The Cross-Sectional, Inter-Industry Structure of Capital Utilization in a Developing Economy: The Case of S. Korean Manufacturing

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I. Introduction

The literature on capital utilization has experienced a remarkable growth of rate.[1] In particular, implications of a model of optimal capital utilization put forth by Kim and Winston (1974) have been shown to be consistent with empirical findings (1) on inter-country, cross-sectional, sectoral rates of capital utilization (Kim (1969), Mason and Sakong (1971), and Winston (1971b) and (2) on intra-country, timetrend rates of capital utilization (Kim and Kwon) (1977). As a sequel to such recent developments, this paper proposes to show an implication of the Kim-Winston model in the context of an intra-country, cross-sectional, inter-industry structure of capital utilization and, then, to test this implication against cross-sectional data from S. Korean manufacturing industries.

II. Analytical Framework

The recent neoclassical theory of capital utilization treats "idleness" of capital stock primarily as being planned or anticipated based on ex ante investment decisions. Then, for a linear homogeneous production function,

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1) To economize space, readers are referred to a comprehensive survey of the literature by Winston (1974). For notable advances since, see Calvo (1975), Clague (1976), and Lecraw (1978).

Kim and Winston (1974) have shown that[2)]

$$H=H(P_K K/P_L L,\ \beta)$$

and

$$\partial H/\partial(P_K K/P_L L)>0$$

and

$$\partial H/\partial\beta<0$$

where K=stock of fixed capital; L="stock" of labor (i.e., the number of workers at work at a given moment); H=number of fixed-hour shifts per period (say, a day) during which K is utilized in production, i.e., rate of capital utilization; P_K=cost of owning a unit of capital stock for a "day"; P_L=wage payment per worker (for a daytime shift of work); and β= night-work wage premium in per cent.

Basically, this formulation states that, first, the more important the K-cost ($P_K \cdot K$) vis-a-vis the L-cost ($P_L \cdot L$) in the firm's cost structure (i.e., the greater the $P_K \cdot K/P_L \cdot L$), the greater the cost-saving and the larger the profit from a more intensive utilization of K, hence, the higher the level of (optimal) capital utilization (i.e., the higher the H). Second, the greater the night-work wage premium (β) to be paid for a multiple-shift operation (for a higher H), the more expensive the multiple-shift production operation, thus, the lower the level of (optimal) capital utilization (i.e., the lower the H).

For the purpose of this investigation, however, it can be assumed that P_K/P_L and are parameters. Since we are dealing with different manufacturing sectors during a short time period (1968~70), it is safe to assume that the same factor-price ratio (distorted or not) prevailed and that the same wage premium applied (through factor mobility, albeit imperfect; and being subject to the same governmental policies and legal requirements). Then, the only relevant independent variable for our present purpose is the capital intensity (K/L) and $dH/d(K/L)>0$. That is, for intra-country, cross-sectional, inter-industry variations, the fist of recent theoretical contributions is that the level of capital utilization is expected to be positively correlated with the technology-affected capital intensity.

2) See also Winston and McCoy (1974).

Although our primary objective is to test the implication of the Kim-Winston approach sketched above, since others have suggested several other lines of inquiry, we will consider them as well. While the above implication is derived from a model based on a linear homogeneous production function, it has been shown that the presence of increasing returns tends to lower the level of optimal capital utilization (Baily (1976), Betancourt and Clague (1975), Marrie (1964). In addition, using Winston's classification (1974), anticipated-and-supply oriented consideration, there is a multitude of other explanations in the literature. Initial discussions of "excess capacity" in LDCs were dominated by the unanticipated-and-supply-oriented factors. In this version, the balance of payments problems create shortages of imported materials and spare parts, electricity is in short supply, skilled work force is lacking and so on. Still other explanations center on the product-demand aspects. Capital idleness may be unanticipated and product-demand oriented as in the "Keynesian" version, or anticipated and product-demand oriented as in the "Chamberlinian" version.

