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ON THE MEASUREMENT OF CAPITAL UTILIZATION IN LESS DEVELOPED COUNTRIES[1]

By DAVID LIM

The shortage of physical capital is often seen as the crucial constraint to growth in less developed countries (LDCS). Thus many development plans are based on the aggregate Harrod4Doruar model where the growth of the economy is seen to depend only on the availability and the productivity of capital. A corollary of such a capital-centred approach to development is that the capital plant and machinery installed are utilized to the full. However, recent studies claim that capital under-utilization exists on a massive scale in manufacturing in LDCs and raise the possibility of a. paradox in capital usage in capital-scarce LDCs.[2] The purpose of this paper is to show that the extent of the under-utilization may have been exaggerated because of errors in the measurement of capital utilization.

I

Interest in the utilization of existing capital plant and machinery began in the Western industrially advanced countries where policy-makers were concerned with the Keynesian cyclical deviation of output from the desired level. A number of capital utilization measures have been devised, the most important of which are the McGraw Hill index, the Federal Reserve Board index, and the Wharton School index.[3] None of these measures is, however, appropriate for estimating the degree to which capital plant and machinery are utilized in LDCs. This is because they leave 'desired' output only loosely defined as the 'capacity' output obtainable, given the technology, under 'normal' conditions.[4] For example, both the McGraw-Hill and the Federal Reserve Board approaches allow firms to respond according to their own subjective definitions of full capacity, while the Wharton School measure assumes the quarterly peak output levels, through which trend lines are drawn, to be the full utilization output levels under 'normal' circumstances. As such there is not a standard and measurable denominator in the actual to planned output ratio. This absence is not serious when the indices are for use in studies which are concerned only with the difference between actual and planned utilization levels. The problem is much more important, however, when the emphasis is on the fundamentally different question of whether the planned level of utilization itself still leaves capital plant idle for much of the available time in capital-scarce LDCs. A completely new measure is necessary.

One of the earliest of the new methods is the shift-measure where the actual number of shifts worked per day is expressed as a percentage of the 'capacity' number of shifts per day. For example, in his study of manufacturing in Pakistan Winston took two and a half shifts to the 'capacity' level and found utilization to be around 14 per cent.[5] Another study of manufacturing in Pakistan, by Hogan, estimated the utilization to be '74 per cent on a one-shift basis, 29 per cent on a two-and-a-half»shift basis, and 25 per cent on a three-shift basis?[6]

Very low rates of capital utilization in LDCs were also obtained when the electricity-measure was used. Electricity is the main source of energy in modem industry so if we can find out how intensively the electric motors are worked then we will know approximately the intensity with which the machinery driven by the electric motors is being operated. The measure, U_e is given by

$$[E_{it}^{m}/(C_{it}^{m}\times 8{,}760/0{\cdot}90)]\times 100$$

where E_{it}^{m} is the actual consumption of electricity by electric motors in plant *i* in year *t* in kilowatt-hours, C_{it}^{m} the rated capacity of electric motors in plant *i* in year *t* in kilowatts, 8,760 the total number of hours in a year, and 0.90 the efficiency of electric motors on the assumption that 10 per cent of the power input into the electric motors is dissipated in the form of heat.[8] U_e was introduced by Foss in his study of capital utilization in US, manufacturing5 and was first used for studying the problem in a LDC by Kim and Kwon for South Korea[10]. The results show that capital utilization in both American and South Korean manufacturing is only around 25 per cent. While the results for the U.S.A., an industrially advanced country with abundant capital relative to labour, did not surprise many, those for South Korea, together with the findings based on the shift- measure in other LDCs, led to the belief that 'the chronic under-utilization of manufacturing capacity is as common among developing countries as urban unemployment'[2] and that there is a paradox in the use of capital resources in capital-scarce LDCs.

