THE JOURNAL OF THE KOREAN ECONOMY, Vol. 8, No. 2 (Fall 2007), 237-259

Endogenous Growth and Agglomeration Economies in Korean Manufacturing: A Sign of Declining Competitiveness*

Yung Joon Lee** · Ky-hyang Yuhn*** · Dae-Shik Lee****

This study evaluates competitiveness in Korean manufacturing from the aspect of scale economies in an endogenous-growth framework. The paper investigated agglomeration economies (urbanization and localization economies) and endogenous-technology economies in Korean manufacturing using industry- and city-sorted data. The study shows that the measure of efficiency estimated by the sum of agglomeration economies and endogenous-technology economies was at the lowest level in 1981, but it continued to improve until 1990 when such a trend started to reverse, and the declining phase of efficiency became pronounced by 1993. Empirical results suggest that the deterioration of external and internal scale economies in the Korean manufacturing sector seems to be a key factor in explaining the slowdown in the potential growth of the Korean economy.

JEL Classification: O4, R1

Keywords: Korean manufacturing, agglomeration economies, urbanization economies, localization economies, endogenous growth

---

* Received August 6, 2007. Accepted November 1, 2007. The authors thank the Korea Institute for Industrial Economics and Trade (KIET) for financial support and the National Statistics Office for providing the valuable regional data used in this study. The authors are also thankful to comments by participants at the International Conference on “Korea and the World Economy V” organized by AKES, RCIE and KDI. Special thanks go to two anonymous referees for their constructive comments and suggestions. Any remaining errors are the responsibilities of the authors.

** Department of Economics, Pusan National University.

*** Department of Economics, Florida Atlantic University.

**** Correspondence for Author, Department of Economics, Pusan National University, Jangjeon-dong, Gumjeong-gu, Busan, Korea, Fax: 82-51-581-3143, E-mail: daslee @pnu.edu

1. INTRODUCTION

The economic performance that South Korea achieved in the past quarter century was touted as a model case for industrialization. The Korean economy grew at an annual rate of more than 7% during the same period and per capita income reached the celebrated number of $10,000 in 1995. The unprecedented growth of the Korean economy was the envy of the world and the focus of academic investigation and public curiosity. In the midst of the expectation that Korea could be the next Japan, a sudden turnaround in the course of the breezing economy occurred in late 1997 when the Asian financial crisis drove the economy to the brink of bankruptcy.

Although some scholars such as Krugman (1994) and Young (1995) warned that the phenomenal growth of the Korean economy (as well as three other Tiger economies—Taiwan, Singapore, and Hong Kong) could not be sustained, arguing that the high growth rate was the "tyranny of numbers" (Young), little attention was paid to such warnings until Korea was placed under an IMF led austerity program. A closer look at the performance of the Korean economy at the disaggregate or industry level evidently reveals that the competitiveness has been continually eroded since the early 1990s. This declining phase of competitiveness is manifested in the deterioration of efficiency in resource usage in Korean manufacturing industries.

The purpose of this study is to evaluate the competitiveness of Korean industries before the Korean financial crisis by investigating agglomeration economies in Korean manufacturing in an endogenous-growth framework. Agglomeration economies (urbanization and localization economies) are discussed as a way of measuring efficiency gains in urban production. There are two separate, but related externalities in urban production: localization economies and urbanization economies. Rapid industrialization prompts urbanization, and urbanization in turn promotes efficiency in production and management by diffusing new innovations. Localization economies[1] are externalities that firms gain by learning from other firms in

[1] Localization economies in a dynamic form are sometimes called Marshall-Arrow-Romer

related industries in a locally proximate area and urbanization economies are externalities that firms gain by learning from all firms in the city, where the diversity of local industries enhances local information spillovers.[2)]

While urbanization and localization economies are concerned with externalities generating local spillover effects, firms also benefit from endogenously induced technology. Recent developments in endogenous growth theory suggest that even though production technology is characterized as constant returns to scale (CRTS), increases in capital and labor can generate some additional effects on production, leading to increasing returns to scale (IRTS). The source of these additional gains in production comes from "learning by doing," and the contribution of such endogenous-technology to production may be called endogenous-technology economies.

This study uses the sum of external (urbanization and localization) and internal (endogenous-technology) economies as a measure of efficiency in resource usage. If such a measure of efficiency of an industry increases, the industry will become more competitive. To examine efficiency gains in Korean manufacturing before the Korean financial crisis, we use an industry- and city-sorted data set for 1981, 1985, 1990, and 1993. Since the data used in this study are panel data in nature, this study provides a unique opportunity to investigate inter-period variations in efficiency based on changes in external and internal scale economies across industries over time.

(MAR) externalities, and urbanization economies in a dynamic context are called Jacobs externalities. Localization economies are external to each firm but internal to each industry in a particular city whereas urbanization economies are external to both a firm and an industry, but internal to a city.

2) According to Henderson (1986), localization economies reflect (i) economies of intra-industry specialization where a greater industry size permits greater specialization among firms in detailed functions, (ii) labor market economies where industry size reduces search costs for firms looking for workers with specific training, (iii) scale for communication among firms affecting the diffusion of new innovation, and (iv) scale in providing public intermediate inputs tailored to the local needs of a specific industry. On the other hand, urbanization economies represent benefits of operating in large urban environments with correspondingly large overall labor markets and large, diversified service sectors to interact with manufacturing.

