Inventory and Critique of Estimates of U.S. Agricultural Capacity

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The objectives of this paper are threefold. They are to: (1) assess where we are in research to measure agriculture's capacity to produce and prevailing levels of capacity utilization rates; (2) observe some possible roadblocks and methodological issues relating to the estimation of agricultural capacity and its utilization, assuming that such estimates should be consistent with those for other economic sectors and compatible with estimates of productivity and efficiency; and (3) suggest avenues that might lead toward estimates of agricultural capacity and its utilization.

Why Measure Capacity?

For a number of nonfarm industries, interest in capacity measurement arose from the recognition that it is an important factor in various economic analyses. It is now indispensable in diagnosing the economic situation as a whole. It is widely used in projections of future capital requirements, of anticipated expenditures on plant and equipment, and of future cost, price and profit conditions. It is an important variable in market studies and is most prominently used in the assessment of existing or proposed private or public economic policies.

The estimation of similar measures in the farm sector would:

1. Provide a vehicle for direct observation of the size, growth and utilization of the industry for private and public purposes;
2. provide assistance in assessing the performance of the industry with respect to general economic goals of growth, stability, equity,

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and efficiency;

3. permit the analysis and early detection of imbalance among trading industries in multi-industry commodity flow systems;

4. permit analytical placement of measures of output in a perspective to allow refinements in productivity and efficiency measures for the industry and analysis of investment behavior;

5. permit analysis of the trade-offs between developing new capacity and using existing capacity more intensively.

CAPACITY MEASURES

Before we discuss the various capacity measures used in the industrial and agricultural sector, let us list them and take note of the general definition of capacity:

1. The McGraw-Hill Capacity Utilization Index
2. The BEA (Bureau of Economic Analysis, U.S. Department of Commerce) Manufacturing Capacity Utilization Index
3. The Federal Reserve Board Index of Capacity Utilization
4. The Wharton Capacity Utilization Index
5. Other Systems

In the literature reviewed we found no work which specifically addressed itself to the construction of time series indicative of current capacity utilization levels for agriculture. Instead, the major concern seems to have centered around the determination of "excess" capacity (Quance and Tweeten; Tyner and Tweeten). More often than not that concept is related to notions of low equilibrium market prices, low factor returns and/or factor malallocation or adjustment problems.

Others have addressed or are addressing the question "Will American

farmers be able to meet anticipated food and fiber requirements (Brandow; Cochrane; Culver and Chai; Heady, Mayer and Madsen)"?

The disparity in the status of capacity measurement in the industrial sector vis a vis the agricultural sector appears to reflect the lack of a similar clear definition in the latter. Perhaps this is due to the fact that the great policy issues of the past 3 or 4 decades have involved surplus production and therefore low returns to farmers.

While there exist various interpretations of the term "capacity" in the nonagricultural sector the basic concept seems to have attained a general consensus. Two basic classifications may be discerned, namely: (1) the engineering term and (2) the economic term.

In engineering terms capacity may be defined as the maximum sustainable level of output of a firm that can be produced in the short run if the demand for its products is not a constraining factor when the firm is operating its existing stock of capital at its customary intensity (Klein and Summers p.2). A somewhat simpler definition would be that capacity is the maximum output that can be produced with existing fixed factors at normal (i.e. usual) production intensity. This definition does not reflect costs of operation, profits, or operational optimization.

The economic term, however, pegs capacity at a point of output where the average short-run cost function of a firm is at its minimum (Norton p.92). The minimum point is chosen because the upswing of the cost curve is indicative of increasingly less efficient use of the fixed factors.

Still another definition of capacity is based on a constant fixed factor/output relationship. It is exactly that output where no change in fixed factor holdings is either desired nor required. In other words

it is that output which occurs at a level just before a change in the plant occurs...or a point at which the short run ends (Phillips).

Capacity then is: 1) an output measure; 2) a short run concept; 3) in economic terms-output at minimum per unit cost levels; and (4) it is independent of demand. Capacity analysis centers primarily on the individual firm. Aggregation toward industry and sector levels may be accomplished through the use of appropriate weights (e.g. value added measures).

Two additional terms frequently used in the literature of the industrial sector may be inserted at this point. One is the capacity utilization rate (also operating rate) which is the ratio of total actual production to capacity. There is also a preferred utilization rate at which a firm optimizes its operation. Research in the nonagricultural sector shows incidentally that most industrial firms operate below that level of capacity utilization. (Hertzberg, Jacobs and Trevathan pp.50-51).