II

It is quite possible that much of the conventional wisdom on capital utilization in LDCS may have arisen because of errors in measuring capital utilization. Take the case of the shift-measure of capital utilization first. Presumably the question asked is the number of shifts worked per day, a day having been divided into three eight-hour shifts of day, night, and dawn, a practice that is commonly found in Western industrially rich countries. If, as is most likely to be the case in LDCs with high structural unemployment, weak trade unions, and extended family help, a shift lasts ten hours, then dividing it by the customary three shifts instead of the correct two point four shifts would result in the under-estimation of the utilization of the capital stock by 20 per cent. Another source of under-estimation lies in the complete emphasis of the shift-measure on the labour input. Suppose we have a plant with two sections, A and B, that are operated on different schedules. Section A is run on a one-shift, eight-hours-per-shift basis, while section B is operated continuously for 24 hours. Suppose further that section A is a very labour-intensive section and employs 97 per cent of the plant's total labour force while section B is a very capital- intensive part that can be operated by 1 per cent of the total labour force on each shift and which has to be operated on a three-shift basis as it is a continuous process. Under such circumstances, it is quite likely for the production manager to give the number of shifts worked per day as one. This would be the correct answer if the exercise is to find out the shift pattern of the majority of the plant's workers but would understate the extent to which the machinery of the plant is being utilized. The utilization of the plant's machinery is, of course, the point of the exercise and the under-estimation will be considerable if the Value of the fixed assets in section B is very much greater than that in section A.

Significant under-estimation of the level of capital utilization is also possible when the electricity-measure is used. First, certain sections of a plant may be operated by other prime movers such as steam engines and turbines, gasoline engines, and water Wheels. For example, the heavy machinery needed in the cane crushing and rolling sections in sugar milling in LDCs is sometimes driven by steam engines and turbines and not by electric power[12]. In the extreme case where the section of the plant driven by non-electric power has been imputed a rated capacity and included as part of C^m but its operation not entered as part of E^m then the source of the under-estimation is obvious. However, under-estimation is also present in the more realistic case where both the rated capacity and the operation of the section driven by non-electric power are not included for the calculation of U_e. An important reason for the preference for non-electric over electric power, when this is technologically feasible, is the cheapness of the former and under such conditions one may expect the section that is driven by non-electric power to be utilized more intensively than those sections driven by electric power. Thus, if, for example, U_e for the electrically driven section of the plant has been estimated as ten per cent and the utilization of the non-electrically driven section is, say, fifty per cent, then, given equal Weights, the utilization for the plant as a whole would be thirty per cent. Secondly, some pieces of machinery may depend more on direct heat than mechanical energy for most of their operation. Examples of such machinery include the kiln in cement and brick manufacturing, the furnace in metal industries, the dryer in tobacco production, and the oven in certain types of food manufacturing, where the machinery may be started by electric power but is then sustained by direct heat. The inclusion of the entire rated capacity of such machinery in C^m but only that part of the operation initiated by electric power in E^m would tend to understate the extent of utilization of the machinery and therefore of the entire plant. The use of non-electric power may not be important in Western industrially advanced countries but it may be widespread in LDCs where electric power is often unavailable or expensive and where solar energy is free and available on a predictable basis for almost all the year round. As such, the use of the electricity-measure will result in the under-estimation of the level of capital utilization in LDCs. Another factor is the lack of a proper system of weights when different sections of a plant with different capital values are operated differently. The section with the lower rated capacity but a higher utilization rate may also be the section with the higher capital value so that an unweighted average will give a wrong picture of the extent to which the capital plant and machinery is utilized.

