87th Congress
2d Session } JOINT COMMITTEE PRINT

MEASURES OF PRODUCTIVE CAPACITY

REPORT

OF THE

SUBCOMMITTEE ON ECONOMIC STATISTICS

TO THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

JULY 24, 1962

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE
86923 WASHINGTON : 1962

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price 15 cents

JOINT ECONOMIC COMMITTEE

(Created pursuant to sec. 5(a) of Public Law 304, 79th Cong.)

WRIGHT PATMAN, Texas, *Chairman*
PAUL H. DOUGLAS, Illinois, *Vice Chairman*

HOUSE OF REPRESENTATIVES	SENATE
RICHARD BOLLING, Missouri	JOHN SPARKMAN, Alabama
HALE BOGGS, Louisiana	J. W. FULBRIGHT, Arkansas
HENRY S. REUSS, Wisconsin	WILLIAM PROXMIRE, Wisconsin
MARTHA W. GRIFFITHS, Michigan	CLAIBORNE PELL, Rhode Island
THOMAS B. CURTIS, Missouri	PRESCOTT BUSH, Connecticut
CLARENCE E. KILBURN, New York	JOHN MARSHALL BUTLER, Maryland
WILLIAM B. WIDNALL, New Jersey	JACOB K. JAVITS, New York

WM. SUMMERS JOHNSON, *Executive Director*
JOHN W. LEHMAN, *Deputy Executive Director*
JOHN R. STARK, *Clerk*

SUBCOMMITTEE ON ECONOMIC STATISTICS

WILLIAM PROXMIRE, Wisconsin, *Chairman*

RICHARD BOLLING, Missouri	PAUL H. DOUGLAS, Illinois
THOMAS B. CURTIS, Missouri	J. W. FULBRIGHT, Arkansas
WILLIAM B. WIDNALL, New Jersey	

JAMES W. KNOWLES, *Economist*

LETTERS OF TRANSMITTAL

JULY 24, 1962.

To the Members of the Joint Economic Committee:

Transmitted herewith for the use of the members of the committee and other Members of Congress is a report of the Subcommittee on Economic Statistics entitled "Measures of Productive Capacity."

Sincerely,

WRIGHT PATMAN,
Chairman, Joint Economic Committee.

JULY 23, 1962.

Hon. WRIGHT PATMAN,
Chairman, Joint Economic Committee,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is a unanimous report of the Subcommittee on Economic Statistics entitled "Measures of Productive Capacity."

At a meeting of the Subcommittee on Economic Statistics, held April 12, 1962, to consider activities the subcommittee might undertake during the calendar year, it was agreed that "hearings on 'measures of productive capacity' might be of value to the Congress in its deliberations now, and it was decided that such hearings should be scheduled for the latter part of May." The subcommittee held 4 days of hearings, May 14, 22, 23, and 24, 1962, which have been printed under the title "Measures of Productive Capacity."

James W. Knowles, economist of the committee staff, and Richard Pollock, my legislative assistant, assisted in the preparation of this report.

Sincerely,

WILLIAM PROXMIRE,
Chairman, Subcommittee on Economic Statistics.

CONTENTS

MEASURES OF PRODUCTIVE CAPACITY

Introduction

The Subcommittee on Economic Statistics of the Joint Economic Committee held 4 days of hearings during May 1962 on the problem of the measurement of "productive capacity," a term generally used to refer to the quantity of output that can be produced per unit of time with a fixed supply of plant, equipment, labor, and material.

These hearings are directly related to congressional action on economic policies. Decisions on tax policy, monetary policy, debt policy, wage and other aspects of employment policy—all depend to a significant degree on an understanding of the relationship of the economy's output to its productive capacity.

For instance, the currently pending congressional decision on the investment tax credit depends importantly on an understanding of the relationship of business investment to the present capacity and its rate of use. Evaluation of the administration's proposed general tax cut may rely on the relationship between investment and capacity and what this relationship suggests about the investment incentives resulting from the pressure of current demand on present productive facilities. The case for tax reduction may hinge in part on the necessity for stimulating demand in order to increase investment. But an understanding of this necessity depends on the pressures production is presently placing on capacity and therefore the likelihood of expanding capacity through investment. It seems likely that when output approaches or exceeds rated capacity there will be a tendency for unit costs to rise more or less sharply and, therefore, a tendency for the enterprise to undertake expansion of capacity if demand is expected to continue for some time at these high levels. But all of this in turn hinges on an understanding of capacity.

With this in mind, the subcommittee regarded a study of the measurement of productive capacity as particularly appropriate for some exploratory hearings for these general reasons:

First. The concepts of capacity to produce and of the ratio of actual output to capacity are in constant use in arguments about both the economic situation and outlook on the one hand, and private and public policies on the other.

Second. Over the years, the hearings of the Joint Economic Committee have revealed repeatedly that the problem of achieving and maintaining a balance between the expansion of productive capacity and the expansion of effective demand is one of the most difficult and baffling problems of economic policy.

Third. While it is true that there are a number of different measures of productive capacity in individual industries or broad industrial sectors, there seems to be disagreement among experts as to the validity and usefulness of the different types of capacity measures.

The subcommittee, therefore, in setting up these four mornings of hearings invited a number of experts to discuss the problem with us. Those chosen were all working on the problem of measuring capacity. We asked them to give their considered judgments as to the uses that are made or could be made of measures of productive capacity, the extent to which measures are now available, the coverage and reliability of existing capacity measures, and what should be done through public and/or private sources, if anything, to improve data on productive capacity. Following is the schedule of witnesses:

Monday, May 14:

The McGraw-Hill index of capacity in manufacturing: Douglas Greenwald, manager, Economics Department, McGraw-Hill Publishing Co.

National Industrial Conference Board studies of capacity: Daniel Creamer, director, Division of Economic Studies, National Industrial Conference Board.

Tuesday, May 22: Wharton School econometrics unit: Index of industrial capacity: Lawrence R. Klein, professor of economics, Wharton School of Finance and Commerce, University of Pennsylvania.

Wednesday, May 23:

Fortune magazine's index of capacity in manufacturing: Sanford Parker, chief economist and member of board of editors, Fortune magazine; and Morris Cohen, associate editor and associate economist, Fortune magazine.

