

INDUSTRIAL CAPACITY AND INDUSTRIAL INVESTMENT

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Abstract

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This paper examines the relationship between capacity growth and the growth and composition of investment. Because capacity is an index of the maximum sustainable output of an industry, capacity growth is unlikely to be determined solely by the growth of an industry's fixed capital stock. Statistical analysis of two-digit manufacturing industries finds that labor force growth, as well as capital stock growth, also helps explain the growth of capacity over the 5-year periods between Censuses of manufacturing. There is evidence that changes in the composition of an industry's capital stock are associated with changes in the growth of its capacity, with more rapid growth being associated with a shift away from more conventional capital types. Application of the statistical analysis to 1993 and 1994 suggests, at most, a fairly modest understatement of capacity growth (and overstatement of utilization rates), even taking into account the recent capital spending surge.

Industrial Capacity and Industrial Investment

Charles Steindel*

The Federal Reserve Board is currently reporting that the capacity of the U.S. manufacturing sector is growing at a rate of over 4 percent a year--up from about 3 percent in 1994. This pickup has occurred in the context of double-digit growth in capital spending. The capital spending surge might suggest that despite the recent increase capacity growth has been and is being understated--meaning that the inflationary pressures suggested by the fairly high reported capacity utilization rates in late 1994 and early 1995 was overstated.

As a check on the ongoing estimates of capacity growth, this paper looks at historic relationships between industry capacity growth and industry capital spending. The next section discusses the definition and measurement of capacity and the possible linkages between the growth and level of investment and capacity. This is followed by a statistical analysis of capacity growth and sketches its implications for recent developments in capacity. On the whole, the statistical analysis suggests, at most, a fairly modest recent understatement of capacity growth (and overstatement of utilization rates), even taking into account the capital spending surge.

What is Capacity?

The Federal Reserve Board's capacity measures are intended to be indexes of the maximum output an industry can produce under

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normal conditions, given its stock of capital and its workforce.¹ They are derived, to a large extent, from annual surveys of industry capacity utilization rates; indexes of industry output are divided by the utilization rates to construct the indexes of capacity. This procedure obviously introduces uncertainty into the high-frequency capacity data. Even the annual data may be off, given possible sampling errors in the utilization surveys and uncertainty about the output measures.² This uncertainty about the short-term capacity measures, along with the occasionally substantive revisions in the preliminary data, can justify some skepticism about the ongoing capacity series.

As a general rule, though, incoming investment data can not

¹For discussions of capacity and its measurement, see Board of Governors of the Federal Reserve System (1986) and Richard Raddock (1994). There is a question about the economic interpretation of the capacity measure. Economists would likely define "capacity" as the level of output associated with the lowest average cost of production; output higher than that level would be associated with upward pressure on prices. If the published capacity data truly reflected this definition, capacity utilization rates would likely fluctuate around 100 percent. The published utilization numbers are generally well below 100 percent. This suggests that the capacity concept measured is more of an "engineering" one. That is, capacity may be thought of as the maximum amount that can readily be produced without a breakdown of plant and equipment or major changes in the organization of production, regardless of unit costs. If "economic" capacity is a fixed proportion of "engineering" capacity there is no problem using the latter measure in analysis of the economics of capacity growth.

²The uncertainty in the output measures stems from possible sampling error in the series used to interpolate higher-frequency output from the benchmarks established every five years from the Census of Manufacturing. See the works cited in note 1, above, and Charles Steindel (1994) for a discussion of this issue.

by themselves be expected to yield much information about current developments in capacity.³ One fundamental break between investment and capacity stems from the distinction between installed capital and investment spending. Growth in capacity is related to the growth of the productive power of the installed capital stock. This latter is not easily measured, but simple observation suggests that even radical increases in capital spending are unlikely to make major changes in the near-term growth of the productive power of the capital stock. Making the rather strong set of assumptions that the growth of capacity depends only on the growth of the productive capital stock, and that every dollar of investment increases the productivity of the installed capital stock by an equal amount, raising the growth of capacity by one-third (eg., from 3 percent to 4 percent), would involve increasing investment by one-third, which would be quite exceptional in the short-run.

