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A COMPARATIVE STUDY ON X-INEFFICIENCY BETWEEN KOREA AND TAIWAN

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This study applies the X-inefficiency theory to analyze different characteristics of the industrial structure between Korea and Taiwan, who have achieved rapid economic growth and export expansion during the past three decades. We measure the X-inefficiency rates of the manufaturing sectors and test the competitive environment hypothesis that the industry in a less competitive environment has more X-inefficiency. Even though there are somewhat distinctive results due to the different industrial structure, the test results imply that uncompetitive industries tend to have greater X-inefficiency.

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I. INTRODUCTION

The reduction in efficiency under the monopolistic market structure is called allocative inefficiency. This inefficiency has been a leading issue in efficiency discussions and, in fact, it would not be an overstatement to say that discussions of efficiency are generally referring to only allocative efficiency. Some economists, however, argue that there is another kind of inefficiency caused by a monopoly. This inefficiency, X-inefficiency, is the welfare loss caused by a monopoly and differs from the welfare loss associated with allocative inefficiency. X-inefficiency is related to the cost levels of enterprises. To the extent that a monopoly causes X-inefficiency, all firms in a monopoly are operating at a cost above the minimum cost level.

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Professor Harvey Leibenstein, a pioneer in the study of X-inefficiency, first coined the term X-inefficiency. The "X" in the term stands for non allocative inefficiency, the source of which is unknown. The traditional theory of the firm assumes that firms are internally efficient. The purpose of X efficiency (XE) theory is to show that a type of inefficiency exists but has been ignored in economic theory because of this assumption. Furthermore, this efficiency may be more important than the allocative efficiency, and the implication of its existence and size will be shown to have important policy implications.

A study of relationship between market structure and X-inefficiency was done by Bergsman(1974). He developed a model for estimating the effects of protection on both allocative inefficiency and other inefficiency for six less developed countries. He found that protection resulted in "monopoly returns" and X-inefficiency plus monopoly returns were considerably larger than costs of misallocation. Lecraw(1977) estimated allocative-price-inefficiency and X-inefficiency for a sample of 400 firms in 12 four-digit industries in Thailand. His results provide the existence of the significant amounts of both allocative-price and X-inefficiency.

In this study, we measure the X-inefficiency rates of the manufacturing sectors in Korea and Taiwan, countries which have achieved economic growth and export expansion with different industrial structures in the past three decades. The study also includes a cross-sectional analysis of each nation as well as a national comparison. The historical experiences of Korea and Taiwan are similar in terms of their initial conditions, choice of development strategy, and policies. Despite their similarities, however, the economies of these two countries also have some important differences. One difference is the degree of industrial concentration in each country. For a market economy to function efficiently, it must be competitive. Competition depends on the presence of many small firms and the absence of overwhelmingly large ones. It is, therefore, of interest to find out whether the different characteristics of the industrial structures in Korea and Taiwan had any effects on the performances of the two economies. In order to do this, this study proposes and tests the competitive environment hypothesis, which is the industry in a less competitive environment has more X-inefficiency.

In section II, the theoretical determinants of X-inefficiency are discussed and the industrial structures in Korea and Taiwan are reviewed. In section III, measuring models to estimate the extent of X-inefficiency and to test the competitive environment hypothesis is developed and employed. Finally, the characteristics of each country's industrial structure are summarized on the basis of the results of the analysis. The paper concludes with some policy implications.

II. THEORETICAL FRAMEWORK

2.1. Determinants of X-inefficiency

What are the determinants of X-inefficiency? In an ideal world of perfect competition where all firms are profit maximizers, information is perfect and costless, and changes in technology are costless and instantaneous, there could be no inefficiency either in the short or long run. All firms would produce the optimal product mix using the optimal combination of factors, achieving the maximum output with their given respective resources.

There are many obvious ways in which reality differs from this ideal situation. All economists agree that the absence of perfect competition admits the possibility of inefficiency because the lack of competitive pressure allows inefficient firms to survive even in the long run.[1] The presence or absence of perfect competion is an empirical, not a theoretical, question. Instead, the theoretical justification for inefficiency hinges on whether firms do or do not maximize profits and on what is meant by "profit maximization." Is profit maximization the attempt to maximize profits or does it refer to success in maximizing profits? Failure to attempt profit maximization may be referred to as ex ante or motivational failure, while unsuccessful attempts to maximize profits may be referred to as ex post (actual or accidental) failures.

