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Capacity Utilization: Concept, Measurement, and Recent Estimates

ON SEVERAL OCCASIONS in the past fifteen years, my colleagues and I have tried to explain disparities among alternative measures of capacity utilization and to justify our own approach to the measurement problem.[1] George Perry, in his contribution to this issue of *Brookings Papers,* has indicated many of the important issues, and I would like to amplify his points or restate them from another viewpoint in the interests of clarification.

Briefly, the Federal Reserve index estimates that as of mid-October 1973, a fair amount of spare capacity existed in the American economy. The estimated operating rate was only 83.4 percent for 1973:3. By contrast, the Wharton index for manufacturing was as high as 96.7 in the same period, and was rising faster than the Federal Reserve index. The McGraw-Hill index was at an intermediate level of 86.5 percent in September. Similar divergences among the indexes had been apparent for several months.

These messages are so different that they suggest the need for a close look into the whole subject. For some years the Wharton and Federal Reserve indexes of utilization followed similar paths. They began to diverge in 1965, when the Wharton index rose sharply, as if signaling the onset of the

1. Lawrence R. Klein and Robert Summers, *The Wharton Index of Capacity Utilization* (University of Pennsylvania, Wharton School of Finance and Commerce, Economics Research Unit, 1966).

strong inflationary pressures that accompanied the Vietnam War.[2] Perry's Table 3 brings out sharply this break in the relationship. For the two subperiods 1954–65 and 1966–72 the series all have large pair-wise correlations, but the Wharton index correlates poorly with the others for the whole period 1954–72. After 1965, the short-run movements in the Wharton series are like those in the others, but its level is much higher in terms of a utilization rate. I feel that the Wharton index gave the correct signals on inflation in 1965 and again at the beginning of 1973.

The Concept

Full capacity has been variously defined as a minimum point on a cost function, a full input point on an aggregate production function, and a bottleneck point in a general equilibrium system. Full capacity should be defined as an *attainable* level of output that can be reached under normal input conditions—without lengthening accepted working weeks, and allowing for usual vacations and for normal maintenance. Preoccupation with measures for individual industries, considered separately from others at the same time, tends to overstate capacity for the system as a whole. The standard Wharton measure of trend lines through peaks of individual production series provides a system of attainable points because many or most industries peak approximately together. The Wharton approach satisfies the condition of feasibility under normal conditions; it runs the risk, however, of calling a local maximum point one of full capacity when it may be only a partial recovery point. This is the problem of the so-called "weak peak."

I believe that 1959 was the last time that the economy peaked out at a local maximum with less than full recovery. Some adjustment for the Wharton index around 1959 became necessary. Preston and I estimated industry production functions and inserted the full employment labor force and capital stock *for each industry*. The value of production computed from these inputs at full use yielded estimates of capacity output that could then be used to adjust weak peaks upward.[3]

2. See *Wharton Quarterly*, Vol. 6 (Winter 1971), p. 16.

3. L. R. Klein and R. S. Preston, "Some New Results in the Measurement of Capacity Utilization," *American Economic Review*, Vol. 57 (March 1967), pp. 34–58.

By distributing the available (full employment) labor force over industries as it would be, historically, at full employment points, we implicitly take account of the feasibility, in a general equilibrium sense, of attaining the output level that we designate as full capacity. This approach is different from one relying on a purely macroeconomic production function or from one that estimates output at full capacity in each sector without taking account of relationships to other sectors. Subsequent to 1959, the economy consistently peaked out at full capacity points. The overshooting of intermediate peaks like those in 1959 when the trend lines are established through peaks has provided us fairly reliable trends on capacity that we now use in the Wharton index.

As the economy approaches a turn, however, before the maximum point has been fully reached—as at the end of 1973—the capacity values in a few cases keep exceeding those in the previous quarter so that the capacity trends must be moved slightly upward. This is a fault of our method, but I think that the resulting upward bias in capacity utilization is less than 2 full percentage points in present circumstances.

According to present forecasts, it is likely that the economy will slow down in coming months; therefore subsequent quarters should not push economic performance in separate industries on to new, higher, capacity points that would lead us to revise upward our capacity trend lines.

The figures in Perry's Table 9 are interesting to me in that they indicate a much smaller upward bias for the Wharton index over the Federal Reserve or McGraw-Hill measures than would be suggested by the comparison of the usual aggregate indexes. The Federal Reserve estimates in Table 9 for major materials industries are more firmly based on direct information from engineering and trade sources. They tend to be no more than about 5 points below the corresponding Wharton indexes.

Generally speaking, I like production function estimates of capacity output, but for quickness of estimation and simplicity of concept, I prefer to work on a large scale with our present method of trend lines through peaks, using production function estimates only for adjustment and extrapolation.[4]

4. Interesting measures of production functions are contained in a research paper by Robert M. Coen and Bert G. Hickman, "Aggregate Utilization Measures of Economic Performance," Research Memorandum 140 (Stanford University, Center for Research in Economic Growth, February 1973; processed).

