SHORT TERM PROJECTIONS OF MANUFACTURING CAPACITY UTILIZATION

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As the papers presented at this conference demonstrate, there is a divergence of views as to whether current measures of capacity utilization overstate or understate the amount of untapped capacity remaining in the economy. I want to sidestep this issue, concentrating instead on one widely used measure of capacity utilization: the Federal Reserve Board's capacity utilization rate for manufacturing. In particular, I want to discuss a simple model which can be used to project manufacturing capacity utilization, as published by the Board, over the next couple of years. Those, including certain members of the Federal Reserve Bank of St. Louis, who feel the Board's measure of capacity utilization is biased downward may argue that capacity problems will develop sooner than our model predicts; those who feel current measures of capacity utilization are biased upward may take the opposite view, arguing that capacity problems will not emerge until later. Nonetheless, examining when capacity is likely to become strained--at least on the basis of the Board's capacity utilization statistic--is an interesting experiment and provides a useful benchmark for discussions about prospective capacity problems. Indeed, to leak

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one of our findings, it is not necessary to take the "St. Louis Fed's" position that currently published measures of capacity utilization are artificially low to show their concern about potential capacity problems within the next couple of years.

The model presented in this paper is for the key sector of manufacturing, although the technique can be applied to other sectors of the economy as well. First, an equation is estimated linking growth in manufacturing output to growth in GNP. Next, additions to manufacturing capacity are estimated, based on projections of investment. The forecast of output is then divided by the forecast of capacity to yield projections of capacity utilization. The model is first used to project capacity utilization from 1977 III - 1978 IV, based on a "consensus" forecast of GNP growth. Next, implications are drawn concerning the impact on capacity utilization of strong protracted economic growth, the Administration's assumption.

Specifying the Model

Manufacturing output and GNP tend to move together. In growth terms, the relationship between these two variables can be specified as:[1/]

$$\overset{o}{IP}_t = a_o + a_1 \overset{o}{GNP}_t + \varepsilon_t \qquad (1)$$

$\overset{o}{IP}_t$ = Percentage change in the manufacturing index of industrial production, i.e., $100\,(IP_t - IP_{t-1}) / IP_{t-1}$.

$\overset{o}{GNP}_t$ = Percentage change in constant-dollar gross national product.

ε_t = Error term.

The change in capacity from one period to the next depends positively on the volume of investment and negatively on the extent of depreciation, which in turn depends on the level of capacity last period. (See Appendix 1 for greater elaboration.) The change-in-capacity equation can therefore be depicted as follows:

$$C_t - C_{t-1} = b_1 C_{t-1} + b_2 I_t + \varepsilon_t' \qquad (2)$$

C_t = Capacity index for manufacturing.

I_t = Real manufacturing investment net of pollution control expenditures.

ε_t' = Error term.

As many economists have observed, investment accelerates as the volume of unused capacity shrinks, i.e., as the capacity utilization rate (CU) rises. Changes in investment are therefore specified to be a function of past changes in capacity utilization:

$$\overset{o}{I}_t = c_o \; c_1 \; \overset{o}{CU}_{t-1} + \varepsilon_t'' \qquad (3)$$

$\overset{o}{I}_t$ = Percentage change in investment (I) from the previous calendar year.

$\overset{o}{CU}_{t-1}$ = Percentage change in capacity utilization (CU) over the previous year (fourth quarter to fourth quarter).

ε_t'' = Error term.

Although this equation greatly abstracts from the underlying determinants of investment, it performs well empirically. Another advantage of this specification is that the capacity utilization rates generated by our model can be used to project investment in subsequent years. That is, when combined with GNP projections, equations (1), (2), and (3) constitute a closed system capable of projecting capacity utilization rates indefinitely into the future.

Empirical Results

Equations (1) - (3) were estimated over the period 1954-1976. Results are reported in Table 1. From the first equation, it is apparent that manufacturing output is more volatile than GNP; the large coefficient for $\overset{o}{GNP}$ indicates that rapid GNP growth is on average accompanied by even more rapid growth in manufacturing output. The coefficient of C_{t-1} in equation (2) indicates that, in the absence of investment, capacity declines 3.35 percent per year, the result of depreciation and obsolescence. The coefficient of I_t indicates that each one billion dollars of non-pollution-control investment expenditures, measured in 1972 dollars, increases the capacity index (1976 IV = 163.2) by 0.29 percentage point. Converting the investment coefficient to an elasticity, each 1.0 percent change in real investment net of pollution control is on average associated with a 1.0 percent change in gross additions to capacity (as opposed to net additions, i.e., additions net of depreciation.)[2/] Finally, as expected, equation (3) indicates that investment accelerates as capacity utilization rises.

