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CONSISTENCY IN MEASURING CAPACITY UTILIZATION

BY INDUSTRIAL SURVEYS *

by

Patricio Millán

The determination of the rate of capacity utilization or of the unused capacity is a difficult and complex problem. A common method in developed and developing countries is that of industrial surveys, in which the managers of the different plants are asked directly about capacity and its utilization. This paper provides some tests to check those answers for consistency. When the tests point out biases, the analyst of the industrial survey should adjust the figures given by the managers.

Section I examines alternative definitions and methods to measure the degree of capacity utilization. The conclusions are that an appropriate definition must include a concept of optimality in the use of the different factors of production and that industrial surveys are still the most adequate technique to be used. Section II describes in general terms how the industrial survey should handle the problem of optimality in the use of the factors of production. An Appendix to the paper suggests the specific questions that could be included in the survey if a relatively objective and comparable measure of capacity utilization is desired.

Section III presents the tests to check the consistency of the answers to the industrial survey in the context of some appropriate questions. Section IV applies the consistency tests to data of the industrial survey of Colombia by the Fundacion para la Educacion Superior y el Desarrollo (FEDESARROLLO) and finds a bias towards overestimation of capacity utilization.

* This is a revised version of a paper presented to the Conference on Capacity Utilization in Industry, Lima, Peru, May 13-16, 1973. The title of the original paper was "Comentarios sobre la Utilizacion de Capacidad en la Encuesta Industrial de Fedesarrollo". The author thanks Daniel M. Schydrowsky for his suggestions and comments on the earlier version of the paper.

I

Alternative Definitions and Methods to Measure Capacity

The difficulties in determining the rate of capacity utilization arise from the fact that there are no agreed-upon definitions of it and from the specific problems of measuring any definition adopted.

Essentially, the degree of capacity utilization involves a comparison between a certain maximum rate of production - full capacity utilization - and the actual situation over a period of time. Both rates must be defined and determined.

Most firms produce more than one type of commodity and therefore they must aggregate to find out a single rate of production. Besides the general aggregation problems, for our purposes it is important to note that a change in the composition of output can alter the rate of capacity utilization even if everything else remains constant. Presumably a shoe factory could produce more physical units of shoes with the same plant, machinery and workers if all the shoes were of the same model.

In the real world the actual composition of output can be different from the "ideal" one. This may be due to differences between private and social prices or to non-optimum behavior of entrepreneurs.^{1/} In those circumstances, should we compare actual output with the maximum of the same composition or with the maximum of the ideal composition?

^{1/} Even if entrepreneurs maximize profits, it is their subjective profit function which includes some elements that society will not take into account. Also their perception of the actual alternatives may not be adequate for optimal behavior.

The aggregation of the different commodities produced by a firm is done using prices. When prices are not fixed in the relevant period there are various measures of aggregate production. More important than this ambiguity is the fact that the actual composition of output and the ideal one are changing in response to the fluctuations in relative prices. As noted above, depending on what composition of output is used, we have different measures of capacity utilization.

Assuming that there is only one type of output and that prices do not change, actual production will be unambiguously defined in physical or monetary terms. But there are still problems in defining maximum production. When determining the degree of capacity utilization the only factor that must be kept fixed is the stock of capital (plant, machinery and equipment) owned by the firm. Therefore the maximum production will differ from actual production if we allow a change in any of the following factors:

1. Hours worked per day: the maximum production will be different if it is calculated over 8, 16 or 24 hours per day (one, two or three shifts of 8 hours) or if overtime is allowed over the basic shifts.
2. Days worked per accounting period: the maximum production will depend on the number of days defined as standard for the month or year if a monthly or annual rate of capacity utilization is being calculated.

3. Number of workers: the maximum production will depend on our assumption about increases in the labor force. Whenever the marginal product of labor is positive, an increase in the number of workers will increase production.

4. Quality of the labor force: the maximum production will differ from the actual if we allow changes in the skills and training of the labor force.

5. Methods of production: the maximum production will differ from the actual if we allow for changes in the location of machineries, the speed at which they are run, the organization of enterprise, the technology ^{2/} or in other characteristics of the productive processes.

6. Time for repairs and maintenance: the maximum production will differ from the actual if we allow for changes in the time of productive use of machinery and equipment.

7. Quality of material inputs: a firm that receives material inputs of good quality could produce more --ceteris paribus-- than another one which receives material inputs of poor quality.

