Working Papers

CENSUS BUREAU SURVEY OF
CAPACITY UTILIZATION

by

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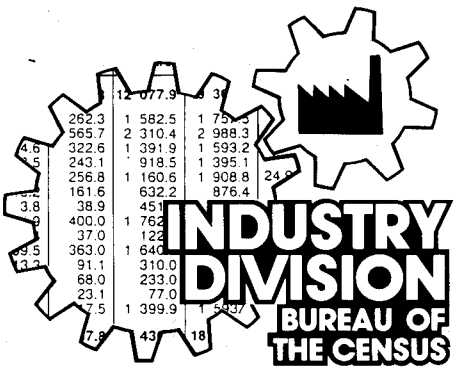
Industrial Statistics



U.S. Department of Commerce
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INTRODUCTION

Capacity and its utilization can be defined in a number of ways depending on how these measures would be used. The motives for these uses are varied and the definition of exactly what capacity is varies likewise. A common definition of capacity for a manufacturing operation is the physical productive capability of the operation during a given period of time. Capacity utilization is the extent to which an operation makes use of its existing physical facilities in the production of its output or set of outputs during the specified time. If the operation makes full use of its facilities and produces all the output that is technically possible, then its capacity utilization is at its highest. This paper discusses very generally, measures of capacity and capacity utilization in terms of these common definitions at various levels of aggregation and some applications of the measures. The second part discusses the Census Bureau's survey attempt to address some capacity and capacity utilization information needs. It includes background of the survey, research efforts to improve the quality and understanding of the data, its uses and limitations, and considerations for future data collection efforts.

THE NOTION OF INDUSTRIAL PLANT CAPACITY AND CAPACITY UTILIZATION

A starting point in identifying production capabilities is the technical capacity of a piece of machinery or integrated machinery comprising a manufacturing plant. The capacity of a plant would take into consideration the capabilities and interaction of the equipment and flow of operations. Given that no other variables enter into play, one could specify an output level that is the limit of the capability of that plant. This concept is generally considered the engineering capacity.

There are, in fact, other variables that would place limits on achieving this maximum output level. The engineering concept assumes that the labor input requirement is met and is constant over the specified time period. It assumes that the product mix is the one that yields the highest output or the capacity for each type of output is specified separately. For plants in some industries like a pipeline process or some continuous processing operations, the level of output is dependent primarily on the capabilities of the plant and equipment. There may be little or no labor intervention. And there may be only one or very few products involved in the process. In such cases the maximum output would be the same or very close to the engineering specification of capacity.

If one considers the production process of a plant that is more labor intensive, has an extensive product mix, or has a longer period of time over which one wants to measure output, the ability to measure a realistic level of maximum output is reduced. For example, a test of how much lumber can be cut from logs in an hour would likely be close to the capacity of the saw mill. Over a period of a week or a month the output might fluctuate depending on the skill of the operator in feeding logs through the machines quickly and accurately or the speed at which technicians can correct machine malfunctions. Measuring capacity in this light depends on an estimation of the capability of labor, which cannot be as easily specified and replicated as that of the machine. The maximum level of production attainable theoretically is not directly observable because of such conceptual and statistical problems. Nevertheless, these are important considerations in determining what the capabilities of an industry truly are. The difference between the maximum level of production and any level of production less than this maximum indicates an amount of excess capacity.

Within an economic framework, the level of output that is most efficient for the plant is often not the maximum level achievable but a level below full capability. If one assumes that there is a demand for the product and that current cost conditions persist, then the most efficient level of output is the most desirable level of production. Consequently, any additional units of output beyond that level would be less profitable. Since the desired level of output is usually less than the capacity level of output, a plant could be producing at 100 percent of its "desired" level and still hold excess capacity. Along these lines, excess capacity can also be defined in terms of the difference between the desired level and what is actually produced.

Concepts of capacity and capacity utilization of an entire firm or company may not necessarily be identifiable from a simple aggregation of measures from plants belonging to the company. For a company with manufacturing operations whose production processes are essentially independent, the total capacity of the company would be the sum of the capabilities of the individual plants. For vertically integrated operations, the company is likely to perceive the total capacity differently than that for individual plants. It has the opportunity to impose constraints from the interaction of the plants on its evaluation of total capability. It may be necessary for some member plants to maintain a level of excess capacity in order for the parent company to achieve full utilization of other plants. For example, company capacity would be defined as the capacity to produce the final product even though an intermediate plant may be capable of higher production. Similar arguments could be made

in the determination of segment or division level capacity within a company. Yet these measures begin to reflect the variables that determine realistic capacity at higher levels of aggregation.

Industry level capacity and capacity utilization could be determined from an aggregation of firm level information if the firms are producing a homogeneous set of products that can be classifiable into discrete categories. Since in most cases they are not, more appropriate measures can be determined from an aggregation of the plants within a specific industry. Further levels of aggregation can be made for a sector of the economy (e.g. manufacturing) from industry level information. Eventually, concepts for the entire economy can be derived from sector level information. Concepts of capacity and capacity utilization at the plant level allows for clearer definition of what capacity includes. For example, determination of domestic versus foreign production is clear from a plant standpoint. For a company or higher level of aggregation, it may be difficult to isolate or define domestic capacity where foreign operations are integral parts of the production system.

The measurement of capacity and capacity utilization is not a simple task. Nevertheless, there are some general views as to what should be measured and insight into possible useful applications. Policy makers, market planners and researchers would like to know the answers to numerous questions on this topic. For example, what is the productive capability of establishments in a particular industry? How many units of output can these establishments produce, how many units currently are being produced, and how much time would be needed to produce the maximum number of output possible assuming the supply of inputs are readily available? What industries are experiencing bottlenecks in production? Is the current level of excess capacity in certain industries or in the economy critical enough to influence the rate of inflation in the economy? Does the level of excess capacity signal increases in the level of investment expenditures? Should the capital stock in the economy be increased? Do persistent levels of zero excess capacity in some industries encourage "outsourcing" and the use of "foreign" capacity? These questions do not comprise a comprehensive list, but they help to demonstrate the importance and wide applications of capacity measures and capacity utilization rates. In micro level studies on such topics as investment, cost, productivity and profits, capacity or capacity utilization rates are usually included as an important variable.