Our empirical findings reveal a striking parallel between the 1997 financial crisis of the Korean economy and the continual decline of efficiency in Korean manufacturing. The efficiency measure which was at the lowest level in 1981 continued to improve until it reached a peak in 1990. This trend started to reverse in the early 1990s, and the declining phase of efficiency became pronounced in 1993.

The plan of this paper is as follows: Section 2 discusses the theoretical framework for the analysis of agglomeration economies and endogenous technology effects. Empirical results are presented in section 3. Section 4 contains summary and concluding remarks.

2. THE MODEL

The production technology employed by firm *i* in city *l* relates value-added output to the primary inputs in the following manner

$$Y_i(t) = G_i(t)F(K_i(t),\ A_i(t)\ L_i(t)), \tag{1}$$

where Y_i represents value-added output produced by firm *i*, K_i the quantity of capital, L_i the quantity of labor, and A_i the efficiency of workers at firm *i*. The efficiency term (*A*) can be thought of as reflecting "learning by doing." The term G_i measures agglomeration (urbanization and localization) economies.

The traditional measure of urbanization economies employed by Kawashima (1975), Nakamura (1985), and Lee and Zang (1998) specifies the effect of urbanization on output as a function of the urban population of city *l* (P_l). The urbanization economies enjoyed by firm *i* in city *l* is given by

$$G_i^U(P_l) = aP_l^b. \tag{2}$$

There are several alternative measures of urbanization economies. For example, Lee (1997) argues that the linear relationship given by equation (2) is not appropriate for measuring urbanization economies and proposed a quadratic relationship of the form[3)]

$$G_i^U(P_l) = P_l^{b1}(P_l^2)^{b2}. \tag{3}$$

On the other hand, a popular approach to measuring localization economies adopted by some authors such as Nakamura (1985) is to formulate localization economies as a function of the size of output in an industry located in city *l*. As precisely argued by Henderson (1986), localization economies for a specific firm in a city come not only from the output size of that industry in a city but also from the output size of entire industries in the city (Y_l). This is particularly true because labor market externalities, public intermediate inputs and the scale of diffusion in new innovations depend on the size of whole industries in a city. Thus we specify agglomeration economies as follows

$$G_i(t) = aP_l^b(t)Y_l^c(t). \tag{4}$$

If the production function is homogeneous of degree one in $L(t)$, it is possible to write the production function (1) as[4)]

$$Y_i / L_i = G_i(t)\ F(K_i(t)/L_i(t),\ A_i(t)). \tag{5}$$

The production function can be specified as a trans-log form

---

3) Recent attempts to measure urbanization economies include the diversity index used by Henderson, Kuncoro, and Turner (1995) and the *g* index used by Henderson, Lee, and Lee (2001). The diversity index uses the Herfindahl-Hirschman index (HHI) as a measure of industrial diversity, and the g index is a refinement of the HHI index.

4) The homogeneity specification enables one to aggregate the individual production technologies by a firm to obtain an industry production function for a city.

$$\ln(Y_i / L_i) = a + b\ln P_l + c\ln Y_l + \alpha_K \ln(K_i / L_i) + \alpha_A \ln A_i + \beta_{KA} \ln(K_i / L_i)\ln A_i + (1/2)\beta_{KK}[\ln(K_i / L_i)]^2 + (1/2)\beta_{AA}(\ln A_i)^2 \tag{6}$$

The parameter *b* in the trans-log function measures the percentage change in output per worker produced by firm *i* in city *l* in response to a one-percentage increase in population in city *l* (= coefficient of urbanization economies), and the parameter c measures the percentage change in output per worker produced by firm *i* in response to a one-percentage increase in the total output of industry *j* in city *l* where firm *i* is located (= coefficient of localization economies).

In order to derive the industry production function, we sum the firm-level production technologies over the industry (*j*) in city *l*. If there are n firms in industry *j*,

$$\Sigma\ln(Y_i / L_i) = a + b\ln P_l + c\ln Y_l + \alpha_K\Sigma\ln(K_i / L_i) + \alpha_K\Sigma\ln(A_i)_l + \beta_{KA}\Sigma\ln(K_i / L_i)_l \ln(A_i)_l + (1/2)\beta_{KK}\Sigma[\ln(K_i / L_i)_l]^2 + (1/2)\beta_{AA}\Sigma[\ln(A_i)_l]^2 \tag{7}$$

The industry production function in city *l* is rearranged (with the subscript *l* subdued) to obtain the estimation equation.

$$\ln(Y / L) = (1/(1-c)\{a + b\ln P + c\ln Y + \alpha_K \ln(K / L) + \alpha_A \ln A + \beta_{KA} \ln(K / L)\ln A + (1/2)\beta_{KK}[\ln(K / L)]^2 + (1/2)\beta_{AA}(\ln A)^2\} \tag{8}$$

Applying Shephard’s Lemma gives the input share equations.[5)]