In the absence of competitive pressure, firms are free to pursue goals other than maximizing profits, and thus can adversely affect resource allocation and efficiency in the long run. The existence of non-profit objectives of individuals and groups within firms is certainly neither a startling nora novel idea in economics. Those ideas include Scitovsky's utility function containing income and leisure, Baumol's objective function to maximize sales subject to some "minimum" level of profits, and Williamson's expense-preference function to maximize manager's own utility.[2]

Motivational failure may also result from the separation of ownership and control of the firm due to differences in objective functions between managers and owners. Note that these are all sufficient, though not necessary conditions for inefficiency; it is possible but unlikely that a managerial firm is as efficient as a profit-maximizing one.[3] Indeed, the leading managerial models in-

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1 Carlsson(1972) synthesizes the various possible determinants of X-inefficiency.

2 T. Scitovsky(1943), W. Baumol(1959), and O. Williamson(1964).

3 As long as the firm is maximizing an objective function, it will reach the frontier, at least in the long run. A firm which maximizes managerial leisure will eventually reach the frontier production function for that kind of output. But this is a different frontier from that which describes the production of the firm's saleable output, and the firm would therefore be observed to be inefficient. Another way of stating this that certain outputs of the firm(namely, managerial leisure) may be assigned zero weights in computing the firm's aggregate output, and this leads to observed inefficiency.

clude the traditional profit maximization analysis as a special case that prevails when the evironmental pressure is sufficiently severe.

It is possible to distinguish between managerial and behavioral models of the firm. While managerial models may be regarded primarily as ex ante non-maximizing, behavioral models emphasize the decision processes by which the firm tries to reach its goal, which may or may not be maximum profits. Thus, in the case when profit maximization is assumed to be the goal of the firm, it is possible to bridge the gap between the behavioral and conventional theories and to put behavioral content into the profit maximization hypothesis by postulating a set of decision rules under which the firm operates.

Examples of such rules of thumb are cost plus pricing, focal point pricing, fixed payout ratios, etc. While it is possible that relatively simple decision rules are more efficient in the long run than "more sophisticated" procedures, adherence to such rules may cause X-inefficiency in particular markets at particular times (i.e., in the short run). Also, once certain rules are established, it may be extremely difficult (costly) to change them. Top officials may be reluctant to disturb colleagues and subordinates, and even more importantly, minor functionaries are often reluctant to disturb the routines of their superiors. Leibenstein uses the terms "inert areas" and "organizational or frictional equilibria" to describe this kind of behavior. If the stimulus is not strong enough -- for example in the form of a threat to the firm's survival or to make the potential net gain greater than the costs (economic, psychic, etc.) of change -- the firm will continue its inefficient practices. Thus, what may be called frictional costs or costs of moving to the frontier from an interior position are one set of sources of inefficiency even in a maximizing model.

Another source is the cost of information and uncertainty, or the cost of discovering the true production function. The reason why the production function is costly to discover has to do with market imperfections in input markets. As Leibenstein pointed out, contracts for labor are incomplete, i.e., the employer does not know the precise capabilities of laborers, and job specifications are incomplete. Also, many inputs are not marketed at all or, if marketed, are not available on equal terms to all firms. Examples of these are managerial skills, technical knowledge, and patent rights. Thus each firm may be faced with a different set of production factors and hence a different achievable production function.

A profit maximizing firm may be X-efficient with respect to its own production function, given its resources (both purchasable and non-purchasable) and environment, while it is inefficient with respect to the industry production function. This is true because other firms in the same industry have different resource endowments (particularly with respect to non purchasable inputs) and can therefore reach a different production function. At the cost of acquiring the proper information and making the necessary adjustments in its production processes, any firm in the industry can reach the industry's frontier.

The presence of uncertainty also makes it costly to discover the true frontier. Uncertainty causes X-inefficiency by adversely affecting the average utilization of capital and the size of the firm and by making production planning more difficult due to the uncertainty of prices of output (especially if the product is new), the unpredictability of competitors, changes in raw material prices and wages, and other costs, especially in projects requiring several years for completion.

2.2. Characteristics of Industrial Structures in Korea and Taiwan[4]

Since the 1960s, both Korea and Taiwan have experienced rapid economic growth. Accordingly, the industrial structures of both countries have changed. The mining and manufacturing industry sector of Korea, which occupied 19.5 percent of GDP in 1965, increased to 30.3 percent in 1983, while the agriculture and fishery sector decreased from 24.7 percent in 1965 to 16.3 percent in 1983. In Taiwan, the mining and manufacturing industry occupied 22.6 percent of GDP in 1965 and 44.2 percent in 1983, but the agriculture and fishery sector decreased from 26.0 percent to 7.5 percent over the same period. In both countries, export manufacturing sector increased rapidly with the progress of industrialization. This growth in manufactured exports reflects the fact that industrialization in both countries was accomplished through the development of the export manufacturing sector.

The shift in the structure of the manufacturing sector in both countries followed the standard pattern in which the relative importance of the primary industries decreases while that of the secondary industries increases. But there are also some differences in the development of the manufacturing sector between these two countries.

