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MEASUREMENT OF CAPACITY
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ABSTRACT: The paper introduces a new simple method for calculating capacity utilization rate. First, a few most commonly used methods are overviewed. These are found too elaborate or unreliable when capacity utilization rate is measured on industry level. The new method is based on fixed capital stock. Potential production is calculated from the fixed capital stock by multiplying it by production/capital stock ratio. Earlier employed similar methods use a trend value for the production/capital stock value. The new method employs the highest previously observed value of the ratio to calculate full capacity production.

KEY WORDS: capacity utilization rate, production capacity

CONTENTS

1. INTRODUCTION

1.1. Aim of the study

The rate of capacity utilization is a commonly used concept when economic matters are discussed or evaluated making it important to specify exact measurements on capacity utilization. This paper introduces a new method of measurement developed to facilitate the short and medium-term forecasts of ETLA. Two main targets were set for the new method: it should be reasonably reliable and it should be easy to use and comprehend.

1.2. The concept of capacity

The difficulties arising in the measurement of capacity utilization are due to the conceptialization of capacity, which has many different definitions. When agreement on the concept of capacity is reached, the rate of capacity utilization can be calculated simply by dividing actual production by capacity production.

There are two main points of departure for laying down a definition of production capacity, the first being technical and the other economic. In technical definitions, always at least one fixed factor of

production sets an upper limit on output. In economic definitions the limiting factor for production is generated from the parameters of the production function or the cost function. The result is an optimum level of production in the sense of cost minimization on profit maximization.

Technical production capacity can be defined as the maximum level of production per time unit when available technical resources are given. While this definition may appear to be sound at first glance, production capacity is not precisely defined in an exact enough manner. In a closer look it becomes apparent that capacity as defined above might be vague. For example in many industries in which the technology used is simple enough, obsolete production machinery may be available that is normally not used, but can be taken into use for production in special circumstances. One such circumstance might be an unexpected rise in the prices of the goods produced.

Another factor leading to vagueness in capacity as defined above is the ability of firms to adjust the hours of work. A factory which is normally run on only one shift can easily treble its production capacity by resorting to three daily working shifts instead of one. Of course this is not readily achieved in full, but well illustrates the

latitude of a loosely defined technical capacity concept.

As we have already observed, production capacity can be defined from the economic point of view as the optimal level of production at which costs are minimized or profits maximized. In this way defined production capacity is also flexible. The main factors affecting economic production capacity are the prices of produced goods and the prices of factors of production. This also stands as the main drawback to the economic definition of production capacity; when prices change the level of production that was earlier considered as the capacity limit can easily be exceeded.

2. AN OVERVIEW OF SOME FREQUENTLY USED METHODS

The methods for studying capacity utilization can be roughly divided into two groups. In first group are various survey methods, and in the other methods exploiting data on production and inputs collected for other purposes, often for official statistics. The following discussion is partly based on an article by Cristiano (1981), mentioned in the list of references.

2.1. Survey methods

Survey methods are based on questionaires that firms are requested to fill in. The questions asked will determine the nature of data on capacity utilization recieved. For instance a question might directly concern the capacity utilization rate or it might only seek to find out whether or not the firm does have spare capacity. This latter method is used in the Suhdannebarometri published by the Confederation of Finnish Industries. In this survey firms are asked if they have unused capacity at the time of completing the questionaire and additionally if unused capacity is anticipated in six-months time. Some other questions concerning capacity are also posed, such as a question pertaining to anticipated production bottlenecks (Suhdannebarometri/1 (1986) p. 27).

Numerous problems are associated with the survey methods. Questions must be simple in order to maintain a high response rate and to obtain answers quickly. Mere "yes" or "no" answer should be adequate, as in the Suhdannebarometri questionnaire. If the question directly concerns the rate of capacity utilization, it would involve calculations in answering the questionnaire. As the effort called for to fill in the questionnaire grows, the responserate to questionnaires declines. Risk also exists that figures required for overly difficult questions are not calculated but guessed.

