Capacity Constraints and the Prospects for External Adjustment and Economic Growth: 1989-90

Capacity pressures in the manufacturing sector are approaching critical levels. In the initial stages of the current economic expansion, the utilization rate in manufacturing moved up sharply from a postwar low of 68 percent of capacity to about 80 percent. The operating rate remained near that level for three years despite continued expansion of the economy overall because a deteriorating trade balance stalled growth in the manufacturing sector. Since the trade balance began to turn around late in 1986, manufacturing output and capacity utilization have risen steadily. The utilization rate in manufacturing is still somewhat below the peak rates of earlier economic expansions; however, continued revitalization of the manufacturing sector could soon place widespread strains on existing productive capacity.

Many analysts believe that the turnaround in the U.S. net export position underway for the past two years is likely to remain an important source of growth in the economy this year and possibly beyond.[1] Continued trade improvement would primarily benefit manufacturers because the value of goods traded internationally originates mostly in the manufacturing sector. However, sufficient productive capacity must be available to ensure that additional demand for manufactured goods leads to further economic growth rather than rising price inflation. The recent rebound in manufacturing investment should ease capacity and price pressures in that sector, but historically capacity growth has not always responded strongly to a pickup in capital spending. If the trade picture continues to improve and demand at home remains strong, then operating rates in manufacturing could soon surpass levels associated with accelerating inflation.

This article examines the implications of continued economic growth in general and of a robust performance of the trade sector in particular for capacity utilization in manufacturing through 1990. Operating rates associated with different paths of economic growth and investment spending are used to assess the conditions under which capacity constraints would contribute to inflationary pressures or would create a barrier to further trade improvement over the next two years.

The two components of the capacity utilization index, output and capacity, are derived independently in the following analysis. First, projections for capacity growth over the next two years are constructed based on investment expectations and estimates of the relation between changes in the stock of capital and capacity. Investment spending assumptions for this period are conditioned on a robust performance of the manufacturing sector. To assess the outlook for manufacturing output, rates of growth are postulated through 1990 for the major components of GNP based on recent trends and current conditions. Alternative paths for exports, imports, and domestic demand are considered in order to measure the sensitivity of manufacturing output to these assumptions. The implications of each scenario for manufacturing output are calculated using an input-output framework, which translates exports, imports, and domestic demand into output by industrial sectors of the economy. These results are combined with the capacity growth calculations to derive outcomes for the

[1] A debated issue among economists and policymakers is whether the dollar must depreciate substantially more in order to realize further trade gains.

rate of capacity utilization in manufacturing over the next two years.

For most of this analysis manufacturing is divided into its advanced processing and primary processing components in order to address concerns that capacity pressures in basic or primary processing industries are likely to become especially tight.[2] Further disaggregation is made in order to highlight particular industries where capacity bottlenecks could become severe.

Current capacity pressures in manufacturing

The capacity utilization series graphed in Chart 1 shows that at the end of 1988 the operating rate in manufacturing was about 84½ percent of capacity, still below previous peaks. The utilization rate peaked at 86 percent late in 1978 and remained near that level for much of the following year. In 1973, immediately prior to the first oil price shock, capacity utilization stood at 87 percent. Even higher rates of utilization were recorded during earlier economic expansions.