In Taiwan, the ratio of manufacturing products to GDP is comparatively higher than that of Korea, and the number of those employed in the Taiwan manufacturing sector is also higher. While this is partly due to the deeper industrialization in Taiwan, the main reason is that Taiwan's industrialization has had a greater employment creating effect compared to Korea's. This is a natural result of the fact that Taiwan has promoted the industrialization strategy by fostering small and medium-sized firms. On the other hand, Korea's industrialization process has focused on promoting large enterprises which lag behind the small and medium-sized firms in terms of employment creation.

The production rate of the heavy and chemical industries, and the volume of exports and employment are increasing, reflecting the fact that the industrial structures of both countries are shifting from the light industry to the heavy and chemical industries. Notwithstanding, around 1980s, the speeds with which the heavy and chemical industries developed in the two countries differs some-

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[4] This section is abstracted partially from Economics and Technology Institute(1989).

what. These differences in the pattern of development of the heavy and chemical industries are due to the substantial investments in the heavy and chemical industries in Korea. This policy in Korea resulted in sluggish business activities in the beginning of the 1980s due to overlapping and excessive investments. But these concentrated investments promoted rapid industrialization, especially export industrialization of the heavy and chemical industries.

In contrast to the industrialization process in Korea, Taiwan promoted public enterprises rather than private enterprises, though a considerable amount of private investment in the heavy and chemical industries was carried out by small and medium-sized enterprises. Thus, the Taiwanese style of industrialization resulted in a slower speed of the export industrialization in the heavy and chemical industries.

In Korea, the shares of large firms' value-added and number of employees to the total value-added and number of employees in the manufacturing sector were 39.2 percent and 26.8 percent, respectively, in 1967; these shares increased to 55.0 percent and 43.2 percent in 1979. On the other hand, in Taiwan, the shares of value-added and number of employees for large firms decreased from 60.1 percent and 36.2 percent, respectively, in 1966, to 51.1 percent and 32.6 percent in 1976. These figures indicate that Korea's industrial structure has shifted toward large enterprises, based on capital-intensive heavy and chemical industrialization.

As shown in 〈Table 1〉, Taiwan's industrial concentration is remarkably different from that of Korea. For instance, Korea's share of high concentration industries of above 60 percent were 55.9 percent and 52.9 percent in 1977 and 1981, while Taiwan's remained at 22.9 percent. In short, Taiwan's industrial market structure is relatively competitive compared to that of Korea. In addition, considering the fact that most of the high-concentration industries in Taiwan are in the public sector, Taiwan's private sector can be said to have a more competitive structure.

[**Table 1**] Industrial Concentration Ratio

(%)

Industrial Concentration Rate	Korea		Taiwan
	1977	1981	1976
80 – 100	32.6	30.2	10.7
60 – 80	23.3	22.7	12.2
40 – 60	26.3	24.5	24.4
20 – 40	16.1	17.5	35.2
0 – 20	2.7	5.1	17.5
	100.0	100.0	100.0

Source : Economics and Technology Institute(1989)

Compared to the industrial concentration ratio of Taiwan, Korea's concentration ratio is very high. Although the part of this difference is due to economic environmental factors, the basic reason for this difference is a difference in the industrial structures of the two countries. Especially noteworthy is the difference in the heavy and chemical industrialization process and the government policies of the 1970s.

A major factor behind the different industrial concentration ratios of Korea and Taiwan is the different industrial technology policies of the two countries, especially monetary assistance and interest rate policies. Taiwan's policy assistance was non-discriminating. Korea's policy assistance, on the other hand, was concentrated in special industrial sectors, especially the export and heavy and chemical sectors ; there was relatively insufficient assistance for small and medium-sized firms.

Korean interest rates were relatively low, while Taiwan adopted a high interest rate policy. The low interest rate economy would result in a relatively more capital-intensive heavy and chemical industrialization than would a high interest rate economy. Thus, with a high interest rate policy, Taiwan has promoted development of labor-intensive and small and medium-sized enterprises. As a result, in spite of the promotion of heavy and chemical industrialization, Taiwan's industrial concentration is not very high. On the other hand, Korea experienced rapid growth of industrial concentration after it began to promote heavy and chemical industrialization. These differences are attributed to the different interest rate policies pursued by the two countries.

III. EMPIRICAL ANALYSIS

3.1. Model for X-inefficiency and Hypothesis

The estimation of a production function provides a vehicle for evaluating the extent of X-inefficiency. It is, therefore, important to examine the estimation methods of the production function and to summarize the estimation method that will be used in this study. Among the many methods of inferring production functions, this paper employs the method used in Arrow, Chenery, Minhas, and Solow (1961) and Diwan (1969).