Views of users: Roye L. Lowry, executive secretary, Federal Statistics Users' Conference; and John D. Norton, assistant director, PARM project, National Planning Association.

Thursday, May 24: Measures of capacity:

Work of the Division of Research and Statistics, Federal Reserve System: Frank de Leeuw, economist, Division of Research and Statistics, Federal Reserve System.

Federal statistical programs concerned with the measurement of capacity: Raymond T. Bowman, Assistant Director for Statistical Standards, Bureau of the Budget.

The testimony was of a high quality and we commend the printed record to other members of the committee and the Congress, and to others interested in development of sound economic policies, public and private. Salient points in the record have been summarized (in the witnesses' own words wherever possible) for the use of the committee members and this summary is printed later in this report, following the subcommittee's findings and recommendations.

The Significance and Present Status of Capacity Statistics

Productive capacity is among the oldest, most used, and most important concepts in economic analysis. Nevertheless, productive capacity continues to be an illusive concept. A considerable range of meanings has been attached to the concept depending in part upon the use to which it is to be put, and in part on whether the problem is approached from a strictly engineering or from some economic point of view. Almost all of the many definitions of capacity have in common these elements:

(1) Capacity refers to a quantity of output that can be produced per unit of time, making use of a given stock of plant and equipment.

(2) Capacity estimates usually, though not always, assume that raw materials and labor will be available in the required quantities and qualities.

(3) Allowance is usually made for "normal" downtime, operating speed, number of shifts per day, and other usual operating conditions in each particular industry or process.

(4) Either explicitly or implicitly, the various estimates assume that the capacity output can be produced either at the lowest average total cost, or at less than some "high" marginal cost.

(5) In some capacity measures for individual industries and in almost all aggregate measures which cover broad segments of the economy, some allowance is made for the effect on capacity of possible bottlenecks, including limits on labor or materials, and for changes in product mix.

Capacity is not directly observable—a characteristic it shares with most economic magnitudes, such as the income of an enterprise, an individual, or a nation. Such intellectual constructs can be measured only when an appropriate set of rules or conventions has been agreed upon as has occurred in the field of accounting as applied in the field of income and balance sheet analysis. The concept of income would not play such a crucial role in private and public decisions if the applicable rules did not exist and were not generally observed.

The necessary rules or conventions have not been developed and generally agreed upon for use in the measurement of capacity, although some individual industries (usually through trade associations) have agreed upon rules for their own industry. This explains in large part the unsatisfactory state of measures of capacity, the many different measures, and the confusion, in some instances, in the interpretation of existing data—public and private. This is unfortunate at a time when clear, reliable measures of capacity and its rate of use could be an important aid in making decisions about tax, monetary, and other stabilization and growth policies.

One witness described the present state of capacity measurement in these words:

"With respect to capacity and utilization statistics we seem now to be in much the same position we were in with respect to labor force and employment statistics in the twenties." (Hearings, statement of John D. Norton, p. 90.)

Users of capacity measures find the available data inadequate for their needs because of—

(1) Lack of consistent definitions and rules of measurement;

(2) Insufficient coverage;

(3) Lack of detail in existing data;

(4) Failure to report regularly, and at frequent enough intervals; and

(5) Lack of integration with other economic measures—output, employment, etc.—at both the aggregate and detailed industry and product levels.

In spite of the elusiveness of the concept and the inadequacies of presently available measures, productive capacity plays an important role in economic thinking. The amount of capacity available, the

86923—62——2

rate at which it has been increasing and is expected to increase in the future, and the rate of utilization of capacity are strategic factors in a wide variety of economic analyses, including—

(1) Diagnosis of the economic situation;
(2) Preparation of projections or forecasts of—
  (*a*) The general economic situation,
  (*b*) Costs and prices,
  (*c*) Future capital requirements,
  (*d*) Expenditures for plant and equipment,
  (*e*) Profits and corporate cash flow,
  (*f*) Future transportation requirements;
(3) Studies of industrial location;
(4) Market studies;
(5) Studies of mobilization planning as a condition of effective preparedness in the cold war; and
(6) Assessment of the effects of existing or proposed economic policies—public and private, especially public monetary and fiscal policies.

Developments in techniques for the preparation, execution, and tabulation of large-scale statistical surveys, especially the use of sampling and processing on electronic computers, now makes possible significant advances in the measurement of productive capacity, comparable to those already achieved in other fields of economic statistics. A number of feasible lines of attack on the problem were presented at the hearing. These are listed in the summary of the hearings presented later in this report. (See pp. 19–20.)

Further progress in developing improved measures of productive capacity will require the fullest cooperation of both public and private efforts. In this connection, the subcommittee wishes to express its commendation for the work of those private organizations, individuals, and Government agencies which was reviewed during our hearings. The competence, ingenuity, and persistence of all concerned were of the highest caliber, offering convincing evidence that knowledge, skill, imagination, and tools are now available for a major breakthrough in this field.

Recommendations

Because of the importance and usefulness of statistics on capacity and its rate of utilization, and the unsatisfactory state of present data and of programs to produce such data, the subcommittee makes the following recommendations:

I. The Office of Statistical Standards of the Bureau of the Budget should take the lead in organizing a cooperative effort, involving both public and private agencies and individual experts, directed toward early development of generally acceptable standards covering the definition of capacity, and setting forth conventions to be generally followed in the construction of standardized measurements of capacity and its utilization. Such standards might well cover also any new standards or conventions which may be necessary for the measurement of inputs into capacity measures, such as the stock of plant and equipment, labor force, materials inputs, etc. It is clear that this is the first and most essential task if substantial improvement is to be

achieved in the foreseeable future. Evidence presented in the subcommittee hearings suggests that this can now be done expeditiously, at least on an interim basis, subject to later refinement as experience dictates.

II. The Federal Government should devote increased attention and resources toward the development of adequate measures of the stock of capital along the lines which already are being pursued and which were outlined at the hearings by the Director of the Office of Statistical Standards, Raymond T. Bowman. The work outlined in the field of measuring capital stocks by the perpetual inventory method appears to deserve aggressive exploitation.