The U.S. Census Bureau's survey of plant capacity utilization represents one organization's attempt to measure these concepts. This survey approach is unique in that it measures these concepts by asking the manufacturers directly for their estimates of capacity and rates of utilization at various levels of operations. Unlike other estimates which are model-based or

based on reports covering companies, survey-based data of individual plants may be more accurate or appropriate for capacity information. Surveying individual plants allows for better industry classification of capacity measures, since company level data may include information for plants involved in non-primary industries.

The survey results provide general purpose information on capacity utilization. They are the only source of statistics for individual industries collected using common definitions. They are designed to reflect year-to-year changes in the economy for a broad spectrum of industrial activities. Consequently, an integral assumption is that normal operating conditions prevail. The table following is an excerpt from the most recent publication. It shows the type of information and industry detail published each year.

In recent years additional demands have been placed on the survey. There is a need for information on absolute measures of capacity and on measures of capacity where the assumptions of normal operating conditions are not applicable. One example is the interest in industrial capabilities under military surge and mobilization conditions. Under such circumstances, the use of current survey information to address the concerns in this area should be done carefully. Depending on the extent of a crisis situation, the degree of the importance of some variables changes or new variables become relevant. Nevertheless, general purpose information on capacity utilization from the Census Bureau serves as a good starting point for most analyses.

Table 2. Capacity Utilization Rates, by Industry: Fourth Quarters 1983 to 1986

[For meaning of abbreviations and symbols, see introductory text]

SIC code	Industry	Preferred rate				Practical rate				Standard errors[1]					
										Preferred			Practical		
										Level		Change	Level		Change
		1986	1985	1984	1983	1986	1985	1984	1983	1986	1985	1986-1985	1986	1985	1986-1985
	All industries	78	78	78	72	67	68	68	66	1	1	1	1	1	1
	Durable goods industries	72	72	73	68	64	66	66	61	1	1	1	1	1	1
	Nondurable goods industries	80	79	78	76	73	72	72	73	1	1	1	1	1	1
	Advanced processing industries	76	76	76	74	71	70	70	67	1	1	1	1	1	1
	Primary processing industries	74	74	74	72	66	67	67	66	1	1	1	1	1	1
20	Food and kindred products	78	78	78	76	71	71	70	69	1	1	2	1	1	2
201	Meat products	87	82	80	80	78	74	76	74	1	2	2	2	3	3
2011	Meatpacking plants	86	84	81	82	82	80	78	77	1	1	1	1	1	1
2013	Sausages and other prepared meats	82	77	74	77	70	71	69	72	3	3	4	4	2	5
2016	Poultry dressing plants	83	83	85	78	83	68	82	72	2	6	6	3	8	9
2017	Poultry and egg processing	92	86	85	85	80	78	81	75	6	4	7	8	6	10
202	Dairy products	80	81	76	81	75	74	71	74	2	2	3	2	2	3
2021	Creamery butter	80	80	(S)	(S)	72	72	(S)	(S)	6	5	7	6	6	8
2022	Cheese, natural and processed	86	83	79	77	83	80	81	73	2	2	2	2	2	3
2023	Condensed and evaporated milk	78	80	82	83	72	78	74	74	7	2	7	6	2	8
2024	Ice cream and frozen desserts	66	65	61	71	60	57	54	58	8	6	10	7	5	8
2026	Fluid milk	81	81	78	84	76	76	72	77	3	2	4	3	2	4
203	Preserved fruits and vegetables	71	76	77	77	66	72	71	71	3	2	3	2	2	3
2032	Canned specialties	85	84	84	87	79	77	75	80	3	3	4	2	3	5
2033	Canned fruits and vegetables	58	72	78	68	54	68	76	67	4	4	5	4	4	6
2034	Dehydrated fruits, vegetables, soups	86	83	(S)	89	88	78	(S)	83	2	6	6	7	6	9
2035	Pickles, sauces, and salad dressing	66	68	70	76	60	66	67	69	6	4	10	8	3	8
2037	Frozen fruits and vegetables	74	76	77	84	67	71	66	80	4	4	5	4	3	5
2038	Frozen specialties	82	83	81	76	80	75	74	67	3	3	4	3	6	7
204	Grain mill products	80	80	80	79	73	74	73	75	2	2	2	2	2	2
2041	Flour, other grain mill products	89	83	81	82	86	81	78	80	3	4	5	3	4	5
2043	Cereal breakfast foods	82	86	85	85	77	82	78	81	2	2	2	2	3	3
2044	Rice milling	72	77	72	84	71	77	72	83	5	3	5	4	3	5
2045	Blended and prepared flour	54	54	55	78	51	51	52	77	8	7	11	6	5	8
2046	Wet corn milling	83	84	[illegible]	83	82	84	84	82	2	6	6	2	6	6
2047	Dog, cat, and other pet food	85	84		70	72	72	76	65	3	3	4	3	3	
2048	Prepared feeds, n.e.c.	73			73	65	65	62	67	4	3	4	3		
205	Bakery products					77	75	77	65	2	2	3	2		
2051	Bread, cake, and related products					77	75	78	64	2	2	4	2		
2052	Cookies and crackers					78	76	75	68	2	2	3			
206	Sugar and confectionery products						69	68	73	7	6				
2061	Raw cane sugar						74	78	88	6	5				
2062	Cane sugar refining						46	83	73	1	1				
2063	Beet sugar							83	84	3	3				
2065	Confectionery products	74	75	69	72			65	74						
2066	Chocolate and [illegible]	80	79	76	78				68						
2067	Chewing [illegible]	86	86	87	89										
	[illegible]	70	74	75	63	62									
207	Fats [illegible]	77	75	66	78	70									
2074	[illegible]oft drinks	70	73	66	66	62									
2075	[illegible]s and syrups, n.e.c.	70	75	65	76	58	62								
	[illegible]eous foods and kindred products	81	76	70	77	66	65								
	[illegible]anned and cured seafoods	(S)	(S)	(S)	82	(S)	(S)								
	Fresh or frozen packaged fish	81	80	(S)	70	72	70								
	Roasted coffee	89	89	84	82	73	74								
2087	Manufactured ice	84	77	(S)	-	67	58								
2088	Macaroni and spaghetti	86	86	80	86	87	83								
2099	Food preparations, n.e.c.	77	76	69	76	61	61								
21	Tobacco manufactures	86	86	89	89	86	79	78	84	1	1	1	1	1	1
2111	Cigarettes	97	93	(S)	(S)	87	81	(S)	(S)	1	1	1	1	1	1
2121	Cigars	69	70	66	75	69	70	66	75	6	5	8	6	5	8
2131	Chewing and smoking tobacco	(S)	(S)	67	87	(S)	(S)	57	80	(X)	(X)	(X)	(X)	(X)	(X)
2141	Tobacco stemming and redrying	66	72	62	62	68	72	62	57	4	2	4	4	2	4
22	Textile mill products	84	81	79	82	79	76	74	76	2	2	2	2	2	2
2211	Weaving mills, cotton	86	88	81	89	84	87	80	89	2	2	3	2	2	3
2221	Weaving mills, synthetic	87	78	79	87	84	76	77	84	4	3	5	4	3	5
2231	Weaving and finishing mills, wool	89	88	72	84	89	87	72	91	5	5	7	5	5	7
2241	Narrow fabric mills	72	80	86	87	67	45	76	85	8	9	11	6	11	12
225	Knitting mills	81	83	81	83	77	78	77	80	5	4	7	5	4	6
2251	Women's hosiery, except socks	82	78	83	91	74	70	77	88	12	13	17	9	11	14
2252	Hosiery, n.e.c.	84	87	83	90	80	75	73	87	7	4	8	5	6	8
2253	Knit outerwear mills	86	83	73	76	83	82	71	73	2	3	4	3	3	4
2254	Knit underwear mills	83	78	100	84	83	78	100	86	10	8	11	10	8	11
2257	Circular knit fabric mills	89	82	(S)	80	86	81	(S)	80	5	2	6	5	2	6
2258	Warp knit fabric mills	51	68	87	85	50	66	83	80	13	16	21	12	16	20
2259	Knitting mills, n.e.c.	(S)	(S)	(S)	72	(S)	(S)	(S)	70	(X)	(X)	(X)	(X)	(X)	(X)
226	Textile finishing, except wool	87	86	80	80	83	81	74	76	4	4	5	4	3	5
2261	Finishing plants, cotton	87	90	80	82	89	86	76	80	5	5	6	7	4	8
2262	Finishing plants, synthetics	89	86	82	83	89	86	81	77	5	3	6	5	3	6
2269	Finishing plants, n.e.c.	77	81	(S)	71	66	69	(S)	69	6	11	13	6	5	8
227	Floor covering mills	83	84	85	82	77	72	71	71	3	3	4	3	3	4
2271	Woven carpet and rugs	77	73	90	81	77	72	90	81	4	3	5	4	2	5
2272	Tufted carpet and rugs	83	85	84	83	77	72	70	72	4	3	5	3	3	4
2279	Carpet and rugs, n.e.c.	(S)	(S)	90	-	(S)	(S)	79	-	(X)	(X)	(X)	(X)	(X)	(X)

