	962	33	1095	1063	32
		96.68	*3.32*		*97.08*	*2.92*
291	4641	4600	41	4881	4837	44
		99.12	*0.88*		*99.10*	*0.90*
34	2975	2875	100	3233	3131	102
		96.64	*3.36*		*96.85*	*3.15*
343	2860	2772	88	3088	2999	89
		96.92	*3.08*		*97.12*	*2.88*
3511	490	477	13	564	549	15
		97.35	*2.65*		*97.34*	*2.66*
3001	515	497	18	465	446	19
		96.50	*3.50*		*95.91*	*4.09*
321	1474	1375	99	1711	1612	99
		93.28	*6.72*		*94.21*	*5.79*
32202	709	686	23	734	705	29
		96.76	*3.24*		*96.05*	*3.95*
323	843	809	34	833	810	23
		95.97	*4.03*		*97.24*	*2.76*

From Table 2 to Table 14, *Mean(u), Max(u), Min(u), Var(u), sc(u)* indicate *sample mean, sample maximum value, sample minimum value, sample variance,* and *sample skewness coefficient,* respectively. In addition, *N* denotes number of establshments.

Table 2 Technical Efficiency of the industry Textiles, except Sewn Wearing Apparel by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.25	0.25	4.06	0.86	0.86	3.01	0.49	0.49	11.58
max(u)	99.99	99.99	27.15	99.99	99.99	38.61	99.99	99.99	49.18
mean(u)	16.26	16.30	15.90	18.53	18.30	18.25	18.71	18.69	19.27
var(u)	38.52	40.84	13.66	49.06	50.56	20.51	44.30	45.32	17.87
sc(u)	3.19	3.18	0.24	3.41	3.42	0.47	3.03	3.03	2.41
N	4156	3800	356	4691	4457	234	6892	6633	259
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	1.16	1.16	6.81	0.52	0.52	7.48	0.36	0.36	6.88
max(u)	99.99	99.99	70.54	99.99	99.99	32.21	99.99	99.99	46.98
mean(u)	20.72	20.72	20.76	15.15	15.15	15.06	14.68	14.68	15.04
var(u)	46.93	47.07	41.72	27.12	27.24	18.72	27.56	27.41	44.21
sc(u)	2.15	2.14	3.01	2.64	2.65	1.13	2.65	2.65	2.40
N	7703	7510	193	8881	8762	119	8388	8314	74
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	0.37	0.37	6.53	0.90	0.90	6.96			
max(u)	99.99	99.99	27.62	99.99	99.99	25.75			
mean(u)	14.12	14.12	14.11	12.24	12.25	12.07			
var(u)	25.66	25.74	16.95	15.63	15.65	13.80			
sc(u)	3.36	3.37	0.88	3.39	3.40	1.60			
N	8877	8797	80	9161	9099	62			

Table 3 Technical Efficiency of the industry Sewn Wearing Apparel, except Fur Apparel by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.98	0.98	3.13	0.95	0.95	6.37	0.45	0.45	6.08
max(u)	99.99	99.99	75.13	99.99	99.99	32.20	99.99	99.99	78.13
mean(u)	23.30	23.34	22.94	15.90	15.93	15.42	20.51	20.52	20.42
var(u)	63.15	63.96	55.55	25.72	26.74	12.46	47.49	47.69	43.22
sc(u)	1.99	1.92	2.73	3.63	3.65	1.11	1.78	1.68	4.35
N	2740	2481	259	3037	2819	218	4415	4225	190
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.79	0.79	11.49	0.44	0.44	9.80	0.25	0.25	4.06
max(u)	99.99	99.99	56.65	99.99	99.99	22.65	99.99	99.99	56.48
mean(u)	21.69	21.67	22.70	13.07	13.07	13.96	18.03	18.01	22.78
var(u)	43.99	43.88	51.75	18.66	18.73	7.92	43.40	42.74	158.40
sc(u)	2.10	2.10	2.00	2.51	2.51	0.87	1.88	1.87	1.05
N	5836	5757	79	7727	7675	52	6255	6224	31
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	0.58	0.58	9.34	1.12	1.12	12.56			
max(u)	99.99	99.99	26.59	99.99	99.99	32.71			
mean(u)	14.72	14.71	16.33	19.28	19.27	20.86			
var(u)	30.90	30.96	16.03	37.16	37.21	20.41			
sc(u)	2.78	2.79	0.34	1.86	1.87	0.53			
N	7757	7721	36	7991	7964	27			