Reliable benchmarks for this work of measuring capital stock by the perpetual inventory method requires an inventory of the Nation's capital whenever the technical problems can be solved. Efforts, therefore, should be made through both public and private channels to solve the problems involved in taking a census of the Nation's wealth, or capital assets, at the earliest date that would be practicable—which, on the basis of the testimony of Mr. Bowman, would appear to be toward the end of the present decade. In connection with this census of national wealth, consideration should be given to the development not merely of data covering the asset side of the national balance sheets but also of data covering the claims or liability side.

III. The Federal Government, under the stimulation and guidance of the Office of Statistical Standards, should devote increased resources to the exploration and testing of the feasibility of obtaining additional data on capacity through census procedures in connection with the Census Bureau's regular surveys of the American economy. The method now being explored by the Census, as explained by Mr. Bowman at the hearings, certainly deserves attention. We would also urge that study be given to the techniques suggested by Mr. Norton and possibly to an adaptation of the McGraw-Hill technique of direct measurement. It appears an exploration of this latter technique would offer an excellent opportunity for a joint public-private project in which McGraw-Hill, the pioneer in this technique, might work in cooperation with a suitable Government agency.

IV. Both public and private efforts could be usefully devoted to increased research into the analysis of the significance of capacity utilization data for the analysis of public and private economic policies, particularly those in such fields as inventories, prices and costs, monetary policies, and tax policies. Public and private policies influence both the rate at which capacity is expanded and the rate at which demand expands to call into use this capacity. The development of a balance between the consequences of various public and private policies in these two directions is essential to the survival of a system of individual freedom, and, as the Employment Act states among its objectives, "of a system of free private and competitive enterprise."

V. We recommend that the committee continue to probe this field of economic information and analysis, not only through this subcommittee's future work but also in connection with other committee investigations.

Summary of Testimony

The 4 days of hearings produced testimony by eight experts on: (*a*) The definition of capacity; (*b*) the present status of measures of productive capacity; (*c*) techniques and data used in constructing several existing capacity and capacity utilization measures; (*d*) the uses to which capacity data are put, or could be put, if adequate data were available; (*e*) recommendations for further improvements in capacity statistics; and (*f*) the present rate of utilization of capacity. This brief summary of the hearings is presented in the witnesses' own words as far as possible, with only such changes in language by the committee staff as were unavoidable in the condensation process. The summary is organized under these six subject headings, except for the uses which are made of capacity data which have been summarized in the subcommittee's own observations above. Those interested in further detail are referred to the printed hearings. The witnesses, in addition to outlining the various uses as previously summarized (see p. 4), provided a number of stimulating examples.

The record of the hearings can be briefly described as a revelation of—

Widespread interest in and use of capacity statistics;

A lack of generally accepted conventions, rules, or definitions as a basis for standardized measurement of capacity, such as exists in other fields like income accounting;

Inadequacies in existing capacity measures as to coverage, detail, regularity of reporting, and standardization;

Ability of the techniques, tools, professional talents, research proposals, and experience with tentative measures which would make possible major breakthroughs in capacity measurement and analysis in the immediate years ahead;

A need for increased research resources, public and private, and for some organizational structure to improve the coordination of public and private efforts in this field; and, most important,

The certainty that improved capacity statistics and analysis would have a large payoff in view of the strategic importance of capacity and its rate of use in the analysis of such basic economic matters as costs, prices, profits, demand for capital goods, the general economic situation and outlook, economic growth, and mobilization planning.

THE CONCEPT OF CAPACITY

The term "capacity" has been given a variety of meanings. There seemed to be general agreement that the term refers to the quantity of output that can be produced per unit of time with a given supply of plant and equipment, labor, and materials. In general, it is assumed that labor and materials will be available in the necessary quantities and qualities, and that the limiting factor is the stock of plant and equipment together with the operating standards which determine the intensity with which it is used at "capacity levels of output."

In general, definitions of capacity can be divided into two categories, which may be termed the "engineering" and the "economic" concepts.

The engineer's concept is physical, denoting the maximum physical

output that can be produced per unit of time with a given fixed stock of capital facilities. This capacity rate of output is the maximum that can be produced on a persistent, repetitive basis without actual breakdown or the incurment of some explicitly or implicitly assumed "exceptionally high" marginal cost of operation.

The economist's definition (as described in the hearings) identifies capacity output with the output rate prevailing when the short-run average total cost per unit is at a minimum. The economist's definition, therefore, is concerned with that output from a given set of productive facilities that coincides with minimum average cost and, under competitive conditions, with the maximum profits for the enterprise. It also implies that when output approaches or exceeds "rated" [1] or "effective" [1] capacity, or the "preferred" [1] rate of use of capacity, there will be a tendency for unit costs to rise more or less sharply and, therefore, a tendency for the enterprise to undertake expansion of capacity if demand is expected to continue for some time at these high levels.

Explicitly or implicitly, the economist's definition typically includes the notion of some reserve of productive abilities over and beyond those in use at the preferred operating rate. This reserve (generally of older, less efficient capacity) is maintained as a safety factor to protect the firm against loss of customers or competitive positions when short-run exceptional peaks in demand occur or when unforeseen longer run shifts appear quickly and additional capacity can be put into place only after a significant lag.

The experts indicated that definitions or concepts of capacity commonly take recognition of so-called "normal" downtime for repairs, maintenance, shift of product mix, etc., and for other variables such as the operating speed of productive processes, number of shifts per day, number of days operated per week or per year, and other operating standards typically followed in particular processes or industries. Measures may also, where possible, take into consideration the problem of balance between various stages in the productive processes and, therefore, whether there may be bottlenecks created at some high rate of demand by restricted supplies of particular facilities or of labor or materials. Also, allowance may be made for the serviceability, age distribution, and condition of installed plant and equipment.

It was repeatedly evident in the record that generally accepted conventions or standards for capacity measurement do not exist, though such general conventions or standards prevail in other fields, like income accounting. It is true, of course, that some individual industries have developed conventions for measuring capacity in their own industries, usually working through trade associations. The lack of conventions accepted for general use plays an important role in limiting progress, and results in some incomparability between the various unstandardized measurements.