[5)] To derive the share equations, we rewrite the productivity form of the function as

$$S_L\,(Labor's\,share) = \frac{\partial \ln Y}{\partial \ln L} = (1/(1-c)[(1-\alpha_K) - \beta_{KK}\ln(K/L) - \beta_{KA}\ln A] \tag{9a}$$

$$S_K\,(Capital's\,share) = \frac{\partial \ln Y}{\partial \ln K} = (1/(1-c))[\alpha_K + \beta_{KK}\ln(K/L) + \beta_{KA}\ln A] \tag{9b}$$

There are several different approaches to modeling endogenous technology. For example, Lucas (1988) has incorporated both physical and human capital into the model in the following fashion

$$Y(t) = F(K(t),\ L(t),\ H(t)), \tag{10}$$

where $H(t)$ represents abilities, skills, and knowledge of workers. This model is constructed based on the idea that the efficiency of labor is enhanced by "learning by doing" fostered by new capital. Following Mankiw (and others) the paper specifies the endogenous-technology term as

$$A(t) = \gamma K(t)^{\lambda}. \tag{11}$$

As discussed, the stock of capital embodies the latest technology, which enables workers to produce more. Endogenous technology can lead to increasing returns to scale (IRTS), even though the current production process exhibits constant returns to scale (CRTS). Endogenous-growth technology has important policy implications. With increasing returns, changes in the saving rate and therefore in the rate of capital formation can

---

$$\begin{aligned}\ln Y = (1/(1-c))\{&a + b\ln P + c\ln L + (1-\alpha_K)\ln L + \alpha_K \ln K + \alpha_A \ln A \\ &+ \beta_{KA}(\ln K)(\ln L) - \beta_{KA}(\ln L)(\ln A) + (1/2)\beta_{KK}[(\ln K)^2 \\ &- 2(\ln K)(\ln L) + (\ln L)^2] + (1/2)\beta_{AA}(\ln A)^2\}.\end{aligned}$$

have permanent effects on the long-run growth path. This conclusion contrasts with the Neoclassical interpretation that the effect of changes in the saving rate on the economy is temporary.

With endogenous technology incorporated into the model, the estimation equations become

$$\begin{aligned}\ln(Y/L) = (1/(1-c))[&a + b\ln P + c\ln L + \alpha_K \ln(K/L) \\ &+ \lambda\alpha_K \ln K + (1/2)\beta_{KK}\{\ln(K/L)\}^2 \\ &+ \lambda\beta_{KA}\ln(K/L)\ln K + (1/2)\lambda^2\beta_{AA}(\ln K)^2] \end{aligned} \quad (12)$$

$$S_K = (1/(1-c))[\alpha_K + \lambda\alpha_A + \beta_{KK}\ln(K/L) + 2\lambda\beta_{KA}\ln K + \lambda^2\beta_{AA}\ln K] \quad (13)$$

The internal economies of scale (IES) which are associated with increases in all factor inputs are then given by

$$IES = \frac{\partial \ln Y}{\partial \ln L} + \frac{\partial \ln Y}{\partial \ln K} = 1 + \lambda\alpha_A. \quad (14)$$

The term $\lambda\alpha_A$ is an "extra kick" to output brought by endogenous technology, and thus $1+\lambda\alpha_A$ measures the economies of scale which consist of the contribution of increases in physical capital and labor inputs to output growth and the contribution of endogenous technology to output growth.

3. EMPIRICAL ANALYSIS

3.1. Estimation Procedure

We have estimated the production function and the input share equations jointly as a multivariate system using the seemingly unrelated regression (SUR) technique of Zellner (1962). This method is desirable in view of the fact that even for a modest number of factors of production, the translog function has a large number of regressors.

Since input shares must sum to unity, the covariance matrix is singular, which makes the proposed estimation procedure inapplicable. This problem can be resolved by dropping one share equation from the estimation system. However, parameter estimates are not invariant to which equation is deleted. Barten's (1969) invariance theorem demonstrates that the maximum likelihood estimation of a system of share equations with one equation deleted is invariant to which equation is omitted. Furthermore, Kmenta and Gilbert (1968) have shown that an iteration of the Zellner estimation procedure until convergence results in maximum likelihood estimates. The paper omits the share equation for labor.

3.2. Data

We have estimated agglomeration economies and endogenous-technology economies using panel data for Korean manufacturing industries in 1981, 1985, 1990, and 1993.[6] The data used in this study have been taken from the Census of Manufactures in Korea compiled by the National Statistics Office. The Census data contain value-added output, gross output, capital stock, employment, and other relevant data per city-industry. The price index used in this study to calculate real value-added output and real gross output is the GDP deflator. The data on urban populations and price indexes have been obtained from various publications of the Bank of Korea. The sample size for each year is as follows:

---

[6] This study has been motivated to investigate what happened to agglomeration economies and overall firm competitiveness in Korea during the transitional period of the Korean economy from the stage of a highly regulated and protected economy to the stage of a more liberalized and open economy. This period roughly coincides with the turbulent period of the Korean economy from the demise of the president Park Chung Hee to the advent of the first civilian government (Kim Young Sam) in almost 30 years. This motivation has necessitated the use of the data set that spans the period of 1980 to 1993.