The above calculation probably overstates the potential gains in capacity growth solely from increased investment. Production represents the combined efforts of many factors other than capital, including labor, raw materials, managerial skill, and technology. Innumerable studies have found that accelerated growth in capital can, in the short or medium term, account for only a moderate acceleration in output growth--a one-third pickup in the growth of the productive capital stock would not be

³Aside from the elementary point that one should look at the data on the fairly small manufacturing component of investment, as opposed to the aggregate data.

expected, by itself, to speed up output growth (and presumably capacity growth as well) by no more than one-sixth.⁴

Nonetheless, the standard arguments against a predominant role for investment in capacity growth need not strictly hold. Different types of investment might be associated with very different effects on capacity growth, particularly in the short run. For instance, increased investment in new high-technology capital may be associated with dramatically higher capacity growth, not only because of the productivity gains directly attributable to the new capital, but also because increased investment in the new types of capital is associated with other improvements in basic production technology. Thus, it is conceivable that a shift in the composition of investment might be associated with more rapid capacity growth, even if it is acknowledged that increased overall investment is unlikely to lead to very dramatic changes in the capacity trend.

Statistical Analysis

This section reports on some statistical analysis of the historic growth of manufacturing capacity, with an eye toward

⁴There's a simple logic to this. The income accruing to capital--such as interest and profits--accounts for less than one-half of output. In the long run, the income going to a factor of production should be a good approximation to its contribution to growth (if a factor contributes more to growth than it earns, market forces would bid up the returns to the factor, increasing its earnings). Of course, it is possible that an acceleration in investment spending will in the short-run, through the multiplier mechanism, disproportionately increase output. However, this output increase would be mostly due a temporary increase in demand rather than a permanent increase in capacity.

highlighting the role of the growth and composition of fixed investment. Application of this analysis to recent data will allow the obtaining of a better sense of the plausibility of the current official estimates of capacity growth.

Capacity data for years of manufacturing Censuses (every 5; the last one was 1992) are probably somewhat more reliable than at other times, because in these years it is possible to get both more accurate measure of industrial output and a better sense of the representativeness of the firms used to survey utilization rates. Since there are only a few of these Census years, one can not infer the effects of shifts in the investment mix on capacity by looking at aggregate capacity growth over the periods between Censuses.

One to get a handle on compositional effects is to look at capacity growth by industry, rather than for the manufacturing sector as a whole. Thus, the statistical analysis was done of capacity growth for 20 two-digit manufacturing industries over the last 4 periods between manufacturing Censuses--1972-77, 1977-82, 1982-87, and 1987-92.⁵ The assumptions underlying the analysis were that capacity growth for an industry during one of these periods was related to the growth of its workforce, some unspecified factor (presumably related to overall technological growth and possibly the business cycle) common to all industries

⁵Actually, capacity data are not published for one two-digit industry--tobacco--while the data for the very large transportation equipment industry can be sub-divided between motor vehicles and other transportation equipment.

in each period, and either the growth of its overall capital stock or the growth of individual components of its capital stock.⁶

Workforce growth was computed by the trend growth rate between Census years.⁷ Using the actual growth in employees between Census years could give a misleading indication of capacity-enhancing labor growth, given the particular circumstances of those years (most notably, the deep 1982 cyclical trough would tend to give a deceptively low reading for employment growth between 1977 and 1982 and a deceptively high reading for 1982-87).

Table 1 shows the statistical results. The first column reports the coefficients from a regression where capacity growth depends on the growth in the overall net capital stock owned by the industry.⁸

The investment series that directly affects the net capital stock is net investment--gross investment less depreciation. The

⁶R. Spence Hilton (1988) also used industry capital stock growth to explain capacity growth. His work used annual data from highly aggregated industries (primary and advanced processing manufacturing). He could not find different effects from growth in different types of capital (equipment and structures). His model did not treat workforce growth as capacity-enhancing.

⁷Specifically, the coefficient on time from a regression of the logarithm of an industry's annual full-time equivalent employment on time. Separate regressions were estimated for each industry for each of the four periods.