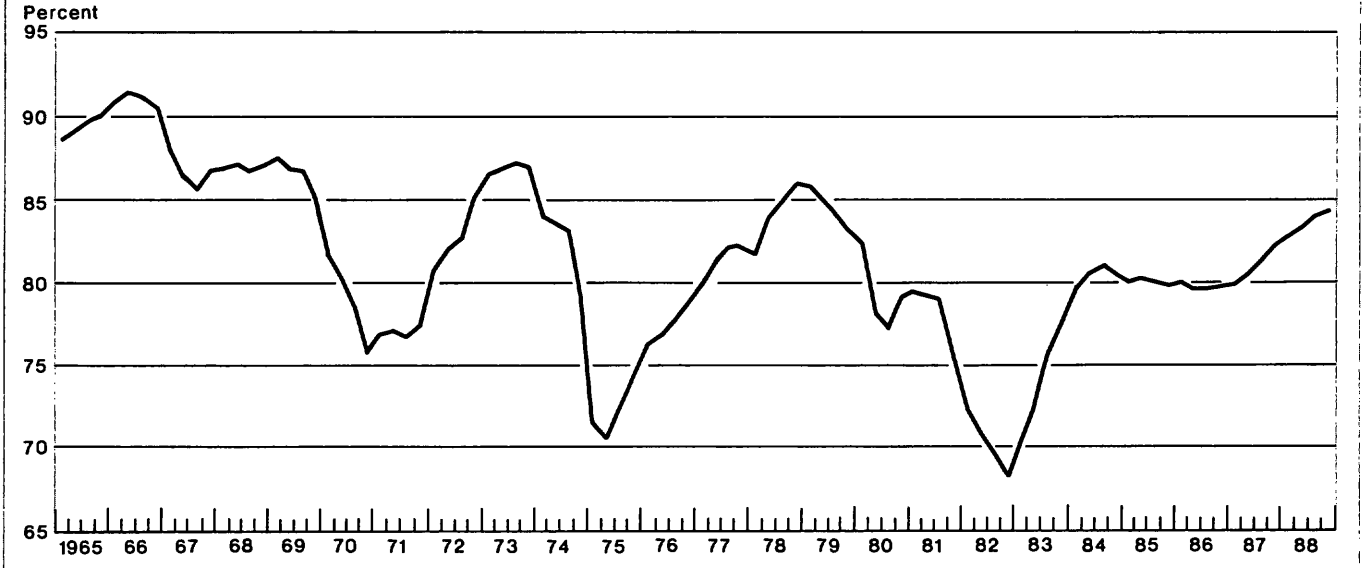
Levels of capacity utilization frequently differ across industries, but typically they move in tandem. As shown in Chart 2, operating rates for primary processing and advanced processing industries have moved closely together over recent business cycles. However, the variability of the primary processing series exceeds that of its advanced processing counterpart. During periods of sustained economic growth, utilization rates in primary processing industries normally rise above rates in other industries, and they usually drop below rates in the advanced processing sector during economic downturns.

The relation between capacity utilization and producer price inflation for manufactured goods is very imprecise, but the series graphed in Chart 3 support the general conclusion that there is an association between rising capacity utilization and higher inflation. The operating rates at which inflationary bottlenecks first emerge and then spread throughout the manufacturing sector are below the peak rates attained during an economic expansion. In the late 1970s producer price inflation advanced markedly as the utilization rate neared its peak level of 86 percent. In early 1973 inflation began to accelerate sharply as the rate of utilization moved beyond 85 percent, almost a year before reaching its peak for the period. The link between capacity utilization and inflation during the 1960s and earlier years is less clear. Moreover, structural changes in the economy since then compromise comparisons of

[2]Advanced processing industries includes producers of processed foods, apparel, chemical products such as drugs and toiletries, furniture, machinery, transportation equipment, and other finished goods. Primary processing industries includes manufacturers of textile products, paper products, industrial chemicals, petroleum products, rubber and plastics, lumber, primary metals, fabricated metal products, and stone, clay, and glass products. Together these two groupings account for all manufacturing output.

Chart 1

Manufacturing Capacity Utilization Rate



critical pressure points between different eras. But even during that earlier period there was a perceptible pickup in price inflation as the utilization rate moved beyond a level between 85 to 86 percent, although the acceleration appears mild compared to later experience. The available evidence does not establish whether there is a stable critical level of capacity utilization above which price inflation necessarily begins to accelerate, nor does past experience indicate how rapidly prices will rise once capacity pressures reach such an inflationary threshold. But the historical record strongly suggests that the inflation rate for manufactured products tends to move up when the capacity utilization rate exceeds a level between 85 and 86 percent.

The outlook for capacity growth

Developing an outlook for capacity begins with an examination of the relation between changes in the stock of capital and capacity growth. Next, estimates of investment spending through 1990 are used to derive changes in the net stock of capital. The results of these two exercises are the basis of capacity projections over the next two years. Later, these capacity estimates are combined with output projections to derive capacity utilization rates through 1990.