Another difficulty of the survey method is that the definition of the capacity concept is left to the person filling in the questionaire. Precise instructions for answering do not necessarily help, as they can be ignored. As it appears, there is no reason to take the results of the survey method as the basis to which capacity utilization rates estimated with other methods should be compared.

2.2. Non-survey methods

Non-survey methods of estimating capacity utilization rate usually exploit official statistics or other previously collected data on production and inputs. The rate of

capacity utilization is estimated from this data by using more or less sophisticated econometric methods. This spectrum ranges from slide rule applications to frontier production function estimations. The requirements on data vary from a mere time series on production to detailed information on the use of inputs, prices, rate of capacity utilization and productivity. Some of the methods are applicable only on the aggregate level of the whole economy, while others have practically no limitations on the level of disaggregation.

2.2.1. Production function method

In the production function method the potential production is estimated by placing in a formerly estimated production function the input volumes available for production. If the aim is to estimate the capacity utilization rate this method leads to an dead end because in most cases the utilization rate of inputs is already sufficiently good as an estimate of capacity utilization and the advantage of production function calculations is low. The production function method thus does not fully correspond to the aims of this study.

2.2.2. Wharton method

In the past the Wharton method was a very popular way for estimating the capacity utilization rate. It is originally based on graphic analysis of the production time series, but also computerized procedures have been introduced. In this method the production curve is drawn on semilogarithmic paper. Then the productuon peaks are connected with a line from peak to peak. Subjective considerations must often be used to figure out which production peaks actually represent full capacity production. The capacity utilization rate is calculated through the vertical distance between the capacity line and the actual production line. Mathematically the capacity production between production peaks 0 and 1 can be expressed by formula

$$Q_c(t) = Q_c(t(p_0)) + (t-t(p_0)) * (Q(t(p_1)) - Q(t(p_0))) / (t(p_1) - t(p_0))$$

where t(p) refers to the production peaks which are assumed to represent full capacity production. The capacity utilization rate is calculated simply by dividing actual production by capacity production.

With the Wharton method the capacity growth is not related

to the increase of the inputs available for production. This problem becomes critical when the production capacity is estimated after the last observed production peak. Usually the problem is solved by assuming that after the last production peak capacity is growing at the same rate as it did between the last two observed production peaks. The disadvantage of this assumption is that when a new production peak is observed the history of the capacity utilization rate will also change from the previous production peak onwards.

The production function method described above makes use of information on all inputs. The Wharton method, however, does not utilize the information on inputs use at all. Between these two methods can be found numerous other methods in which some of the features of both of these extremes are present.

2.2.3. Okun's method

The so-called Okun's method is based on an investigation of the labor input. The capacity utilization rate is measured by the unemployment rate. This method has been used on the aggregate level for the whole economy. For separate industries its application is more difficult. On the aggregate level the unemployed labor clearly

represents unused capacity. In a single industry the matter is more complicated. Unemployment is most usual among the less-educated unskilled labor force. The links of such labor to the industry in which it was last employed in are weak. The unskilled labor force may seek new employment in any other industry as well, so it is not exclusively for the service of the industry from which it was laid off. Another complication connected with this method is that at same time when there is unemployed unskilled labor in an industry the lack of skilled workers may form a botleneck for production in the same branch. In conclusion it may be assumed that Okun's method is not an appropriate one for industry-level capacity utilization estimation.

2.2.4. Methods based on fixed capital stock

Capacity utilization measurement methods based on fixed capital stock have been presented by Panic (1978) and Valppu (1984) among others. In these methods potential production is assumed to be a multiplicative of fixed capital stock. The ratio between potential production and fixed capital stock is supposed to change linearly in time. This linear relation is arrived at by estimating a regression equation where time is the explanatory variable. The result of the regression is a straight line

on a plane, in which the x-axis is time and the y-axis is the ratio of production to fixed capital stock. Mathematically this can be expressed

$$k^* = a + b * t$$

where k^* = production/capital ratio and b is the rate of change of the ratio. To calculate the potential production the constant term a is raised so that the line is above the actual observed time series of the production/capital ratio, just tangent to it at one or more points.