Yet another approach draws on linear programming calculations. In studies of chemical production and petroleum refining, Malenbaum and Griffin measure capacity as the "bottleneck" point in expansion along a given ray corresponding to a fixed product mix.[5] When one product hits such a bottleneck, all others dependent on it for intermediate input are restricted at less than full capacity utilization. This provides a maximum output point while preserving a given product mix.

The Malenbaum and Griffin estimates for petroleum and chemicals were checked against the Wharton estimates of utilization for the same industries. In general, little agreement was found between the results from the engineering-type estimates and the standard Wharton procedures, especially for short-run movements. But in most cases, the Wharton estimates of utilization for petroleum refining are higher by about 4–5 percentage points than those based on the linear programming model. For the chemical industry, the results are closer, but in a few isolated years the discrepancy exceeds 5 percentage points.

Systematic analysis and coverage of all major sectors by production function estimation, input-output methods, and linear programming calculations promise the greatest return in precision of measurement, but that combined approach seems to be a long way off, except for intensive research in separate industries.

In this connection, I disagree with Perry's view that limitations on production resulting from shortages of intermediate products (like today's anticipated shortages of fuel) should not affect the concept of capacity. Capacity is a general equilibrium concept, which should be altered in the light of bottlenecks whose effects can be traced through an input-output analysis. That is the whole point in using capacity utilization measures as signals of inflationary pressure, and accounts for my view that other measures strongly overstate the amount of spare capacity available by not taking account of interrelationships among industries.[6]

5. Helen Malenbaum, "Capacity Balance in the Chemical Industry," in Lawrence R. Klein (ed.), *Essays in Industrial Econometrics*, Vol. 2 (University of Pennsylvania, Economics Research Unit, 1969); James Griffin, *Capacity Measurement in Petroleum Refining: A Process Analysis Approach to the Joint Product Case* (Heath, 1971).

6. A technique for estimating capacity utilization rates in an input-output model is given in L. R. Klein, "Some Theoretical Issues in the Measurement of Capacity," *Econometrica*, Vol. 28 (April 1960), especially pp. 280–86.

Capacity Utilization as an Explanatory Variable

Indirect use of capacity measures is important in the construction of econometric models and serves as a validation test for the series actually being considered. The indirect uses are in equations for (a) price formation; (b) capital formation; (c) trade. Capacity utilization is one of the most strategic variables in the Wharton model, and shows up in several places. In the basic equation for price formation—the manufacturing deflator—a nonlinear transformation of capacity is one of the most significant variables:

$$\log \frac{1}{1 - CPMF},$$

where *CPMF* is capacity utilization in manufacturing constrained to lie between 0.87 and 0.99. In this nonlinear transformation, stronger upward pressure on prices develops as *CPMF* comes closer to its limiting value, 0.99.

In equations for capital formation, a one-quarter lag effect is introduced by the linear term $(CPMM)_{-1}$, where *CPMM* is capacity utilization in manufacturing and mining. This is a strong near-term effect. The other variables have effects spread out over more quarters. Perhaps a nonlinear transformation would be appropriate here too, but it has not been tried.

In some studies of export equations, capacity limitations on export performance have proven significant. In the trade model of the Organisation for Economic Co-operation and Development, exports for the United States are made to depend on "pressure of demand," which is quite close to the Wharton index measure.[7] In new estimates of U.S. export functions for use in the Wharton model, I have found that European capacity utilization, measured analogously with the Wharton methods, is a highly significant variable.

These are the main avenues by which the capacity utilization variables enter the entire model. They are strongly significant, from a statistical viewpoint, in all these cases. But a proper assessment of the marginal coeffi-

7. F. G. Adams, H. Eguchi, and F. Meyer-zu-Schlochtern, *An Econometric Analysis of International Trade* (Paris: Organisation for Economic Co-operation and Development, 1969).

cients of capacity variables depends on good specification of the rest of each equation and on use of nonlinear transformations where appropriate.

Best econometric practice should be followed in specifying investment functions with lag distributions of output and capital stock; capital rental variables should be appropriately introduced. Unless these steps are taken, the marginal effects of capacity utilization on investment may not be correctly assessed. In the same way, the price equations with capacity utilization variables should have unit labor costs, instead of wage rates without appropriate productivity corrections as in Perry's estimates. His estimates and assessments of the role of capacity in models leave me doubtful that he has captured the right marginal effect, because some of his other variables are not optimally specified and because he does not use a nonlinear transformation of capacity where needed, in the price equation. This is particularly important when inflation rates are high.

Using capacity measures as strategic regressors depends on the statistical compilation of historical series—measured as trends through peaks of production curves in the Wharton case. But forecasting application requires a procedure for extrapolating capacity utilization in the same way that other endogenous variables are extrapolated. This is accomplished through the use of production functions. These equations are first estimated from historical sample data with observed inputs of actual employment in the form of a short-run dynamic adaptation to a long-run production function. The short-run model is

$$\Delta \log L = \lambda(\log L^* - \log L_{-1}),$$

where

$$L^* = -\frac{1}{\alpha}\log A - \frac{\gamma}{\alpha}t - \frac{\beta}{\alpha}\log K + \frac{1}{\alpha}\log X + e,$$

and

L = employment
K = capital stock
X = output
e = error.