The shortage of data on the composition of electricity consumption in LDCs and the subsequent use of the pattern in advanced countries as a proxy is another possible source of under-estimation.[13] Electricity is used in an industrial plant basically for lighting, driving motors, as a raw material in electro-chemical processes, and for heating and air-conditioning.[14] It is clear that the actual composition of electricity consumption varies with the industry-group but less clear that there can also be considerable differences for the same industry-group in temperate, developed countries and tropical, underdeveloped ones. In tropical LDCs the longer duration and the greater intensity of sunlight and the general inability of trade unions to demand better Working conditions (e.g. for air-conditioning) means that the percentage of electricity consumed in the form of lighting and cooling Will be smaller than the percentage consumed in the form of lighting and heating in temperate, developed countries. The use of ratios calculated for the temperate, developed countries in tropical under- developed ones Will therefore result in an artificially low figure for the consumption of electricity for driving motors (E^m) and for the level of capital utilization (U_e).

Technological factors can also lead to under-estimation. The electricity- measure fails to recognize that not all electricity-using capital is designed to be operated simultaneously. For example, the production of iron and steel, basically a continuous three-shift process, faces lengthy loading and unloading procedures between firings of the furnaces. Such periods of inactivity should not technically be classified as idle time for the furnaces. To do so against a rated wattage of the machinery which is set at the maxi- mum of 8,760 hours a year would be to under-state the level of capital utilization very substantially. At the same time the use of the electricity- measure does not allow for the fact that certain machinery in industries such as food, beverages, tobacco, and engineering and allied activities 'tend not to be used at constant power since the same piece of equipment might be used for several different processes'.[15] As C^m, the rated capacity of the electric motors, is set at the maximum Whatever the frequency and the type of use of the machinery, under-estimation of the utilization of the equipment is bound to result.[16]

III

Clearly a more reliable measure of capital utilization in LDCs is needed. One possibility is to use the Winston time-measure, U_t, which measures the number of hours the capital plant is utilized a year as a percentage of 8,760 hours, the total number of hours available in a year.[17] U, therefore associates, like the electricity-measure, 24 hours a day and 365 days a year with 'full' capacity, a not altogether satisfactory assumption as time has to be set aside for compulsory holidays and for repairs and maintenance. The latter stoppage is especially important as it varies between industries and between firms within the same industry if different techniques of production are being used.

However, U_t can still be useful as a first approximation of capital utilization, especially if adjustment is made for the intensity of use. Most machines can be operated at different speeds though there is probably only one 'optimal' speed which corresponds to the least tear and wear. Production managers tend naturally to operate their plants at such a rate and when their intentions are realized the intensity of use of the plants may be said to be 100 per cent and there is no need to adjust U_t. If, on the other hand, the actual speed of operation is only 50 per cent of the 'optimal' speed, then the intensity of use would be only 50 per cent and M has to be adjusted downward by half. The need therefore for an additional time—and-intensity measure of capital utilization, U_t, is clear.

Our discussion of the shift and the electricity measures shows the importance of using a proper weighting system if a reliable picture of the extent of capital usage is to be obtained. Thus in cases where different sections of a plant have different production schedules and therefore capital utilization rates, the share of each section in the total replacement value of the plant is used as the weight in calculating U_t and U_{ti}. for the plant as a whole.

It can be seen that U_t and U_{ti}. are fundamentally different from the McGraw-Hill-type measure of capital utilization (U_m) and a comparison between them brings out quite clearly the weakness of Um as a measure of capital utilization in LDCs. In Fig. 1 *MN* refers to the 24 hours available in a day to Firm A, MH_a the actual number of hours the plant is operated (6), and MH_p the number of hours of operation planned (12). The McGraw-Hill approach is concerned with MH_a/MH_p," while we are interested in MH_a/MN. U_m Would be 50 per cent and U_t only 25 per cent, so that the McGraw-Hill-type measure would overstate the extent of capital utilization when the emphasis, as should be the case when we are talking about usage in capital-scarce LDCs, is on the use to which a piece of machinery is put over time. Failure to distinguish between Um and U, can lead to the anomaly where one firm actually uses its plant less fully than another and yet has a higher reported utilization level. In Fig. 1 *ST* refers to the 24 hours available in a day to Firm B. The actual number of hours operated is 8 so that U_i, is 33.3 per cent. On the other hand, Firm A has a reported utilization rate of 50 per cent when U_m is used while it is actually running its plant for only 25 per cent of the total available time.