Ⅲ. The Variables and the Data

The variables relate to manufacturing industries only disaggregated to the level of a 30 sector subgrouping during the period of 1968-70 in S. Korea. The study limits itself to manufacturing industries because of many serious conceptual difficulties in defining and measuring capital utilization in other activities. Due to different systems of sectoral classification in the data sources, 8 of the 30 sectors had to be dropped for lack of (some) cohort variables. The full description of the data sources and computational details is given in Kim and Kwon (1973), except where otherwise indicated.

Rate of Capital-stock Utilization (U): This rate is based on the now-familiar electricity method,[3] which measures the rate of capial-stock utilization by measuring the rate of capital-equipment utilization; and the

3) See Foss (1963), Heathfield (1972), Jorgenson and Griliches (1967), and Kim and Kwon (1977).

rate of capital-equipment utilization is in turn measured by the rate of utilization of electric motors which drive electricity-powered capital equipment. Thus U is defined as the ratio, in per cent, of the actual to the maximum number of hours per year during which electricmotor-driven equipment in any given sector has been operated, where the maximum number of hours is 8,760 (365 day a year multiplied by 24 hours a day). Thers are two alternative estimates, U_1 and U_2, due to two alternative approaches in estimating the capacity (kw) of electric moters.[4)]

Capital Intensity (X_1): The capital intensity, the center-piece variable in our model, is the instantaneous capital-labor ratio, which is expected to have a positive influence of the utilization rate. Computationally, this variable is measured as the amount of machinery equipment (in 10,000 Won in 1970 constant price) per male-equivalent "productive" worker, where the female work force is standardized in units of male-equivalence by use of the female-to-male wage ratio.[5)]

Concentration Ratio (X_2): X_2 is the standard 4-firm (market-share) concentration index.[6)] The market share is computed in terms of the share

4) Very briefly, the "rated" electric-motor capacity (kw) was estimated on the basis of the "contract capacity" (kw) of individual firms with the power company. Two independent (sets of) estimates of the conversion factors were employed: one estimate was based on the partial record at the power company, and the other was obtained through our own questionnaire by mail. The U_1 measure relies on the first source and the U_2 on the second source.

5) X_1 so measured is not precisely the desired instantaneous capital-labor ratio. At any instant when production takes place, not all equipment may be in operation and not all (productive) workers may be "on duty." Of course, that presents no problem if the fractions of firm's equipment and employees working at any instant are the same. The problem would be most serious if, e.g., all equipment is operated for two shifts a day and two different groups of workers work the two shifts. However, the data problem is not very serious in our case. Given a rather modest average rate of capital utilization (26.5% and 23.3% for U_1 and U_2, respectively, for the industries in the regression analysis), most industries do not engage in shift-work. When some do from time to time, the prevailing practice is one of an overtime-type arrangement. A compelling reason for firms to avoid establishing separate crews is the government-mandated night-work-premium rates of 50% to 100%.

6) The data for this variable come from computer print-outs at one stage in processing the raw data from the 1966 mining and manufacturing survey. The data were kindly made available by K. U. Lee. See Lee (1977) for details.

of "shipments."[7] This variable is introduced partly as a proxy for the scale factor on the grounds that industries characterized by significant scale economies are expected to be dominated by a small number of large firms. The index can also be taken as a proxy measure of the degree of market imperfections, leading to capital utilization implications in the Chamberlinian tradition. A priori expectation in the literature is that the greater the concentration ratio, the lower the utilization rate.

Import-dependence of Inputs (X_3): This measure is the ratio of "non-competitive" imports of intermediate inputs to total intermediate-input requirements.[8] This variable is considered in order to incorporate the conventional view that the "foreign exchange gap" is a major deterrent in achieving a higher level of capital utilization.

Export-dependence of Final Product (X_4): This variable is defined as the proportion of exports in total output, measuring the degree of dependence of an industry's output of foreign demand. If the smallness of a domestic market is an inhibiting factor in capital utilization, as it is frequently argued, the greater the export (world market) dependence, the higher the utilization rate.