The parameter ratio β/α is estimated from long-run statistics on average factor shares. Capacity output is estimated from this pair of equations under two conditions: $\Delta \log L = 0$; and $L = LF$, the labor force.

A separate estimate of a full capacity production function is not made;

full capacity output is defined as a point on the long-run production function, determined by using full employment inputs.

Contemporary Findings

The preceding discussion describes the analytical econometric application of capacity measures. What signals have the actual data been giving recently? Since the last low point, in the fourth quarter of 1970, the Federal Reserve index has gained 9.2 points, rising from 74.2 to 83.4. The Wharton index for manufacturing has gained 13 points in the same period, moving from 83.7 to 96.7 (see Table 1). More significant, 96.7 is very near the historical high value for the index. After the index surpassed 95, in the first quarter of 1973, the strong inflationary pressures that had been suspected earlier, when the index exceeded 90 in 1972:3, became unmistakable. Aggregate capacity utilization rates for the United Kingdom and five Western European countries are shown in Table 2.

It has been evident for some time that one strategic industry after another was passing critical values for utilization rates each quarter, and that the slack areas were specialized sectors where definite cutbacks had been ordered—aerospace is a typical example. Table 3 shows estimates for individual industry components of the Wharton index. Throughout 1973, the sectors of high capacity utilization are primary and fabricated metals; nonelectrical and electrical machinery; motor vehicles and parts; instruments; clay, glass, and stone products; lumber and furniture; miscellaneous manufactures; textiles; apparel; paper; printing and publishing; chemicals; petroleum; rubber and plastics; food; crude oil and natural gas extraction; electric power; and gas utilities. With a line-up of high (Wharton) rates for a group of industries like these, severe capacity limitations quite evidently were building up.

Since business cycle peaks (both specific and reference) have been strong and well-defined since 1959, we have felt quite confident that our measures using trend lines through peaks provide adequate estimates of capacity, but until a new turn occurs, we must always be in doubt at the end of a cyclical phase about the exact position of the trend lines. There is only one reference point and not two, as is the case for more distant peaks. Yet, in the last half of 1973, we found little occasion to revise our series. The overall index in the first quarter for manufacturing, mining, and utilities was estimated

Table 1. U.S. Capacity Utilization Rate, by Major Categories, Quarterly, 1969–73

Output as percent of capacity

Year and quarter	*Durables*	*Nondurables*	*Manufacturing*	*Manufacturing, mining, and utilities*	*Services*	*Contract construction*	*Total, manufacturing, mining, and utilities; services; and construction*
1969:1	95.9	96.6	96.2	96.2	95.0	92.1	95.5
2	95.8	96.7	96.2	96.2	94.8	92.2	95.5
3	96.6	97.3	96.9	96.9	95.3	91.1	96.0
4	93.7	95.7	94.5	94.7	94.7	87.3	93.9
1970:1	88.4	94.0	90.6	91.2	93.7	87.8	91.3
2	88.0	93.1	90.0	90.6	92.5	86.8	90.5
3	86.5	92.0	88.6	89.3	93.4	87.3	89.8
4	79.5	90.3	83.7	84.9	92.7	87.7	86.6
1971:1	82.0	90.6	85.4	86.3	92.8	87.8	87.7
2	82.8	91.0	86.0	86.8	93.4	87.8	88.1
3	81.5	91.2	85.3	86.0	93.8	87.7	87.6
4	81.3	91.4	85.2	85.7	92.0	88.8	87.2
1972:1	82.6	92.4	86.4	87.1	93.6	90.9	88.7
2	85.7	93.9	88.9	89.3	93.6	89.6	90.2
3	87.9	95.1	90.7	91.0	93.6	88.3	91.2
4	91.5	95.9	93.2	93.4	93.5	88.6	92.8
1973:1	93.9	96.8	95.0	95.0	95.0	89.2	94.4
2	95.9	96.7	96.2	96.0	94.7	87.5	94.8
3	96.2	97.5	96.7	96.6	n.a.	n.a.	n.a.

Source: Tabulation from University of Pennsylvania, Wharton EFA, Inc.
n.a. Not available.