THE CENSUS BUREAU SURVEY OF PLANT CAPACITY UTILIZATION

The Census Bureau survey results of industrial capacity directly from manufacturers provide an indication of how various estimates derived from other models are behaving. However, comparisons to derived estimates are only valid to the extent survey definitions coincide with model definitions. To understand the definitions of the Census Bureau survey, we have to understand its original intent and structure.

The original intent of the survey was to provide a source of capacity related information that satisfied three main criteria[1]. First, the survey would be a vehicle to collect data on an establishment or plant basis. Precise measures of capacity and capacity utilization for individual plants would reduce much of the complication of the product and process mix inherent in other company-based indexes of industrial capacity. The Census Bureau could develop more detailed estimates of capacity utilization in particular 4-digit SIC codes and geographic area. Second, the Census Bureau would be able to design a probability sample that would provide statistically defensible estimates and measures of sampling errors associated with the data. In other words, the Census Bureau could produce estimates from a representative sample of industrial establishments that had well understood statistical properties. Third, because the Census Bureau has a host of information on manufacturing activities such as employment, capital expenditures and shipments for individual plants, it could link capacity information to these other economic variables for better evaluation and review of capacity information and further study of the relationships of these variables. The capacity survey panel has been and continues to be a sub-sample of the Annual Survey of Manufactures (ASM) for just this reason. Of significant importance was the hope that the Census survey would serve as a reliable benchmark for the Federal Reserve Board series on capacity in manufacturing.