The fit of all three equations is quite good, as judged by the R^2 values, and all coefficients are statistically different from zero.

Table 1

Regression Results*
(t-statistics in parentheses)

$$I^{o}P_t = -.756 + 2.203\ \overset{o}{GNP}_t \qquad (1)$$
$$\quad (\ 4.22)\ (16.46)$$

$R^2 = .751$ SE = 1.37 DW = 1.85
Sample Period: 1954 I - 1976 IV

$$C_t - C_{t-1} = -.0335\ C_{t-1} + .2923\ I_t \qquad (2)$$
$$\quad (3.23) \qquad (7.10)$$

$R^2 = .935$ SE = .576 $\hat{\rho} = .578$ DW = 1.70
Sample Period: 1954 - 1976

$$\overset{o}{I}_t = 4.196 + 1.754\ C^{o}U_{t-1} \qquad (3)$$
$$\quad (2.97) \quad (6.55)$$

$R^2 = .671$ SE = 6.74 DW = 1.71
Sample Period: 1954 - 1976

Note: $I^{o}P$ = Quarterly growth of manufacturing output
$\overset{o}{GNP}$ = Quarterly growth of real gross national product
C = Index of manufacturing capacity
I = Real manufacturing investment net of pollution control expenditures
$C^{o}U$ = Growth of capacity utilization in manufacturing

* The Cochrane-Orcutt iterative technique was used to adjust for first-order autocorrelation in equation (2).

Even more important, simulation results (presented in Appendix 2) indicate that the model does a good job of tracking capacity utilization during the current recovery. Having passed this test, the model was then used to run two experiments, described in the following sections.

Projecting Capacity Utilization, 1977 III - 1978 IV

Based on the increase in investment projected for 1977 -- $\overset{o}{I}_{77}$ = 12.9 percent[3/] -- capacity is projected to increase by 3.2 percent between 1976 IV and 1977 IV. The increase is assumed to be distributed equally throughout the year, implying a quarterly growth in capacity of 9.791 percent.[4/] Output growth is projected using the median of eight prominent forecasts of real GNP growth, as published in the September 1977 issue of the Conference Board's Statistical Bulletin (see Table 2). The output growth and capacity expansion projections are brought together in Table 3.[5/] Based on the Conference Board median GNP forecasts, our model projects that capacity utilization in manufacturing will increase steadily to 85.8 percent in 1978 IV. Capacity will expand at a 3.2 percent annual rate in 1977 and at a 3.9 percent rate in 1978, compared to the 2.3 percent rate of 1976; manufacturing output will increase over the forecast period at an average annual rate of 6.3 percent.

The 85.8 percent rate projected for 1978 IV is but 2 percentage points below the 1973 quarterly peak and 2.8 percentage points below the highest peacetime peak recorded. Hence, based upon the median

Table 2

Real GNP Growth,
Median Conference Board Forecast

		Compound Annual Growth Rate	Quarterly Growth Rate
1977	III	4.4 percent	1.082 percent
	IV	4.6	1.131
1978	I	4.45	1.094
	II	4.4	1.082
	III	4.2	1.034
	IV	3.4	.839

Source: The Conference Board, Statistical Bulletin, September 1977.

Table 3

Capacity Utilization Projections
Based on Median Conference Board Forecast

		$\overset{\circ}{C}$	$\overset{\circ}{GNP}$	$I\overset{\circ}{\ }P$	ρ	CU
1977	II					82.6
	III	.791	1.082	1.628	1.008	83.3
	IV	.791	1.131	1.736	1.009	84.0
1978	I	.961	1.094	1.654	1.007	84.6
	II	.961	1.082	1.628	1.007	85.2
	III	.961	1.034	1.522	1.006	85.7
	IV	.961	.839	1.092	1.001	85.8

Note: $\overset{\circ}{C}$ = Percentage change in capacity (from previous quarter)
$\overset{\circ}{GNP}$ = Percentage change in real GNP
$I^{o}P$ = Percentage change in manufacturing output
$\rho = (IP_t \ / \ IP_{t-1}) \ / \ (C_t \ / \ C_{t-1})$
CU = Capacity utilization (percent)

forecast of GNP growth, as published by the Conference Board, our model indicates that the manufacturing sector is likely to contain some modest amount of untapped capacity at the end of 1978, yet little enough so that concern over bottlenecks in 1979 seems warranted.