Competing Imports of Final Product (X_5): Again, along the line of the small-market argument, it has been contended that the market for domestic product becomes smaller as the import-supplied share of total domestic-demand becomes larger hence a lower rate of capital utilization. Thus the ratio of imports of final product (plus customs duties) to total domestic demand is computed and included as X_5 in the regression analysis.

To summarize, in the context of the inter-industry structure of capital utilization, the aforementioned neoclassical model implies that

$$U = U(X_1)$$

7) Due to unavailability of the data, the maket share in 1966 is assumed to prevail in 1968, 1969, and 1970.

8) A "noncompetitive" import refers to an item which is neither currently produced, nor is projected to be produced domestically in the near future (in any sizeable quantity). The source of data for the variables X_4, and X_5 is the Input-Output Tables. Since the Tables are not available on an annual basis, the variables are computed from the 1968 Table; and then the resulting data are assumed to apply in all three years.

where

$$dU/dX_1>0.$$

Inclusion of other considerations found in the literature leads to an expanded set of explanatory variables such that

$$U=U(X_1, X_2, X_3, X_4, X_5)$$

and $\partial U/\partial X_1>0$, $\partial U/\partial X_2<0$, $\partial U/\partial X_3<0$, $\partial U/\partial X_4>0$, and $\partial U/\partial X_5<0$.

According to Winston's classification, X_2 stands for both the anticipated-and-supply-oriented scale-factor and the anticipated-and-demand-oriented Chamberlinian characteristics of (product) market structure. X_3 is a conventional unanticipated-and-supply-oriented variable. The variables X_4 and X_5 are of the anticipated-and-demand-oriented variety rooted in the smallness-of-the-market argument. These independent variables or their proxies can also be found in other empirical studies: X_1 and X_2 in Betancourt and Clague (1978), Lecraw (1978), Lim (1976), Riedel (1975), Thoumi (undated), and Winston (1971a); X_3 in Riedel (1975), Thoumi (undated), and Winston (1971a); X_3 in Riedel (1975), Thoumi (undated), and Winston (1971a); and X_5 in Winston (1971a).

Ⅳ. Empirical Results

The estimation of the inter-industry structure of capital utilization is performed by the ordinary least-squares (OLS) method in the linear form. The regression coefficients are estimated by pooling the inter-sectoral cross-section (N=22) and the 3-year (1968-70) time-series data. Table 1 summarizes the results of the regression analysis. It should be pointed out beforehand, however, that an examination of matrix of correlation coeffieients reveals a very close relationship ($r=0.938$) between our two alternative measures of capital utilization, U_1 and U_2. It is also noteworthy that $|r_{ij}|>0.25$ for all $i=j$; and that $|r_{ij}|<0.17$ for $i\neq j$ in the estimation equations (1.1) through (1.6) and (2.1) through (2.6). The most prominent feature of our results as shown in the table is the over-riding influence of the capital-intensity variable (X_1). Irrespective of the choice of the regressands (U_1 and U_2) and of estimation formulations, the capital intensity variable is found to be the most influential variable in accounting for the inter-industry variations in the rate of capital utilization. This variable alone is shown to account for between 49% and 68% of variations in the inter-industry rate of capital-stock utilization, depending on whether the regressand is U_1 or U_2, respectively. Also, the t-value in all cases is at least 7.69. Another remarkable feature is the stability of the coefficients for X_1 in alternative equations.