The production/capital ratio obtained with this procedure is assumed to be the ratio corresponding to conditions at full capacity utilization. The value obtained by the formula is used to calculate the production capacity from the known capital stock. The production/capital ratio can easily be extrapolated from this and also allows calculation of capacity utilization forecasts, if figures for capital stock are available.

As such, the method used by Panic and Valppu is also easily applicable on the disaggregated industry level. Certain important factors can work to reduce the reliability of this method, however. Firstly, the

official statistics on capital stock are not as reliable as most other statistics even though they are improving. Secondly, the assumption of the method that the rate of change in the production/capital ratio is constant might be criticized. It can be argued that the investment volume has a significant effect on the production/capital ratio. For practical purposes the main disadvantage of these methods is that every time a new observation of production or capital stock is obtained, the parameters defining the full capacity production/capital ratio are changed too. This leads to a situation where the whole time series of the capacity utilization rate changes each time new data is obtained.

A common feature is found in almost all methods discussed above: they all produce a smoothly progressing time series for production capacity. This becomes clear, when a closer look is taken at the concept of capacity. Production capacity should be defined as a factor seting an upper limit on production. If this factor could be changed rapidly production would not be limited.

The smoothness of the time series of production capacity has one convenient consequence for the calculation of the capacity utilization rate: whatever capacity concept is used, the changes in the capacity utilization rate are

more or less the same. This viewpoint allowes the conclusion to be drawn that if the main object of interest is the change in the rate of capacity utilization, a suitable concept of production capacity can be freely select, with an eye for unwieldy, easy use in practical purposes. This has been the main principle in developing a new method for the measurement of capacity utilization presented in the next chapter.

3. AN ALTERNATIVE METHOD BASED ON FIXED CAPITAL STOCK

The main aims in developing the new method to estimate capacity utilization have been ease of use, sufficient comparability of results, availability of data also on the industrial level, reliability and the potential use of the method for prediction purposes. In addition the method should be understandable also to laymen.

Fixed capital stock was taken as the starting point of the production capacity estimate, which will limit the resulting capacity utilization indicator to serve mainly as a capital stock utilization indicator. However, when the weak link between industry and its labor force is taken into account, little room is left for other kinds of indicators.

From this starting point, it would have been natural to continue towards the type of capacity utilization measures used by Panic and Valppu. This approach was abandoned, however . Firstly, these methods require a new estimation of the whole time series for the capacity utilization rate each time a new observation is added to the data, as was previously discussed. The instability of the time series would have become a problem because the series is to be published at least twice a year in conjunction with ETLAs

forecasts.

Secondly, an unsolved problem remains in the predictive use of the method of Panic and Valppu. It is not at all clear whether or not new estimations of the capacity series should be performed each time the predictions of capital stock and production change.

The results of the method based on production/capital ratio trend were also not satisfactory. After several runs it was evident that it would not be realistic to use the same trend growth coefficient both for the sixties, which represented a long period of steady growth, and for the seventies, which encompassed the oil crisis that broke the growth path. Of course breaking the trend in the estimations would have also been possible, for instance by using dummy variables, but this would have made the estimation technique even more difficult to use. In addition a criterion would have been required to select an appropriate year for break the trend.

The new method was developed by eliminating the weak points in the trend method. The method to estimate the production/capital ratio was modified so that the use of regression analysis was no longer necessary. At the same time a procedure was created to prevent the data of a

particular year from influencing the estimates of the capacity utilization rate refering to previous years. In other words, a new observation or a change in the data of the last observation year leaves the rest of the history of the capacity utilization rate unaltered. The assumption of the steady growth of the production/capital ratio could also be ignored when using the new method.

In short, the new method can be described as follows. The estimate of production capacity is calculated by multiplying the capital stock with the largest thus far observed production/capital ratio. Mathematically this can be expressed

$$pk_t = \max\ (Q_i\ /\ K_i)\ ,\ i = 1,\ldots,t$$

and

$$Q^c_t = pk_t * K_t$$

Further more, the capacity utilization rate can be calculated with the formula

$$CU_t = 100 * Q_t\ /\ Q^c_t$$

In other words, each time actual production exceeds the

capacity production calculated with the old production/capital ratio, the capacity utilization rate of a particular year is assigned the value of 100 and the observed production/capital ratio is used to calculate production capacity in the following years.