We firstly calculate the cost minimizing labor (L^*) and capital (K^*) using the parameters of the estimated CES production function. Then, using the L^* and K^* that were derived the X-inefficiency rate is calculated by comparing the actual production costs with the cost-minimizing production costs (this is similar to the Lecraw (1977) model which calculated X-inefficiency in the manufacturing industries of Thailand).

X-inefficiency is related to the cost level of enterprises. An enterprise that is X-efficient is operating at the industry's minimizing cost level, while an enterprise that is X-inefficient is operating at a cost level that is above the mini-

[5] For the detailed discussion of the cost-minimizing factors, refer to Kang(1990).

mizing cost level. Accordingly, the fact that a monopoly causes not only allocative inefficiency but also X-inefficiency means that a monopoly firm operates above the minimizing cost level.

Allocative price inefficiency was estimated by taking the ratio of the actual capital-labor ratio (K/L) to the capital-labor ratio which would minimize cost (K^*/L^*),

$$D1 = \frac{(K/L)}{(K^*/L^*)}$$

If D1 is greater than 1, then the firm's capital-labor ratio is excessively capital-intensive; that is, its actual K/L ratio is in excess of that which, given input prices, would minimize costs. If D1 is less than 1, then the K/L ratio is excessively labor-intensive. Increasing the value of D1 results in the use of a more excessive capital-intensive technology ; this is associated with higher expected profits, less product market competition, firms which are owner-managed, and firm managers who are inexperienced in doing business in LDCs.

In order to calculate the degree of X-inefficiency of firms, the X-inefficiency rate (D2) is defined as the ratio of actual costs associated with the minimizing cost level.

Using the cost minimizing labor (L^*) and capital (K^*),

$$D2 = \frac{\text{actual production cost}}{\text{cos-minimizing production cost}} = \frac{rK + wL}{rK^* + wL^*}$$

The X-inefficiency rate is the ratio of actual costs to the costs associated with the cost-minimizing levels. Therefore, if $D2 > 1$, there is X-inefficiency, and if $D2 = 1$, the enterprise is X-efficient. The degree of the value of D2 specifies the degree of X-inefficiency.

For the analysis of industrial characteristics of Korea and Taiwan as they are related to X-inefficiency, the following testable hypothesis is proposed : the industry in a less competitive environment has more X-inefficiency. This competitive environment hypothesis can be subjected to econometric tests if it has data of the relative competitiveness of different industries.

The most important factor involved in testing the hypothesis proposed above is the selection of proxy variables for the competitive environment. Korea and Taiwan have achieved rapid economic growth with outward-looking policies during the last three decades. Therefore, international competition as well as market competition must be taken into consideration.

In order to prepare the testable model for the competitive environment hypothesis, estimates of D1 and D2 are used as the dependent variable. Regressors include the concentration ratio and capital-intensity as proxies for market competition, and the degree of foreign dependency and the tariff level as proxies for international competition. For foreign dependency, the export/output ratio is used as a proxy for the degree of export dependency, and the import/consumption ratio is used as the proxy for the degree of import dependency.

Regression equations for testing the hypothesis can be set up as follows :

$D1 = f(CR, KI, XD, ID, TL)$, $D2 = f(CR, KI, XD, ID, TL)$
where CR = concentration ratio, KI = capital intensity,
XD = export dependency, ID = import dependency, TL = tariff level

These two regression equations are estimated using data on 28 industries in Korea (3-digit level) and 20 industries in Taiwan (2-digit level) for the 1970 ~1989 period.

3.2. Data

It is very difficult to measure the X-inefficiency rate precisely. The most important process in deriving the X-inefficiency rate is the inference of the parameters of the CES production function, which is closely related to the consistency and accuracy of the data. To set up the model for analysis, data on value-added, labor and capital are needed. Here, labor refers to total labor hours of total laborers and wage rate is the average wage rate per time unit. Although it is not difficult to measure value-added, labor, and wage rates, there are many problems in measuring capital and the rate of return on capital because of the difficulty in defining these terms and other problems. Therefore, for these two variables, concrete definitions should be established and appropriate alternative variables should be used.

Capital stock can be defined in various ways depending on the purpose of the analysis. The actual capital stock of a production function is generally defined as an indicator of production capacity of existing capital assets in an unit period, and is calculated as the reacquisition value (gross capital stock) of the capital which was appraised according to a base year and reprocurement value (net capital stock). To measure capital stock, Pyo's(1987) first estimate net capital stock using different depreciation rates for each industry and asset and then estimate gross capital stock considering capital abolition for Korea.[6]

Considered to be the opportunity cost of capital, the rate of return on capital is determined by the credit and financial status of a company and an appraisal by investors of the potential profitability of the firm. Accordingly, in this analysis, two alternative variables are used on proxies for the rate of return on capital. The first alternative variable is (value added-wages)/tangible fixed assets. The second proxy is the average loan interest rate of financial institutions and other sectors.