Table 4 Technical Efficiency of the industry Manufacture of Basic Chemicals by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	1.24	1.24	6.28	0.02	1.07	0.02	2.05	2.05	14.39
max(u)	99.99	99.99	69.96	99.99	99.99	50.75	99.99	99.99	32.53
mean(u)	21.95	21.85	23.94	30.69	30.72	29.96	26.88	26.98	24.37
var(u)	59.31	58.22	78.13	130.08	128.67	169.96	83.06	85.20	25.72
sc(u)	3.03	2.99	3.35	1.59	1.71	−0.48	1.60	1.58	−0.21
N	791	752	39	802	771	31	730	701	29
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.25	0.25	2.72	2.75	2.75	13.57	0.04	0.04	3.88
max(u)	99.99	99.99	43.55	99.99	99.99	31.25	99.99	99.99	21.47
mean(u)	24.19	24.13	25.32	21.99	21.94	23.17	10.16	10.18	9.52
var(u)	92.02	92.31	86.56	63.46	65.48	20.98	27.34	28.06	8.32
sc(u)	1.99	2.09	−0.38	3.08	3.09	−0.23	7.90	7.86	1.74
N	994	947	47	994	948	46	1053	1014	39
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	0.71	0.71	11.10	3.05	3.05	11.93			
max(u)	99.99	99.99	44.08	99.99	99.99	33.01			
mean(u)	21.59	21.54	23.01	21.84	21.81	22.85			
var(u)	83.27	84.74	38.15	67.22	68.65	18.84			
sc(u)	2.38	2.40	0.74	3.02	3.02	0.46			
N	1090	1055	35	1209	1174	35			

Table 5 Technical Efficiency of the industry Manufacture of Basic Iron and Steel by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.41	0.41	10.19	12.07	12.07	34.98	0.91	0.91	14.79
max(u)	99.99	99.99	32.95	99.99	99.99	86.02	99.99	99.99	53.61
mean(u)	16.83	16.58	18.75	48.48	48.12	51.87	34.34	34.17	36.13
var(u)	40.16	42.60	17.50	126.25	128.68	92.80	132.88	136.18	95.59
sc(u)	4.68	4.87	0.98	0.79	0.79	1.21	1.39	1.50	−0.31
N	498	441	57	439	397	42	649	594	55
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	4.84	4.84	30.59	1.03	1.03	13.91	3.29	3.29	13.18
max(u)	99.99	99.99	83.19	99.99	99.99	49.37	99.99	99.99	69.66
mean(u)	47.06	46.85	50.01	31.27	31.16	33.28	35.83	35.82	36.06
var(u)	167.90	170.57	123.36	95.08	97.13	53.97	138.38	139.87	101.83
sc(u)	0.60	0.61	0.69	1.55	1.61	−0.35	0.93	0.93	0.76
N	727	679	48	862	818	44	990	954	36
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	0.87	0.87	20.34	2.39	2.39	12.72			
max(u)	99.99	99.99	42.04	99.99	99.99	23.73			
mean(u)	28.69	28.65	29.88	16.41	16.39	17.37			
var(u)	66.87	68.31	24.10	35.54	36.42	5.71			
sc(u)	2.18	2.19	0.24	6.34	6.31	0.29			
N	995	962	33	1095	1063	32			