This procedure is extremely simple and can be easily computerized with calculations performed using a spreadsheet program. The varables in the above formulas correspond to the data as follows:

Q	value added at 1980 prices
K	gross fixed capital stock at 1980 prices
pk	production/capital ratio
Q^c	production capacity in value-added terms at 1980 prices
CU	capacity utilization rate

Value added is used as a production variable as it is most commonly used for such purposes and is free of such problems as double accounting. It is also readily available. Gross fixed capital stock is used as a capital stock variable because it is the best available proxy for measuring the volume of capital services that fixed capital stock is producing.

4. THE RESULTS OF THE ALTERNATIVE METHOD

The new method was applied to measure capacity utilization in the manufacturing industry. The data used and the results are presented in the appendix table. The results are also shown graphically in the two figures in the appendix. It should be poined out that the method produces rational results only after the first full capacity production peak is reached. In this case the first peak year appears to be 1962. The results obtained are not directly comparable with the results estimated with the trend method of Panic and Valppu. Most important difference is that the new method usually yields more than one full capacity year.

When using the new method, the production/capital ratio does not change after the last peak year, unless a new peak is achieved. Thus the ratio can remain constant for several years, even though it is known to rise when new, more effective investment goods are introduced into the production process. This usually leads to an underestimation of production capacity and correspondingly to an overestimation of the capacity utilization rate. In any case, if full capacity years occur with sufficient frequency, the error resulting from the constant production/capital ratio will not become too large.

A second disadvantage of the new method is that it cannot cope with a decreasing production/capital ratio. This drawback might be considered minor, because the hypothesis that investment goods a continually becoming more effective or that their effectivity at least does not decrease is commonly accepted. Statistical error, for example in the form of investment goods included in the capital stoch even though they have become obsolete, lies beyond the scope of this study. The occurence of errors of this kind is clearly observable in the data and calculations presented in the appendix. The production/capital ratio has remained constant since the beginning of the seventies because considerable amount of production capacity became obsolete when relative prices changed as a result of the oil crisis. The obsolete capacity of the time period ranging from the mid-seventies into the eightiesy complicates comparisons of capacity utilization rate figures for this period to those of earlier years. If it is supposed that the capacity that became obsolete in the seventies will never again be taken into use, a more accurate capacity utilization rate can be obtained if a new starting year for the calculations is choosen somewhere in the late seventies. In this case, the capacity utilization rate series from the sixties to the early seventies would be lost, however.

The method presented here can be directly applied at any aggregation level, the only condition being that the required data is available and is reliable enough. This is not always the case in the smaller subbranches of the manufacturing industry. To date the method has been applied only on the level of the entire manufacturing industry.