The Korean data used for the empirical analysis of this study were obtained

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6 See Pyo(1987) for a detailed explanation on his estimation method of capital stock.

qfrom various issues of the Report on Mining and Manufacturing Survey by the Economic Planning Board from 1970 to 1989, Financial Statements Analysis by the Bank of Korea, and Labor Statistical Yearbook by the Ministry of Labor. Due to the lack of data on the number of employees and labor hours in some industries, the CES production function was estimated using data for 19 years from 1971 to 1989. The production function of the total manufacturing sector and 26 3-digit industries was estimated.[7)]

The year-end gross values of tangible fixed assets were calculated using purchasing and selling amounts from the Report on Mining and Manufacturing Survey. The average loan interest rate is obtained from the Financial Statements Analysis. In order to convert nominal values to real values, the wholesale price index was used to deflate wages and value-added.

Among the competitive environment variables, the concentration ratios, CR3 and CR5 estimated by the Fair Trade Committee of the Economic Planning Board were used for the degree of industry concentration. For the variable defining the degree of foreign dependency, adjustments were made to the values of export and import dependency derived in the input-output table of the Bank of Korea. For the tariff level, a simple average of data for 3 years (1978, 1982, 1988) from the Agency of Korea Customs was used.

Taiwanese data from 1970 to 1989 were obtained from various issues of the Taiwan Statistical Data Book, Taiwan GNP, Survey of Taiwan Industrialists by the Council for Economic Planning and Development. Due to insufficient data on the number of employees and value-added, the CES production function was estimated using 1973~1988 data. For comparative study with Korea, 2-digit industries that are similar to the Korean 3-digit industries were selected, and the production function was estimated for the total manufacturing sector and 20 2-digit industries.

Since there are no estimated data on capital stock in Taiwan, the "real operational asset" was employed as a proxy variable. This variable is calculated using the same increasing rate from 4-year data(1971, 1976, 1981, 1986) in the Survey of Taiwan Industrialists. As for tangible fixed assets a proxy for the rate of return on capital, the values of "real fixed assets" in the Taiwan Statistical Data Book were used as proxies.

For the variable on competitive environment hypothesis, a simple average of CR5 for 4 years (1985-1988) in the Taiwan Statistical Data Book was used for the degree of industry concentration. For the degree of foreign dependency, export and import data from the Taiwan Trade Statistical Monthly, which is published by the Ministry of Finance, were employed. Production data were obtained from the Taiwan Industrial Production Statistical Monthly, which is

[7] Although an estimate of the production function for the total manufacturing sector and for 28 3-digit industries was intended, the tobacco industry (314) and the footwear industry (324) were excluded because of insufficient data.

published by the Council for Economic Planning and Development. Tariff level data, however, were not available.

3.3. Empirical Findings for X-inefficiency

To estimate the CES production function, the Arrow, Chenery, Minhas, and Solow (ACMS) method and the Diwan method were applied. As a proxy variable for the rate of return on capital, the ratio of (value added-wages)/tangible fixed asset (VWT hereafter) and the average loan interest rate (ALI) were used. As a result, the X-inefficiency rate (D1 and D2) was consistent in both Korea and Taiwan when the ACMS method was applied and when VWT was used as a proxy variable for the rate of return on capital. This means that estimating the CES production function by the ACMS method is the result of using a strong restraint condition of the ecomomies of scale parameter to be 1. In addition, the fact that using the VWT variable yields consistent results shows that this proxy variable reflects the rate of return on capital relatively well. Consequently, the ACMS production function estimation method and the VWT measure will be used in analyzing X-inefficiency.

Table 2. shows the X-inefficiency rates for the total manufacturing sector and 26 3-digit industries in Korea. Because a log value for the parameter of the production function was not available for one industry, D1 and D2 of the total manufacturing sector and only 25 of the 26 industries were estimated. The table indicates that the total manufacturing sector in Korea is capital-intensive and 15.3 percent X-inefficient.

Among the industries, the leather, rubber, primary iron and steel, primary non-ferrous metals, machinery, and transport equipment industries have relatively large values of D1. That is, these industries are more capital intensive compared with the real factor price ratio. On the other hand, the wood, furniture, and other petrochemical industries are labor intensive. The values of D2, which reflects the X-inefficiency rate, were above 2 in the leather, primary iron and steel, and primary non-ferrous metals industries, indicating that the X-inefficiency rates of these industries are over 100 percent. The wood and furniture industries show the lowest X-inefficiency rate. Recall that there exists a close relationship between D1 and D2. The coefficient of correlation between D1 and D2 is 0.987, indicating an almost absolute correlation.[8]

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[8] This absolute correlation between $D1$ and $D2$ can be derived by the numerical expressions. $D2$can be rewritten as follows ;

$$D2=\frac{r\left(\frac{K}{L}\right)+w}{r\left(\frac{K^*}{L^*}\right)+w}\times\frac{L}{L^*}$$

Since $D1>1$ means $\frac{K}{L}>\frac{K^*}{L^*}$, the first term of $D2$ is greater than 1 as $D1>1$.