Table 2. Aggregate Capacity Utilization Rates, Five Western European Countries and the United Kingdom, Quarterly, 1970–73

Output as percent of capacity

Year and quarter	*Belgium*	*France*	*Germany*	*Italy*	*Netherlands*	*United Kingdom*	*Six-country average*
1970:1	91.3	91.9	97.8	91.1	92.7	95.4	94.6
2	92.2	89.9	97.7	89.3	91.3	94.8	93.7
3	92.7	87.6	95.4	87.9	91.5	94.7	92.3
4	92.0	89.5	93.9	87.4	91.7	94.8	92.2
1971:1	92.5	91.3	95.8	86.0	93.3	93.2	92.7
2	90.3	89.2	95.8	82.4	92.1	93.4	91.7
3	90.3	91.9	93.6	80.5	91.5	92.8	91.2
4	88.8	91.6	91.9	83.4	91.8	90.9	90.4
1972:1	92.4	93.0	92.9	82.8	92.3	85.7	89.8
2	92.0	93.5	93.4	80.7	92.4	92.1	91.5
3	91.6	96.0	92.0	78.5	91.3	92.9	91.5
4	93.4	94.0	94.7	82.8	93.6	94.8	93.0
1973:1	93.6	98.1	95.8	81.9	94.3	95.8	94.5

Source: Same as Table 1.

Table 3. U.S. Capacity Utilization Rates and Weights, by Industry, First Quarter, 1973, Estimated in April and October 1973

Industry	Utilization rate, first quarter 1973 (percent): April 1973 estimate	Utilization rate, first quarter 1973 (percent): October 1973 estimate	Weight
Primary metals	100.0	97.8	0.0188
Fabricated metal products	93.6	96.3	0.0194
Nonelectrical machinery	89.3	93.6	0.0316
Electrical machinery	95.1	97.6	0.0281
Motor vehicles and parts	100.0	99.9	0.0220
Aircraft and miscellaneous transportation equipment	65.4	65.6	0.0162
Instruments	91.0	93.6	0.0084
Clay, stone, and glass products	97.9	98.0	0.0087
Lumber and products	99.5	100.0	0.0067
Furniture and fixtures	99.1	95.6	0.0050
Miscellaneous manufactures	100.0	100.0	0.0045
Textile mill products	94.5	99.0	0.0086
Apparel products	92.2	95.2	0.0107
Leather and products	77.9	76.9	0.0026
Paper and products	100.0	100.0	0.0102
Printing and publishing	90.9	90.7	0.0154
Chemicals and products	100.0	98.4	0.0213
Petroleum products	100.0	98.0	0.0067
Rubber and plastic products	100.0	98.5	0.0081
Food	99.2	100.0	0.0214
Tobacco and products	84.6	87.3	0.0018
Coal	84.5	85.9	0.0010
Oil and natural gas extraction	91.8	92.0	0.0031
Metal mining	94.2	88.3	0.0009
Stone and earth minerals	77.8	85.0	0.0015
Electric utilities	100.0	99.0	0.0144
Gas utilities	96.1	92.8	0.0043

Source: Same as Table 1.

at 94.2 in April 1973. In October, this same value, with hindsight and revised data, was estimated to be 95.0.[8] The changes were usually not more than one or two points, and rarely as large as five or six. They are detailed by industry groups in Table 4. As in 1965, the overall indicator of average utilization has served as a fairly good early warning signal.

8. This figure is more comprehensive than the manufacturing series, cited earlier. If construction and service industries are included, the average rate is estimated at 94.4 for 1973:1.

Table 4. U.S. Capacity Utilization Rates and Weights, by Industry, Quarterly, 1969–73

Utilization rates are output as percent of capacity

Year and quarter	*Primary metals*		*Fabricated metal products*		*Nonelectrical machinery*		*Electrical machinery*		*Motor vehicles and parts*		*Aircraft and miscellaneous transportation equipment*		*Instruments*	
	Utilization rate	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*
1969:1	94.0	0.0214	99.1	0.0198	93.7	0.0319	99.4	0.0273	90.8	0.0226	93.2	0.0167	100.0	0.0081
2	95.6		99.7		94.7		100.0		87.3		93.9		100.0	
3	99.0		100.0		95.3		99.5		92.1		93.4		98.3	
4	100.0		97.8		93.2		92.9		86.4		90.0		95.2	
1970:1	90.7	0.0207	94.3	0.0197	89.7	0.0318	90.2	0.0275	76.2	0.0225	82.1	0.0165	93.1	0.0082
2	91.0		93.1		88.2		90.1		81.5		77.3		91.6	
3	91.1		92.6		86.9		88.3		79.2		73.5		87.9	
4	84.3		87.4		81.4		82.6		57.9		68.6		83.9	
1971:1	87.9	0.0201	86.6	0.0196	78.0	0.0317	82.3	0.0277	83.9	0.0223	64.5	0.0164	82.4	0.0083
2	90.4		88.0		77.6		83.8		82.9		63.2		82.9	
3	74.4		87.0		80.0		83.3		85.1		62.7		83.8	
4	76.2		85.3		79.3		83.6		84.7		61.8		82.9	
1972:1	83.3	0.0194	85.3	0.0195	79.1	0.0317	85.3	0.0279	84.9	0.0222	61.8	0.0163	84.3	0.0084
2	88.2		88.2		83.4		88.3		88.0		64.5		87.0	
3	92.9		90.0		88.5		89.9		87.2		64.2		89.2	
4	98.1		93.3		91.8		94.2		94.5		65.2		90.1	
1973:1	97.8	0.0188	96.3	0.0194	93.6	0.0316	97.6	0.0281	99.9	0.0220	65.6	0.0162	93.6	0.0084
2	98.6		98.6		98.0		99.7		100.0		67.3		96.8	
3	100.0		100.0		99.8		100.0		96.7		66.9		98.3	