Table 6 Technical Efficiency of the industry Manufacturing of General Purpose Machinery by Size

unit : %

Year	1983			1988			1992		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	6.06	6.06	8.90	3.46	3.46	25.54	1.89	1.89	20.90
max(u)	99.99	99.99	47.65	99.99	99.99	60.19	99.99	99.99	51.34
mean(u)	29.44	29.33	32.41	35.74	35.68	38.35	31.19	31.18	32.69
var(u)	80.09	80.32	66.99	112.17	113.80	42.95	69.34	69.72	37.14
sc(u)	2.06	2.15	−0.54	1.00	1.01	0.80	1.15	1.16	0.94
N	902	869	33	1516	1478	38	3013	2976	37
Year	1996			1999			2000		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.65	0.65	11.21	2.72	2.72	5.78	0.15	0.15	8.66
max(u)	99.99	99.99	40.93	99.99	99.99	45.32	99.99	99.99	24.99
mean(u)	21.18	21.19	20.83	28.28	28.28	28.54	17.26	17.25	18.13
var(u)	42.72	42.97	21.17	58.67	58.74	51.58	26.82	26.93	14.07
sc(u)	2.92	2.92	1.41	1.70	1.72	−0.48	3.18	3.20	−0.37
N	4863	4807	56	4254	4216	38	4641	4600	41
Year	2001								
	Whole	SMEs	LEs						
min(u)	0.65	0.65	3.23						
max(u)	99.99	99.99	24.28						
mean(u)	17.52	17.52	17.91						
var(u)	23.03	23.13	11.48						
sc(u)	3.43	3.44	−1.54						
N	4881	4837	44						

Table 7 Technical Efficiency of the industry Motor Vehicles & Trailers Manufacturing by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	5.43	5.43	25.95	9.53	9.53	29.55	2.44	2.44	14.90
max(u)	99.99	96.89	99.99	99.99	99.99	60.25	99.99	99.99	44.04
mean(u)	32.23	31.74	38.52	42.32	42.07	46.94	26.81	26.80	26.88
var(u)	152.35	144.22	222.26	173.91	179.49	48.07	70.90	73.74	28.06
sc(u)	1.88	1.71	2.78	0.86	0.90	−0.46	1.68	1.67	0.79
N	360	334	26	595	565	30	1441	1352	89
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	2.33	2.33	22.07	0.82	0.82	14.54	1.17	1.17	7.69
max(u)	99.99	99.99	55.06	99.99	99.99	77.80	99.99	99.99	64.18
mean(u)	36.95	36.88	38.48	27.68	27.66	28.18	23.34	23.29	24.89
var(u)	91.62	94.32	32.40	65.55	65.54	66.17	64.28	64.04	69.49
sc(u)	0.89	0.90	0.21	1.98	1.91	3.67	2.64	2.68	1.65
N	2320	2215	105	3180	3054	126	2812	2716	96
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	1.50	1.50	10.42	1.59	1.59	11.37			
max(u)	99.99	99.99	36.87	99.99	99.99	39.94			
mean(u)	21.26	21.18	23.71	22.93	22.91	23.64			
var(u)	50.90	51.48	28.25	38.89	39.62	16.03			
sc(u)	3.53	3.60	0.22	2.33	2.35	0.51			
N	2975	2875	100	3233	3131	102			

Table 8 Technical Efficiency of the industry Parts for Motor Vehicles and Engines Manufacturing by Size