Table 1. Capital Utilization in a Developing Economy
(T-Values in Parentheses)

Regressands	Equation Nos.	Regressors					
		X_1	X_2	X_3	X_4	X_5	R^2
U_1	(1. 1)	0. 080 (7. 87)	—	—	—	—	. 492
	(1. 2)	0. 079 (7. 72)	—	−0. 037 (0. 50)	—	—	. 494
	(1. 3)	0. 080 (7. 87)	—	—	0. 131 (0. 95)	—	. 499
	(1. 4)	0. 080 (7. 81)	—	—	—	−0. 017 (0. 47)	. 493
	(1. 5)	0. 079 (7. 71)	—	−0. 048 (0. 64)	0. 144 (1. 03)	—	. 502
	(1. 6)	0. 080 (7. 69)	—	−0. 043 (0. 57)	—	−0. 020 (0. 55)	. 496
	(1. 7)	0. 085 (8. 43)	−0. 233 (2. 28)	—	—	—	. 530
	(1. 8)	0. 085	−0. 238 (2. 29)	−0. 050 (0. 68)	0. 130 (0. 93)	−0. 020 (0. 54)	. 543
U_2	(2. 1)	0. 103 (11. 52)	—	—	—	—	. 675
	(2. 2)	0. 102 (11. 39)	—	−0. 092 (1. 43)	—	—	. 685
	(2. 3)	0. 103 (11. 89)	—	—	0. 264 (2. 23)	—	. 698
	(2. 4)	0. 105 (11. 67)	—	—	—	−0. 043 (1. 35)	. 684
	(2. 5)	0. 102 (11. 84)	—	−0. 116 (1. 84)	0. 296 (2. 52)	—	. 714
	(2. 6)	0. 103 (11. 64)	—	−0. 108 (1. 68)	—	−0. 051 (1. 61)	. 698
	(2. 7)	0. 106 (11. 63)	−0. 135 (1. 46)	—	—	—	. 685
	(2. 8)	0. 106 (12. 10)	−0. 144 (1. 63)	−0. 124 (1. 99)	0. 264 (2. 23)	−0. 040 (1. 29)	. 732

As to the other variables, the signs of all regression coefficients are "correct." Although the level of statistical significance of the coefficients depends on the choice of the regressand and of the estimation equation, the consistency of the signs in alternative specifications tends to support the arguments of other writers. However, as evidenced in the table, the avriables X_2 through X_5 apparently did not matter "much" in the particular case under investigation. Judging from the values of R^2 in alternative estimation equations, the improvements are either nil or so marginal that to consider more than X_1 seems to have been hardly worth the effort.

The capital-intensity variable (or its proxies), X_1, is reported to be "correct" and statistically significant in Betancourt and Clague (1978), Lecraw (1978), Lim(1976), Riedel (1975), Thoumi (undated), and Winston (1971a). Howeverm, the relative importance of this variable is not reported in, and cannot be ascertained from, any of these studies. This shortcoming has now been corrected, and the results are shown to be striking. The findings presented here also serve as an indirect support for the aforementioned two other implications of the neoclassical approach.

In view of such robustness of X_1 not reported by others, additional estimates have been made to search for possible statistical pitfalls. First, the pooling method (of cross-section and time-series) may cast some suspicion on the results. Thus the same set of equations (as in table 1) has been estimated for each of the three annual data. An analysis of the results from three separate annual data warrants few changes in the conclusions based on the pooled data. The signs of the coefficients using the annual cross-section data are identical to those based on the pooled data with a minor exception: the signs of coefficient for X_3 are all positive for U_1 in 1968 with the t-values no greater than 0.19. The t-values for X_1 are at least 3.99 in all 48 equations (16 equations/year for 3 years). The improvements in R^2 of adding other variables to X_1 are no greater than 0.084. The lowest R^2 values in (1.1) are 0.467 for U_1 and 0.642 for U_2.

Second, it will be recalled that X_1 contains an adjustment factor based on the male-female wage differential. If the wage differential is a measure of the productivity differential, this adjustment would allow for different qualities of labor input. However, the wage differential may be a result of sex discrimination, in which case such adjustment would introduce a bias. To experiment, an alternative estimation was made using the capital-intensity variable without the wage-ratedifferential adjustment. A comparison of the two sets of results reveals again no major contrasts. The (initial) adjusted X_1 yields somewhat better results in terms of t- and R^2-values with respect to both the pooled and the yearly data.