PRESENT STATUS OF CAPACITY STATISTICS

As already indicated, the record reveals a lack of agreement on concepts and on generally accepted conventions for standardized measurements of capacity. This, of course, has had considerable

[1] These terms are those used by the various witnesses to describe that rate of use of physical facilities, beyond which investment tends to rise more rapidly.

consequences in producing a wide variety of capacity data which cannot be compared precisely with each other or with other economic data. But over and beyond this, the record revealed a number of additional inadequacies in existing capacity measures, including limited coverage, lack of detail, irregularity of reporting, and perhaps some difficulty of access to the information for some users.

For broad aggregates such as total manufacturing, all industrial activity, or the total private economy, five sets of measures were included in the record. These include: The series for total manufacturing published by the McGraw-Hill Publishing Co.; those developed by the National Industrial Conference Board; the Wharton School econometric unit index of the rate of use of industrial capacity, comparable in coverage to the Federal Reserve Board's index of production; Fortune magazine's capacity indexes for manufacturing, energy-producing industries, communications, railroads, and all private nonfarm industries; and measures for total manufacturing and for major materials developed by Frank deLeeuw for the Federal Reserve System.

There exist, in addition, statistics on capacity for individual industries or products, compiled either by the Government or by private organizations. Estimates of the amount of capacity data available for industries and products were provided by John D. Norton (hearings, pp. 100–103). The Government's standard industrial classification system divides manufacturing into 20 so-called 2-digit industry groups, and these in turn into subproduct classes at the 3-digit, 4-digit, 5-digit, etc., classification levels. Of the 20 groups at the 2-digit level, there were 5 for which no capacity data were found. Of the 1,076 product classes at the 5-digit classification level, some capacity data were found for 201, of which 99 represented published data. Thus capacity data were found for about 19 percent of the 1,076 classes at this detailed 5-digit classification level. Continuous time series covering the postwar or longer periods are available for 17 basic materials.

From this brief summary, it is apparent that there is much scattered material on capacity for various products and industries, for various time periods, but relatively few time series of consistent data. Even these time series must be characterized as being of inadequate quality, partly because of a lack of standardization of concepts, partly because of inadequate raw material for the computations, and partly because of still unsolved problems of measurement. The degree of ingenuity and skill utilized in developing the maximum of information from available raw materials is outstanding, but the results clearly indicate—as all witnesses appearing seemed to agree—that there is a substantial need for increased standardization and for an improved flow of basic information from which to construct measures of capacity.

THE M'GRAW-HILL MEASURES OF MANUFACTURING CAPACITY

The McGraw-Hill capacity index is a measure of growth of manufacturing capacity as compared with capacity existing in the base period, December 1950. It is solely a measure of capacity in terms of plant and equipment. It does not measure capacity in terms of available manpower or materials which at times may also limit productive ability.

The McGraw-Hill index of manufacturing capacity is based on replies to its annual plant and equipment survey covering companies which represent about 40 percent of total manufacturing employment. Since 1948, questions on recent and planned additions to capacity have been included regularly in the annual McGraw-Hill surveys. Since 1955, companies have regularly been asked to report also the rate of capacity at which they were operating at the end of the preceding year.

McGraw-Hill allows the companies to set their own definitions of capacity and only asks that respondents stick to their definitions. In general, "companies follow a commonsense definition of capacity, such as maximum output under normal work schedules." [2]

The replies are on a company basis, not on a plant or establishment basis. Companies are classified by standard industrial categories in terms of their major product lines. Individual industry indexes are constructed by combining the year-to-year relative changes reported by the individual companies. Each reporting company's relative importance in its industry is taken into account in computing 15 individual industry indexes. For these calculations, employment is used as the weighting factor of relative importance.

The overall manufacturing capacity index is calculated by combining the individual industry indexes with each weighted by their relative importance in the total as measured by the value-added weights developed by the Federal Reserve Board for use in its index of manufacturing production.

Since early 1955, McGraw-Hill has asked companies how much capacity they were actually operating at the end of the year. The same computational methods used for the capacity computation were used to arrive at individual industry operating rates, total manufacturing operating rates, and preferred operating rates.

THE NATIONAL INDUSTRIAL CONFERENCE BOARD'S MEASURES OF CAPACITY

The Conference Board's approach to the problem of measurement is through changes in the relation of fixed capital to output, both expressed in constant prices. It is based on the technological relationship of a stock of capital and the output derived from it. The derivation, however, is not in terms of physical units and engineering relationships, but in terms of financial units reflecting economic choices and values. The basic data are the reports by accountants of business operations and transactions as they are reported in corporate balance sheets and profit-and-loss statements.

In this context, capital means fixed capital, that is, structures and equipment. The volume of structures and equipment is measured by the value (net of depreciation) placed on these assets by manufacturing enterprises in their balance sheets, corrected for price changes. Output is taken at cyclical peaks and is measured by gross operating receipts corrected for changes in inventories and for price changes.

In general, the procedure is to establish a fixed capital-output ratio for each industry classification for a benchmark year, a year which independent evidence indicates was a period when capacity was "virtually fully utilized." A significant rise in the capital-output

[2] Hearings, p. 4.

ratio above the benchmark ratio for an industry in a subsequent year would be evidence of excess capacity—unless the technological changes in the interval were strikingly capital intensive, which could be established from other evidence. On the other hand, a significant decline in the fixed capital-output ratio suggests that structures and equipment are being operated at greater efficiency. The additional capacity from this efficiency source is incorporated in the measurement.

THE WHARTON SCHOOL CAPACITY UTILIZATION DATA

The Wharton School econometrics unit computes a series on the rate of utilization of industrial capacity, comparable in coverage to the Federal Reserve index of industrial production. The rate of utilization is inferred from output data on the basis of the assumption that at each output peak in each industry there is no used capacity, or, at least, that the rate of use of capacity is high and about the same at each peak.

The Wharton School analysts plot large time charts for each of the 30 components of the Federal Reserve index of industrial production. The data are seasonally adjusted monthly values averaged into quarters of a year. Series of peak values are then established for each industry for the period since 1946. Peak values are picked out by inspection, by determining points where values exceed the immediately preceding and adjacent values with special treatment for exceptional cases.