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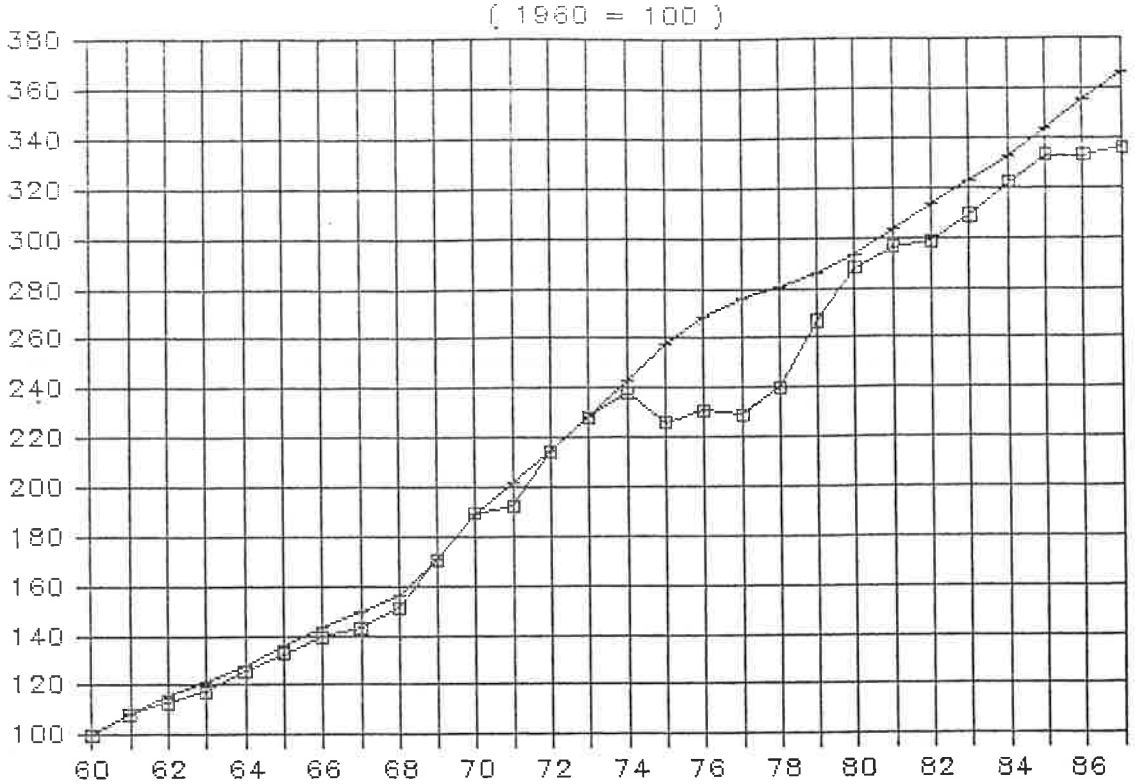
DATA AND RESULTS OF CALCULATIONS FOR MANUFACTURING INDUSTRY

	GFCS80P	GFCF80P	DGFCS80P	DRATE	MRPC	VALAD80P	CAP	PRODI	CAPI	RCAPU
60	54718	4564			0.307	16779	16779	100.0	100.0	100.0
61	59019	6013	1712	0.031	0.308	18202	18202	108.5	108.5	100.0
62	62901	5610	1728	0.029	0.308	18953	19399	113.0	115.6	97.7
63	66018	4846	1729	0.027	0.308	19714	20361	117.5	121.3	96.8
64	69746	5445	1717	0.026	0.308	21073	21510	125.6	128.2	98.0
65	73829	5795	1712	0.025	0.308	22279	22770	132.8	135.7	97.8
66	78193	6100	1736	0.024	0.308	23389	24115	139.4	143.7	97.0
67	81599	5206	1800	0.023	0.308	24045	25166	143.3	150.0	95.5
68	84882	5187	1904	0.023	0.308	25387	26178	151.3	156.0	97.0
69	89136	6297	2043	0.024	0.321	28649	28649	170.7	170.7	100.0
70	95266	8329	2199	0.025	0.334	31784	31784	189.4	189.4	100.0
71	101831	8930	2365	0.025	0.334	32310	33974	192.6	202.5	95.1
72	107754	8460	2537	0.025	0.334	35962	35962	214.3	214.3	100.0
73	112754	7716	2716	0.025	0.340	38282	38282	228.2	228.2	100.0
74	120046	10221	2929	0.026	0.340	39986	40758	238.3	242.9	98.1
75	127277	10414	3183	0.027	0.340	37937	43213	226.1	257.5	87.8
76	132979	9174	3472	0.027	0.340	38768	45149	231.1	269.1	85.9
77	136675	7481	3785	0.028	0.340	38433	46404	229.1	276.6	82.8
78	138738	6158	4095	0.030	0.340	40289	47104	240.1	280.7	85.5
79	141228	6868	4378	0.032	0.340	44791	47949	266.9	285.8	93.4
80	145183	8517	4562	0.032	0.340	48408	49292	288.5	293.8	98.2
81	150174	9660	4669	0.032	0.340	49740	50987	296.4	303.9	97.6
82	155158	9733	4749	0.032	0.340	50150	52679	298.9	314.0	95.2
83	159719	9415	4854	0.031	0.340	51864	54227	309.1	323.2	95.6
84	164377	9663	5005	0.031	0.340	54040	55809	322.1	332.6	96.8
85	169726	10569	5220	0.032	0.340	55870	57625	333.0	343.4	97.0
86	175706	11203	5223	0.031	0.340	55870	59655	333.0	355.5	93.7
87	181217	10979	5468	0.031	0.340	56429	61526	336.3	366.7	91.7