Table 4. U.S. Capacity Utilization Rates and Weights, by Industry, Quarterly, 1969–73 *(continued)*

Year and quarter	*Clay, stone, and glass products*		*Lumber and products*		*Furniture and fixtures*		*Miscellaneous manufactures*		*Textile mill products*		*Apparel products*		*Leather and products*	
	Utilization rate	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*
1969:1	100.0	0.0091	100.0	0.0073	96.1	0.0050	99.1	0.0049	99.5	0.0097	94.2	0.0113	91.7	0.0029
2	98.5		96.3		95.4		99.8		99.7		93.3		90.4	
3	95.7		95.1		95.1		100.0		100.0		93.9		87.3	
4	94.4		95.7		92.5		98.4		98.5		93.5		85.8	
1970:1	91.2	0.0090	91.9	0.0072	87.1	0.0050	97.6	0.0048	93.3	0.0094	89.6	0.0112	85.2	0.0028
2	89.6		90.8		85.3		97.3		91.7		88.9		86.2	
3	87.6		91.5		85.1		95.8		89.8		87.1		83.7	
4	87.1		90.7		82.1		91.2		86.9		84.4		80.3	
1971:1	87.9	0.0089	92.1	0.0070	80.7	0.0050	90.9	0.0047	87.2	0.0092	84.4	0.0110	80.9	0.0027
2	91.0		93.2		85.2		93.1		89.1		85.8		82.6	
3	88.5		94.1		86.6		94.1		90.3		86.0		79.4	
4	88.2		97.7		85.5		92.0		90.4		86.8		79.0	
1972:1	90.9	0.0088	97.7	0.0068	86.8	0.0050	93.4	0.0046	88.4	0.0089	87.3	0.0109	80.3	0.0026
2	91.6		96.7		90.1		94.6		92.9		89.5		84.5	
3	93.7		97.5		92.9		96.8		95.8		91.6		82.1	
4	95.8		99.0		94.2		96.1		98.4		93.9		79.9	
1973:1	98.0	0.0087	100.0	0.0067	95.6	0.0050	100.0	0.0045	99.0	0.0086	95.2	0.0107	76.9	0.0026
2	100.0		99.0		98.2		99.6		99.4		93.5		78.3	
3	99.5		97.8		100.0		99.6		100.0		94.6		75.8	

Year and quarter	Paper and products		Printing and publishing		Chemicals and products		Petroleum products		Rubber and plastic products		Food		Tobacco and products	
	Utilization rate	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*
1969:1	99.0	0.0103	96.6	0.0153	97.8	0.0211	93.0	0.0083	97.3	0.0079	97.0	0.0233	84.2	0.0019
2	99.0		96.0		99.1		93.0		99.8		96.6		82.3	
3	100.0		95.7		100.0		94.2		100.0		97.8		81.1	
4	98.8		94.0		97.2		96.2		95.0		96.6		79.5	
1970:1	97.2	0.0103	92.6	0.0153	94.8	0.0211	94.8	0.0079	92.0	0.0079	98.0	0.0228	80.3	0.0019
2	95.1		92.4		93.0		94.2		89.8		98.0		83.4	
3	93.2		91.6		92.9		94.1		87.0		96.9		83.3	
4	91.6		88.0		91.0		96.8		81.2		97.8		83.6	
1971:1	92.6	0.0103	86.8	0.0154	90.7	0.0212	96.8	0.0075	85.6	0.0080	98.3	0.0224	80.6	0.0019
2	91.3		86.3		92.4		94.2		89.0		98.1		78.1	
3	92.1		86.8		92.7		93.8		88.8		97.8		79.2	
4	93.0		87.5		92.9		94.7		86.1		98.1		77.5	
1972:1	96.6	0.0102	87.5	0.0154	94.7	0.0213	95.6	0.0071	89.6	0.0081	98.3	0.0219	81.8	0.0019
2	96.6		87.1		96.5		94.8		94.7		99.6		79.0	
3	99.2		88.9		97.7		96.1		95.2		99.0		80.9	
4	99.3		91.1		97.8		98.3		94.8		98.6		85.3	
1973:1	100.0	0.0102	90.7	0.0154	98.4	0.0213	98.0	0.0067	98.5	0.0081	100.0	0.0214	87.3	0.0018
2	99.1		90.8		99.0		100.0		99.8		99.1		85.8	
3	98.7		93.6		100.0		99.8		100.0		99.8		82.2	

Table 4. U.S. Capacity Utilization Rates and Weights, by Industry, Quarterly, 1969–73 (*continued*)