In the agricultural sector a definition of capacity can only be inferred from an understanding of excess or undercapacity as used by various research workers. It appears that capacity levels in excess of commercial demand at socially acceptable prices are regarded as excess capacity and capacity levels below that demand as insufficient capacity. This leaves us with the implication that capacity is represented in the agricultural sector by some kind of equilibrium position of market demand and supply equality. (Quance and Tweeten p.57).

APPROACHES TO CAPACITY MEASUREMENT

The McGraw-Hill, BEA, and Federal Reserve Board systems depend heavily on primary data collected principally for capacity utilization

measurement. The Wharton measure uses output data derived from the Federal Reserve Board Industrial Production Index of 30 manufacturing industries and from association and trade publications and some Census data for 6 other industries.

McGraw-Hill's surveys, which are normally conducted in the Spring of each year, serve as a basis for a number of indexes such as the annual capacity utilization rate (Dec. of the previous year) index, the prorated capacity utilization for the current year and an index of changes in capacity (1967=100) during the current year. This agency also obtained information on preferred capacity utilization rates in 1973 from which it was estimated that the operating rate in December 1972 was 85% while the effective rate (ratio of preferred to actual operating rate) was 93% percent (Gang).

For the BEA Manufacturing Capacity Utilization Index a panel of firms (2400 companies accounting for 75 percent of gross depreciable assets held by manufacturers in 1969) is requested to respond to a questionnaire containing elements regarding their operating rates and preferred operating rates. This survey is conducted on a quarterly basis. Participating firms are grouped into durable and nondurable goods manufacturers and are placed into 3 asset size classes. The survey itself is part of a larger continuing BEA program which provides indexes of actual and expected plant and equipment expenditures as well as information on manufacturer's carryover and new investment projects. (Herzberg et. al.)

Construction of the Federal Reserve Board Index of Capacity Utilization involves use of both the McGraw-Hill Capacity Index and the

McGraw-Hill Capacity Utilization Index as well as the Federal Reserve Board Industrial Production Index and a perpetual inventory measure of gross capital stocks. Series are constructed for manufacturing and major materials. This agency develops a capacity measure which is adjusted by time series analysis in which directional biases are mutually corrected (De Leeuw, 1962 p.128).

The Wharton School Capacity Utilization Index, however, uses only secondary data (the FRB Industrial Production Index) and depends largely on theoretically based inferences for its implementation. This system is called the "trend-through-peaks" method and consists simply of plotting on large graphs the output of a number of industries (including about 30 elements of the FRB industrial production index) in quarterly increments. Peak quarters are marked (a peak quarter is one whose values exceed those of the immediately preceding and following quarters) and are then connected by straight lines. It is assumed that peaks and the straight lines connecting them represent 100% capacity utilization rates. The distance between the straight line and the production level for each quarter is the reciprocal of the capacity utilization rate. Capacity and operating rates can then be easily calculated.

This procedure is followed for each industry separately. The graphs of all industries in the sample are then combined and aggregated into the industrial sector (Klein and Summers pp. 1-4). While the Wharton Index is one of the easiest to construct, a number of biases seem to have entered the system in recent times which have caused its results to deviate strongly from indexes using the survey method (Perry).

Other indexes, particularly those of the industrial Conference Board

and of Fortune Magazine, depend on an assumption of a constant fixed factor/output relationship. Here balance sheet data of participating firms in a sample are used to establish a perpetual fixed factor inventory to facilitate index construction (U.S. Senate p.9 and p.10). The complexities, particularly with respect to the perpetual inventory method and shortcomings of these systems, are such that only rather limited use can be made of them. Still other systems using production functions (Klein and Preston) and rather complex variations of assumptions regarding the fixed factor/output relationship (Bert Hickman) have not produced any of the workable capacity utilization rate indexes as described previously.

In the agricultural sector most of the studies relating to capacity were principally concerned with examining market equilibria in relation to "excess capacity." Most of such studies utilized econometric, linear programming or simulation models to study market prices and quantities, factor returns, and resource allocation efficiency. Thus the concept of excess capacity was made directly and at least partially dependent on demand.

One methodology used to address the question, "will American farmers be able to meet anticipated food and fiber requirements?" is examination of a group of extrapolations. These researchers compared projections of per capita demand with those of yields and production.

Since these methods did not result in current capacity and capacity utilization measures (indexes or series) we searched for alternatives. These included consideration of the use of aggregate production functions and supply functions to estimate capacity indicators, the adoption of some of the methods employed in the non-farm sector, and finally the use

of production possibility functions.

Before we can offer a critical evaluation of the approaches discussed in this section, we will consider some of the characteristics of the agricultural sector which may present special complications in the development of a capacity index.