FIG. 1. Different measures of capital utilization.

It can also be argued that U_t and U_{ti}, produce more accurate estimates of the level of capital utilization in LDCs than either the shift or the electricity- measure. They, unlike the shift-measure, emphasize the capital and not the labour input both in the direction of the question asked and in the weighting system used. As such they will give a more accurate picture of capital usage. U_t and U_{ti} also do not suffer from most of the weaknesses of the electricity-measure. Firstly, the problem over the use of non-electric sources of energy does not arise. Secondly, the information used for calculating U_t and U_{ti} is non-technical and can therefore be easily given, so there is little need to use the data collected for developed countries as a substitute. Thirdly, the technological problem of the non-simultaneity of operation of all the sections of a plant is less important as the unit of time- measurement of a day is more likely to cover the technologically determined stoppages. The other technological problem of the multiplicity of processes for the same piece of equipment is not solved by using U_t, but the adjustment for the intensity of use does go a long way in circumventing it. The intensity of use of a piece of equipment is always raised in relation to the type of use and when there is a multiplicity of uses for the same piece of equipment the most important function in terms of time is always chosen.

IV

Table I shows the values of U_t and U_{ti} for 350 West Malaysian manufacturing establishments in 1972 at the 3-digit level of the Malaysian Industrial Classification (MIC), which is based on the post-1968 UN International Standard Industrial Classification (ISIC). The 350 establishments represented about 10 per cent of the total number of manufacturing establishments in West Malaysia in 1972 and were divided into the twenty- eight industry-groups at the 3-digit MIC/ISIC level in accordance with the share of each industry-group in the total value added of the manufacturing sector. This rule was followed Whenever it was necessary to move down to the 4- or the 5-digit MIC/ISIC level. The only constraint imposed was that each industry-group must have at least three establishments in order to

TABLE I

Capital utilization in West Malaysian manufacturing in 1972: 3—digit MIC/ISIC

MIC/ ISIC	Description	No. of Est.	U_t				U_{ti}			
			K	*E*	*VA*	*UW*	*K*	*E*	*VA*	*UW*
311	Food	42	62·5	62·5	63·6	50·5	58·0	57·7	59·6	46·4
312	Other food	9	52·1	54·8	60·5	48·8	46·2	50·7	55·8	43·4
313	Beverages	10	64·5	63·0	63·5	46·8	61·0	59·3	59·6	44·7
314	Tobacco	13	50·4	48·9	50·8	39·8	49·5	44·7	49·9	35·7
321	Textiles	18	84·9	90·2	88·0	79·4	80·4	84·8	78·7	73·7
322	Wearing apparel	4	44·8	40·2	40·7	46·7	44·8	40·2	40·7	46·7
323	Leather and leather products	3	26·4	26·3	26·2	26·5	18·7	20·8	18·9	20·4
324	Footwear	3	28·6	45·9	29·0	45·3	24·4	35·2	26·9	34·5
331	Wood and rattan products	31	53·1	58·2	52·4	44·6	45·9	49·0	47·0	40·1
332	Furniture	3	46·2	37·0	36·3	36·4	44·4	33·5	32·6	32·7
341	Paper and paper products	4	55·3	57·5	56·1	59·1	47·3	50·7	47·4	51·9
342	Printing and publishing	20	53·5	60·8	73·0	44·7	52·7	59·2	71·8	42·2
351	Industrial chemicals	7	86·4	78·0	57·5	64·9	84·2	73·2	56·5	61·8
352	Other chemical products	18	42·5	44·4	51·2	35·8	38·6	39·7	45·8	33·6
353	Petroleum and coal products	5	87·1	85·0	90·1	82·2	83·9	82·3	87·6	78·1
355	Rubber products	48	78·2	71·4	64·7	70·7	72·5	67·2	61·7	64·1
356	Plastic products	10	73·3	76·5	77·6	71·4	67·8	72·1	73·6	66·2
361	Pottery, china, etc.	3	36·0	34·4	35·9	30·7	33·4	32·3	33·3	29·8
362	Glass and glass products	3	94·0	93·5	96·8	72·4	92·8	92·3	96·1	71·5
369	Non-metallic mineral products	23	90·7	78·5	90·6	65·5	87·7	74·5	86·9	61·4
371	Iron and steel products	11	89·3	77·8	76·8	57·6	80·4	70·0	69·3	51·5
372	Non-ferrous metal products	3	87·6	82·5	81·0	69·0	86·1	81·3	78·2	67·7
381	Fabricated metal products	16	57·5	50·4	53·7	47·0	43·8	39·5	40·7	39·3
382	Machinery	12	32·1	39·3	35·3	35·9	25·1	32·6	28·1	30·4
383	Electrical machinery	13	70·8	71·3	63·3	62·7	70·0	71·0	62·7	61·5
384	Transport equipment	12	34·7	40·1	32·9	34·1	33·4	37·7	31·3	31·2
385	Professional equipment, etc.	3	75·7	76·4	75·4	66·9	65·0	64·9	65·0	58·4
390	Other manufacturing	3	84·9	82·9	82·1	82·1	70·1	70·1	70·3	71·3
3	Total manufacturing	350	74·9	65·9	64·7	54·6	70·7	61·5	60·6	50·1
	Standard deviation		26·1	22·5	24·6	24·2	27·2	23·7	25·6	25·2