Period	Number of Industries[7)]	Number of Cities[8)]
1981	9	50
1985	9	61
1990	9	74
1993	22	74

3.3. Empirical Result

3.3.1. Overall evaluation

The estimated statistics are presented in tables 1-8. We have first performed the likelihood ratio test to see whether the coefficients of external (urbanization and localization) and internal (endogenous-technology) economies of scale taken together are significantly different from zero ($H_0 : b = c = \lambda = 0$). The test results show that the null hypothesis is rejected for all estimation equations at the conventional level of significance. This implies that urbanization and localization economies and endogenous-technology economies are collectively significant in Korean manufacturing. Due to space limitations, the results on the estimation of parameters and the likelihood ratio test are not reported, but are available upon request from the authors.

One of the major findings with respect to externalities is that localization economies were prevalent throughout the sample period while urbanization economies were less pronounced. Tables 1-4 show that localization economies are significant in 5 out of 9 industries (55.6%) in 1981, 5 out of 9 industries (55.6%) in 1985, 6 out of 9 industries (66.7%) in 1990, and 15 out of 22 industries (68.2%) in 1993. By contrast, the coefficient of urbanization economies is significant only in 1 out of 9 industries in 1981, 2 out of 9 industries in 1985, 1 out of 9 industries in 1990, and 3 out of 22 industries in 1993. Furthermore, urbanization effects are found to be negative in many industries.

---

7) There were 23 two-digit industries in 1993, but the tobacco industry has been excluded from the analysis, because the tobacco industry has only 13 observations in 1993.

8) A city is defined as an area with over 50,000 residents.

Table 1 Agglomeration Economies and Endogenous Economies: 1981

Industry	Localization Economies (c)	Urbanization Economies (b)	Endogenous-Technology Economies(ë)	Internal Economies of Scale[1)]	Total Economies of Scale[2)]
31 Food	–0.037 (–0.371)	0.205 (1.636)	–0.009 (–0.126)	0.999	1.167
32 Textiles	0.097** (5.585)	–0.037 (–1.094)	0.049** (3.651)	1.010	1.070
33 Wood	–0.042 (–0.585)	0.058 (1.040)	–0.042** (–6.479)	1.036	1.052
34 Paper	0.133** (5.413)	–0.031 (–0.598)	0.044** (2.695)	1.013	1.115
35 Chemicals	0.069 (1.239)	0.055 (0.659)	0.114# (1.938)	0.997	1.121
36 Nonmetal Products	0.132# (1.952)	–0.096 (–1.674)	0.019 (0.759)	0.978	1.014
37 Basic Metal	0.046 (0.996)	0.072 (0.966)	–0.016 (–0.803)	0.996	1.114
38 Machinery	0.096** (5.986)	–0.054# (–1.949)	0.026** (4.362)	0.995	1.037
39 Other	0.141** (3.698)	–0.066 (–0.969)	–0.039** (–6.543)	0.979	1.054

Notes: 1) Internal economies of scale (Economies of scale due to factors) = $1 + \lambda\alpha_A$.
2) Total economies of scale = Localization + Urbanization + Internal economies of scale.
3) Numbers in parentheses are *t*-ratios.
4) **, *, and # indicate significance at the 1%, 5%, and 10% levels, respectively.

These findings are similar to those of Henderson (1986) who investigated urbanization and localization economies in U.S. and Brazilian manufacturing industries, but different from those of Nakamura (1985) who has explored urbanization and localization economies in Japanese manufacturing industries. (A comparison with these studies will be discussed later).

Another noticeable feature of the empirical results is that the coefficient of endogenous-technology economies is positive and significant in most industries. Positive and significant endogenous-technology economies are found in 4 out of 9 industries (44.4%) in 1981, 5 out of 9 industries (55.6%) in 1985, 7 out of 9 industries (77.8%) in 1990, and 14 out of 22 industries (63.6%) in 1993. This finding not only shows that the endogenous-growth

Table 2 Agglomeration Economies and Endogenous Economies: 1985

Industry	Localization Economies (c)	Urbanization Economies (b)	Endogenous-Technology Economies(ë)	Internal Economies of Scale[1)]	Total Economies of Scale[2)]
31 Food	0.068 (1.427)	0.131* (2.237)	0.089** (7.395)	1.027	1.226
32 Textiles	–0.029 (0.865)	0.052 (0.733)	–0.023** (–10.181)	1.107	1.130
33 Wood	0.105** (3.260)	–0.0004 (–0.009)	0.052 (1.583)	0.988	1.093
34 Paper	0.170** (9.368)	–0.107** (–3.054)	0.087** (3.987)	1.028	1.091
35 Chemicals	0.043 (1.497)	0.013 (0.277)	0.050 (0.919)	1.008	1.064
36 Nonmetal Products	0.193** (3.512)	–0.031 (–0.698)	0.057** (5.938)	0.954	1.016
37 Basic Metal	0.130** (4.806)	–0.039 (–1.238)	0.097** (5.156)	1.030	1.121
38 Machinery	0.072** (3.490)	–0.028 (–0.620)	0.032* (2.509)	1.007	1.051
39 Other	–0.002 (–0.065)	–0.021 (–0.448)	–0.085** (–7.341)	1.136	1.113

Notes: 1) Internal economies of scale (Economies of scale due to factors) = $1 + \lambda\alpha_A$.
2) Total economies of scale = Localization + Urbanization + Internal economies of scale.
3) Numbers in parentheses are *t*-ratios.
4) **, *, and # indicate significance at the 1%, 5%, and 10% levels, respectively.

model is an appropriate framework for the investigation of efficiency in Korean manufacturing, but also favors the view that much of the growth of the Korean economy has been attributable to substantial increases in capital stock.