⁸The capital stock for a year is the average of the end-of-year data published by the Bureau of Economic Analysis. eg., an industry's 1972 capital stock is the average of its year-end 1971 and 1972 stocks.

Table 1

Determinants of Industry Capacity Growth

	(1)	(2)	(3)	(4)
1972-1977 dummy	.062 (.026)	.042 (.028)	.043 (.029)	.047 (.027)
1977-1982 dummy	.061 (.028)	.045 (.029)	.045 (.029)	.051 (.028)
1982-1987 dummy	.063 (.019)	.039 (.024)	.038 (.024)	.046 (.020)
1987-1992 dummy	.075 (.021)	.060 (.024)	.061 (.025)	.059 (.022)
Trend change in log workforce	.476 (.091)	.451 (.091)	.453 (.093)	.456 (.092)
Change in log capital stock	.483 (.092)		-.187 (.865)	
Change in log standard capital		.319 (.097)	.477 (.737)	
Change in log other capital		.184 (.074)	.219 (.140)	
Change in log standard plus 3 times other capital				.496 (.091)
Adjusted R ²	.569	.581	.576	.576
Standard Error	.083	.082	.082	.082
Sum of squared residuals	.507	.486	.485	.498

Standard errors in parentheses.

Dependent variable: Change in log capacity.

Standard capital consists of real net stock of construction, metalworking, general industrial, special industry, and service industry machinery plus industrial buildings.

Other capital consists of all other real net fixed nonresidential capital.

There are 80 observations.

growth in an industry's capital stock from one Census year to another is directly proportional to the ratio of cumulated net investment over these years to the initial year's capital stock.

The column 1 results suggest that a one-percent increase in an industry's underlying workforce (as noted above, not a one-percent increase in actual employment) adds a bit less than one-half percent to its capacity. A one-percent increase in its net capital stock also adds a bit less than one-half percent to capacity. The sensitivity to the workforce is a bit less, and that of capital a bit more, than the usual findings for the sensitivity of output (as opposed to capacity) to growth in labor and capital.⁹ The point estimates of the labor and capital contributions to capacity sum to just shy of one, but are clearly in the vicinity of constant returns to scale for the two factors.

Notable are the large coefficients on the time-period variables. These suggest that over a five-year period a typical

⁹This result suggests that respondents to utilization surveys view growth in the capital stock as a bit more important factor in capacity growth than would be suggested by studies of long-term growth. In turn, this is probably consistent with an "engineering" view of industrial capacity, where the main limiting factor in the short-term is the size of the capital stock.

It is also possible that simultaneity bias is working to boost the coefficient on capital. Industries experiencing rapid growth in output and capacity may invest heavily in fixed capital assets since they are probably relatively optimistic about their long-term prospects. However, in all likelihood there would be a similar (but probably smaller) upward bias in the labor coefficient. On the whole, an upward bias in the coefficient on capital is not of great concern for this paper, since one of the purposes of the statistical analysis is to check whether a large effect for capital would produce a sharp increase in an estimate of recent capacity growth.

industry would see roughly 6 or 7 percent growth in its capacity. even if there was no growth in its capital stock or workforce.

U.S. manufacturing capacity grew 80% between 1972 and 1992; the column results suggest that over one-third of this--about 30% of the 80% growth--is "explained" by the period variables.¹⁰ These residual factors probably include things such as economies of scale, growth in organizational expertise, benefits of R&D spending, and the increasing education and skills of the workforce. Large residual factors are commonly found in studies of economic growth. One encouraging sign in the column 1 results is the relative stability of these time coefficients. The estimation period of the regression includes the still unexplained resurgence in manufacturing productivity in the 1980s¹¹, which may have also been associated with a rebound in capacity not accounted for by labor and capital inputs.

The other columns of Table 1 show variations of the column 1 equation reflecting the decomposition of the capital stock into growth of various components. Each industry's capital stock is divided in two; one part being conventional industrial equipment and structures--machinery (except office machinery) plus

¹⁰Specifically, the sum of the four period variables is .261. Since the estimated equation is in logarithms, the percentage increase corresponding to this sum is computed from the anti-log of .261.