Therefore, if $D1>1$ and $L>L^*$, $D2>1$.

[**Table 2**] X-inefficiency Rate : Korean Industry

Industry	D1	D2
Food & Beverages	1.728	1.539
Textiles	1.340	1.232
Apparel	0.903	0.943
Leather	2.866	2.087
Wood Products	0.410	0.565
Furniture	0.482	0.686
Paper Products	1.143	1.105
Printing & Publishing	1.131	1.083
Industrial Chemicals	0.994	0.997
Other Chemical Products	1.513	1.415
Petroleum Products	1.465	1.454
Other Petroleum Products	0.777	0.825
Rubber Products	1.953	1.547
Plastic Products	0.840	0.897
Pottery, China & Earthware	0.914	0.954
Glass & Glass Products	1.160	1.107
Other Non-merallic Mineral	1.780	1.623
Iron & Steel Basic Industries	2.400	2.073
Non-ferrous Metal Basic Products	2.154	2.125
Fabricated Metal Products	1.072	1.048
Machinery	2.241	1.794
Electrial Machinery	1.040	1.014
Transport Equipment	1.975	1.699
Measuring Equipment	1.038	1.006
Other	1.262	1.159
Total	1.204	1.153

Note : The number indicates the averages of D1 and D2.

The X-inefficiency rates for industries in Taiwan are shown in ⟨Table 3⟩. Of the total manufacturing sector and 20 2-digit industries, the average value of D1 and D2 of 17 industries and the total manufacturing sector were calculated. Three industries were excluded since the parameters of production function could not be estimated. The table shows that the total manufacturing sector in Taiwan is capital-intensive and has an X-inefficiency rate of 26.9 percent. The food, transportation equipment, and other manufacturing industries are more capital-intensive compared with the real factor price ratio and the apparel, wood and furniture, and electric machinery industries are relatively labor-intensive. The correlation coefficient between D1 and D2 is 0.974, again indicating an almost absolute correlation although less than that of Korea. Compared with Korea, Taiwan is more capital-intensive and has a higher X-inefficiency rate which seems somewhat counterintuitive results.

[Table 3] X-inefficiency Rate : Taiwan Industry

Industry	D1	D2
Food	1.815	1.613
Beverages & Tobacco	2.449	2.360
Textiles	1.185	1.090
Apparel	0.979	0.985
Leather	1.442	1.275
Wood & Furnirure	0.957	0.960
Paper & Printing	1.279	1.166
Petroleum & Coal Products	1.612	1.582
Plastic Products	1.285	1.127
Non-Metallic Mineral Products	1.600	1.346
Primary Metal Industries	1.283	1.215
Fabricated Metal Products	1.308	1.110
Machinery	1.206	1.095
Electrial & Electronic Equipment	0.815	0.832
Transpotortion Equipment	2.089	1.740
Precision Equipment	1.445	1.293
Other	2.287	1.872
Total	1.395	1.269

Note : The number indicates the averages of D1 and D2.

This result is quite different from what was originally expected. Nevertheless, the surprising findings can be explained. One possible explanation lies in the managerial efficiency of large enterprises. It seems that the increased economic concentration or rise of the chaebol, i.e., large business groups in Korea, may in part be a requirement for rapid economic growth. X-inefficiency in terms of organizational and entrepreneurial advantages possessed by chaebol may have been particularly important in their moving into new, large-scale, capital-intensive areas requiring modern technology, such as heavy and chemical industries. This may also explain the government's tendency to rely on large chaebol groups to achieve efficiency through economies of scale, especially in the heavy and chemical industries, and to promote exports by establishing general trading companies.

A second explanation for the unexpected results is that the proxy variables of capital stock used for both countries rely on different estimation methods. Given that the capital stock is the most important variable in the estimation of the production function, the results obtained using a cross-sectional approach in the hypothesis test which is presented in the next, seem to be more appropriate.

Therefore, comparing the X-inefficiency rates of both countries by the absolute value of D1 and D2 seems inappropriate. It would be more reasonable to compare the X-inefficiency rates of industries within each country rather than the X-inefficiency rates of industries across the two countries.

3.4. Test Results for Hypotheses

The regression results of the competitive environment hypothesis test for Korea and Taiwan are summarized in ⟨Table 4⟩ The results for Korea provide that we cannot reject at the 5 percent marginal level of significance the hypothesis that capital intensity, import dependency and tariff level have a positive effect on the level of allocative inefficiency for D1. The concentration ratio and export dependency do not, however, have any statistically significant effect. Capital intensity may indicate the presence of scale economies ; import dependency on the use of imported capital equipment ; and the tariff level larger capacities than economically efficient at the level of free-trade prices. It appears that they all tend to lead to the use of an overly capital-intensive technique.