The current survey measures utilization of two types of industrial capacity, one in terms of cost effectiveness and the second in terms of maximum output. To derive estimates of the utilization, it collects information about values of production for activity in the fourth quarter of the year, a value at a level the manufacturer would have preferred to operate that is cost effective, and third, a value of full capacity that includes reserve capacity the manufacturer does not expect to use on a regular basis. The first utilization rate calculated is the ratio of actual production to the "preferred" level of operation referred to as the preferred rate. In some instances

[1]Edward A. Robinson and Wayne M. McCaughey, "Census Bureau's Pilot Study On Capacity And Operating Rates," Presented at Meeting of American Statistical Association, December 28, 1973.

we can conceive of this ratio as being greater than one where the manufacturer may be producing beyond a cost effective level for a short time in order to meet a short term demand. The second utilization rate is the ratio of actual production to what is reported as full capacity. We label this level "practical" capacity and, hence, practical utilization rate. In terms of the levels of operations, we expect that in some situations the preferred level of operation and the practical capacity might in fact be the same, for example in continuous processing operations. But, for the most part, we expect the practical capacity to be higher than the preferred level of operation and always higher than the actual production level. We will discuss later the differences in what we expect and what we have observed in the survey.

THE CHALLENGE

The challenge then becomes the translation of economic concepts into measurable characteristics. The Census Bureau survey is intended to cover manufacturing plants in 450 diverse industries. Plants in the survey range in size from the small independent operation of as few as 20 employees to the large plant of over 500 employees that is part of a multiunit conglomerate. The survey form may fall into the hands of a plant manager, a government reports unit, an accountant, a personnel official, or the plant owner among others. Some are very sophisticated in their understanding of how the particular plant should be operating and what its capabilities are. Some go to great lengths to find out. Some do neither. The problem then became how do we collect information consistent from one type of operation to another, from one type of respondent to another, from one year to another. A number of practical considerations had to be taken into account in designing such a survey. Concepts in the survey needed to be defined in as real and concrete variables as possible and conform to record-keeping practices of businesses as much as possible; and we had to have the ability to aggregate data for individual plants and across industries.

In its first years the survey simply asked at what rate the particular plant operated in the fourth quarter of the year and what information was used to estimate that rate. It included questions about number of shifts and hours in operation per day, number of days in operation per week, number of production worker employees, hours worked by production workers and the like. This information was to be reported for various levels of operations. The intent of asking what information was used and the levels of these items was to determine what kind of information might be available for estimating capacity and what respondents perceived as the measure of their production capabilities.

The number of employees as reported in the 1974 ASM became the mechanism for giving weight to the rates of each plant for developing aggregate levels for succeeding years. It became apparent that weighting the data by the plant's employment using a fixed year caused distortions in the aggregated survey estimates. P. J. Waite, Wikoff, and McCaughey describe these problems and the subsequent revisions to the estimation methods in their presentation in August 1981 to the American Statistical Association[2]. They determined that the estimation by employment size (1) did not allow for changes in the relative importance of a plant over time, (2) was in fact, an input measure inconsistent with the concept of capacity utilization as being a measure of output and (3) assumed that the employment of the plant at a specific point in time was its full capability. The estimation method was revised so that the capacity of a plant was measured in terms of levels of value of production, an output measure. And the utilization rates were calculated from the reported levels of production.

An even better measure of output would have been value added by the manufacturer. Within a 4-digit industry, value of production was selected as the best available proxy for value added since plants within the same industry classification tend to have similar relationships between value of production and value added. Because these relationships do not necessarily hold across industries, the new estimation process included a value added measure in calculating utilization at 3-, 2-, and all industry levels. The estimation methods using value of production levels to calculate industry level utilization rates and value added adjustments to estimate utilization of aggregates of industries were introduced with the 1978 survey. The entire series was revised back to 1973. These changes have been the most significant in the survey.

The 1982 survey introduced a new survey format. The estimation methods, definitions, and inquiries for most of the basic data remained the same. But by using computer generated, pin-fed paper for the form we were able to supply the respondent with the information reported in the previous year and the name of the person who completed the previous year's report. We added questions about changes in the level of full capacity from the previous year to eliminate what might be arbitrary movements and reduce individual subjectivity in this estimate. These questions would also help identify and understand legitimate reasons for such movements.

[2]Preston J. Waite, John R. Wikoff, and Wayne M. McCaughey, "Methodological Changes to the Census Survey of Industrial Capacity," Presented at the meeting of the American Statistical Association, August, 1981.

At the time, some data users raised concerns about whether or not giving respondents their previous data would encourage them to report the same information each year since it was easily available. We have not evaluated responses for individual reports; but on the aggregate, we still observe year-to-year change in the level of the estimates.

WHERE WE ARE TODAY

The major changes that were made to the survey addressed some of the real problems of the early years but not all. We continue to recognize some of the same deficiencies noted in the Waite paper and have added some of our own.

Problems with Concept of Capacity in Certain Industries

One survey form is designed to measure capacity in over 450 different industries. The definitions and criteria presented had to be general enough to apply to all industries yet specific enough to give some bounds to what we are attempting to measure. This in itself leaves the respondent room to interpret the meaning of operations at the various levels. Even so, for some industries the notion of full or most profitable production levels is extremely difficult to capture.

The first survey in 1973 recognized that some industries were lightly-capitalized or had special problems in estimating capacity. For these reasons the first survey did not cover apparel and textiles, printing and publishing, leather and leather products, ordnance and accessories or miscellaneous manufacturing industries. The 1974 and later surveys did cover these industries. We still have difficulties in these industries where much of the work is done outside of the plant on a contractual basis like the apparel industry. The printing and publishing industry presents several situations. In some cases publishers do no printing and defining the capacity of such a publishing operation makes little sense. In this case, the measure of capacity is a measure of the capabilities of the editors or publishers rather than the facility. The productivity of the editorial staff could fluctuate depending on the workload. Since there is very little capital involved the limit on the preferred and practical levels are much more difficult to define. Likewise, in newspaper and magazine printing, because of the very short life of the product, the respondents' perception of the preferred level of production is often biased by the knowledge of the current subscription levels. For these respondents the preferred level is not synonymous with the most cost efficient level but rather the number of daily newspaper sales. It is difficult for them to estimate a level of operation independent of that circulation level. Then, their preferred and actual operations tend to become one and the same.