Capacity Utilization as Implied by the Administration's Projections of GNP Growth

The Administration recently set a goal of reducing the aggregate unemployment rate to 4.6 percent by the end of 1981. To achieve this goal, they estimate that real GNP must grow from 1977 through 1981 by an average of 5.1 percent per year.[6/] The implications for capacity utilization can be examined by plugging the 5.1 percent growth rate into our model -- an experiment which indicates the Administration's goal is apparently overly optimistic. Based on the Administration's GNP figures, our model projects that capacity utilization would reach its 1973 peak in 1978 IV, its peacetime peak in 1979 I, and its all-time peak in 1980 I (see Table 4). Assuming 5.1 percent GNP growth could be sustained, capacity utilization would rise to 96 percent in 1981 IV. Historical experience, however, indicates that a utilization rate this high is unattainable for manufacturing; widespread shortages and bottlenecks would emerge well before such a rate could be achieved.

Of course, investment is not actually predetermined through 1981. The investment values forecast by the model were based on the historical relationship between changes in capacity utilization and changes in investment growth. But investment growth can be influenced by other factors as well; e.g., by changes in tax policy or in the degree of uncertainty facing businessmen. Therefore, if the Administration wants to foster prolonged economic growth it must attach increased importance to stimulating investment, thereby slowing the rise in capacity utilization and postponing the time when capacity will become strained. Yet, even if investment is spurred the Administration's goal may still prove elusive. Our model suggests that, on the basis of continued strong GNP growth, capacity problems are likely to appear within the next two years.

Table 4

Capacity Utilization Projections
Based on the Administration's GNP Scenario

		$\overset{\circ}{C}$	$\overset{\circ}{GNP}$	$\overset{\circ}{IP}$	ρ	CU
1977	II					82.6
	III	.791	1.251	2.000	1.012	83.6
	IV	.791	1.251	2.000	1.012	84.6
1978	I	.985	1.251	2.000	1.010	85.4
	II	.985	1.251	2.000	1.010	86.3
	III	.985	1.251	2.000	1.010	87.2
	IV	.985	1.251	2.000	1.010	88.0
1979	I	1.131	1.251	2.000	1.009	88.8
	II	1.131	1.251	2.000	1.009	89.6
	III	1.131	1.251	2.000	1.009	90.4
	IV	1.131	1.251	2.000	1.009	91.2
1980	I	1.251	1.251	2.000	1.007	91.8
	II	1.251	1.251	2.000	1.007	92.5
	III	1.251	1.251	2.000	1.007	93.1
	IV	1.251	1.251	2.000	1.007	93.8
1981	I	1.348	1.251	2.000	1.006	94.4
	II	1.348	1.251	2.000	1.006	94.9
	III	1.348	1.251	2.000	1.006	95.5
	IV	1.348	1.251	2.000	1.006	96.1

Appendix 1: Projecting Capacity Growth

Additions to manufacturing capacity are estimated from investment data. Investment is measured in real or constant-dollar terms, since capacity is related to real rather than nominal investment. In addition, pollution control expenditures are netted out, since these expenditures do not augment productive capacity. Yet, even with these adjustments, translating investment data into capacity growth can be tricky.

One difficulty is that the composition as well as volume of investment is important. Investment which eliminates a production bottleneck may have a tremendous impact on capacity. On the other hand, investment which expands plant size may, while providing additional office space, leave plant capacity unchanged. A new machine, if added to the existing stock of equipment increases capacity, but if some existing equipment is retired when the new machine is put in place capacity need not be increased. Furthermore, expenditures on modernization generally provide for smaller capacity growth than outlays on new plant and equipment. Finally, the impact of an investment dollar is likely to vary from industry to industry. A dollar spent in an industry approaching capacity will have a more pronounced impact on aggregate capacity than a dollar spent in an industry possessing abundant unused capacity.

Also complicating the investment-capacity relationship is the fact that investment frequently increases capacity with a lag. Projects requiring years to finish are likely to add to capacity only when completed or nearly so. A plant half-completed may not augment a firm's capacity at all. Moreover, the lags involved may vary both over time and by type of investment.