Year and quarter	*Coal*		*Oil and natural gas extraction*		*Metal mining*		*Stone and earth minerals*		*Electric utilities*		*Gas utilities*	
	Utilization rate	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*	*Utilization rate*	*Weight*
1969:1	92.6	0.0020	95.0	0.0040	92.4	0.0013	92.6	0.0016	97.8	0.0143	96.9	0.0043
2	92.0		98.1		81.9		89.0		98.1		97.0	
3	91.5		97.1		87.6		87.5		100.0		98.0	
4	94.2		97.9		98.8		89.1		98.2		98.9	
1970:1	94.2	0.0017	97.7	0.0038	98.6	0.0012	84.4	0.0016	98.5	0.0143	100.0	0.0043
2	94.0		96.9		86.2		84.7		98.4		100.0	
3	95.0		96.6		89.7		83.2		98.1		99.6	
4	94.1		100.0		100.0		82.1		97.3		99.2	
1971:1	100.0	0.0015	97.3	0.0035	96.6	0.0011	79.5	0.0016	97.3	0.0144	97.6	0.0043
2	98.1		96.5		84.7		77.8		96.2		97.0	
3	95.6		94.6		71.2		74.2		96.4		94.4	
4	56.7		93.0		90.2		75.4		96.2		91.2	
1972:1	90.1	0.0013	93.4	0.0033	88.6	0.0010	75.7	0.0015	96.0	0.0144	95.7	0.0043
2	92.0		95.0		78.9		76.9		96.9		94.0	
3	87.9		95.3		80.5		78.8		97.7		93.8	
4	84.6		93.8		85.3		82.0		98.5		93.9	
1973:1	85.9	0.0010	92.0	0.0031	88.3	0.0009	85.0	0.0015	99.0	0.0144	92.8	0.0043
2	85.4		91.9		85.1		84.1		97.0		92.2	
3	89.0		93.5		87.3		87.1		100.0		91.7	

Source: Same as Table 1.

Comments and Discussion

Alan Greenspan: I will be briefer than usual, since the Klein-Long paper has anticipated many of my comments. The total operating rate sought here is not an arithmetic weighting of operating rates in individual industries, but rather the rate obtained from some type of input-output or linear programming system. Since interrelationships exist among materials flows from industry to industry, the weighting system needed to obtain an overall operating rate is one that rests on these flows. The measure of the economy's position in terms of an overall operating rate depends on the degree of shortage in parts of the system. Today shortages exist and they are restricting production. Particular industries, such as coal mining, may exhibit excess capacity, but this "slack" has only a limited impact on the adjustment of the overall economy to inflationary pressures.

Unfortunately, it is not easy to use an input-output system to get the kind of answer that is required. The economy is faced with specific engineering constraints—that, for example, so much electric power is needed in the electrolytic process to produce so much aluminum ingot; but there is also a considerable range of substitutability among materials which is basically a function of price. Therefore, the analysis requires not only some judgments about engineering interrelationships, but also the price vector that determines which materials or processes will be used. Without something of that sort, the concept of capacity is meaningless.

The real test of the concept is about to be thrust upon us, because the economy faces a classical case of deprivation of a basic material input—oil. What will that do to the level of industrial activity? Some preliminary work has had results that I don't fully know how to interpret. The analysis suggests that as soon as the price of energy began to rise in 1972, energy per unit of output dropped rapidly, clearly implying some price elasticity in the relationship of energy input to output of goods. The infrastructure of production in this country is obviously based upon the low levels of energy prices that have persisted for many decades. What is uncertain, unfortunately, is what the structure of production would be with energy prices two to three times what they have been. The input-output coefficients system would be markedly different. What is visible to date is dramatic evidence of the short-term elasticity of energy input with respect to price. It would be nice to believe that all the nation has to do is sit tight, allow prices to rise, and let the whole adjustment process take place with zero effect on capacity. But there is no way to be sure, because of uncertainty about engineering constraints that complicate the economic constraints.

In principle, "capacity" has meaning. In the current period of lengthening lags in deliveries, and of all sorts of reported shortages and difficulties in obtaining goods (regardless of price), the economy must be producing at capacity in any meaningful sense. If the numbers do not indicate that the economy is currently at capacity, then I suggest that the numbers are wrong, and that the correct concept of capacity must reflect the situation.

Next, I would like to raise a couple of issues about the Wharton method of measuring capacity. As I understand it, output of two-digit SIC manufacturing industries is used in constructing the estimates. One problem is that the two-digit data imply a lower level of capacity than would four-digit data since all four-digit industries within a two-digit grouping would not reach operating rates of 100 at the same time. Since this is such a simple computational problem, I don't understand why the classifications of the industrial production index are not used in their full detail. If they were, I suspect that the aggregate operating rate would automatically lose a point or two.