NOTE: Columns are weighted by K the replacement value of the fixed assets of the establishment, E the number of employees, and VA the value added while UW stands for unweighted.

obtain meaningful results for the minor industries. The selection at the establishment level was carried out randomly.

Data on U_t, U_{ti}, and other variables were collected by in-depth interviews with production-managers and when necessary they were supplemented by data collected from records submitted to the Registry of Companies. Four different values for each of the two measures of capital utilization were calculated. These are the values weighted by the replacement value of the fixed assets (*K*), the number of employees (*E*), and the value added (*VA*), and the unweighted value (*UW*).[18] A number of interesting observations can be made. The first is that the values of U_t and U_{ti} weighted by *K* tend to be higher than those weighted by *E* and *VA* and those that are not weighted. For example, the values of *U*, when weighted by *E* and *VA* and when unweighted for the manufacturing sector as a whole are 65.9, 64.7, and 54.6 respectively, compared with 74.9 when weighted by *K*. This suggests that establishments with larger fixed assets per employee tend to utilize their plant and machinery longer than those with smaller fixed assets per employee. It also brings out the importance of using the proper Weighting system—in this case, *K*—if an accurate picture of the utilization of capital stock is required.

Secondly, there are very considerable differences in the levels of U_t and U_{ti}, among the twenty-eight industry-groups. Some industry-groups, such as the manufacture of leather and leather products, footwear, other chemical products, pottery, china and earthenware, machinery, and trans- port equipment, with Values for which are less than 40, may be said to have low utilization rates, While others such as the manufacture of textiles, industrial chemicals, petroleum and coal products, rubber products, glass and glass products, non-metallic mineral products, iron and steel products, non-ferrous metal products, and electrical machinery, with values of U_{ti}, that are greater than 70, may be called the high utilization industries.