Third, a concern was voiced by Betancourt and Clague (1978) that "continuous process" industries tend to be capital-intensive, and thus the statistical significance of X_1 may reflect the influence of the continuous-process, nature of production rather than that of capital intensity. To address this reservation, the same regression analysis was repeated with the exclusion of continuous-process industries reducing N from 66 to 48. The dominance of the capital-intensity variable was still evident. The t-values of the coefficients for X_1 are at least 6.69 for U_1 and at least 5.36 for U_2. Also, the R^2-values are found to be affected only slightly as far as U_1 is concerned. Although the R^2-values become substantially smaller in the case of U_2 (e.g., in the estimation equation (2.1), $R^2=0.404$ when $N=48$, while $R^2=0.675$ when $N=66$), even this difference becomes partially mitigated by multicollinearity (e.g., while in none of the cases $|r_{ij}|\geq 0.25$ for $N=66$, three such cases are found for $N=48$). Thus it is contended that even the consideration of continuous-process industries does not change the nature of empirical evidence sufficiently to alter our basic conclusion.

Fourth, alternative indices of X_2 and X_3 were experimented with. Another index of X_2 based on value-added (rather than on "shipments") was tried. Yet, no sizeable differences can be noted in the final results. The role of X_3 was also scrutinized by measuring the variable as the ratio of total imported imputs ("competitive" or not) to total intermediate inputs. The results of the initial X_3 (based on imports of noncompetitive inputs) are found to be substantially better in terms of either the t- or R^2-values. This is as expected: Since the competitive imports have two potential sources of supply (i.e., domestic and foreign), whereas the noncompetitive imports have only one (i.e., foreign), the effect of any balance of payments difficulties on (domestic) final output (and, thus, on capital utilization) can be better captured by the initial index based on noncompetitive imports.

V. Summary and Conclusions

Lately a number of models of optimal utilization have been put forward. Although these models of differ in specifics and emphasis, there is a core of commom features; and certain implications can be derived from them. Three of the more important implications of practical value, especially for LDCs, are the relative levels of capital utilization in the contexts of (a) cross-sectional, sectoral, inter-country comparison; (b) intra-country, time-series comparison; and (c) intra-country, cross-sectional, inter-industry comparison. This paper is an empirical investigation of item (c), intended to supplement and reinforce earlier theoretical and empirical work dealing with items (a) and (b).

There already exist several studies dealing with the inter-industry structure of capital utilization. The novelty in the approach of this paper is that the variables in the regression equations are so measured that the correspondence between the earlier theoretical constructs and the present empirical work is shown to be clearer and less roundabout. Moreover, unlike other empirical studies (based on the questionnaire-generated data), this study is based on the electricity measure of capital utilization. Although it is not the place to discuss the relative merits of the two measures, the significance of this paper should be obvious when evaluated in light of the past studies on the inter-country and on the time-series differentials also based on the electricity measure.

We take our main empirical findings as strongly supportive of earlier theoretical and empirical studies. Although the capital-intensity variable (or its proxies) has been included in the estimation equations and found to be statistically significant in studies by others, the role of this variable postulated in the theoretical framework and its usage in the regression analysis have been rather vague or unnecessarily indirect. The approach taken in this paper has been to call attention to the central role of the capital-intensity variable in the analysis of inter-industry optimal capital utilization and, hence, to show why this variable is expected to be of primary importance in the empirical analysis. Evaluating the empirical evidence, our findings show not only that the capital-intensity variable is statistically (very) significant as other studies have also found, but also, more importantly, that the explanatory power in terms of R^2 of this variable overshadows influences of any or all other considerations. Of course, this is not to suggest that the other variables are expected to be of equally dubious practical importance in other countries and periods where and when the constraints on the balance of payments and domestic market size are (more) severe. At the same time, we do assert that the evidence of consistently dominant influence of the capital-intensity variable provides strong empirical support for the recent neoclassical approach to the optimal utilization of capital stock, whether the theory is viewed in the context of inter-country, time-series, or inter-industry differentials.