The severity of these problems is difficult to assess *a priori*. While the composition of investment may vary substantially over time for a particular company or industry, in the aggregate the composition of investment may remain relatively stable. Therefore, how well aggregate investment explains capacity growth is ultimately an empirical question. So is the question of whether capacity growth this period is significantly related to previous investment. Each period, investment dollars are spent which increase capacity only in the future. At the same time, however, certain projects started in the past are finished, adding to capacity in the current period. If these two lag effects wash out sufficiently, then empirically capacity growth may not be related to previous investment, but only to current investment. To investigate the relationship between investment and capacity, the following model was developed.

Capacity in a given period (C_t) is identically equal to capacity last period minus the loss in capacity due to depreciation and obsolescence (D_t) plus the gross additions to capacity ($CADD_t$), i.e.,

$$C_t \equiv C_{t-1} - D_t + CADD_t. \qquad (4)$$

It is assumed that capacity depreciates at a constant rate each period:

$$D_t = \alpha \, C_{t-1}. \qquad (5)$$

In addition, it is assumed that gross additions to capacity are related to current and possibly previous investment:

$$CADD_t = \beta_1 I_t + \beta_2 I_{t-1} + \dots \qquad (6)$$

where I_t refers to real investment net of pollution control expenditures.

Combining the above equations, capacity can be rewritten as:

$$C_t -(1-\alpha)C_{t-1} + \beta_1 I_t + \beta_2 I_{t-1} + \dots \varepsilon_t. \qquad (7)$$

where ε represents the error term. Alternatively, the change in capacity can be expressed as:

$$C_t - C_{t-1} = -\alpha C_{t-1} + \beta_1 I_t + \beta_2 I_{t-1} + \dots \varepsilon_t. \qquad (7')$$

Estimates of α and β are the same whether obtained by estimating equation (7) or equation (7').

The capacity variable of this study refers to manufacturing capacity as measured by the Board of Governors of the Federal Reserve System.7/ Capacity values were obtained for the fourth quarter of each year (see Table 5). Fourth-quarter values were chosen because both the Board of Governors and McGraw-Hill estimate capacity growth on an end-of-year basis.

The investment variable (I) is an estimate of real plant and equipment expenditures over the calendar year net of pollution control spending. The variable is defined as follows:

$$I = PE\ (100 - POL)/P$$

where PE = Expenditures for new manufacturing plant and equipment, in billions of (current) dollars;

POL = Percent of plant and equipment expenditures for air and water pollution control;

P = Implicit GNP price deflator for business fixed investment.

The PE data are published by the Bureau of Economic Analysis, the POL data by McGraw-Hill.[8/]

Equation (7') was estimated over the period 1954-76.[9/] Lagged investment terms did not contribute to the explanatory power of the equation, nor were their coefficients statistically significant. Only current investment proved to be statistically important. Therefore, the lagged investment terms were dropped. (Regression results are reported in Table 1, equation (2).

Table 5

Values of the Investment and Capacity Variables

	Investment (I)	Capacity (C)
1953	18.9	62.7
1954	17.8	65.1
1955	18.3	67.9
1956	22.2	71.4
1957	22.7	74.2
1958	17.2	76.6
1959	17.2	79.3
1960	20.3	83.0
1961	19.4	85.9
1962	20.2	88.8
1963	21.6	92.1
1964	25.4	96.1
1965	30.4	102.7
1966	35.6	110.2
1967	35.0	117.9
1968	33.3	124.7
1969	35.1	131.1
1970	33.1	136.1
1971	28.9	140.0
1972	28.7	144.7
1973	33.2	150.3
1974	36.2	155.7
1975	33.0	159.5
1976	34.2	163.2

Appendix 2: Simulating the Model

To test its predictive ability, the model was simulated over the first nine quarters of the current recovery. The equations, estimated over the period 1954 I to 1974 IV, were used to generate forecasts for 1975 II - IV. After updating the equations through 1975 IV, forecasts for 1976 were made. Finally, after extending the sample period through 1976 IV, capacity utilization was forecast for the first two quarters of 1977.

Simulation results uncovered no apparent bias. Although capacity utilization was somewhat underpredicted during 1976, the model did get back on track. Capacity utilization was recorded to be 82.6 percent in 1977 II, compared to a projected rate of 82.7 percent (see Table 6). Thus, capacity utilization rose 11.7 percentage points during the first nine quarters of the recovery, compared to the 11.8 percentage points projected by our model. Moreover, actual capacity utilization and the rate predicted by our model never diverged by more than 1.3 percentage point. Our model even picked up the decline in capacity utilization registered in 1976 IV.