Furthermore, seasonality is a very tough problem for periods of peak output. I gather the unadjusted data were not used because occasionally they produce some peculiar results. Seasonally adjusted data may be just as misleading. In July, for example, seasonally adjusted operating rates increased sharply, merely reflecting the fact that unadjusted production fell less than usual during normal vacation periods because demand was so strong. I therefore have considerable difficulty interpreting seasonally adjusted operating rates when the economy is close to peak output.

I have a further question about how declining industries are handled. For example, when military equipment capacity is being dismantled or the aerospace industry is declining, a gap develops between the McGraw-Hill operating rate and the Wharton operating rate. The McGraw-Hill rate tends to be much higher in the declining industries. The Wharton ratchet technique works predictably on the up side, but how does it work on the down side?

Finally, just a note on the use of capital stock figures. They are notoriously poor on retirements, but there are also problems on additions. A considerable portion of gross fixed investment represents plants under construction, a category that is highly variable. In a period like the present, when there are long lags between construction starts and completions, I think (though I have no data to verify this) that a disproportionate amount of the increase in gross fixed assets, both as currently reported and as calculated using survival curves, results from the increase in plants under construction. The Federal Reserve's use of the capital stock with a 50 percent weight may thus introduce a significant upward bias to their capacity estimates. I do hope that Perry's paper will lead to a thoroughgoing revision in this index.

I find Perry's analysis of the cyclical bias in the McGraw-Hill index of operating rates exceptionally interesting. It explains a lot of what has been observed but could not be accounted for in those series. I think that Doug Greenwald could improve the McGraw-Hill numbers through an effort to adjust for these effects.

Douglas Greenwald: I would like to clarify a few points about the McGraw-Hill index relevant to George Perry's paper. First of all, McGraw-Hill gets all its answers on capacity utilization rates and investment plans from one survey in the spring. It is a package survey which we think draws relatively consistent responses from companies. But it does have some problems. One involves diversification by firms, which may make industry classifications misleading. For example, the rubber industry may report that it is adding 10 percent to capacity, when in reality all of this addition is devoted to chemicals. I don't know how to correct for this, but it is an important qualification to capacity numbers for individual industries. Another problem is determining the amount of investment devoted to expansion, modernization, pollution control, and employee health and safety. We have been concerned about the first three of these for some time, and questions designed to get at expenditures for health and safety equipment were added to our survey last spring.

With regard to data on operating rates in specific industries, we do have on our worksheets data on all two-digit manufacturing industries, and I will make these data available. We also now have unpublished data on thirty-eight three- and four-digit industries.

Finally, I think the differences in operating rates among firms can be illuminating. In a survey last fall, we asked companies where they were operating with respect to their preferred rate, and their reasons for operating above or below this level. The responses included some very odd reasons for operating above or below their preferred rate, but I do think their distribution is significant. While 47 percent of the companies reported that they were operating under their preferred rate, 30 percent said that they were operating over the preferred rate and 23 percent said that they were operating either at the preferred rate or very close to it.

Nathan Edmonson: I agree with most of what Alan Greenspan said, especially on the question of bottlenecks. A high rate of capacity utilization in one industry may not tell much about the economy as a whole, given considerable ability to substitute materials. Copper strikes, for example, have brought out almost unlimited possibilities for substitution for copper as an input. Our intent in forming the major materials utilization series was to assemble information on an admittedly small, but nevertheless strategic, group of materials industries. If the average utilization rate in these industries were high, and the variance of the rates for individual industries around this average were small, then substitution would become a moot point—firms would have to substitute one scarce good for another. The alternative to this approach would presumably be to use industry capacities and input-output coefficients to build a matrix of constraint relations. Capacity would then be defined as the maximum of value added, or some other measure of production, subject to these constraints. The weakness of this approach is that it ignores the possibilities of substitution. That is why we prefer to use information on the major materials industries.

My second comment is in response to a specific point made in Perry's paper: that the capacity index obtained by dividing the industrial production index by the McGraw-Hill utilization rate shows positive correlation with the output series (Table 1). Perry suggested that one possible explanation of this cyclical movement is that industries find capacity when things get tight and forget about it when things get slack. This is especially likely in an industry with a very heterogeneous product mix and a fairly nebulous notion of capacity. Another possible explanation may relate to the value-added weighting of the industrial production index. The benchmarking of the industrial production index to the Census of Manufacturers is done by seven-digit product classes, which are then added together using value-added weights. When capacity gets tight, I think it is safe to assume, producers tend to favor their more profitable product lines. Assuming a positive correlation between value added and profitability, the value-added weighting system would tend to exaggerate the level of the cyclical peaks in the production index, as the product mix would be shifted toward higher-value products when utilization is high. The implied capacity measure is constructed by dividing independent estimates of utilization collected from firms into the relevant components of the industrial production index. If the product-mix effect is in the production index (the numerator) but not in the reported utilization rate (the denominator), the resulting capacity measure would exhibit the same upward movement at cyclical peaks as the production index. The work we have done with industry people leads us to believe that these product-mix effects may not be picked up in the reports on utilization. In materials industries especially, capacity is a fairly simple and well-established concept, often based on engineering estimates that do not take account of the product mix. In the paper industry, capacity utilization is expressed as the ratio of actual tons of paper to potential tons of paper, and the tonnage measure is *not* sensitive to product mix. Much the same can be said for estimates of utilization rates in the steel industry and in petroleum refining. To the extent that product mix may not affect the reported utilization rates as it does the industrial production index, a cyclical bias would emerge in this estimate of capacity as it alone among the capacity indexes studied is directly benchmarked to industrial production.