When a series of peaks has been established for any given sector, straight line segments are drawn to connect successive peaks. Values of the series along the constructed straight line segments are termed capacity, and the ratio of actual production to these capacity values for each quarter are computed, yielding percentage utilization measures. The capacity point between any two peaks is determined by the connecting straight line segments, but values for quarters subsequent to the last peak in each series are computed differently. The last connecting segment is extrapolated with the same slope as the segment connecting the last two established peaks. If output rises above this extrapolation, the slope of the line is increased to bring its terminal point equal to the last output value, and capacity values determined since the last peak are revised accordingly.

Ratios of output to capacity established by this method for each sector are then averaged, using Federal Reserve index weights, to give a national industrial measure of capacity utilization.

The measure of capacity output is in the same units as the production index. They are both on a 1957 base of 100 for actual production, so that the base for capacity output is not 100. The ratio, representing degree of capacity utilization, is a pure number without specific units of measurement or base value.

Any single industry will have an operating ratio of 100 percent in peak quarters, but because all industries do not reach peak output in the same quarter, the composite ratio will never reach a value of 100 percent.

FORTUNE MAGAZINE'S CAPACITY MEASURES

Fortune's approach to capacity is primarily geared to the measurement of capital requirements; that is, the focus is on the contribution capacity measurement can make to the analysis of the outlook for

capital goods spending. The concept of capital is gross, not depreciated, plant and equipment. Two measures of the growth of the capital stock have been devised. The first employs the techniques pioneered by George Terborgh, research director, Machinery & Allied Products Institute. Purchases of capital goods, "properly deflated," [3] have been cumulated over time, subtracting from the cumulative total each year the retirements of capital goods purchased in past years. Retirements are inferred from Terborgh's "survival curves," which are based on the "useful life" criteria of the Treasury's Bulletin F. The second technique consists in calculating the capital stock from the corporate books, i.e., from "Statistics of Income" (updated by FTC–SEC data). Starting with the "proper reflation" [3] of the capital stock at the end of World War II, capital expenditures were calculated by adding the depreciation in any year to the change in depreciated assets for the year. These estimated capital expenditures were added to the gross stock of plant and equipment at the start of the year, and the surviving gross stock at yearend was subtracted to estimate retirements. All of this was done on a price-deflated basis.

Indexes of capital for specific industries can be compared with various other measures—i.e., physical capacity, McGraw-Hill chain indexes, and the "ratchets" for peak production in various industries as shown by Federal Reserve data for some 90 subindustries. After this comparison, Fortune found that its estimates were about in line with the other measurements, but inasmuch as the growth of "capacity machinery" matched overall capital growth in each of the two main subgroups (metals and nonmetals) of manufacturing, and new machinery may be more efficient than old, it seemed reasonable that capacity growth might, in general, exceed capital growth. Fortune, therefore, calculated an index of capacity, whose growth would exceed that of capital but be less than that of McGraw-Hill's capacity index. Hence, the index is adjusted upward annually by a one-half percent annual factor for improved capital efficiency.

Output is compared with the index of capacity and a utilization rate is computed. The computations were carried out for manufacturing (and its subgroups), other sectors, and for the total private nonfarm economy.

TWO MEASURES OF CAPACITY DEVELOPED BY THE STAFF OF THE FEDERAL RESERVE BOARD

The Federal Reserve System has a great deal of interest in measures of capacity as a means of facilitating analysis of investment, costs, and prices. For this reason, the staff has attempted to develop various measures of capacity, including two composite measures which were presented at the hearings.

Capacity and output indexes for major materials

The first of these two measures (developed by the staff of the Federal Reserve Board) covers monthly output series and annual capacity levels for 17 major materials, as follows: Iron, steel, aluminum, copper, coke, cement, cotton yarn, synthetic fibers, pulp, paper, paperboard, petroleum, synthetic rubber, sulfuric acid, ammonia, chlorine, and benzene.

[3] These are witness' own terms and were used without further explanation.

It will be noted that the coverage of the basic materials area is fairly broad, although building materials are represented only by cement; and industrial chemicals are underrepresented.

The capacity figures underlying these indexes are drawn from Government and trade association surveys, and represent physical quantities of potential output covering, for the most part, continuous or nearly continuous operation processes.[4]

Typically, the figures for the individual products incorporate allowances for repair time and usually exclude "obsolete" capacity. They also typically assume some standard of preferred practice in regard to number of days of operation per week, or per month, or per year, and preferred or usual practice in regard to number of shifts per day.

The individual capacity indexes are combined into an overall index, as are the output indexes, using weights developed from value-added data which are directly related to the weights in the Board's index of industrial production.

The principal limitation of this index is that it is confined to basic manufactured materials, which, though covered adequately, are only a small fraction of the entire industrial section. Expansion of coverage is prevented by a lack of data on physical capacity for the other industries.

In the opinion of the Federal Reserve staff, the area covered by this index is probably of strategic importance in evaluating price pressures and bottleneck developments, but may not serve as well as an indication of developments for the whole broad segment of industrial activity.

An index of manufacturing capacity

The second measure developed in the Federal Reserve studies is a "crude series" [5] representing capacity for the total of all manufacturing industries. This "crude series" was developed as part of a study of the determinants of quarterly capital spending by manufacturers. The series is related to the Federal Reserve Board's index of manufacturing production as an output measure and therefore has been calculated so as to be conceptually as close to that index as possible.

The technique makes use of three different series related to capacity. The first series used is the Commerce Department's estimates of manufacturers' fixed capital stock in 1954 dollars. The second series is the McGraw-Hill index of manufacturing capacity. Both of these series were assumed to have a gradually shifting relationship to the desired capacity measure, on the grounds that many of their differences from the desired measures—differences in weighting, in sampling bias, in treatment of capital retirements, in implied treatment of quality changes—would have effects which develop gradually over time. Both of these series showed a steady upward trend, with the McGraw-Hill series growing at about 2½ percent per year more than the Commerce series.

The third series is derived from the McGraw-Hill rate of operations data. The rate of operation figures were used to develop a capacity measure by dividing the Federal Reserve Board output index by the McGraw-Hill rate of operations. Since this measure is directly tied

[4] The witness refers here to production processes, such as chemical or paper production, which are carried out on a more or less continuous flow basis, often on a 24-hour-a-day basis. The production line operates continuously or shuts down completely.