The fact that urbanization economies in Korean manufacturing were not a major source of external economies indicates that resources in Korean manufacturing were not productive in larger cities and may even be less productive. Resources in manufacturing are generally more productive in larger cities only when infrastructure, communication, and other pubic sector systems are optimal in relation to the size of population.

Table 3 Agglomeration Economies and Endogenous Economies: 1990

Industry	Localization Economies (c)	Urbanization Economies (b)	Endogenous-Technology Economies(ë)	Internal Economies of Scale[1)]	Total Economies of Scale[2)]
31 Food	0.051 (0.764)	0.162* (2.689)	0.063** (8.754)	1.037	1.250
32 Textiles	0.012 (0.367)	0.056 (1.076)	–0.003 (–0.145)	0.999	1.067
33 Wood	0.083** (3.326)	0.019 (0.510)	0.046** (2.917)	0.998	1.100
34 Paper	0.129** (4.340)	–0.023 (–0.479)	0.066** (4.221)	0.995	1.101
35 Chemicals	0.059* (2.507)	–0.011 (–0.329)	0.006 (0.844)	1.002	1.050
36 Nonmetal Products	0.151** (3.751)	0.003 (0.142)	0.049** (10.495)	0.957	1.111
37 Basic Metal	0.069 (1.529)	–0.050 (–1.266)	0.041** (11.733)	1.008	1.027
38 Machinery	0.127** (6.351)	–0.045 (–1.559)	0.029** (9.011)	0.992	1.074
39 Other	0.095** (4.652)	–0.045 (–1.256)	0.081** (3.427)	1.026	1.076

Notes: 1) Internal economies of scale (Economies of scale due to factors) = $1 + \lambda\alpha_A$.
2) Total economies of scale = Localization + Urbanization + Internal economies of scale.
3) Numbers in parentheses are *t*-ratios.
4) **, *, and # indicate significance at the 1%, 5%, and 10% levels, respectively.

When a high density of population creates congestions in infrastructure and communication systems, urbanization effects can be negative in sign or insignificant in magnitude. The Korean manufacturing sector seems to have lost the benefits of urbanization in the late stage of industrialization, probably in the early 1980s, as a massive emigration from rural areas to larger cities occurred in concordance with rapid industrialization. Many Korean cities appeared to be in excess of the optimal capacity given infrastructure and communication resources, which led urbanization benefits from the clustering of diverse industries to be insignificant or even negative. Furthermore, government

Table 4 Agglomeration Economies and Endogenous Economies: 1993

Industry	Localization Economies (c)	Urbanization Economies (b)	Endogenous-Technology Economies(ë)	Internal Economies of Scale[1)]	Total Economies of Scale[2)]
15 Food	0.140* (2.512)	0.075 (1.993)	0.048** (18.458)	0.967	1.182
17 Textiles	0.038 (1.753)	–0.014 (–0.439)	–0.006** (–0.228)	0.998	1.022
18 Clothing	0.046* (2.061)	–0.003 (–0.054)	–0.080 (–9.064)	0.956	0.999
19 Leather	0.048# (1.835)	–0.082# (–1.809)	0.071 (1.582)	1.068	1.034
20 Wood	0.026 (0.594)	0.036 (1.049)	0.025# (1.712)	1.023	1.085
21 Paper	0.180** (4.653)	–0.085* (–2.572)	0.069** (5.154)	0.994	1.089
22 Publication	0.060 (1.640)	0.006 (0.076)	0.027 (0.504)	1.009	1.075
23 Petroleum	0.257** (4.254)	–0.069 (–1.576)	0.063** (3.957)	0.965	1.153
24 Chemicals	0.039 (1.194)	–0.055 (–1.535)	0.042** (11.583)	1.107	1.091
25 Rubber	0.006 (0.362)	0.007 (0.267)	0.054** (8.255)	1.060	1.073
26 Nonmetal Products	0.075* (2.143)	0.013 (0.395)	0.053** (3.447)	1.039	1.127
27 Basic Metal	0.129** (3.225)	–0.046 (–1.331)	0.039** (13.269)	0.984	1.067
28 Fabricated Metal	0.089* (2.440)	–0.075 (–1.752)	0.005 (0.076)	1.003	1.017
29 Machinery	0.129** (4.745)	–0.051 (–1.731)	0.048** (8.535)	0.945	1.023
30 Office	0.094* (2.366)	–0.036 (–0.956)	–0.016 (–1.485)	0.989	1.047
31 Electronics	0.130** (3.164)	–0.048 (–0.893)	0.076* (2.174)	0.972	1.054
32 Communi-cations	0.074** (3.373)	0.013 (0.367)	0.070* (2.499)	1.031	1.118
33 Medical Products	0.058 (1.624)	–0.018 (–0.419)	0.047** (3.395)	1.008	1.048
34 Automo-biles	0.062# (1.906)	0.113* (2.293)	0.052** (3.615)	1.007	1.182
35 Transpor-tation	0.057* (2.188)	0.029 (0.709)	–0.084 (–1.574)	0.967	1.053
36 Furniture	0.072** (3.112)	–0.022 (–0.493)	0.058* (2.263)	1.025	1.075
37 Recycling	0.019 (0.489)	–0.006 (–0.136)	0.023 (0.320)	1.014	1.027