Thirdly, and most importantly for our purpose, the values of U_t and U_{ti} do not suggest the existence of capital under-utilization on the massive scale that is generally believed to characterize the use of capital stock in LDCs. U_t weighted by *K*, *E*, and *VA* for the manufacturing sector as a whole are 74.9, 65.9, and 64.7 respectively, while the unweighted value is 54.6. The corresponding values for U_{ti}, are 70.7, 61.5, 60.6, and 50.1. On the assumption that a shift lasts 8 hours and that there are sixty compulsory holidays a year, the values of M which correspond to the one-, two-, and three-shift levels of operation are 27.8, 55.7, and 83.6 respectively. The value of 74.9 for U_t, when it is weighted by capital therefore suggests that the capital plant and machinery of the manufacturing sector as a whole were operated at nearly three shifts a day in 1972.[18] This level of utilization of the capital stock is very much higher than the level generally believed to be typical of the level of capital utilization in manufacturing in LD Cs. Even if we were to assume equal weights for the establishments whether they are large or small the value obtained for U_t, 54.6, still indicates a level of operation that is close to two shifts a day and way beyond what is expected.

The same conclusion is reached if we examine the frequency and the percentage frequency distributions of the 350 establishments by U_t, and U_{ti}. It can be seen from Table II that when U_t, is used as the measure of capital utilization 31.6 per cent of the 350 establishments operated one shift or less a day, 29.5 per cent operated between one and two shifts, and 38.9 per cent operated between two and three shifts. These figures hardly support the conventional wisdom about capital usage in manufacturing in LDCs.

TABLE II

Distribution of manufacturing establishments by U_t and U_{ti}

	U_t		U_{ti}	
Range	*Frequency*	*Percentage frequency*	*Frequency*	*Percentage frequency*
0–5	5	1·4	2	0·6
6–10	0	0	1	0·3
11–15	0	0	2	0·6
16–20	4	1·1	21	6·0
21–25	27	7·7	46	13·1
26–30	75	21·4	51	14·6
31–35	27	7·7	28	8·0
36–40	13	3·7	12	3·4
41–45	9	2·6	15	4·3
46–50	16	4·6	19	5·4
51–55	28	8·0	18	5·1
56–60	10	2·9	17	4·9
61–65	10	2·9	10	2·9
66–70	8	2·3	7	2·0
71–75	16	4·6	12	3·4
76–80	13	3·7	25	7·1
81–85	20	5·7	18	5·1
86–90	9	2·6	12	3·4
91–95	17	4·9	9	2·6
96–100	43	12·3	25	7·1
Total	350	100·0	350	100·0

Even if we were to adjust for the intensity of use, it can be seen that 33.7 per cent of the 350 establishments operated between two and three shifts per day, while 31.1 per cent operated between one and two shifts. Again these figures suggest a level of capital utilization that is considerably higher than is generally expected in manufacturing in LDCs.

V

It is possible that the use of U_t, the time-measure, can produce exaggerated values for the level of capital utilization. Suppose we have two plants, A and B, with exactly the same rated capacity, C^m. Plant A runs its equipment at a certain speed for 12 hours a day While Plant B operates its equipment at twice that speed for the same length of time. On the assumption of constant returns to scale in the use of electric power, E_A^m, the consumption of electricity by the electric motors in Plant A, would be half of E_B^m, the consumption of electricity by the electric motors in Plant B. U_E for Plant B would be given by (Eg/0m)Z which is, say, equal to 40 per cent and IL for Plant A by $(E_B^m/C^M)Z$ Which will therefore be equal to 20 per cent.[19] On the other hand, if the time-measure, U_t, had been used and a day taken to be the period concerned, then the capital utilization of both plants would be the same at 50 per cent. One consequence of this would be that Plant A is credited with a 20 per cent utilization rate with the electricity-measure and a 50 per cent utilization rate with the time-measure for exactly the same work-load.

It is therefore possible that the relatively high values obtained for U_t for West Malaysian manufacturing are misleadingly high. However, this is unlikely as the use of U_{ti}, which adjusts U_t, for the intensity of use and which Would therefore have circumvented the measurement problem, also produces relatively high Values. Its values when weighted by *K*, *E*, and *VA* for the manufacturing sector as a whole are 70.7, 61.5, and 60.6 respectively, while the unweighted value is 50.1. It is more likely that the electricity-measure, like the shift-measure, under-estimates the real level of capital utilization and that a more accurate picture would have been given by the time and the time-and-intensity measures.