¹¹See Steindel (1992a and 1992b), Stephen Oliner and Daniel Sichel (1994) and S. Brock Blomberg and Steindel (1995) for rejections of the popular hypotheses that high-tech investment or corporate restructuring played major, easily quantified, roles in this recovery.

industrial buildings--and the other part consisting of all other equipment and structures--office machinery (mostly computers) and a hodge-podge of other capital types, such as furniture, cars, and trucks.

Column 2 shows the results of a regression estimated with the growth of the two capital categories as variables; column 3 further includes the growth of the overall capital stock. We can think of columns 1 and 2 as two competing ways of relating capital stock growth to capacity growth. In the column 1 regression, all capital types are fundamentally the same--technically, they are perfect substitutes, and one 1987 dollar's worth of computers adds as much to an industry's capacity as one 1987 dollar's worth of metalworking machinery.¹² Column 2 weakens the assumption of perfect substitution; according to the formulation of the regression, an industry's capacity can not grow unless it has some minimal amount of both capital

¹²Stated in these terms the extreme unrealism of this view can be made more clear. Changing the base year for aggregating the capital stock of an industry, or the total for the manufacturing sector as a whole, will typically change the relative quantities of a base year's dollar worth of two capital types; one 1987 dollar's worth of computers would be a much more powerful machine than one 1982 dollar's worth of computers; while one 1987 dollar's worth of an industrial building probably isn't a much different building than one 1982 dollar's worth. Thus, adding together the stock of computers and industrial buildings valued in 1987 dollars will give a very different aggregate than adding them up valued in 1982 dollars. Most notably, the historic growth of the two aggregates could be very different (see Steindel (1994) for a discussion of this issue). Since the growth of the aggregate capital stock of an industry can be changed merely by the simple accounting change of changing the base year for adding up its components, it seems to hard to take it seriously as a plausible signal of industry capacity growth.

categories. The column 3 regression essentially tests the assumptions of columns 1 and 2. If column 3 is statistically superior to column 1, we may reject column 1's assumption of perfect substitution between capital types. If column 3 is better than column 2, there are problems with column 2's formulation of the role of capital growth in capacity growth. A direct comparison of columns 1 and 2 has no formal statistical meaning.

Standard statistical tests (a T-test for comparing columns 2 and 3; an F-test for comparison of columns 1 and 3) strongly suggest that the column 3 formulation is not superior to either column 1 or column 2. Both formulations thus pass this simple test of their robustness.

The column 2 results show a considerably higher coefficient on the standard capital types than on the nonconventional forms of capital--a one-percentage point increase in the stock of standard capital is associated with a .32 percentage point increase in an industry's capacity, while a one-percentage point increase in the unconventional stock is associated with only a .18 percentage point increase in capacity. However, this result does not mean that the marginal product of standard capital--the bang for the investment buck--is larger than that for nonconventional capital. In fact the reverse seems to be true. The real stock of nonconventional capital is small compared to the stock of standard capital. This means that a one constant-dollar increase (as opposed to a one percentage point increase)

will result in a greater percentage-point increase in the nonconventional stock than in the standard stock. In fact, since the nonconventional capital stock in most industries is less than half the size of the standard stock, the column 2 results actually suggest that unconventional capital has a higher marginal product than standard capital.

Column 4 presents the results of a regression which imposed the constraint that the marginal product of unconventional capital is 3 times the size of that of standard capital (some experimentation suggested that the standard error of the regression model is minimized near that constraint). In general, the coefficients of the time and labor variables are very similar to those in Column 2. The coefficient on the redefined capital stock is close to that on the total stock in Column 1; however, for most industries the growth of this redefined stock in recent years has been faster than the usually measured stock, since unconventional capital types have been growing relative to the standard items.