unit : %

Year	1983			1988			1992		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	10.59	10.59	28.45	2.03	2.03	10.38	1.55	1.55	23.06
max(u)	99.99	99.99	59.42	99.99	99.99	58.06	99.99	99.99	56.93
mean(u)	39.12	38.99	42.17	31.46	31.55	29.91	39.74	39.69	40.70
var(u)	125.00	127.71	54.25	106.56	109.15	59.87	102.10	104.75	39.55
sc(u)	1.30	1.33	0.04	1.29	1.28	1.02	0.68	0.69	0.23
N	586	562	24	1399	1323	76	2217	2126	91
Year	1996			1999			2000		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	0.59	0.59	15.23	0.54	0.54	9.85	1.62	1.62	9.33
max(u)	99.99	99.99	74.23	99.99	99.99	69.89	99.99	99.99	29.40
mean(u)	28.43	28.38	29.68	22.46	22.46	22.29	18.73	18.71	19.39
var(u)	69.25	70.26	41.05	49.80	49.02	75.09	33.24	33.98	9.72
sc(u)	1.87	1.86	3.18	2.48	2.41	3.44	4.03	4.02	0.31
N	3057	2946	111	2670	2587	83	2860	2772	88
Year	2001								
	Whole	SMEs	LEs						
min(u)	1.63	1.63	11.21						
max(u)	99.99	99.99	39.17						
mean(u)	22.87	22.86	23.37						
var(u)	38.56	39.24	15.32						
sc(u)	2.34	2.35	0.63						
N	3088	2999	89						

Table 9 Technical Efficiency of the industry Building of Ships by Size

unit : %

Year	1978			1983			1988		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	6.90	6.90	36.20	26.95	26.95	46.31	22.55	22.55	37.56
max(u)	99.99	99.99	66.77	99.99	99.99	86.56	99.99	99.99	73.83
mean(u)	42.79	42.34	51.63	61.80	61.06	68.99	49.72	49.31	55.80
var(u)	221.89	223.26	121.98	261.24	263.30	204.90	213.09	218.03	109.47
sc(u)	0.85	0.91	0.07	0.34	0.41	−0.21	0.75	0.82	−0.08
N	271	258	13	107	97	10	177	166	11
Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	16.22	16.22	46.65	8.70	8.70	33.27	2.72	2.72	24.44
max(u)	99.99	99.99	68.16	99.99	99.99	66.16	99.99	99.99	61.00
mean(u)	50.95	50.67	58.18	45.51	45.49	46.11	37.21	37.14	39.72
var(u)	203.45	207.46	48.16	181.13	182.76	135.32	154.59	156.17	96.79
sc(u)	0.46	0.50	−0.44	0.55	0.55	0.47	1.40	1.41	0.56
N	301	290	11	460	447	13	431	420	11
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	3.07	3.07	13.79	10.83	10.83	22.38			
max(u)	99.99	99.99	47.81	99.99	95.95	99.99			
mean(u)	29.62	29.66	28.42	41.97	41.96	42.50			
var(u)	110.70	111.05	104.23	137.69	133.36	316.72			
sc(u)	1.52	1.55	0.31	0.74	0.58	2.09			
N	490	477	13	564	549	15			

Table 10 Technical Efficiency of the industry Computers and Peripheral Equipment by Size

unit : %

Year	1983			1988			1992		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	24.49	24.49	42.29	12.41	12.41	28.67	6.94	6.94	24.93
max(u)	99.99	99.99	86.02	99.99	99.99	84.58	99.99	99.99	74.05
mean(u)	58.94	58.73	61.45	42.57	41.15	53.09	40.16	39.91	54.67
var(u)	58.73	241.01	14.41	392.65	379.32	397.82	189.55	193.90	117.90
sc(u)	0.29	0.29	0.31	0.93	1.04	0.41	1.01	1.04	0.17
N	143	132	11	101	89	12	283	265	169
Year	1996			1999			2000		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	2.50	2.50	25.52	2.05	2.05	15.08	4.27	4.27	11.21
max(u)	99.99	99.99	69.78	99.99	99.99	31.13	99.99	99.99	44.03
mean(u)	40.55	40.60	39.34	25.10	25.20	22.29	32.08	32.06	32.56
var(u)	208.05	211.34	137.18	106.94	109.63	26.14	138.63	141.63	59.04
sc(u)	1.30	1.29	1.29	2.04	2.02	0.27	1.61	1.63	−0.77
N	397	381	16	459	443	16	515	497	18
Year	2001								
	Whole	SMEs	LEs						
min(u)	1.98	1.98	25.88						
max(u)	99.99	99.99	70.19						
mean(u)	33.10	13.18	35.82						
var(u)	171.61	173.85	117.58						
sc(u)	1.12	1.11	1.77						
N	465	446	19						