The Values obtained for U_t, and U_{ti} in this paper do not contradict the current view that capital-scarce LDCs paradoxically under-utilize their capital plant and machinery. Despite the relatively high over-all capital utilization, capital utilization when adjusted for the intensity of use, U_{ti}, is less than 50 in thirteen of the twenty-eight industry-groups when weighted by capital. This suggests a substantial opportunity for increasing utilization to at least the full two-shift level and thus for increasing employment and output without the necessity of substantial increases in investment. However, the level of capital utilization for the West Malaysian manufacturing sector is certainly much higher than might be expected from a reading of the existing literature on capital utilization in manufacturing in LDCs. One suspects that the extremely low levels of capital utilization obtained by previous studies may be due to errors in the measurement of capital utilization in LDCs.

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2. See Gordan Winston, 'Capital utilization in economic development. Economic Journal, Mar. 1971 ; Y. C. Kim and J. K. Kwon, Capital Utilization in Korean Manufacturing, 1962-71: Its Level, Trend and Structure: A Final Report submitted to the Agency for International Development, May 1973; and I. Little, T. Scitovsky, and M. Scott, Industry and Trade in Some Developing Conutries, London, Oxford University Press, 1970, chapter 3.
3. See the fifth Annual McGraw-Hill Survey, McGraw -Hill Publications Company. Economics Department, Apr. 1972; Frank de Leeuw, 'A revised index of manufacturing capacity', Federal Reserve Bulletin, Nov. 1966. pp. 1605-15; and Lawrence R. Klein and Robert Sumners, The Wharton Index of Capacity University of Pennsylvania, University or Pennsylvania, Wharton School of Finance and Commerce. Economics Research Unit. 1966.
4. See George L. Parry, 'Capacity in manufacturing', and Lawrence R. Klein and Virginia Long, 'Capacity utilisation: concept, measurement and recent estimates', in Bookings Paper on Economic Activity. No. 3, 1973.
5. Winston, op. cit.
6. W. P. Hogan, 'Capacity creation and utilisation in Pakistan', Australian Economic
7. Papers, June 1968.
8. The adjustment can also be made by reducing the consumption of electric power (the numerator) by 10 per cent,
9. Murray F. Foss, 'The utilisation of capital Equipment : postwar compared with prewar', Survey of Current Business, June 1963. Foss's method was used by D. W. Jorgenson and Z. Griliches, 'The explanation of productivity change'. Review of Economic Studies, July 1967.
10. Kim and Kwon, op. cit.
11. Little, Scitovsky and Scott, op. cit, p.93
12. This is certainly the case in sugar milling in the Philippines. See R. Bautista, Industrial Capital Utilisation in the Philippines, mimeo., 1974.
13. Given the absence of the tradition and the machinery for data collection in LDCs, information on the composition of electricity consumption in LDCs is extremely difficult to obtain. What many researchers using the electricity-measure to estimate capital utilization in LDCs do is to make use of the detailed data collected by Foss on the composition of electricity in U.S. manufacturing. see Kim and Kwon, op. cit., for an example of this.
14. The most important use is for the driving of motors. The exception is the non-ferrous metal industry where the third use is the most important. The important point to note here is the consumption of electricity for lighting end heating/cooling is not an insignificant item.
15. Devin F. Heathfield, 'The measurement of capital usage using electricity consumption data for the U.K.', Journal of the Royal Statistical Society A, Vol. 135, part 2, 1972. p. 211.
16. This tendency is present, of course. whether U_e, is used in developed or less developed countries
17. See Gordon Winston, "The theory of capital utilization and idleness', Journal of Economic Literature, Dec. 1974, p.1310.

18. Because of the use of capital as the weight for calculating U_t between industry-groups, establishments, and sections, this does not mean, of course, that every industry-group, establishment, or section operated nearly three shifts a day.
19. Z is a constant that is given by [100/(8,760/0.90)].