Problems of Appearing and Disappearing Capacity

When we compare the results from the survey from year to year, we observe that the estimates of practical capacity vary differently than what would appear to be changes in capital stock. Changes in industrial capacity that occur for reasons other than changes in the capital stock are referred to as appearing and disappearing capacity. There are several reasons for these other changes in the estimates of practical capacity in the Census Bureau survey.

(1) The annual value of production at full or "practical" capacity is based on the particular product mix experienced in each survey year. When the product mix changes, its aggregate value and estimated value of production at practical capacity changes when, in fact, there has been no physical change in the facility.

(2) The respondent uses different assumptions from the previous year about availability of labor or other criteria noted in the instructions. Or a different respondent does not know the basis for assumptions used in the previous year.

(3) The respondent's perception of production capabilities changes with the economic environment.

The 1982 inquiry mentioned earlier was planned to try to isolate and quantify these differences. The question asked that, if the reported value of production at practical capacity differed from the previous year except for price changes, the respondent should identify the reason for the difference. Multiple answers made it difficult to decipher the results. But more puzzling was that the value of production reported by those giving no reason for change other than price had greater differences than could be explained by inflation. Our conclusion at this point is that we need to refine the question and provide for every respondent to answer.

Problems With the Fourth Quarter Reference Period

Collecting information after the end of the year has the advantage of approaching most businesses at a time when they are closing out bookkeeping records for the tax year, for stockholders' reports and the like. But, for some highly seasonal industries that typically are idle or at low operating levels in the fourth quarter, reporting preferred operations and practical capacity becomes a problem. This is often the case in some food industries where the basic food is available only certain times of the year. The respondent tends to assume that in the fourth quarter preferred operations and practical capacity should be low or zero because the materials simply are not available. We would like to expand the survey instructions

to cover these kinds of special cases.

Because of concern about the implications of the fourth quarter, we began asking the values of production on an annual basis to compare with the fourth quarter information. We could also compare this value with data from the annual survey of manufactures to evaluate the quality of the reported data in the plant capacity survey. Lack of resources have prevented us from using this information to its fullest.

SURVEY EVALUATION AND RESEARCH

There are a number of on-going in-house projects that attempt to evaluate and improve the reliability of the survey. Research topics cover consistency of survey response, estimation methods and derivation of independent estimates of capacity. This paper highlights three projects in these areas.

Staff members recently completed a draft report on issues of consistency of the survey responses, appropriateness of these responses from an economic standpoint, and, timeliness and adaptability of establishments for changing levels of production. Another objective of the report was an effort to make extensive use of information currently collected on the survey but not included in the official publication of the results.

Three types of relations were selected for analysis. First, patterns across establishments in the relationship between responses about preferred level of operations and responses about practical capacity were examined. Second, patterns in the relationship between responses about actual and preferred levels of output, and responses about the number of production workers and production worker hours used at the two levels of output were analyzed. Finally, patterns in the relationship between responses about how many weeks it would take increase actual output to preferred output and the amount of difference between actual and preferred levels of output were considered.

Responses of individual establishments to the survey were tabulated for two 3-digit industries-- Motor Vehicles and Equipment (SIC 371) and Meat Products (SIC 201), and for two years, 1982 (a recession trough) and 1984 (2 years after the recovery began). These industries were selected in order to maximize the difference in their production processes and raw materials requirements. Thus comparisons in patterns were made between responses to related questions in two different industries and in recession and recovery years. Some interesting findings were obtained from the study. As shown in Table 1, a very large fraction of establishments reported that their preferred and practical levels of capacity utilization were about the same. A similar finding was noted in the earlier

TABLE 1

DISTRIBUTION OF ESTABLISHMENTS BY THE RATIO OF THEIR RESPONSES ON PRACTICAL AND PREFERRED OUTPUT, BY INDUSTRY AND YEAR

Ratio of Practical to Preferred Levels of Output	Distribution of Establishments							
	SIC 371				SIC 201			
	1982		1984		1982		1984	
	#	%	#	%	#	%	#	%
1.0	137	56	128	55	116	55	103	42
1.0 - 1.1	21	8	50	22	46	22	96	39
1.1 - 1.2	41	16	20	9	23	11	28	11
1.2 - 1.3	13	5	8	3	10	5	12	5
>1.3	36	14	25	11	16	8	6	2
Totals	248	100	231	100	211	100	245	100

Note: This table presents responses to the direct questions on the level of preferred and practical outputs.

study by Waite et al. for an earlier time period[3]. This finding may be reflecting respondents' lack of understanding of the current definitions of preferred and practical levels rather than wide-spread existence of unconventional short-run cost output relations that depict monotonic decreases in average cost (as output increases) then abrupt cost increases once a minimum is attained.

Another finding suggested that patterns in the relations between responses on outputs and inputs (production and production worker hours) were broadly consistent with cost-output relations for output ranges below the level at which average cost reaches a minimum. These patterns are displayed in Tables 2 and 3. Assuming the establishment operates under a normal short-run cost curve and the preferred level of output is associated with the minimum average cost output, the closer the establishment's actual output is to its preferred level of operation proportionate changes in input will bring about equivalent proportionate changes in output. However, there was a large concentration of establishments that demonstrated significant changes in output without noticeable changes in input. It was believed that this occurrence was a result of input measurement problems or transitory factors. Namely, establishments did not think that large deviations from their preferred levels would last long enough to warrant equivalent proportionate changes in inputs, especially labor. These patterns were most clear for the durable industry, especially in the recovery year.

The final major finding of the study is related to the second. On average, establishments whose actual levels of production were further away from their preferred levels of operation needed a greater number of weeks to increase their production to the preferred levels. Assuming that establishments experienced no transitory factors, a positive relation was observed between the average number of weeks for expansion and the deviations between actual and preferred levels of output. Table 4 shows that these patterns were more distinct for the motor vehicles industry in both years; and, less clear for the meat products industry in either year. However, given the importance of getting accurate estimates of these dynamic response times (Eg. military mobilization planning), much more work needs to be done on this relationship for all industries.