The regression results for D2 also show that we cannot reject at the 5 percent marginal level of significance the hypothesis that capital intensity, import dependency, and tariff level have a positive effect on the level of X-inefficiency. It is clear that the factors that lead to the choice of overly capital-intensive techniques also contribute to X-inefficiency. In other words, in the case of Korea the policy of promoting capital-intensive industries with tariff protection has led to waste of capital and X-inefficiency.

The regression results for Taiwan show that only the industrial concentration ratio is a statistically significant factor for D1. Multiple regression results for D2 also show that only the industrial concentration is statistically significant. That is, in case of Taiwan the industries that are more concentrated are those which are more capital intensive and more X-inefficient.

The different results for Korea and Taiwan may be explained in terms of different growth strategies taken by these two economies. Although they both have taken an export-oriented growth strategy, Korea's industrial structure is centered on large private enterprises and heavy and chemical industries whereas Taiwan's industrial structure is generally focused on small and medium-sized firms and light industries and large public enterprises in mostly import-substitute industries. In case of Korea, large private enterprises are basically in the export business and their large size would therefore not confer any monopoly power to them. In contrast, the large public enterprises in Taiwan would have monopoly power and would therefore be inclined to be more X-inefficient than their Korean private counterparts. It should be also noted here that the different results for the two countries can be due in part to the different proxy variables we have used for import dependency.[9]

[9] Korea : import dependency = import/total supply = import/intermediate + consumption + export
Taiwan : import dependency = import/production

[Table 4] Regression Result for the Hypothesis Test

Korea	
$D1=0.945-1.012CR+0.368KI-0.158XD+1.755ID+3.267TL$	
(1.498) (−0.760) (1.801) (−0.713) (1.824) (1.961)	$R^2=0.370$
$D2=0.811-0.468CR+0.287KI-0.068XD+1.146ID+2.150TL$	
(1.879) (−0.526) (2.089) (−0.460) (1.776) (1.920)	$R^2=0.425$
Taiwan	
$D1=1.214+1.574CR-0.198KI-0.048XD+0.042ID$	
(4.607) (2.121) (−1.288) (−0.215) (0.116)	$R^2=0.364$
$D2=1.013+1.585CR-0.165KI+0.007XD+0.077ID$	
(5.250) (2.915) (−1.470) (0.045) (0.289)	$R^2=0.523$

Note : Number in parentheses indicates the t-value of the coefficients.

Ⅳ. CONCLUSION

The purpose of this study is to apply the X-inefficiency theory in analyzing the different characteristics of the industrial structure in Korea and Taiwan. In general, X-inefficiency grows with less competitive pressure because competition has the effect of making firms more rational. Since the lack of competition is the main theoretical determinant of X-inefficiency, a competitive environment hypothesis was proposed in this study. The hypothesis is that an industry in a less competitive environment has greater X-inefficiency.

The test results for Korea show the hypothesis that capital intensity, import dependency and tariff level significantly affect the X-inefficiency rate cannot be rejected at a relatively high significance level. In Korea, the industries with relatively high capital intensity, relatively high import dependency, and relatively high tariff rates are the heavy and chemical industries which the government promoted as import-substitute industries in the 1970s. Given that they were actively promoted with subsidized credit and protection from foreign competition, it is not surprising to find a relatively high rate of X-inefficiency in these industries. On the other hand, in Taiwan only the industrial concentration variable cannot be rejected at a relatively high significance level. This is to be expected as the more highly concentrated industries in Taiwan tend to be state-owned enterprises in protected domestic markets and would thus tend to be more capital intensive and more X-inefficient.

The fact that the industrial concentration variable is statistically significant for Taiwan but not for Korea may be in part due to the omission of the tariff variable for Taiwan. It is, however, more likely that the difference in their industrial structure. Because of Taiwan's focus on small and medium-sized firms and light manufacturing industries, capital intensity hardly affects X-inefficiency whereas for the Korean industrial structure, which is based on large firms and heavy and chemical industries, capital intensity affects X-inefficiency to a greater degree.

Since the results of this study imply that uncompetitive industries tend to have greater X−inefficiency, it suggests many policy implications. That is, in enforcing policies, it is important to move in a direction in which the competitive environment is promoted. For instance, although we could accept the notion and existence of scale economies, extreme capital intensity could hinder the competitive environment of the market economy. Additionally unconditional industries protection could hamper the competitive environment and increase X-inefficiency.