Table 6

Simulations of Capacity Utilization

		$\mathring{C}$	$\mathring{GNP}$	$\mathring{IPP}$	ρ	$\hat{CU}$	CU	$\hat{CU}$-CU
1975	I						70.9	
	II	.668	1.573	2.627	1.019	72.2	71.3	.9
	III	.668	2.735	5.008	1.043	75.4	75.3	.1
	IV	.668	.745	1.930	1.003	75.6	76.8	-1.2
1976	I	.595	2.130	3.946	1.033	78.1	79.0	-.9
	II	.595	1.234	1.965	1.014	79.2	80.2	-1.0
	III	.595	.959	1.357	1.008	79.8	80.8	-1.0
	IV	.595	.288	-.126	.993	79.3	80.6	-1.3
1977	I	.791	1.833	3.282	1.025	81.3	81.2	.1
	II	.791	1.503	2.555	1.018	82.7	82.6	.1

Note: $\hat{CU}$ = Capacity utilization as simulated by the model
CU = Actual capacity utilization

Footnotes

1/ Nonlinear versions of equation (1) were also tried, but their results were empirically inferior.

2/ The term $G_t \equiv C_t - (1-\alpha)C_{t-1} = C_t - .9665\ C_{t-1}$ measures the gross change in capacity, i.e., the difference between actual capacity and the level which would have prevailed in the absence of any investment. Since G = .2923 I, the elasticity of G with respect to I, evaluated at the mean, is $\eta = .2923\ \bar{I} / \bar{G}$ where $\bar{I}$ and $\bar{G}$ refer to the mean values of I and G over the estimation period (1954-76). $\bar{I}$ = 26.92 and G and 7.89. Hence, η = .2923 (26.92 / 7.89) = 1.0. In other words, each 1 percent change in our investment variable is associated with a 1 percent change in gross capacity growth. Therefore, if in a certain year $25 billion in investment would increase capacity by 5 percent in gross terms, then raising investment to $30 billion (an increase of 20 percent) can be expected to raise gross capacity growth to 6 percent (also an increase of 20 percent). The finding that investment changes and changes in capacity growth are linked in such a manner is appealing on theoretical grounds, and suggests that our investment variable does a good job of capturing gross additions to capacity.

3/ Interestingly, the 1977 projection of investment derived from equation (3) falls in between the investment plans reported by the BEA and by McGraw-Hill in late spring. Based on the growth in capacity utilization between 1975 IV and 1976 IV, equation (3) projects that manufacturing investment in 1977, as measured by our investment variable (I), will exceed investment in 1976 by about 12.9 percent. The BEA investment survey figures translate into a 9.3 percent increase in I; the McGraw-Hill figures, into a 14.3 percent increase (assuming a 6 percent increase in the price of investment goods (P) and using the 1977 estimate of pollution control expenditures reported by McGraw-Hill).

4/ That is, $(1.00791)^4 = 1.032$.

5/ Capacity utilization in time period t is defined as the ratio of actual output to capacity output, i.e.,

$$CU_t = IP_t/C_t.$$

By lagging this relationship one period, it can easily be shown that the utilization rates in successive periods are related as follows:

$$CU_t = \rho \, CU_{t-1}$$

$$\text{where } \rho = \frac{IP_t \,/\, IP_{t-1}}{C_t \,/\, C_{t-1}}.$$

This is the formula used to project capacity utilization.

6/ See Office of Management and Budget, Midsession Review of Fiscal 1978 Budget, Special Supplement, July 1, 1977.

7/ Among other advantages, the Board of Governors series is readily available to the general public, has a long track record, and lacks any apparent cyclical bias. For a discussion of the major series of capacity utilization, see James Ragan, "Measuring Capacity Utilization in Manufacturing," Federal Reserve Bank of New York Quarterly Review, Winter 1976, pp. 13-20.

8/ The pollution control data are actually available only since 1967; but, because pollution control expenditures did not begin their rapid ascent until the late sixties, the fraction of investment expenditures devoted to pollution control prior to 1967 was probably close to the fraction spent in 1967. This was the assumption made. Thus, the pre-1967 values of POL were set equal to the 1967 value (2.8 percent). The BEA also publishes a series on pollution control expenditures, but it does not begin until six years after the McGraw-Hill series.

9/ The estimation period was annual, rather than quarterly, because truly independent capacity values were available only once per year. Both the Federal Reserve Board (whose series is used in this study) and McGraw-Hill obtain capacity values at year-end. Although quarterly estimates are available, these are simply interpolations between annual observations.