8. Utilization of owned and unused equipment: certain firms may possess old unused equipment that could be used in production.

^{2/} We are referring ourselves to disembodied technical change.

Any combination of the above factors will define a different rate of maximum production and therefore a different rate of capacity utilization. Common sense indicates that we are not interested in the maximum production from an engineering point of view. It does not make sense to hire workers up to the point where their marginal product is zero! Maximum production should be defined where the marginal product of labor is equal to the wage rate. In economic terms, the appropriate procedure is to define maximum production as the level of production where all factors are used at their optimal level.

Therefore the rate of capacity utilization has meaning only in the context of economic welfare analysis. Maximum production is in truth optimal production and is determined at the optimal number of hours worked per day, number of days worked per accounting period, number of workers, etc. For each of the factors of production - excluding the stock of physical capital - the social optimum is found at the utilization level where social benefits are equal to social costs. If net social benefits of increasing any one of them are positive then that factor should be increased to define maximum production and the rate of capacity utilization. ^{3/}

From the above arguments it is clear that the social optimum rate of production may not coincide with the private optimum. Entrepreneurs will define maximum production at the point where the use of

^{3/} A similar position is taken by Daniel M. Schydrowsky in "Full Capacity Utilization: A Working Note on Some Problems and Empirical Requirement for a Definition", paper presented to the Conference on Utilization of Capacity in Industry, Lima, Peru, May 13-16, 1973

the factors enumerated above maximize profits at market prices. In all real situations market prices differ from social prices and therefore the entrepreneurs' rate of capacity utilization will not coincide with society's measure of it. This distinction has great relevance for developing countries where distortions between social and market prices are extensive. ^{4/}

None of the studies of capacity utilization that I am aware of has calculated the optimum social rate of production. The maximum production that they use is quite often arbitrarily defined, without any optimality analysis.

Five alternative methods of measuring capacity utilization have been employed. One of them compares actual output with a linear interpolation between two peak outputs or with a linear extrapolation of previous peak outputs. ^{5/} An analogous method compares a basic capital-output ratio--thought to represent the full capacity--with the current capital-output ratio ^{6/}. Presumably the previous peak output or the basic capital - output ratio would represent the optimum rate of production, although there are differences in prices, quantity of capital, composition of output, etc. between the base and the current period. These studies will only consider changes in production that are due to fluctuations in demand. No attention is paid to the

^{4/} Even in developed countries the existence of taxes introduces an edge between market and social prices and therefore between the private and the social rate of capacity utilization.

^{5/} L.R. Klein and R. Summers, The Wharton Index of Capacity Utilization, Studies in Quantitative Economics, No. 1, University of Penn., 1966

^{6/} Daniel Creamer, Capital Expansion and Capacity in Post-war Manufacturing, Studies in Business Economics No. 72, National Industrial Conference Board, New York, 1961 and Recent Changes in Manufacturing Capacity, Studies in Business Economics No. 79, National Industrial Conference Board, N.Y. 1962

use of the different factors of production.

Another approach has been to utilize econometrically estimated production functions. Maximum production is calculated as a function of the stock of capital and the full employment supply of labor.^{7/} A similar method would use direct engineering estimates of maximum production.^{8/} No optimality considerations seem to be present in these procedures.

The fifth method ascertains capacity and capacity utilization rates by survey methods. The entrepreneur is asked to determine his actual production and the maximum production of his firm.^{9/} The problem is that maximum production is not always defined in the survey and is left to the subjective interpretation of the firms' managers. In the following section this method will be examined in detail.

It has been argued that the survey method is the only procedure that could be used in developing countries.^{10/} The argument is that their fluctuations in demand are not the relevant reason to explain why firms do not work at full capacity and that there is not enough data for econometric or engineering estimates. Essentially this position seems correct, although the most important argument is not mentioned. According to our concept of capacity utilization we should have an optimal rate of production to use as a benchmark to compare

^{7/} L.R. Klein and R.S. Preston, "Some New Results in the Measurement of Capacity Utilization", American Economic Review, March 1967.

^{8/} A.S. Manne and H.M. Markovitz, (eds.), Studies in Process Analysis: Economy-Wide Production Capacities, Cowles Foundation for Research in Economics at Yale U., Monograph No. 18, John Wiley and Sons, N.Y. 1963

^{9/} McGraw-Hill Pub. Co., Department of Economics, Annual Survey of Business Plans for New Plants and Equipment, various issues.