A second project is focused on analyzing the imputation methodology of the survey. Imputation is the process of estimating values for missing data entries or for reports not received in time to include in the tabulations. The current method of imputation was designed to accommodate estimates of capacity utilization rates. When estimating levels of values of

[3] Ibid.

TABLE 2

DISTRIBUTION OF ESTABLISHMENTS BY THE RATIO OF THE PERCENT CHANGE IN PRODUCTION WORKERS TO PERCENT CHANGE IN OUTPUT IN GOING FROM ACTUAL TO PREFERRED OUTPUT, BY INDUSTRY AND YEAR

% Change in Production Workers / % Change in Output	Distribution of Establishments							
	SIC 371				SIC 201			
	1982		1984		1982		1984	
	#	%	#	%	#	%	#	%
< 0	2	1	12	6	5	3	8	4
= 0	43	18	64	35	103	55	133	60
0 - .1	5	2	3	2	2	1	5	2
.1 - .2	9	4	4	2	6	3	6	3
.2 - .3	9	4	4	2	11	6	8	4
.3 - .5	27	11	15	8	5	3	10	4
.5 - 1.0	79	33	38	21	28	15	35	16
> 1.0	65	27	45	24	27	14	18	8
Totals	239	100	185	100	187	100	223	100

TABLE 3

DISTRIBUTION OF ESTABLISHMENTS BY THE RATIO OF THE PERCENT CHANGE IN PRODUCTION WORKER HOURS TO PERCENT CHANGE IN OUTPUT IN GOING FROM ACTUAL TO PREFERRED OUTPUT, BY INDUSTRY AND YEAR

% Change in Production Worker Hours / % Change in Output	Distribution of Establishments							
	SIC 371				SIC 201			
	1982		1984		1982		1984	
	#	%	#	%	#	%	#	%
< 0	4	1	14	8	7	4	13	6
= 0	36	15	47	25	61	33	95	43
0 - .1	2	1	5	3	-	-	-	-
.1 - .2	6	3	1	1	8	4	5	2
.2 - .3	5	2	3	2	5	3	4	2
.3 - .5	18	8	12	6	6	3	5	2
.5 - 1.0	84	35	42	23	44	24	54	24
> 1.0	84	35	61	33	56	30	47	21
Totals	239	100	185	100	187	100	223	100

TABLE 4

RELATIONS BETWEEN RATIO OF ACTUAL AND PREFERRED LEVELS OF PRODUCTION AND AVERAGE NUMBER OF WEEKS FOR EXPANSION, BY INDUSTRY AND YEAR

Actual / Preferred	SIC 371				SIC 201			
	1982		1984		1982		1984	
	% Plant Distribution	Average # Weeks	% Plant Distribution	Average # Weeks	% Plant Distribution	Average # Weeks	% Plant Distribution	Average # Weeks
.9 - 1	8	4.9	33	4.3	33	5.0	35	3.6
.8 - .9	7	3.5	25	6.2	26	6.6	35	7.4
.7 - .8	14	5.6	13	8.7	24	4.6	12	4.8
.6 - .7	15	7.2	14	9.9	10	5.9	6	7.6
.5 - .6	17	9.4	6	12.0	5	5.1	5	4.0
.4 - .5	11	7.9	3	18.5	2	2.7	2	6.7
.3 - .4	18	12.4	4	4.7	1	8.0	1	4.0
.2 - .3	7	16.0	1	6.5	1	2.0	1	4.0
.1 - .2	2	9.0	1	12.0	-	-	2	2.5
0 - .1	1	19.5	-	-	-	-	-	-
Totals	100	8.7	100	7.1	100	5.4	100	5.4

production used to calculate utilization, the methodology falls short for a number of reason. This study is concerned with examining three areas of imputation methodology that affect the accuracy of the estimates of value of production; namely, (1) use of derived annual value of production rather than value of shipments from the ASM, (2) relationship between fourth quarter production and annual production, (3) significance of re-imputation using current ASM data. Before briefly addressing each of these areas, a summary description of the current imputation methodology is in order. Presently, only fourth quarter production values, at each level of capacity--actual, preferred, and practical-- are imputed. Other data items collected on the survey are not imputed under the current methodology. This is because these items are not in the tabulation process; however, they are used extensively in reviewing the appropriateness of responses to other questions on the survey. Fourth quarter actual value of production is imputed by assuming that one-fourth of the establishments' prior year ASM shipments value is a proxy for the actual value of production. Both preferred and practical values of production are derived by applying a utilization rate, which may be a reported value or an industry average, to the estimated actual value of production.

On the first topic area mentioned above, the assumption that value of shipments is a good proxy for value of production is investigated. The researchers are comparing the annual value of shipments from the ASM to a derived annual value of production using ASM information. This comparison should show the extent of the difference between shipments and production values. The assumption that fourth quarter activity is synonymous with an average quarter is the subject of the second topic area. In this phase, the researchers are attempting to get a better measure of the proportionate contribution of fourth quarter to the annual values. They are comparing one fourth the annual values of shipments and production to the actual fourth quarter estimates of value of production reported in the survey. The determination of the appropriateness of the current imputation procedures will depend on the significance of the differences in these values.

The third topic area tests the significance of using current year's ASM data as opposed to prior year's ASM data. The current methodology is based on prior year's information because it is the only information available at the time of tabulation. To date the project has not produced any major results. Initial efforts are concentrated on preparing the data for the research. Since aggregate industrial capacity estimates are usually the primary focus of the survey results, trying to improve a small amount of imputed data is not always warranted. However, while about 95 percent of the survey panel usually return the survey form in time for tabulation, about 25 percent of our final estimate of the value of production is imputed. The

non-response for this item, in part may suggest the difficulty in reporting estimates of values of production at differing operating levels.