SPECIAL CHARACTERISTICS OF THE FARM SECTOR FOR CAPACITY MEASUREMENT

Whatever the reasons for the lack of attention paid to measurement of agricultural capacity and its related indexes on an ongoing basis, we believe that such an effort may be feasible. Nevertheless, we think some characteristics of the farming sector are not common throughout the economy and should be considered specifically in successful designs for capacity measurement in agriculture. The purpose of this section is to identify a selected few of these characteristics.

Output Mix

To a degree perhaps unmatched in any other major materials producing or manufacturing industry farmers can substitute products for each other, given the same set of fixed factors. Thus the appropriate degree of aggregation or dissaggregation is an important methodological judgment. And the aggregation question is further complicated by the large number of characteristically different kinds of farm fixed factor sets contained within a relatively large population of producing units.

Weather

Output rates from one production period to another can be profoundly affected by weather variations. The identification and treatment of these effects are serious issues for farm sector size and input efficiency measurement.

Intrasectoral Production of Capital Stocks

Three broad classes of fixed factor stocks on farms which could conceivably limit capacity may be considered. One is represented by machinery, equipment and structures. Another is represented by land. And a third is represented by breeding herds and flocks, trees, and vines, bushes, and other perennial plantations. This third class of fixed factors is entirely produced, reproduced, and utilized within the sector. Its magnitude can be very quickly diminished, but its expansion rate is considerably affected by well-known biological life cycles.

Implement Leasing and Contract Work

Job contracting involving the use of equipment and implement leasing are certainly not unique to agriculture. But there is evidence to indicate that recent trends in the structural change in farming include increased substitution of job hire and equipment leasing for the services of owned quipment and own account operations. Conventional wisdom would point one toward certain service and trade industries for the existence and utilization of capital stocks whose services are employed in agriculture.

Government Programs

Again, this is a feature that is not unique to agricultue even though it implies very complex and important considerations for constructing measures of industry size and efficiency. One may be hard pressed to name an industry that has more facets more profoundly anointed or afflicted, depending upon one's viewpoint, by public policy. Of direct and particular interest for the measurement of capacity and its utilization are those programs through which industry-wide capacity growth and utilization decisions are shared by the public and private sectors.

These should be very carefully considered in the construction of capacity measurement methodology, especially if post-measurement explanations of change are desired.

Seasonality

A very significant number of commodities in the industry's output mix are literally harvested over a very short season once per year. This implies careful consideration of subsectoring possibilities for capacity and efficiency measurement. And it raises questions about whether measurement of capacity utilization any more frequently than once a year would be meaningful for important agricultural subsectors.

ALTERNATIVE CAPACITY MEASUREMENT APPROACHES AND THEIR CRITIQUE

The question now arises whether any of the methods described previously may be adopted for capacity measurement in the agricultural sector. The criteria of acceptability should include (aside from feasibility) the degree of accuracy that can be attained as well as the compatibility of the system with existing systems in the industrial sector. This last point is particularly important since increasingly a systemic approach taken in the analysis of the whole food and fiber sector includes industries located in both the agricultural and industrial sectors.

(1) The aggregate production function:

Klein and Preston have experimented with and discussed an aggregate production function approach to capacity estimation for some nonfarm sectors. Their approach defines full capacity output in terms of the utilization of all available capital and labor in a production function of Cobb-Douglas form. However, Walters concludes that there may be no point in employing such a concept as an aggregate production function

except over narrow sections of the economy.

We are not ready to say the aggregate production function approach is infeasible. But if we are mindful of the characteristics of agriculture noted previously, inclusion of all of agriculture in a single function may be too much heterogeneity for good results.

(2) The supply function:

A supply function is a schedule of quantities of a product that would be offered on the market at various prices. The function, however, does not reflect the source of the available goods. Some may have been derived from present production (i.e. may have been produced with the presently existing set of fixed factors) and some may have come from storage. Examination of the supply function could therefore not clearly indicate the level of capacity utilized for current production.

Nor is the supply elasticity indicative of capacity levels as is claimed by Hathaway. He contends that supply functions become highly inelastic as "excess" capacity levels are attained. Since capacity is a short run measure and since the supply function is inelastic in the short run (0.10 with falling prices and 0.15 with rising prices according to Quance and Tweeten) capacity utilization rates or capacity levels can not be "read" by interpreting long run supply elasticities. It therefore appears that the supply function--at least at the present state of the arts--would not be applicable for capacity indications.

(3) Equilibrium Price-Quantity Models:

These models have been frequently used to examine price-quantity relationships in production and consumption. They have often yielded "explanations" of low factor returns or adjustment impacts on agriculture

in terms of a concept of "excess capacity." But their use does not appear promising as part of a methodology designed to quantify the same concepts of capacity and its utilization that are quantified in the nonfarm sector.