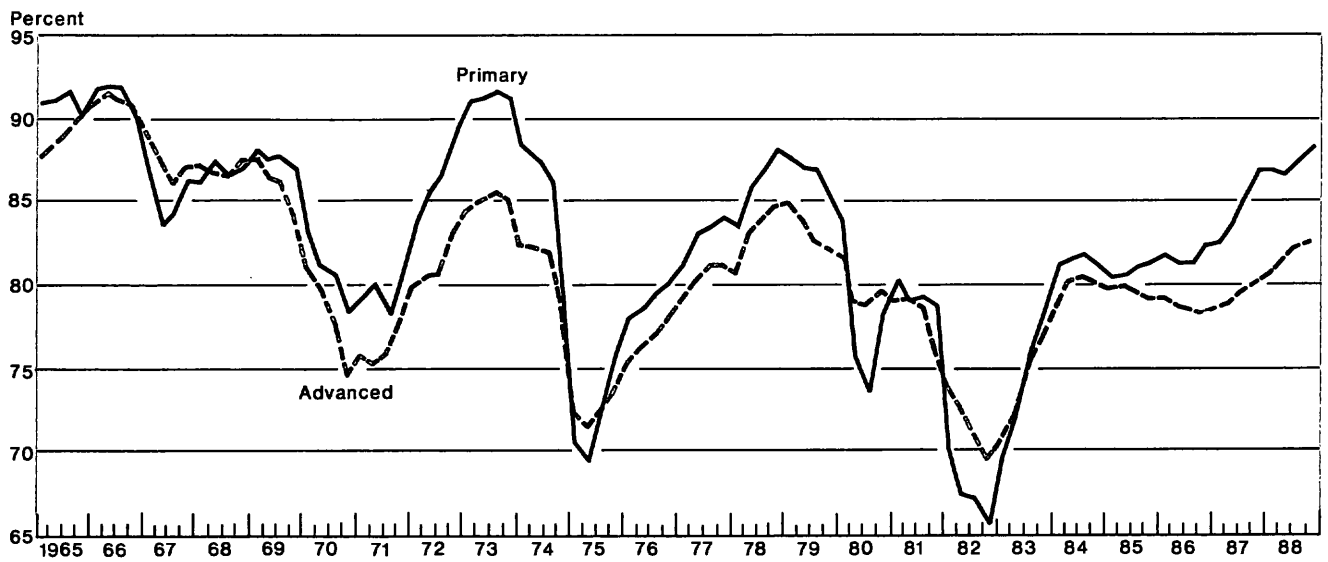
Capacity growth and capital stock changes

Indexes of capacity are typically based on manufacturers' responses to surveys on the maximum output their establishment could produce "using a realistic employee work schedule with the machinery and equipment in place."[3] The preceding quotation highlights the importance of the capital stock, or plant and equipment, as a determinant of capacity. In practice, other factors can affect capacity, or survey respondents' perception of existing capacity. For example, the increased labor and depreciation costs associated with operating machinery at high rates normally cause estimates of capacity to fall well below the theoretical engineering maximum pace of operations. Cost considerations of this kind in part determine what constitutes a "realistic employee work schedule" to use with capital. Rising profitability brought on, say, by a generally improving business climate or declining labor costs can induce managers to step up their pace of operations and alter their calculation of a "realistic" work schedule. In this environment, a manager's estimate of capacity can rise with no material change in the physical capital stock. Analysts frequently comment on the tendency of capacity estimates to behave in this manner over business cycles, and some effort is made to minimize this fea-

[3]This is the definition of "practical capacity" used by the Bureau of the Census. For a helpful presentation of the conceptual and practical difficulties in constructing capacity measures, see Richard Raddock, "Federal Reserve Estimates of Capacity and Utilization," Board of Governors, 1987.

Chart 2

Capacity Utilization in Primary and Advanced Processing Industries



ture in constructing capacity indexes. Over time, however, the size of the capital stock and the technology it embodies dominate other determinants of capacity.

The close association between capacity growth and changes in the capital stock is highlighted in Chart 4. The net capital stock measures the rate of expansion of the stock of plant and equipment after discounting for the effects of depreciation. The plotted series confirm that a slowdown in the rate of expansion of capital this decade, related to a downturn in investment spending, was a major factor behind the slowing in capacity growth over the same period. Net capital expanded about 3½ percent per year on average during the late 1970s, and annual capacity growth ranged from 3 to 3½ percent. In contrast, in the current expansion, net capital has expanded about 1 percent per year, and capacity growth has mostly stayed between 2½ and 3 percent. On the basis of this close historical relationship, the following analysis uses anticipated movements in the stock of capital to derive the outlook for capacity over the next two years.