Table 2 draws out the implications of the columns 1, 2, and 3 results for aggregate manufacturing capacity growth since 1992. The following assumptions were used to make these estimates:

1. The average growth of production-worker employment in 1993 and 1994 was used as the labor input for each industry.
2. The 1987-92 time coefficient estimated for each equation was assumed to hold for the period since then.
3. Each industry's share of economy-wide gross investment in the

Table 2
Aggregate Capacity Growth, 1993-1994

	1993	1994
FRB estimate	2.4%	2.8%
Column (1) estimate	2.4%	3.1%
Column (2) estimate	2.5%	3.4%
Column (3) estimate	2.6%	3.6%

two capital types in 1994 was the same as in 1993, and the depreciation rate each industry saw for each capital type in 1993 held in 1994.

4. Each industry's contribution to 1993 aggregate capacity growth was weighted by the product of its 1992 capacity index level and its production weight; each industry's 1994 contribution to aggregate capacity growth reflects its recomputed 1993 weight in capacity.

The three columns give virtually identical results for 1993, which are also very close to the official estimates that overall capacity grew 2.4% in that year. The 1994 results show a bit wider spread, and are somewhat higher than the official estimate of 2.8% growth. The extreme case is the estimate from column 4; this equation suggests that 1994 capacity levels may have been about a percentage point higher than the official estimate, taking into account the difference between the two estimates of capacity growth in both 1993 and 1994. Even this difference, though, does not greatly alter one's qualitative views about recent capacity pressures in manufacturing--a one percentage point boost to capacity estimates would have lowered late 1994 utilization rates from around 85% to around 84%. Such an adjustment to utilization, all else equal, would probably only modestly reduce one's views of the potential for increased inflation.

While the alternative estimates were only made for annual data, they all imply that quarterly growth in capacity should

have been at an annual rate of at least 3 1/2 percent in 1994. This is a bit higher than the official estimates for that year, but the estimates that capacity growth is now growing at over a 4 percent rate seems quite plausible. On the whole, then, the incoming estimates of capacity growth seem hard to challenge for not systematically reflecting investment developments--if capacity growth turns out to be very much higher than the official numbers now show, it's likely because disembodied technical progress is considerably higher than in 1987-92.¹³ While this is possible, an appeal to the investment data as now reported does not support the presumption that capacity growth is being significantly understated.

Conclusion

Examination of the capacity concept, and statistical examination of the link between industry capacity growth and investment, shows that swings in investment, while important, can not be expected to lead to very dramatic short-term changes in capacity growth. There is some slight evidence that differences in the composition of investment and capital stock growth may make a difference to capacity growth. Application of the statistical results to 1993 and 1994 data produce estimates of capacity growth that are modestly higher than, but on the whole, supportive of the published estimates.

¹³Or, of course, the investment and employment data turn out to be stronger than currently reported.

References

Blomberg, S. Brock and Charles Steindel. "Industry Restructuring Measures and Productivity: Evidence from the 1990s." Federal Reserve Bank of New York Research Paper 9509, May 1995.

Board of Governors of the Federal Reserve System. Industrial Production: 1986 Edition. Washington, 1986.

Hilton, R. Spence. "Capacity Constraints and the Prospects for External Adjustment and Economic Growth: 1989-90." Federal Reserve Bank of New York Quarterly Review, vol. 13-14 (Winter-Spring 1989), pp. 52-68.

Oliner, Stephen D. and Daniel E. Sichel. "Computers and Output Growth Revisited: How Big is the Puzzle?" Brookings Papers on Economic Activity, 1994:2, pp. 273-334.

Raddock, Richard. "Industrial Production and Capacity Utilization since 1990: A Revision." Federal Reserve Bulletin, vol. 30 (March 1994), pp. 220-226.

Steindel, Charles (1992a). "Industry Productivity and High-Tech Investment." Federal Reserve Bank of New York Research Paper 9202, January 1992.

_____. (1992b). "Manufacturing Productivity and High-Tech Investment." Federal Reserve Bank of New York Quarterly Review, vol. 17, no. 2 (Summer 1992), pp. 39-47.

_____. (1994). "Assessing Recent Trends in Manufacturing." Federal Reserve Bank of New York Research Paper 9409, July 1994.