Table 11 Technical Efficiency of the industry I/O Units and Peripheral Equipment by Size

unit : %

Year	1988			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	12.65	12.65	30.45	12.65	12.65	32.43	2.03	2.03	14.88
max(u)	99.99	99.99	91.31	99.99	99.99	77.65	99.99	99.99	31.64
mean(u)	45.95	44.19	60.01	47.07	46.70	52.28	25.51	25.66	21.65
var(u)	439.42	432.39	302.86	276.79	284.39	159.07	114.07	116.73	33.72
sc(u)	0.59	0.73	0.02	1.18	1.23	0.41	2.26	2.24	0.57
N	90	80	10	136	127	9	343	330	13
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	4.12	4.12	12.83	2.26	2.26	26.95			
max(u)	99.99	99.99	49.31	99.99	97.50	99.99			
mean(u)	32.74	32.67	35.48	38.77	15.50	49.44			
var(u)	146.75	148.17	91.40	250.86	240.33	429.39			
sc(u)	1.60	1.63	−0.70	0.61	0.52	0.93			
N	445	434	11	398	383	15			

Table 12 Technical Efficiency of the industry Semiconductor and Other Components by Size

unit : %

Year	1983			1988			1992		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	7.08	7.08	24.50	4.27	4.27	13.26	6.36	6.36	11.91
max(u)	99.99	99.99	82.03	99.99	99.99	37.66	99.99	99.99	92.88
mean(u)	53.42	51.69	59.20	22.94	22.78	24.52	43.93	44.14	41.18
var(u)	228.84	255.74	98.45	60.36	64.06	21.74	167.71	168.14	156.33
sc(u)	0.20	0.46	−0.72	2.72	2.77	0.40	0.55	0.53	0.70
N	191	147	44	701	636	65	921	854	67
Year	1996			1999			2000		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	2.06	2.06	4.18	1.74	1.74	12.43	1.95	1.95	5.78
max(u)	99.99	99.99	83.77	99.99	99.99	47.27	99.99	99.99	51.62
mean(u)	26.57	26.60	26.16	26.16	26.12	26.59	25.72	25.65	26.57
var(u)	91.72	90.03	120.74	82.89	85.49	48.41	97.64	100.06	63.90
sc(u)	2.23	2.23	2.11	1.79	1.84	0.12	2.26	2.31	0.79
N	1336	1259	77	1241	1155	86	1474	1375	99
Year	2001								
	Whole	SMEs	LEs						
min(u)	0.26	0.26	7.53						
max(u)	99.99	99.99	46.42						
mean(u)	27.98	28.03	27.20						
var(u)	81.37	83.33	49.28						
sc(u)	1.62	1.65	0.08						
N	1711	1612	99						

Table 13 Technical Efficiency of the industry Communication Equipment by Size

unit : %

Year	1992			1996			1999		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	13.13	13.13	38.13	9.23	9.23	29.13	1.93	1.93	8.53
max(u)	99.99	99.99	84.86	99.99	99.99	64.53	99.99	99.99	29.56
mean(u)	55.00	54.67	61.94	42.12	41.93	46.27	16.97	16.96	17.30
var(u)	207.44	206.27	207.74	187.82	190.18	128.19	60.95	61.69	41.97
sc(u)	0.15	0.17	−0.10	0.73	0.76	0.17	3.46	3.51	0.66
N	177	169	8	279	267	12	560	541	19
Year	2000			2001					
	Whole	SMEs	LEs	Whole	SMEs	LEs			
min(u)	1.85	1.85	15.35	2.25	2.25	16.28			
max(u)	99.99	99.99	43.73	99.99	99.99	45.36			
mean(u)	25.49	25.50	22.46	28.67	28.74	26.93			
var(u)	85.39	86.63	40.87	112.16	114.96	42.55			
sc(u)	1.88	1.86	1.54	1.77	1.76	0.45			
N	709	686	23	734	705	29			