The concentration of economic power may be inevitable, so long as a discrepancy in entrepreneurial capabilities among individuals exists. At the same time, it cannot be denied that diversification of business activities is, at least partly, a natural manifestation of profit-seeking and risk-dispersing motives. Therefore, public policy toward pro-competition should tread the line between discouraging the inefficient or anti-competitive diversification and respecting bona fide entrepreneurship. The most effective means for this may be to expose firms to competitive pressures. Faced with tight competition, no firm has recourse but to shed itself of excess capacity in terms of organization and inefficient management. In this respect, pro-competition policies such as the removal of entry barriers to firms from home and abroad are both fundamental and necessary.

Finally, future research directives and problems for empirical analysis on X-inefficiency remain. First, since the estimated parameters of the production function sensitively react to the materials, calculating level and methods, research period, and model setting, it is recommended that several models employing various methods be estimated and compared with one another. Second, development of more practical and economically proper proxy variables for the capital stock and the rate of return on capital, which are the most critical variables in estimating the production function, is required. Third, development of generalized competitive variables, which is the most important variable in the competitive environment hypothesis, and development of adequate proxy variables for X-inefficiency are also necessary.

REFERENCE

Arrow, K., Chenery, H., Minhas, B., and Solow, R., "Capital-Labor Substitution and Economic Efficiency." *Review of Economic Statistics*, Vol. 43, 1961, pp.225-50.

Bank of Korea (BOK), *Economic Statistical Yearbook*, various issues (in Korea). Seoul : BOK. various years.

Baumol, W., "The Revenue Maximization Hypothesis." *in Business Behavior, Value, and Growth*, pp.45-53, New York : Macmillon, 1959.

Bergsman, J., "Commercial Policy, Allocative Efficiency and X-efficiency", *Western Economic Review*, Vol.8, 1974, pp.409-33.

Carlsson, B., "The Measurement of Efficiency in Production : An Application to Swedish Manufacturing Industries, 1968." *Sweden Journal of Economics*, Vol. 74, Dec. 1972, pp.468-85.

Chung, H. S., "Contribution Analysis of Export on Economics Growth : Comparion for Korea and Taiwan" (in Korea). *Korean Economy*, No.18-2, Sung Kyun Kwan University, 1992.

Chung, Woo-Taik, *Estimation of X-inefficiency : Korea and Taiwan*, unpublished Ph.D. dissertation, University of Hawaii, 1992.

Council for Economic Planning and Development (CEPD), Taiwan Statistical Data Book, Various issues. Taipei : CEPD, various years.

__________, *Taiwan Industrialists Production Statistical Monthly*, various issues. Taipei : CEPD, various years.

Diwan, R., "Alternative Specifications of Economies of Scale." *Economica*, Nov. 1969, pp.442-53.

Economic Planning Board, *Report on Mining and Manufacturing* Survey *(in Korea). Seoul : EPB, various years.*

Economics and Technology Institute, Industrial Structure and Economic Performance for Korea and Taiwan (in Korea). Seoul : Korea University. 1989.

Frantz, R., *X-Inefficiency : Theory, Evidence and Applications. Boston :* Kluwer Academic Publishers. 1988.

Kang, Myung-Hun, "A short Consideration of X-Inefficiency" (in Korea). *Kyung Je Hak Yon Gu*, Vol. 38, No. 1, The Korean Economic Association, 1990, pp.1-25.

Kim, C. K., Yoo, J. S., and Hwang, K. M., *The Productivity Analysis of the Manufacturing Sector in Korea, Taiwan and Japan* (in Korean). Seoul : Economic Institute in Hanyang University. 1984.

Lecraw, D., "Empirical Tests for X-Inefficiency." *KYKLOS*, Vol. 30, No.1, 1977, pp.116-20.

Leibenstein, H., *General X-Inefficiency Theory and Economic Development.* New York : Oxford University Press. 1978.

Ministry of Finance (MOF), *Taiwan Trade Statistical Monthly*, various issues.

Taipei : MOF, various years.

Ministry of Labor, *Labor Statistical Yearbook*, various issues. (in Korea). Seoul : Ministry of Labor, various years.

Pyo, Hak-Kil, "The Estimation of Capital Stock in Korea" (in Korean). *Kyong Je Hak Yon Gu*, Vol. 35, The Korean Economic Association, 1987, pp.57-90.

Scitovsky, T., "A Note of Profit Maximization and its Implication." *Review of Economic Studies*, Vol. 11, No.1, 1943, pp.57-60.

Weiss, L., and Pascoe, G., "Concentration, X-Inefficiency and Mr. Pelzman's Superior Firms." *Social System Research Institute Working Paper*, No. 8501, Madison : University of Wisconsin, 1985.

Williamson, O., *The Economics of Discretionary Behavior* : Management Objective in a Theory of the Firm. Englewood Cliffs, N.J. : Prentice-Hall. 1964.