^{10/} Almarin Phillips, "Measuring Industrial Capacity and Capacity Utilization in Less Developed Countries", Industrialization and Productivity, Bulletin No. 15, United Nations Industrial Development Organization, Vienna 1970.

with actual production. None of the other methods referred to in the above paragraphs gives an adequate optimum - private or social - for less developed countries.

II

Capacity Utilization in Industrial Surveys

The common practice of industrial surveys is to ask the plant manager for an estimation of the utilization of installed capacity. Without any additional specification the value of this information is very limited. The managers will compare their current production with a "subjective" maximum rate of production. Nobody will be able to find out the assumptions he has made in regard to the use of the different factors of production in determining this maximum.

Another simple possibility is to ask for the maximum production under the existing conditions and circumstances. By this we implicitly imply that the manager should assume no changes in the use of any of the factors of production. The purpose of a question such as this one is to measure idle capacity that is due to deficiencies in demand. The trouble is that firms will respond to variations in demand changing their utilization of some factors of production, most notably the number of workers and the hours worked per day (overtime). There is no way to elude a definition about what changes should be assumed in the characteristics of the production process. At least we should allow for changes in employment even in the simple case of demand-induced excess capacity.

The manager of the firm that is interviewed could be allowed to determine the employment level of the maximum rate of production. If he behaves according to the postulates of traditional economic theory he will choose the optimal number of workers. Of course this will be the private optimum.

Many economists have argued that in developing countries the industrial wage rate is greater than the social opportunity cost of labor because the extent of open and disguised unemployment in those countries is enormous. Therefore, even if firms hire workers up to the point where the benefits of the last unit are equal to the wage rate, they will be employing less workers than what is socially optimum. This problem has a direct solution in terms of the questions of the industrial survey. Knowing the shadow price of labor, the manager could be asked to give the number of additional workers he would hire at that wage rate and the increases in production that would result from that action. 11/

Idle capacity because of deficiencies in demand does not seem to be the most relevant type for developing countries. By far the most crucial correction there is in the number of hours worked per day. Developing countries have abundant labor and scarce capital and therefore they should use their existing capital stock very intensively. In terms of working hours this implies that all firms should be working

11/ The growth in production should be roughly equivalent to the increase in the number of workers times the average between the existing and the shadow wage rate. This would be the consistency test for this case. It assumes that the marginal product of labor is a straight line between both wage rates.

the maximum number of hours per day. In many real situations this is not the case because shadow prices differ from market prices. Profit maximization at market prices determines a single shift mode of operation while three shifts will be obtained at shadow prices. Since maximum production is the socially optimum production, three shifts should be used as standard.

For firms that are working less than three shifts the maximum production will be given by current production plus the production of the additional shifts up to three plus the additional production that could be forthcoming in the existing shifts. The survey questions should be designed to ascertain these increases in production (see Appendix).

Days not worked by the firm include Sundays and holidays, periods of collective vacations and shutdowns because of labor strikes. Maximum production should clearly include the production that was lost because of the labor strikes. In regard to Sundays and holidays a calculation must be made to determine if net social benefits of working those days are positive or negative. If they are positive they should also be included in maximum production. The way to proceed in this respect in the industrial survey is to classify the days not worked by the firms and assume that production per day is constant.

Changes in the quality of the labor force, methods of production, time for repairs and maintenance and quality in material inputs are difficult to evaluate. The best approach is not to make corrections

because of these factors and assume that managers are operating at the optimal point.

III

Testing the Consistency of the Industrial Survey

Every manager that is answering an industrial survey will have his own biases and prejudices that will be reflected in his replies. It is therefore essential that his answers be checked against unambiguous facts. Questions should be designed for this purpose.

The tests for consistency will depend on what information is desired and how the questions are formulated. Here we will concern ourselves with getting reliable estimates of capacity utilization in developing countries. The essential condition for consistency is that maximum production be equal to current production plus production of the additional desirable shifts plus the additional production that could be forthcoming in the existing shifts.

Instead of presenting our own questions, we will develop the consistency tests for the questions about capacity utilization in the industrial survey of Colombia conducted by FEDESARROLLO ^{12/}. The tests will be different for other statements of the questions, but they can be easily modified to fit those circumstances. The questions of FEDESARROLLO are appropriate to find an adequate measure of capacity

^{12/} Fundacion para la Educacion Superior y el Desarrollo. They publish a quarterly review titled "Coyuntura Economica."