Table 14 Technical Efficiency of the industry Television and Radio Receivers by Size

unit : %

Year	1983			1988			1992		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	2.65	2.65	26.21	0.75	0.75	14.12	5.09	5.09	13.08
max(u)	99.99	99.99	71.05	99.99	92.85	99.99	99.99	99.99	67.93
mean(u)	40.94	40.42	44.82	28.04	28.16	26.44	30.19	30.17	30.86
var(u)	171.45	181.76	79.28	94.32	95.03	83.04	77.50	78.17	60.86
sc(u)	0.68	0.76	0.20	1.37	1.12	5.51	1.66	1.66	1.97
N	456	402	54	1355	1260	95	1489	1434	55
Year	1996			1999			2000		
	Whole	SMEs	LEs	Whole	SMEs	LEs	Whole	SMEs	LEs
min(u)	2.64	2.64	19.62	2.07	2.07	16.47	0.88	0.88	9.58
max(u)	99.99	99.99	75.74	99.99	99.99	56.63	99.99	99.99	39.17
mean(u)	27.29	27.27	28.15	29.54	29.63	26.56	16.97	16.21	16.96
var(u)	80.45	80.09	94.51	156.95	159.54	68.25	48.26	48.89	33.68
sc(u)	2.15	2.10	3.38	1.25	1.23	1.90	4.47	4.53	1.85
N	1320	1282	38	851	825	26	843	809	34
Year	2001								
	Whole	SMEs	LEs						
min(u)	2.43	2.43	11.26						
max(u)	99.99	99.99	61.63						
mean(u)	37.92	37.83	41.25						
var(u)	127.44	128.02	100.14						
sc(u)	0.62	0.66	−0.74						
N	833	810	23						

References

[1] Aigner, D.J., C.A.K. Lovell, and P.Schmidt, "Formulation and Estimation of Stochastic Frontier Production Function Models," *Journal of Econometrics*, 6, July 1977, pp. 21~37

[2] Battese and T. J. Coelli, "A Stochastic Frontier Production Function Incorporating Model for Technical Inefficiency Effects," No.69, Department of Econometrics, University of New England Armidale, 1993.

[3] Chen, T. and Tang, D., "Comparing Technical Efficiency between Import-Substitution-Oriented and Export-Oriented Foreign Firms in a Developing Economy," Journal of Development Economics 26 1987 pp. 277~289.

[4] Caves, Richard E. and David Barton, *Efficiency in U.S. Manufacturing Industries,* The MIT Press, 1990.

[5] Farrell, M.J., "The measurement of Productive Efficiency," *Journal of the Royal Statistical Society,* 120, Part 3, 1957, pp. 253~282.

[6] Forsund, F.R., C.A.K. Lovell, and P. Schmidt, "A survey of Frontier Production Functions and of Their Relationship to Efficiency Measurement," Journal of Econometrics, 13, May 1980. pp. 5~25.

[7] Greene, William H., "Maximum Likelihood Estimation of Econometric Frontier Functions," *Journal of Econometrics,* 13, 1980. pp. 27~56.

[8] Jobson, J and B. Korkie, "Performance hypothesis testing with the Sharpe and Trenor measures, *Journal of Finance* 34, pp. 889~908.

[9] Kim, Sangho and Han, Gwangho, "A Decomposition of Total Factor Productivity Growth in Korean Manufacturing Industries: A Stochastic Frontier Approach," *Journal of Productivity Analysis*, 16, 269~281, 2001.

[10] Kumbhakar, S.C. and Lovell, Knox C. A., "Stochastic Frontier Analysis," Cambridge University Press, 2000.

[11] Lee, Keun, Keunkwan Ryu and Yoon Jung Mo, 2002, "Long–Term Performance of Chaebols and non–Chabols in Korea," School of Economics, Seoul National university.

[12] Lee, Suk–Chae, 1991 in Cho and Kim 1991 eds.[9], "The Heavy and Chemical Industries Promotion Plan(1973–1979) ".