[5] Witness' own term.

to the output index, its bias relative to the desired measure should not change greatly over time. However, it is probably subject to more short-term random influences than the other two series.

The desired capacity measure was estimated by assuming that the ratio of the third measure (that derived by dividing the Federal Reserve Board output index by the McGraw-Hill rate of operations) to each of the other two measures is dependent on time and random disturbances. Regressions of this type between the series supplied two estimates of capacity for each year and the final series is an average of these. The final measure grew at about 1½ percent per year less than the McGraw-Hill capacity index and at about 1 percent more than the Commerce Department's capital stock series. This series makes use of data many steps removed from actual figures on capacity of particular capital goods. The measures, therefore, are necessarily "crude," [6] but tests presented for the record indicated potential usefulness even in their present crude stage.

MEASURING CAPACITY IN THE PAPER INDUSTRY

An additional study of the measurement and analysis of capacity statistics was furnished for the record by Robert S. Schultz III, an economist specializing in analysis of the paper industry. (See hearings, pp. 148–165.) This study was included to provide a specific example of the problems that arise in estimating capacity in an individual industry.

Ostensibly the capacity of each paper machine at a given point in time is taken, and these figures are summed to give a capacity figure for the industry. This capacity figure is so-called "effective capacity" as opposed to "rated capacity" (an engineering term), and this estimate of machine capacity is developed after the machine is installed and has been in operation long enough to determine from production records what its output can be under representative conditions.

The "basic design of the machine, its 'trim' (width), its speed and drying equipment, determine some optimum maximum daily output of a particular grade at some optimum basis weight. The effective maximum daily output, the effective capacity, can run sharply below this optimum because of shifts to other basis weights, other grades, or because a short order book enforces frequent downtime for change-overs." [7] However, despite the varying impact of these different factors, there is enough constancy in their combined effect so that it is possible to determine reasonably significant effective daily capacity for any given machine, based on its operating record. A week may be adequate to average out a large part of any temporary divergent effects; over a month, or a quarter, these divergences substantially disappear.

Among the other problems in measuring capacity noted in this study (and common to other capacity estimates) were:

(1) What is the definition of the industry?

(2) Are the capacity figures utilized to be those figures which show year-end capacity? year-opening capacity? or some average for the year?

(3) Are the capacity estimates to be based on the "historic" 6-day week—now becoming a thing of the past as papermills

[6] Witness' own characterization.
[7] Hearings, p. 152.

integrate backward toward the raw pulp mills—or on the "maximum or all-out" basis, which is determined by multiplying the effective daily capacity by the number of days a year the mill reports as representing its preferred operating policy?

PROBLEMS OF COMPARABILITY AND BIAS

The record discloses problems of comparability, imprecision, and bias resulting from statistical techniques or data inadequacies.

Comparability

The various capacity measures discussed during the 4 days of hearings cannot be easily compared to arrive at conclusions as to the current state of capacity and its rate of use. The reasons are essentially threefold in character. First, the different indexes vary as to coverage. The McGraw-Hill and the deLeeuw indexes cover total manufacturing and are comparable in coverage to the corresponding segment of the Federal Reserve Board index of industrial production. One of the Fortune indexes is similar in coverage, but Fortune also provides measures for the total private economy and some other major nonmanufacturing sectors. The Wharton School index covers industrial production as a whole on a basis comparable to the total Federal Reserve Board index of industrial production. The National Industrial Conference Board measures cover total manufacturing. The Federal Reserve Board measure for major materials covers a selected list of 17 basic materials but no finished products, while the paper by Robert S. Schultz III, included in the record, covers solely "paper." In addition, the measures of McGraw-Hill, Fortune, and the National Industrial Conference Board furnish estimates of capacity for major subgroups within manufacturing.

It is also necessary to take some care that comparisons be made in a way that recognizes the difference in the time period to which the various indexes refer. In some cases the capacity and rate-of-use-of-capacity data refer to the average for each quarter; in others, to annual averages. The McGraw-Hill data usually refer to the capacity existing at the end of the calendar year and to its rate of use at that time.

A third source of difficulty in comparing the various capacity measures is the scales of measurement employed by the producing agencies. The problems can best be illustrated by reference to the McGraw-Hill and Wharton School indexes. The McGraw-Hill index provides a measure of the rate of use of capacity in which both output and capacity are measured according to the conventions usual to each particular firm answering the questionnaire. The surveys also provide a measure of a "preferred" rate of operation of capacity, about 90 percent, which appears to represent, from the respondent's point of view, "* * * the quantity rate at which profits are maximized." [8] On the other hand, the Wharton School index provides a scale of measurement in which the rate of operations at cyclical peaks in output for

[8] Hearings, p. 15.

each industry is assumed to be 100 percent of capacity. The weighted average of these individual industry numbers appears to average about 95 to 96 in periods of high level use of capacity, such as 1955–56. At the end of 1961, the Wharton School rate was about 93 percent and the McGraw-Hill rate about 83 percent—a difference of 10 percentage points. Most of this difference, however, is due to the difference in scale. The McGraw-Hill rate of use is usually between 89 and 97 percent of the Wharton School rate. Klein illustrated the difference as follows:

Assume that a McGraw-Hill rate of 90 percent is equal to 100 percent on the Wharton School scale; then at the end of 1961 the 93 percent shown by the Wharton School index would be comparable to an adjusted McGraw-Hill rate of 92.2 percent, arrived at by dividing 83 by 90 and multiplying the result by 100.[9] This adjustment does not necessarily make the two rates completely comparable but considerably reduces the arithmetic difference due to scale.

This same factor of scale of measurement tends, in general, to make the National Industrial Conference Board utilization rates seem a little higher than the Wharton School rates just as the McGraw–Hill series is lower, while the Federal Reserve Board, or deLeeuw, series also tends to have a lower scale of measurements than the Wharton School measures.

The table below was constructed from data supplied by the witnesses as one way of illustrating the differences and similarities between the various capacity series. The table shows the rate of utilization of capacity as measured by the five organizations for total manufacturing or the measure nearest to this in coverage. The Federal Reserve, Fortune, and McGraw-Hill indexes cover total manufacturing; the National Industrial Conference Board index covers all manufacturing except newspapers; and the Wharton School index covers total industrial production, including mining and utilities, as measured by the Federal Reserve Board index of industrial production. Other points of interest in comparison are shown in footnotes to the table.