A third project underway is concerned with the use of economic and econometric models in the development of estimates of capacity and capacity utilization. In particular, it examines and compares estimates of capacity and capacity utilization derived from static and dynamic models. Data from the Census Bureau's survey on plant capacity would be used along with information from other sources for estimating the models. The project also includes an extensive review of the literature on capacity. A full discussion on this project will be presented later in the conference.

USES AND LIMITATIONS OF THE SURVEY DATA

Measures of capacity and capacity utilization produced by the Census Bureau are useful for a variety of purposes. Foremost among these uses are for economic and policy analyses. Although these capacity measures are not officially included as components of the major composite indexes of cyclical indicators, they are still published annually and carefully observed. On a very aggregate level, movements in the survey data on capacity utilization are consistent with movement in broad indicators of cyclical fluctuations in demand facing the plants responding to the survey. For example, comparisons of capacity utilization with national unemployment rates and other business cycle indicators show that the preferred utilization rate of all manufacturing was negatively correlated with movements in the unemployment rate of married males, spouse present between 1975 and 1984. This unemployment measure is highly correlated with cyclical movements in aggregate demand. McElhattan noted that even though the negative relationship between unemployment and inflation has received wide-spread attention, the capacity utilization rate may be a more reliable indicator of inflation.[4]

Variations in the level of excess capacity do reflect changes in the performance of the economy. As an indicator of the health of the economy, reductions in the amount of excess capacity suggest economic growth. In other words, there is an increase in the amount of actual economic activity. However, as the actual aggregate level of production moves closer to the practical capacity level, shortages and bottlenecks would arise in basic material industries. Conversely, increases in the level of excess capacity or reductions in the actual aggregate level of production indicate that the economy is declining.

[4]McElahattan, Rose, "Inflation, Supply Shocks and the Stable-Inflation Rate of Capacity Utilization," Winter 1985 Economic Review Number 1; Federal Reserve Bank of San Francisco, Ca.

Consequently, underutilization and unemployment of economic resources become inevitable. Indeed, the desirability of zero excess capacity in the entire economy is clearly a debatable issue.

As discussed earlier, one survey objective was to provide a reliable benchmark for the Federal Reserve Board series. The various limitations, changes to the survey and the behavior of the data series have prevented the FRB from making full use of the data. Nevertheless, FRB does monitor the survey results carefully and uses the data in developing materials indexes. The FRB's primary interest in the survey is a source of a measure of the level of capacity. They estimate capacity for the year on which to base monthly utilization rates. Initially the Census Bureau provided FRB with utilization rates to derive capacity levels. More recently, we have provided FRB with the series of levels of operations directly from the survey. These measures are still subject to the methodological problems pointed out in the previous section.

In addition to serving as a signal of the status of the economy, Census Bureau capacity data are also used to analyze the well-being of specific industries. Some industries are more concerned about capacity utilization and the duration of excess capacity than others. For example, in the food processing industry, Census Bureau capacity utilization information is used to analyze the stability of capacity levels. In particular, the U.S. Department of Agriculture uses the information to determine the extent to which increases in capacity level offset increases in output.

The U.S. Department of Defense is interested in capacity information to analyze the level of practical capacity and the time necessary to achieve that level in defense related industries, the competition of defense production with non-defense production and the capability of the economy to continue production in crisis circumstances. The current survey can satisfy some of these data needs. Surge and mobilization conditions describes the defense forces capability and preparedness to respond to crisis situations. Under such conditions, depending on the seriousness of the crisis, Census Bureau estimates of preferred levels of capacity are virtually irrelevant. Since cost considerations may be secondary, practical capacity utilization could be the norm. In effect, there is virtually no constraint on the maximum capacity utilization. The most limiting constraint would be the availability and quality of suitable human resource. Even at that stage, the ability to use "foreign" capacity is unpredictable. Whether the surge and mobilization is relatively instantaneous or planned affects the relevancy of the estimates of capacity.

For some industries, the implications of foreign trade on domestic markets are dependent on the extent of capacity utilization in these industries. In the footwear and textile industries for example, Census Bureau capacity data have been used along with other information to examine the effects of imports on domestic manufacturing, capacity utilization, and employment in these industries. The International Trade Administration (ITA) and the International Trade Commission (ITC) have been responsible for these and similar case studies.

Census Bureau capacity data are used in the determination process for requests by companies for economic assistance. The Economic Development Administration (EDA) handles such requests and uses the capacity information as an indicator of the status of the industry. State employment agencies also use capacity information when analyzing the level of excess capacity in certain industries. The underlying purpose is to identify industries that could accommodate possible employment increases of selected population groups such as the handicapped and disabled veterans.

Private researchers and academicians are known to be frequent data users. For numerous micro-level studies, econometric models usually include a capacity utilization variable in their investment equations[5]. Studies on costs, prices, and profits also make use of capacity information. An example of a testable hypothesis is that a high rate of capacity utilization leads to high costs for materials[6]. Studies on factor productivity and its relationship to excess capacity are other candidates for using Census Bureau capacity data. Finally, industrial trade associations have made extensive use of capacity to monitor the performance of their industries. The Census Bureau survey data are used for making inferences or conducting analyses about trends in capacity utilization. Limitations arise because of problems in measurement (pointed out earlier), stability of practical capacity levels, and the mix and duration of establishments in the panels. The relevancy of these problems depends on whether the analysis is examining individual establishments or an aggregate of establishments.

Changes in the practical utilization rate imply that there is a stable base or practical capacity level from one period to the next. In other words, "true" changes would show how much of the fixed facility is or is not in use since the last period. However, there is evidence that the level of practical capacity as reported in the survey varies from year to year.