Notes: 1) Internal economies of scale (Economies of scale due to factors) = $1 + \lambda\alpha_A$.
2) Total economies of scale = Localization + Urbanization + Internal economies of scale.
3) Numbers in parentheses are *t*-ratios.
4) ** Significant at the 1% level of significance. * Significant at the 5% level of significance. # Significant at the 10% level of significance.

regulations on firm locations, and land uses could also lead to the production inefficiency of firms located in large cities.[9)]

The immediate impression from our empirical analysis is that localization economies and endogenous-technology economies were two engines which significantly contributed to the rapid growth of Korean manufacturing. The dominance of localization and endogenous-technology economies in Korean manufacturing is related to structural changes in Korean manufacturing over the past several decades. First, in the early 1980s, Korea moved toward the liberalization of the economy — permitting greater imports, reducing government support/control of specific industries, and relaxing financial market constraints. Second, urban de-concentration in manufacturing spread dramatically throughout the country in the 1980s, leading to a sharp decline in the share of large cities in national economic activity.

The concerted policies of liberalization and urban decentralization in the 1980s served as a catalyst for creating diversified economic growth. While industries have spread across provinces, within provinces, they have tended to concentrate in one or two cities, thus promoting a high degree of urban specialization among smaller cities (Henderson, Lee, and Lee, 2001). Economic liberalization has prompted Korean industries to agglomerate in cities with comparative advantage and stimulated new growth. These significant benefits of specializing locally in the sets of inter-related manufacturing led localization economies to hold strongly in Korean manufacturing.

3.3.2. Inter-period analysis: declining competitiveness

The most striking aspect of our empirical results is that both localization and endogenous-technology economies began to lose steam in the early 1990s. According to tables 5-8, the coefficients of localization economies for all industries in 1981 was 0.071 and increased to 0.083 in 1985, but this magnitude showed little change until 1990 (0.086). After 1990, it began to drop and reached 0.083 in 1993. As discussed, localization economies are

[9)] The referee has pointed out this aspect.

Table 5 Agglomeration Economies by Industry: 1981

	Localization Economies	Urbanization Economies	Endogenous-Technology Economies	Internal Economies of Scale	Total Economies of Scale
All Industries	0.071	0.012	0.016	1.000	1.083
(1) Traditional	0.038	0.049	0.011	1.015	1.101
(2) Heavy	0.082	0.010	0.039	0.990	1.083
(3) Machinery	0.096	–0.054	0.026	0.995	1.037
(4) Other	0.141	–0.066	–0.039	0.979	1.054

Table 6 Agglomeration Economies by Industry: 1985

	Localization Economies	Urbanization Economies	Endogenous-Technology Economies	Internal Economies of Scale	Total Economies of Scale
All Industries	0.083	–0.003	0.040	1.032	1.101
(1) Traditional	0.079	0.189	0.051	1.038	1.135
(2) Heavy	0.122	–0.019	0.068	0.997	1.067
(3) Machinery	0.072	–0.028	0.032	1.007	1.051
(4) Other	–0.002	–0.021	–0.085	1.136	1.113

more or less associated with the traditional economies of scale in the Marshallian sense, which reflects intra-industry specialization. Empirical results suggest that such specialization advantages gradually petered out in the 1990s.

This declining trend in localization economies is in tandem with the trend in endogenous-technology economies. The endogenous-technology effect reached a peak in 1990 and then began to dwindle in the early 1990s. This poor performance of localization economies and endogenous-technology economies appears to be primarily responsible for the deterioration of efficiency experienced by Korean manufacturing industries in the 1990s. We first look at internal economies of scale (IES) which are defined as the sum of percentage increases in output due to the growth of physical factor

Table 7 Agglomeration Economies by Industry: 1990

	Localization Economies	Urbanization Economies	Endogenous-Technology Economies	Internal Economies of Scale	Total Economies of Scale
All Industries	0.086	0.007	0.042	1.002	1.095
(1) Traditional	0.069	0.054	0.043	1.007	1.130
(2) Heavy	0.093	–0.019	0.032	0.989	1.063
(3) Machinery	0.069	–0.045	0.029	0.992	1.074
(4) Other	0.095	–0.045	0.081	1.026	1.076

Table 8 Agglomeration Economies by Industry: 1993

	Localization Economies	Urbanization Economies	Endogenous-Technology Economies	Internal Economies of Scale	Total Economies of Scale
All Industries	0.083	–0.014	0.031	1.006	1.075
(1) Traditional	0.077	–0.010	0.022	1.002	1.069
(2) Heavy	0.099	–0.038	0.042	1.026	1.088
(3) Machinery	0.086	0.0003	0.023	0.988	1.075
(4) Other	0.046	–0.014	0.041	1.020	1.051

inputs and percentage increases in output due to endogenous technology. It is readily seen that the internal economies of scale began to decline in the early 1990s. The measure which was 1.000 in 1981 climbed to 1.032 in 1985, but fell substantially in the 1990s, ranging between 1.002 (1990) and 1.006 (1993).