The top half of the table shows the rates as reported by each organization; the bottom half adjusts them so that for 1 year (1955) the rates are the same. The indexes were adjusted by multiplying each by the ratio of the rate reported for 1955 to a common rate of 90. This base rate was chosen primarily because it is the "preferred rate" reported by manufacturers to McGraw-Hill. All now show 90 for the average of 1955, therefore, except for the McGraw-Hill index. This measure is 92 for the end of 1955 which appeared to be roughly consistent with an average of 90 for the year. The adjusted indexes are not necessarily fully comparable. The effects of differences in coverage or errors and biases that might result from the statistical techniques used in computing the basic index are still present.

[9] Hearings, p. 56.

Measures of the rate of utilization of capacity for total manufacturing as shown by 5 organizations, 1947–62

AS REPORTED

[Percent of capacity]

Year	Federal Reserve Board	Wharton School [1]	National Industrial Conference Board [2]	Fortune magazine [3]	McGraw-Hill [4]
1947	90	95		98	
1948	87	93		96	
1949	78	83		88	
1950	88	90		99	
1951	91	92		102	
1952	90	91		101	
1953	93	94	100	104	
1954	83	86		94	84
1955	90	94	97	102	92
1956	89	95	91	100	86
1957	85	93	88	96	78
1958	76	84	87	87	80
1959	84	92	94	97	85
1960	84	92	93	96	77
1961	82	90	92	95	83
1962—1st quarter	[5] 85	[5] 94			
2d quarter				100	

ADJUSTED [6]

1947	90	91		86	
1948	87	89		85	
1949	78	79		78	
1950	88	86		88	
1951	91	88		90	
1952	90	87		89	
1953	93	90	93	92	
1954	83	82		83	84
1955	90	90	90	90	92
1956	89	91	84	88	86
1957	85	89	82	85	78
1958	76	80	81	77	80
1959	84	88	87	85	85
1960	84	88	86	85	77
1961	82	86	85	84	83
1962—1st quarter	85	[5] 90		88	

[1] Covers total industrial production as measured by the Federal Reserve Board index and therefore includes mining and utilities in addition to manufacturing.

[2] Rate of capacity utilized at peak of operations in each year. Covers all manufacturing except newspapers. Data were supplied too late to be included in the printed record of the hearings.

[3] Data are for the unrevised Fortune series for all manufacturing and were received after the hearings had been printed. Fortune is now engaged in a checkup and revision of their series which may change some of these rates given in this table. The series shown was arrived at by dividing an index of output by an index of capacity, both of which were computed with 1956 equal to 100. Therefore, the rate of utilization has an arbitrary value of 100 for the year 1956.

[4] McGraw-Hill data are for the end of each year and are therefore not strictly comparable to the other series shown which are averages for the year.

[5] Preliminary.

[6] The data in the bottom half of the table have been adjusted so that they all have an arbitrary value of 90 percent of capacity in the year 1955 in order to reveal differences in relative movements. The McGraw-Hill series was not adjusted in any way since its value of 92 for the end of 1955 would appear to be roughly comparable to a value of 90 for the average of the year used by the other indexes.

Source: Hearings on "Measures of Productive Capacity" before the Subcommittee on Economic Statistics of the Joint Economic Committee, May 14, 22, 23, and 24, 1962.

Imprecision and bias

To further complicate the using of existing measures of capacity, there are problems arising from possible bias in the various indexes as measures of changes in capacity over time, due either to statistical procedures employed or to the nature of the data available for the construction of the indexes. There are six broad sources of such biases in the measures, some of which affect all of the measures, others only selected ones.

One of these measures—the McGraw-Hill measure—is unique in that it is derived from field surveys by questionnaires in which the respondent firms are asked to state the percentage change from the previous year in their capacity to produce, and the current rate at which present capacity is being utilized. From its very nature it is subject to error to the extent that either: (*a*) The respondents do not reply consistently according to consistent definitions and procedures; or (*b*) the sample of firms or companies is not truly representative of the universe being sampled.

As to the representativeness of the McGraw-Hill sample, the company has repeatedly pointed out, as it did in the hearings, that companies that participate in the surveys are generally the largest companies in their particular industries. These large companies (according to McGraw-Hill) account for a disproportionately large share of plant expansion, hence their expansion rate may exaggerate the trend for individual industries and for the total of manufacturing as well. In addition, there is always the problem that mergers, bankruptcies, retirements, etc., may affect the way in which changes in capacity are reported. Such events affect changes in the ownership of capacity rather than changes in the magnitude of capacity. Furthermore, with few exceptions, the companies in the sample are classified by industry according to their principal product. Product diversification has become increasingly important. For example, a rubber company's new chemical plant may raise the rubber industry's capacity index when, in fact, it should be raising the chemical industry's index. Many of these errors are offsetting.

McGraw-Hill believes, however, that the overall index for all manufacturing is not much affected one way or the other. In fact, Mr. Greenwald stated that the Department of Economics at McGraw-Hill—

> * * * has made every effort to minimize these possibilities of bias. At most, they may mean that the capacity index overstates the growth of manufacturing capacity by about 5 points during the period of 11 years. But the results of our 15th annual survey indicating that manufacturing capacity has increased by about 80 percent since 1950 measured in physical volume, and that there is still spare capacity in manufacturing, remains, we believe, correct.[10]

A second source of possible bias arises from the way in which output is measured. The usefulness of capacity measures and, in part, their derivation, requires measures of output. Most of the measures make use of physical output indexes computed and published by the Federal Reserve Board. They may also use sales or value-added measures, deflated to a constant price basis by dividing by price indexes. Even where physical output indexes, such as the Federal Reserve Board index, are used as a measure of output, they may be compared to capital stock measures which are based on dollar figures deflated by price indexes. There arises, therefore, the possibility of bias in the capacity measures because the price indexes may have an upward or downward bias. This may affect the accuracy with which the various measures reflect the growth of capacity and the rate at which it is used.