(4) The Wharton School System:

While this system is by far the easiest of all those mentioned to use, a careful application of our criteria to its usefulness in the agricultural sector indicates that this method does not appear to meet our requirements.

The method requires an industry-by-industry analysis which is based on monthly or quarterly output data. It operates best in those industries which have a continuous annual output with fairly regular cyclical changes and which adhere rather closely to the movement of the business cycle. That is, a certain degree of coincidence in capacity utilization rates among the varioud industries is required to give effective index information for the sector as a whole. More precisely, they require a fairly equal distribution of peaks of output among all industires. Otherwise capacity utilization rates would be determined for the sector by the distribution of the peaks rather than by their intensity. In the agricultural sector, continuous production is possible only in a few subsectors. Also the volatility in output in most of the agricultural industries would make adjustment of the full capacity line a serious problem and would provide an unacceptable data base for index construction.

(5) Systems employing the survey method:

Application of the survey method (McGraw-Hill, BEA) for capacity index construction has considerable merit. It has proven successful in

the industrial sector (Perry, p.741). It is the only method through which producer intentions of expansion or restriction of capacity levels may be obtained. Similarly, only through this method can the preferred capacity utilization rate be ascertained.

While we are aware of the shortcomings of this system, particularly in terms of the time factor involved, we believe that this method warrants our serious consideration.* In recommending trial of the "McGraw-Hill Method" we suggest that the noted special characteristics of agriculture be carefully considered.

Implementation could involve a purposive sample of producers in various regions and in some of the major agricultural industries such as food grains, feed grains, industrial crops and livestock. We would request information on three questions; namely the capacity utilization rate, the preferred capacity utilization rate at which the farm was operating during the preceding year, and intentions of changes in fixed factors on the farm planned for the following year. We would necessarily need to assume that the producer (or manager) has some intuitive concept of the capacity of his farm which may be based on available acreage, machinery or head of livestock. We also assume that he would not only be cognizant of the extent of use of his fixed factors but that he would be able to express any deviation from their full use in percentage terms. We similarly assume that he has in mind some--to his farm--economically optimal use of its fixed factors and the extent to which they differ from maximum operation. We finally assume that any planned change of capital stock can be expressed by him in terms of changes in total capacity. Special care would need to be given to the nature of this change, whether,

for instance, newly acquired acreage comes from idle nonagricultural land on his farm, productive land acquired is from another farmer, or newly acquired land is from outside agriculture. Similar care should be exercised for cases of acreage reduction and any transfers of capital stocks.

Farms participating in the sample should be grouped into subsectors on the basis of major activity and weighted by the value of total output.

In contrast to the industrial sector, we would not have an industry-by-industry capacity breakdown, but rather a subsector by subsector analysis, which can be aggregated to the whole agricultural sector by participation weights. The resultant bank of information could then be related to a variety of factors pertinent to the agricultural economy and afford greater insight into the behavior of firms under various capacity pressure conditions.

We assume that continued experience on the part of both researchers and respondents would bring considerable improvement in the information obtained through surveys. In particular, we envision that a meticulous process of observing the actions of agricultural producers at various capacity levels and operating rates could lead to a set of conclusions regarding the impact of capacity pressures on the farm, the subsector and the whole agricultural sector over time.

(6) The production possibility function

If we were to recognize some of the important characteristics of agriculture and experiment with subsectoring plans for the purpose of reducing the industry's heterogeneity, one such plan might result in the specification of feed-livestock and nonlivestock subsectors. Imagine, then, the existence of a production possibilities frontier, the estimation

of which assumed fixed, currently available land and capital stocks, and presently used technology. The point on that frontier which represents the maximum combined output of both subsectors meets both the length of run and capacity level designation properties of capacity as represented in the McGraw-Hill, BEA and FRB measures. Thus it might be used as the denominator for the computation of a capacity utilization rate.

Then imagine an interior point representing current production from the same set of fixed factors and the same technology. The sum of combined subsector production at that point could be used as the numerator for the computation of a capacity utilization rate.

Further examination of the feasibility of this approach for estimation of agricultural capacity and its utilization is in process. The basic departure from approaches examined in the literature is in the identification of industry subsectors. One of the attractive features of this approach as a modeling framework is its possible feasibility through the use of either survey responses to capacity utilization questions or of secondary data.

Summary

Both of the latter two recommended systems may meet our criteria, particularly as they potentially relate to conceptual accuracy, feasibility and compatibility with measures in the industrial sector. However these methods offer no immediate series since it will take considerable time to develop the required data bank. The eventual outcome, we believe, will bring research results closer to reality than could be expected from the use of the other methods noted.

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FOOTNOTE

* Since the BEA and FRB systems are mainly special refinements of the McGraw-Hill method, only the latter will be considered here.

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