[5]See Berndt and Kokkelenberg.

[6]In his study entitled "The Growth of Materials Capacity and the Outlook for Its Utilization," de Leeuw suggested that factor costs do influence the amount of capital per unit of capacity rather than the level of capacity itself.

Consequently, changes in the utilization rate can occur not only because of changes in the actual production level, but also because of changes in the practical capacity or both levels. Furthermore, changes in the preferred utilization rate are even more problematic since the preferred level of capacity is less likely to remain stable.

These conditions are inherent when analyzing individual plants or aggregated data for the industry over time. In addition, when analyzing industry aggregations, the changes in composition and number of establishments further complicates the analysis. Changes in composition and number of establishments result each year from new operations entering the panel, the closing of operations and occasionally changes in industry classification. The mix of establishments changes most dramatically with the selection of a new survey panel every five years. Indeed the argument has been made that at such a level of aggregation, the mix of establishments in the panel is not crucial for determining industrial estimates. Nevertheless, it appears that the Census Bureau estimates of capacity and capacity utilization are more suitable for determining point estimates of these measures.

In order to circumvent some of these problems the development of a longitudinal establishment panel database would be a useful alternative. To the extent that there is a great deal of overlap among survey panels and that a relatively high number of cases are selected for the sample repeatedly, the creation of such a database should not be too complicated. With a database of this nature, researchers and policy makers would be better equipped to track levels and changes in capacity and capacity utilization over time.

The conventional definitions of capacity and capacity utilization may be inappropriate under certain circumstances. In general, when the assumption of "normal" conditions is refuted, alternative measures of capacity would have to be developed. Implicit in the instructions to respondents of the survey is the notion of measuring capacity levels and utilization rates in the short run. For instance, use of a quarterly period and reference to "normal" operating conditions implies a period long enough where total capacity is fixed. As such, the shape of the cost curves in the short run has implications for movements along the curves. The long run can be defined as a period long enough whereby all variables are allowed to change. In effect, total capacity is subject to change. From basic economic theory, the long-run average cost curve is described as an envelop of the short-run cost curves that the plant faces. Estimates of capacity derived during the short-run period may have limited application for the long run.

Fourth quarter estimates may not be typical of all quarters in some industries primarily because of the question of seasonality. Because the survey is conducted only for the fourth quarter it does not capture the true performance of these plants outside seasonal conditions. There is an ongoing debate as to whether estimates from these plants should be included in the industrial estimates of capacity. There is currently no formal mechanism for adjusting these estimates to account for seasonality. Even though information for the survey is collected for the fourth quarter of each year, these quarterly data are sometimes interpreted as annual estimates. Central to this interpretation is the assumption that the fourth quarter reflects a typical quarter. To the extent that this is not true, use of Census Bureau estimates as annual estimates may be limited. Therefore, caution must be exercised when analyzing these types of industries.

FUTURE CONSIDERATIONS FOR THIS SURVEY

The Census Bureau survey has become more consistent over its 13 year life. We believe it would benefit from a number of processing, methodological, and definitional refinements. Yet, there are many gaps in capacity information that might be filled by enhancing the Census Bureau program. Among these ideas are:

- Review the rationale for the quarter reference period and the frequency of the survey-- As we pursue efforts to improve the survey, we have heard questions raised about the rationale for the fourth quarter reference period and have received have suggestions to increase the frequency of the survey. We are not sure that a change from the current quarterly period is warranted. The justifications usually given for using the quarter as a common denominator reference period are not clear. Consequently, more information in this area is needed.

  Increased frequency of the survey would depend on the contribution more frequent survey results would make beyond what is available now. The need for more frequent data would have to be weighed against the allocation of resources and reporting burden.

- Increase the frequency or amount of visits with companies with plants in the survey-- Such visits would serve two purposes. Survey analysts often discuss responses and reporting problems with companies. The situations are those where the respondent recognizes a need for assistance and calls the analysts for clarification or where the analysts note inconsistent data and call the respondent for clarification. Discussions with a representative sample of respondents would help us understand the extent to which they provide accurate information and also quantify the affect of those who misunderstand or misreport.

Secondly, discussions with companies that do not attempt to complete the survey items would shed light on the reasons for not complying.

- Evaluate and publish other information currently collected in the survey-- There is and has been interest in results from other information collected in the survey. Current research about this information will help refine the data collection and review of such items. Tabulating the information requires careful development of appropriate estimation methodology for industry aggregates.

  We also need a comprehensive report tying together the various research projects, particularly where the findings of one might have implications on another. Such work would include extending the current research on consistency of responses in two industries to all industries.

- Develop a longitudinal establishment file-- A longitudinal establishment file would allow research and trend analysis that is subject to the limitations described in this report. The development of a longitudinal file is not a new idea. Such a data file currently exists at the Census Bureau. However, the file does not contain capacity information. o Investigate the feasibility of conducting a company, division or segment level survey-- A survey of large sampling units like entire companies has the advantage of requiring fewer reports to cover the same or similar activities as small sampling units like plants. The fewer number of reports can be processed more quickly than a sample of plants and, consequently, requires less resources and, overall, less reporting burden of the company. At issue is what "capacity" and its utilization mean at this level. As discussed earlier, perception of capacity at such levels approaches truer measures of maximum capacity. It may or may not allow for use of capacity outside the company to supplement or complement potential company bottlenecks. Relevant questions to be investigated include (1) can a survey be designed to collect information from large reporting units that can be interpreted and aggregated consistently; (2) are respondents from the large reporting units better qualified to measure capacity than those at plants; and (3) should such a survey complement, supplement, be reconciled with the current survey?

By Census Bureau standards the plant capacity survey is relatively young. In its history we have collected not only a wealth of survey data but also a vast amount of information on the nature of capacity measurement. Yet, it seems that this information has raised more questions that it has answered.

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