When we focus on the overall economies of scale, the evidence of declining competitiveness in Korean manufacturing becomes more noticeable. The measure of overall scale economies increased from 1.083 in 1981 to 1.101 in 1985. However, our empirical results show that Korean industries experienced a substantial decline in the overall economies of scale in the 1990s. The measure of overall scale economies decreased to 1.095 in 1990, and then fell further to 1.075 in 1993. This indicates that a one percent increase in both capital and labor inputs led to a 1.101% increase in output in 1985 but only to a 1.075% increase in output in 1993. The efficiency of Korean manufacturing has continually fallen since the early 1990s.

3.3.3. Cross-sectional analysis: decentralization and specialization

We have classified industries into four broad categories: traditional, heavy, machinery, and other industries to examine characteristic patterns in agglomeration economies and endogenous-technology economies. As tables 4-8 show, localization economies are lowest in the traditional industry and highest in the heavy industry. These differences in localization economies among industries were a prevailing pattern throughout the four sample periods, 1981, 1985, 1990, and 1993.

One should expect to find that localization economies are strongest for industries in which cities tend to specialize and die out in as such advantages from specialization disappear. It is found that traditional industries experienced significantly lower localization economies than other industries. The estimates of localization economies are in line with structural changes in Korean manufacturing over the past two decades. Throughout the 1980s, re-concentration across small cities strongly increased in the heavy industry, and fell moderately in the traditional industry. While the forces of decentralization pushed for general re-concentration, the forces of local agglomeration and specialization pushed in the direction of re-concentration into smaller-medium size cities as industries left the major metro areas. It is found that traditional industries experienced small and significantly lower agglomeration economies than the other industries: the estimates of localization economies are in line with structural changes in Korean manufacturing over the past two decades.

Endogenous-technology economies showed a similar pattern to localization economies. The traditional industry experienced stronger endogenous-technology economies until 1990, but by 1993 the heavy industry exhibited stronger endogenous-technology economies. This finding shows that the localization and endogenous technology effects were the dominant influence on the overall economies of scale in Korean manufacturing. Tables 5 through 8 show that by 1993, the overall economies of scale were strongest in the heavy industry (1.088), followed by the machinery industry (1.075), and the traditional industry (1.069).

3.3.4. Implications

Although the economic turmoil in Korea (and other Asian countries) was directly triggered by financial-sector problems such as huge short-term debts, overvalued currency, low foreign exchange reserves, and the inefficient financial system, our empirical results hint that the deterioration of external and internal scale economies in the Korean manufacturing sector may be a remote cause of the economic crisis. (The discussion of the causes of the financial crisis is beyond the scope of this study.) Many factors have been intertwined to create such worsening industrial environments in Korea.

The burst of political freedom and economic liberalization in the late 1980s pushed wages to rise at a dizzying rate. The hikes in wages were a compensation for long suppressed wage increases under the military regimes, but the skyrocketing wages have set the vicious circle of higher wages-higher prices-higher interest rates-higher production costs in motion. There is a consensus that steep increases in production costs contributed to the erosion of competitiveness in Korean manufacturing industries because real wage increases were believed to outpace productivity growth.

Another factor that underlies the declining competitiveness is the business practice that has prevailed among Korean corporations for many years. It is known that the *chaebol* (Korean conglomerates) have long been occupied with the “Big Is All Business” or “Too Big To Fail” philosophy. As economic liberalization and globalization rapidly expanded, Korean conglomerates borrowed heavily from domestic and international financial institutions to invest in a variety of businesses ranging from movie theaters to semiconductors to automobiles. The profitability of such projects was not a main consideration because such investment decisions were ultimately made by the owners of the family-dominated conglomerates who were more concerned with market share and the ranking of the *chaebol*. The appetite for "heavy borrowing and excessive investment" was in fashion at various layers of business in Korea, and the obvious consequence was a fall in the productivity of capital per worker (K/L). The dominance of conglomerates in many businesses has drained the advantages that small- and medium-sized firms could benefit from intra-industry specialization.

Related to the prevalence of the *chaebol* in the Korean economy is cronyism in business. Although the Korean government moved toward economic liberalization in the 1980s, the government has deeply intervened in economic activity in the form of various supports, regulations, and controls. In particular, the "pro big business" policy has been a catalyst in seeding "crony capitalism" in Korea. Finally, banks have made nonsense loans to businesses making nonsense investments without analyzing risk associated with investment projects. This lending practice has been the norm nurtured by the crony culture and a symbol of the misallocation of resources in Korea. As these adverse environments accumulated, the Korean manufacturing sector became less and less efficient in terms of localization economies and endogenous-technology economies.

3.3.5. Comparison with other studies

Since the methodology employed by this study shares common features with that of Henderson (1986) and Nakamura (1985), the test results for agglomeration economies in Korean manufacturing are compared with those studies. Nakamura estimated urbanization and localization economies using cross-sectional data of cities for 1979 in 20 industries (two-digit level of Standard Industrial Classification of Japanese manufacturing industries). He concluded that urbanization economies showed up more strongly in light industries than in heavy industries.