[13] Loveman, Gary and Werner Sengenberger, 1990, in "Introduction: Economic and Social Reorganization in the Small and Medium−sized Enterprise Sector" W.Sengenberger, G.W. Loveman and M.J. Piore, eds. in "The Re−emergence of Small Enterprises."

[14] Levy, Brian, 1990, "Transaction costs, the Size of Firms and Industrial Policy: Lessons from a Comparative Case Study of the Footwear Industry in Korea and Taiwan," *Journal of Development Economics.*

[15] Levy, Brian, 1991, "Obstacles to Developing Small and Medium−Sized Enterprises: An Empirical Assessment," World Bank.

[16] Levy, Brian and Wen−Jeng Kuo, 1987, "The Strategic Orientation of Firms and the Performance of Korea and Taiwan in Frontier Industries; Lessons from Comparative Case Studies of Keyboard and Personal Computer Assembly," Seoul: KDI Working Paper 8719.

[17] Levy, Brian, 1990, "Transaction costs, the Size of Firms and Industrial Policy: Lessons from a Comparative Case Study of the Footwear Industry in Korea and Taiwan," *Journal of Development Economics.*

[18] Meesen, W. and J. van den Broeck, "Efficiency Estimation of Cobb−Douglas Production Functions with Composed Error," *International Economic Review* 18 June 1977a , pp. 435~444.

[19] Meesen, W. and J. van den Broeck, "Technical Efficiency and Dimensions of the Firm: Some Results on the Use of Frontier Production Functions." *Empirical economics 2,* No.2, 1977b, pp. 109~122.

[20] Meller, Patricio, "Efficiency Frontiers for Industrial Establishments of Different Sizes," *Explorations in Economic Research 3* 1976, pp. 379~407.

[21] Milgrom, P. and J. Roberts 1990, "The economics of Modern Manufacturing Technology, Strategy, and Organization," *The American economic Review* June 1990.

[22] Mills, D.E. and L. Schmann 1985, "Industry Structure with Fluctuating Demand," *The American Economic Review* pp. 758~767.

[23] Mood, A.M., F.A. Graybill and D.C. Boes, Introduction to The Theory of Statistics, Third Edition.

[24] Murphy, K. M., A. Shleifer and R. W. Vishny, "Industrialization and the Big Push," *Journal of political Economy*, 1989, 97:5, pp. 1003~1026.

[25] Pack, Howard, "Industrialization and Trade" in H.Chenery and T.N. Srinivasan eds. *Handbook of Development Eco-nomics*, Vol. 1, 1988.

[26] Pack, Howard and Larry E. Westphal 1986, "Industrial Strategy and Technological Change," *Journal of Development Economics*, 22, pp. 98~124.

[27] Piore, M. and C. Sabel 1984, The Second Industrial Divide: Possibilities for Prosperity, New York.

[28] Murphy, K. M., A. Shleifer and R. W. Vishny, "Industrialization and the Big Push," *Journal of political Economy*, 1989, 97:5, pp. 1003~1026.

[29] Nugent, J.B. and M.K. Nabli, 1989, "Development of Financial Markets and the Size Distribution of Manufacturing Establishments: International Comparisons."

[30] Nugent, J.B., 1989, "Variations in the Size Distribution of Korean Manufacturing Establishments Across Sectors and Over Time," Seoul: Korea Development Institute.

[31] Nugent, J.B., 1991, "What Explains the Trend Reversal in the Size Distribution of Korean Manufacturing Establishments," *Journal of Development Economics,* 1996, Vol. 48, pp. 225~251.

[32] Pack, Howard and Larry E. Westphal 1986, “Industrial Strategy and Technological Change,” *Journal of Development Economics*, 22, pp. 98~124.

[33] Wade, Robert, 1990, Governing the Market: Economic Theory and The Role of Government in East Asian Industrialization, Princeton University Press.

[34] Yoo, Seung Min, 1991, “Technical Efficiency in Korea” Seoul: KDI Working Paper No. 9106.