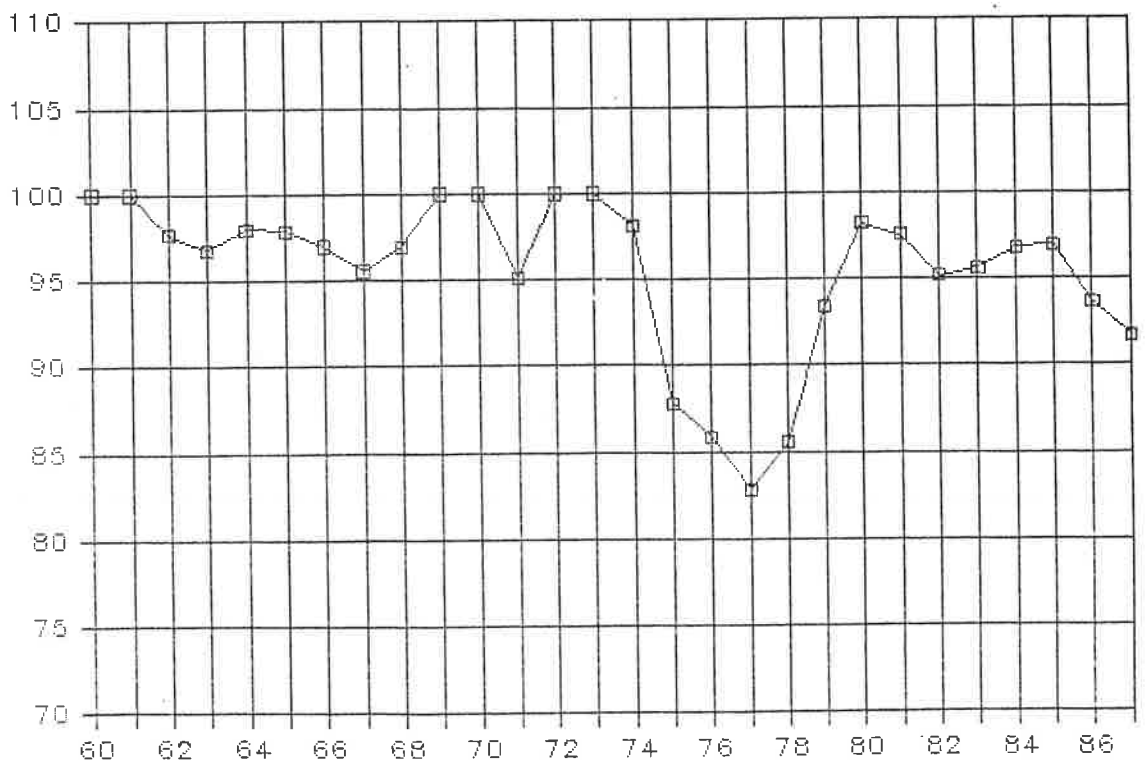
GFCS80P	Gross fixed capital stock in 1980 prices
GFCF80P	Gross fixed capital formation in 1980 prices
DGFCS80P	Depreciation from gross fixed capital stock in 1980 prices
DRATE	Depreciation rate of gross fixed capital stock
MRPC	Maximum observed ratio of production to capital stock
VALAD80P	Production (value added) in 1980 prices
CAP	Capacity production in 1980 prices
PRODI	Index of production (base year 1960)
CAPI	Index of capacity production (base year 1960)
RCAPU	Rate of capacity utilization

ACTUAL AND POTENTIAL PRODUCTION

(1960 = 100)



CAPACITY UTILIZATION RATE



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