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Baily, Mary A., "The Effect of Differential Shift Costs on Capital Utilization," *Journal of Development Economics 3* (Mar. 1976), 27-47.

Betancourt, Roger R., and Christopher K. Clague, "An Economic Analysis of Capital Utilization," *Sourthern Economic Journal 42* (July 1975), 69-78.

________, "An Econometric Analysis of Capital Utilization," *International Economic Review 19* (Feb. 1978), 211-227.

Calvo, Guillermo A., "Efficient Capacity Utilization with Differential Shift Welfare Costs," unpublished manuscript (New York: Columbia University, 1975).

Clague, Christopher, "The Theory of Capital Utilization and the Putty-Rubber Production Function," *Journal of Development Economics 3* (Sept. 1976), 277-278.

Foss, Murray F., "The Utilization of Capital Fquipment: Postwar Compared with Prewar," *Survey of Current Business 43* (June 1963), 8-16.

Heathfield, David F., "The Measurement of Capital Usage Using Electricity Consumption Data in the U.K.," *Journal of the Royal Statistical Society 135* 208-220.

Jourgenson, Dale W., and Zvi Griliches, "The Explanation of Productivity Change," *Review of Economic Studies* 34 (July 1967), 249-283.

Kim, Young Chin, "Sectoral Output-Capital Ratios and Levels of Economic Development: A Cross-Sectional Comparison of Manufacturing Industry," REVIEW 51 (Nov. 1969), 453-458.

Kim Young Chin, and Jene K. Kwon, *Capital Utilization in Korean Manufacturing,* 1962-71, mimeo, Final Report to U.S. AID (Seoul: Korea Industrial Development Research Institute, 1973).

________, "The Utilization of Capital and the Growth of Output in a Developing Economy: The Case of South Korean Manufacturing, *Journal of Development Economics* 4 (Sept. 1977), 295-278.

Kim, Young Chin, and Gordon C. Winston, "The Optimal Utilization of Capital Stock and the Level of Economic Development," *Economics* 41 (Non. 1974), 377-386.

Lecraw, Donald J., "Determinants of Capacity Utilization by Firms in Less Developed Countries," *Journal of Development Economics* 5 (June 1978), 139-153.

Lee, Kyu Uk, *Market Structure and Monopoly Control* (Seoul: Korea Development Institute, 1977) (in Korean).

Lim, David, "Capital Utilization of Local and Foreign Establishments in Malaysian Manufacturing," REVIEW 58 (May 1976), 209-217.

Marris, Robin, *The Economics of Capital Utilization* (Cambridge, Cambridge University Press, 1964).

Mason, R. Hal and Il Sakong, "Level of Economic Deveolpment and Capital-Labor Ratios in Manufacturing," REVIEW 53 (May 1971), 176-178.

Riedel, James C., "Determinants of the Intended Level of Capital Utilization in Taiwan Manufacturing," unpublished manuscript (Kiel, West Germany: Institut für Weltwirtschaft, 1975).

Thoumi, Feancisco E., "Fixed Capital Utilization in Colombian Manufacture," unpublished manuscript (Washington, D.C.: World Bank, undated).

Winston, Gordon C., "Capital Utilization in Economic Development," *Economic Journal* 81 (Mar. 1971a), 36-60.

________, "A Comparison of Capital Utilization in Pakistan and the U.S.," unpublished manuscript (Williamstown, Mass.: Williams College, 1971b).

________, "The Theory of Capital Utilization and Idleness," *Journal of Economic Literature* 12 (Dec. 1974), 1301-1320.

Winston, Gordon C., and Thomas O. McCoy, "Investment and the Optimal Idleness of Capital," *Review of Economic Studies* 41 (July 1974), 419-428.