Henderson also examined agglomeration economies for 16 U.S. industries (two-digit industries) by using the 1972 Census of Manufactures and 11 Brazilian industries (two-digit industries) using 1970 Industrial Census. In contrast with Nakamura, Henderson confirmed strong localization economies in Brazilian manufacturing. Except for printing, all coefficients for localization economies had correct signs, and most of the coefficients were significant at a reasonable level. Henderson also discovered a similar pattern for U.S. industries: localization economies were strong and generally significant except for textiles. However, he found that only the nonmetallic-materials industry had a significant positive urbanization effect. For the remaining industries, there was an almost, equal division between positive and negative urbanization effects. He concluded that in general, external economies of scale are ones of localization, not urbanization.

There is a high degree of similarity between the results for Korean industries and the results by Henderson for the U.S. and Brazilian industries, but some disparity is found between the results of this paper and those of Nakamura for Japanese industries. Like Henderson, we have found that the dominant source of external scale economies is localization economies and discovered that localization economies are stronger in heavy manufacturing industries than in light manufacturing industries. These comparisons raise one question. It has been generally perceived that the industrialization of Korea has followed a similar path to that of Japan with a time lag of approximately 10 years. If so, why does the pattern of agglomeration economies in Korean industries stand in contrast with that of Japanese industries, but have a close resemblance to that of U.S. and Brazilian industries? This question will be left for future research.

4. CONCLUDING REMARKS

This study has been to evaluate the competitiveness of Korean industries from the aspect of scale economies in resource usage in an endogenous-growth framework. To this end, we have investigated agglomeration economies and endogenous-technology economies in Korean manufacturing using panel data (1981: 9 industries in 61 cities, 1985: 9 industries in 61 cities, 1990: 9 industries in 74 cities, and 1993: 22 industries in 74 cities). This panel approach provides a valuable opportunity for investigating how the competitiveness of Korean manufacturing industries has shifted over time.

The findings are summarized as follows: (i) External scale economies in Korean manufacturing are mainly due to localization economies, and the contribution of urbanization economies to efficiency in urban production is marginal. (ii) Endogenous-technology economies also hold strongly in Korean manufacturing. (iii) However, localization and endogenous-technology effects have gradually declined since the early 1990s.

An important conclusion to be drawn from our empirical results is that the measure of efficiency estimated by the sum of agglomeration economies and endogenous-technology economies suggests that the Korean manufacturing sector began to lose a competitive edge in the early 1990s. The measure which was at the lowest level in 1981 continued to improve until 1990 when it reached a peak, but the measure of external and internal scale economies began to decline in the early 1990s, and such a trend became pronounced by 1993. It is argued that the seeds of the Korean economic crisis were already sown in the early 1990s.

Many factors may be intertwined to result in the deterioration of efficiency in Korean manufacturing in the 1990s. The fashionable argument is that the continual expansion of the big *chaebol* industrial combines has depressed advantages that small- and medium-sized firms could benefit from inter-industry specialization and endogenous technology spillovers. Our empirical analysis renders support to the popular view, suggesting that such an environment eventually caused localization and endogenous technology economies to decline.

REFERENCES

Henderson, J. V., "Externalities and Industrial Development," *Journal of Urban Economics*, 42, 1997, pp. 449-470.

Henderson, J. V., A. Kuncoro, and T. Turner, "Industrial Development in Cities," *Journal of Political Economy*, 103, 1995, pp. 1067-1090.

Henderson, J. V., T. Lee, and Y. J. Lee, "Scale Externalities in Korea," *Journal of Urban Economics*, 49, 2001, pp. 479-504.

Kawashima,T., "Urban Agglomeration Economies in Manufacturing Industries," Papers and Proceedings, Regional Science Association, 1975.

Kmenta, J. and R. F. Gilbert, "Small Sample Properties of Seemingly Unrelated Regression," *Journal of the American Statistical Association,* 63, 1968, pp. 1180-1200.

Krugman, P., "The Myth of Asia's Miracle," *Foreign Affairs*, 1994.

Lee, Y. J., "The Growth of Cities and Regional Productivity in Korean Manufacturing," presented at the AEA meetings in New Orleans, Louisiana, 1997.

Lee, Y. J., H. S. Na, and D. S. Lee, "Short run Employment Functions for the Japanese, Korean, and Taiwanese Manufacturing Industries: An Interrelated Factor Demand Model," *Seoul Journal of Economics*, 4(2), 1991, pp. 147-172.

Lucas, R., "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22, 1988, pp. 3-42.

Nadiri, M. I. and M. A. Schankerman, "The Structure of Production, Technological Change, and the Rate of Growth of Total Factor Productivity in the U.S. Bell System," in T. Cowing and H. Stevenson, eds., *Productivity Measurement in Regulated Industries*, New York: Academic Press, 1983.

Nakamura, R., "Agglomeration Economies in Urban Manufacturing Industries: A Case of Japanese Cities," *Journal of Urban Economics*, 17, 1985, pp. 108-124.

Romer, J., "Increasing Returns and Long Run Growth," *Journal of Political Economy*, 94, 1993, pp. 1002-1037.