George Perry: I would like to comment on the suggestion, made by Klein and Long and by Greenspan, that an input-output approach be taken to measuring aggregate capacity. Certainly, a lot of important information is lost in simply averaging a lot of disparate operating rates for individual industries. And a more sophisticated concept of aggregate capacity, which took account of bottlenecks and shortages, would be nice to have. But, even if the many difficulties in constructing such a measure could be overcome, it might not be the best one for most uses. A material shortage or a bottleneck in an industry supplying intermediate products can restrain output and raise prices in a user industry, just as a shortage of physical capacity in that industry would. But the two sources of restraint differ in many respects. It would be helpful to know that, even in the presence of underutilized facilities, auto output could not expand because steel was unavailable; but, for an investment equation, this concept might give the misleading idea that the auto industry was operating at "capacity" in this situation. Quite apart from this, none of the present indexes clearly meets the criterion of a more sophisticated aggregation better than the others. If output in 1973 was constrained by bottlenecks and material shortages to a greater extent than usual, that in itself does not recommend the index that registers the highest operating rates for the year. Rather, with the present state of the art of measuring capacity, it seems better to note separately the level of operating rates and conditions in the labor and materials markets and analyze from there.

General Discussion

William Branson questioned the procedure of choosing among utilization measures on the basis of their performance in explaining prices, investment, trade flows, and the like. He directed this criticism at both Perry's paper and Klein's defense of the Wharton measure. Lawrence Krause, on the other hand, approved a methodology by which one picks a utilization measure on the basis of the questions one wishes it to answer. Krause agreed that a linear programming approach might produce a useful measure of potential production for the entire economy, but noted that such an approach would have to make specific allowance for the possibilities of substituting foreign for domestic materials. William Nordhaus suggested that labor constraints as well as capital constraints be considered in formulating a capacity concept.

There was some discussion of the merits of the Wharton measure in particular. Klein answered Greenspan's question about declining industries: in such cases, judgments are made as to how much of the retired capacity could be reactivated at short notice, and the downward trend in capacity is "leveled off" accordingly. Branson pointed out that the effectiveness of other utilization variables in explaining trade flows in other models weakens Klein's case for the Wharton measure. Murray Foss reported the success of the Wharton measure, as compared to the FRB measure, in his own regressions explaining investment between 1964 and 1973. Gardner Ackley was disturbed by the inherent inability of the Wharton measure to determine differences in capacity pressures at different cyclical peaks, except to the extent that the aggregate measure would vary due to a different time dispersion of individual industry peaks. In particular, he noted that its failure to distinguish between inflationary and noninflationary peaks would hinder the Wharton measure's performance in price equations.

Charles Holt and Franco Modigliani thought it would be useful to sort out the effects of preferred and actual utilization rates by including both as independent variables in Perry's regressions. Stephen Goldfeld added that this procedure would be particularly important if the response of the dependent variable to utilization was nonlinear as the preferred rate was approached. Perry agreed that in principle one expected these nonlinearities to be important; but the limited attempts to find nonlinear effects reported in the text did not turn up many significant cases. Modigliani and Nordhaus objected to the use of utilization levels to explain rates of price increase. They noted that since an increase in utilization will raise prices by raising the desired markup, the proper explanatory variable for the *rate of change* of prices is the *rate of change* of the utilization rate. Otherwise, a utilization rate that simply remained high could create an ever-widening gap between prices and wages. Perry replied that he had reported on results from both specifications because he agreed with these doubts conceptually, but found that the empirical results did not confirm the doubts. Arthur Okun suggested that the price equation might be viewed as a reduced form of a larger model in which utilization worked through investment to accelerate the growth of capacity. In this case, an unusually high rate of utilization could be sustained only by the continued frustration of plans to expand capacity to meet demand. Thus prices could reasonably be expected to rise, even though utilization remained stable at a high level.

Foss cited independent evidence on the tightness of capacity in 1973. Two series related to capacity utilization published in *Business Conditions Digest*—percent of firms reporting slower deliveries, and percent of firms reporting long-term commitments to buy production materials—exceeded previous postwar peaks during 1973. Also, as of June 1973, 48 percent of the firms (weighted by gross fixed assets) responding to a BEA survey reported that they were short of capacity, as compared with 48 percent at the peak in 1969 and 51 percent at the 1966 peak. Foss also reported that the chief reason given by firms responding to the McGraw-Hill survey for operating below their preferred rates was a supply constraint; only 24 percent of those operating below preferred rates cited insufficient demand.