A third source of error which can result in a bias in measurement over time arises from the use of capital stock data in arriving at capacity estimates. This requires estimates of the amount of plant and

[10] Hearings, pp. 19–20.

equipment added each year, the amount retired, in some cases the amount of depreciation charged off, and, in all cases, measures of the change in price of the items added to and taken out of the capital stock in order to deflate the data to a constant price basis. Theoretically, the price indexes should measure the change in the cost to the purchaser of a constant amount of capacity of constant efficiency. Present price indexes for capital goods are not believed to be constructed so as to meet this criterion. Similar problems can be raised about the realism of current schedules of depreciation and retirement that are used in these calculations. Therefore, the use of capital stock data to construct a capacity index may introduce a bias, though it is not clear from the record whether such bias is an inevitable result of errors arising in estimating capital stocks.

In the case of McGraw-Hill, reference was made to a source of bias which affects most of the indexes; namely, classification error. Where measures of capacity and output are computed by industry, it is possible that ouptut and capacity for a given firm, though classified in a single industry, nevertheless cover products which should be classified in more than one industry. To the extent that such classification errors are not offsetting, particular industries' measures of change in output and capacity, and hence the rates of use of capacity, may be biased, rising or falling over time more than if no classification error occurred. While this possibility exists, it is not clear to what extent it affects the result cited in the hearings.

In most of the aggregate indexes, the output, capacity, and rate-of-use data for individual companies or industries are combined in the larger totals by weighting the individual estimates by their relative importance in the total. In general, output weights in the base period are used—generally the weights developed by the Federal Reserve Board for its index of industrial production. However, it may be argued that for capacity measures the relevant weights are those for capacity in the base period. None of the indexes discussed in the hearings used such capacity weights. The use of capacity weights was discussed as a possibility for future research, particularly by Mr. Klein in connection with the Wharton School index. The point would seem relevant, however, for all weighted combination indexes.

At least one of the indexes—the Wharton School index—may be affected by a source of bias which may be called the "ratchet" bias. It is not clear whether this same bias may affect, to some extent, the Fortune indexes. In the Wharton School index, capacity is measured, as shown above, by trend lines connecting successive peaks in output for each individual industry analyzed. Implicit in this technique is the assumption that successive peak outputs represent about the same relative rate of use of productive resources available to each industry. So long as this condition is met, the index may measure changes in the rate of use in capacity over time without bias though random errors of measurement may occur. However, if successive peaks are sometimes "strong" (that is, represent high rates of use of capacity) and sometimes "weak" (that is, represent relatively low rates of capacity), then trend lines connecting the peaks will represent a biased estimate of the trend of capacity. The bias will be downward if the "weak" peaks are the latest or most recent, and will be upward if the "weak" peaks are earlier.

For the postwar period it would appear that the Wharton School data exhibit movements roughly comparable up to about 1955 or 1956 to those of Fortune, deLeeuw or Federal Reserve Board, and National Industrial Conference Board. The Wharton School data show, however, substantially less growth in capacity than the McGraw-Hill index over this earlier postwar period.

After about 1955, the Wharton School index seems to be subject to a downward bias. The 1953 peak was a "strong" peak. The 1957 peak was apparently "moderately weaker." And the 1960 peak also was a "weak" peak according to most of the measures of capacity use.[11] Under these circumstances, the Wharton School technique would tend to produce measures of change with a downward bias for recent years. The Wharton School estimate of the rate of capacity in the first quarter of 1962 is about the same as in 1955 though the other measures give lower rates, a result consistent with such a downward bias in the capacity measure. It appears that the basic technique employed in the Wharton School index is subject to possible periodic shifts in bias from this source and that elimination of possibility would require developing improved methods of interpolation between successive peaks and of procedures for assessing the relative strength of successive peaks.

RECOMMENDATIONS BY WITNESSES FOR WAYS OF IMPROVING CAPACITY INDEXES

(1) Extension of engineering-type estimates: The series included in the Federal Reserve index of capacity for major industrial materials could be expanded to other parts of the economy; i.e., industrial production sectors not now reporting figures, house vacancies, unoccupied hotel rooms, idle freight cars, etc. (Klein, hearings, pp. 57–58).

(2) Estimation of cost curves for several industrial sectors of the economy: Points of minimum average cost, if they exist, could then be estimated as capacity output points for these industries (Klein, hearings, p. 58).

(3) Capacity at business-cycle peaks: Intensive studies can be made for each of the 30 industrial component sectors in the Wharton School measure to assess the relative "strength" of successive business cycle peaks and, hence, by how much the trend line of capacity could be raised above peaks instead of passing through peaks (Klein, hearings, p. 58).

(4) The aggregation of capacity: Another method of determining the aggregate figure for capacity could be devised so that the figure is no longer computed by using weights developed by the Federal Reserve Board for its composite index of industrial production. Perhaps weights that are proportional to capacity outputs could be used and/or it could be required that the national figure satisfy a linear input-output system (Klein, hearings, p. 58).

(5) The greatest contribution the Federal Government could make would be to work with private groups to develop some generally agreed concepts of what capacity is (Lowry, Federal Statistics Users' Conference, hearings, p. 83).

[11] See, for example, hearings, table II, p. 12; chart 1, p. 125; and chart 3, p. 129.

(6) The Federal Government might do more in the way of direct collection of capacity statistics. For the manufacturing sector, the quinquennial census and the annual survey are the appropriate media for obtaining the needed information. All firms with an employment exceeding 100 employees should be required to answer the surveys, while the remainder of the firms could be sampled (hearings, Norton, pp. 110–120, and deLeeuw, pp. 130–131).

(7) Greater analysis in depth by use of modern computer techniques (hearings, Norton, pp. 87, 113–114; and Bowman, Bureau of the Budget, pp. 140–141).

(8) The American Iron and Steel Institute should resume its annual capacity survey (hearings, deLeeuw, p. 131). (The discontinuance of the American Iron and Steel Institute's annual capacity survey has removed one of the most important sources of data for the indexes (p. 124).)

(9) To improve the content and accuracy of the capital stock estimates, it would be desirable to take a census of wealth before the close of this decade, and then about every 10 years (hearings, Bowman, p. 141).

(10) The Federal Government should provide an estimate of the growth of capital facilities on the basis of the perpetual inventory method (hearings, Bowman, pp. 139–140).