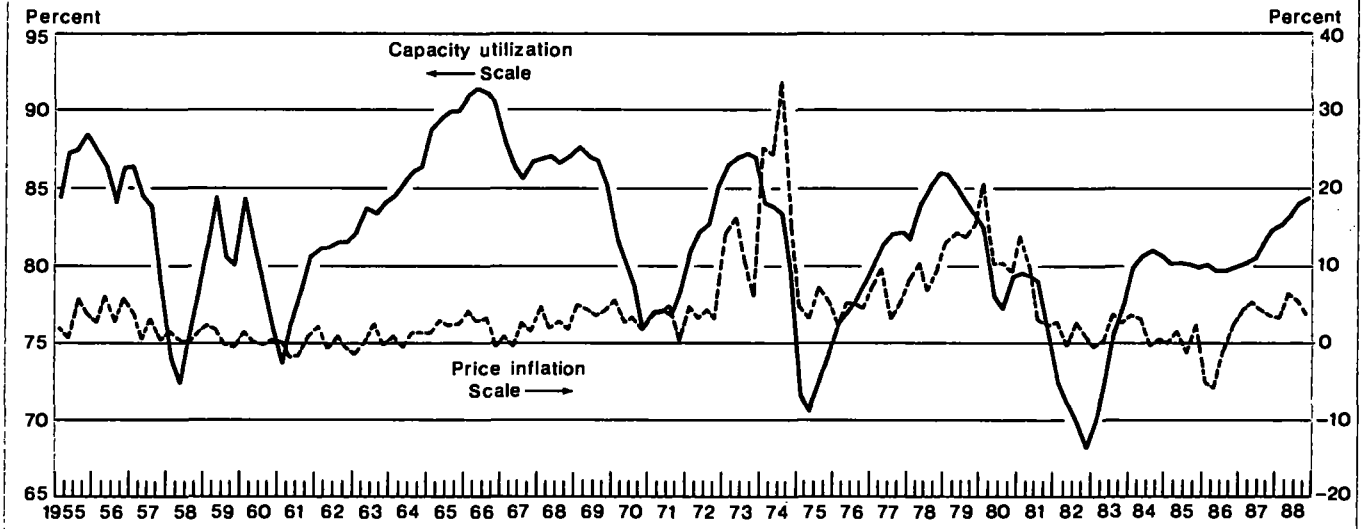
Despite the close association of these two series, several factors can distort the relation between investment and changes in productive capacity. On the one hand, not all investments are made to expand productive capacity. Some additions to the capital stock have replaced labor as part of a trend towards automation and have not raised capacity. Whenever new capital serves as a substitute for labor and is not accompanied by increased employment, capacity growth may lag the rate of growth in capital. On the other hand, more recent vintages of capital embody the latest technology and can raise capacity even in instances where the depreciation of older plant and machinery causes the total stock of available capital to decline or remain unchanged. Price indexes of capital goods, which are used to deflate the value of the capital stock into "real" or constant dollar indexes, do not always fully capture the impact that advancing technology has on the quality of new capital goods. Consequently, capacity at times may expand at a faster rate than net additions to the capital stock.

To sort out these various effects, an equation was estimated using the aggregate manufacturing capital stock and capacity data underlying Chart 4. The results of this exercise, reported in Appendix A, indicate that a one percentage point rise in the rate of growth of the net capital stock increases capacity growth by about three-tenths of one percentage point. Moreover, capacity may rise over 2 percent even in periods when the net capital stock is unchanged. The capital stock-capacity relation also was estimated separately for the primary processing and advanced processing industries of the manufacturing sector. These results, also presented in Appendix A, are similar to those found for the total manufacturing sector. Estimates also were

Chart 3

Capacity Utilization and Manufacturing Prices

Percent Change, Seasonally Adjusted Annual Rates



derived for 21 industries making up the manufacturing sector, and in most cases the estimated sensitivity of capacity to changes in capital stock growth rates is close to the three-tenths level found in the aggregate equations.

The outlook for the net capital stock

Projected changes in the net capital stock are based on estimates of future investment spending and rates of depreciation according to the following relationship:

(1) $KK = I/K - D/K$,

where KK is the percentage change in the net capital stock from the start to the end of any period, I is the level of new investment, D is the value of depreciation on existing capital, and K represents the value of the capital stock at the start of the period. The first of the two ratios in the above equation, I/K, measures the rate at which new investment adds to the existing stock of capital while D/K represents the rate at which capital depreciates. Their difference determines the rate of expansion of the net capital stock. Recent values and projections through 1990 of these variables are presented in Table 1 for all of manufacturing and for the primary and advanced processing industries.

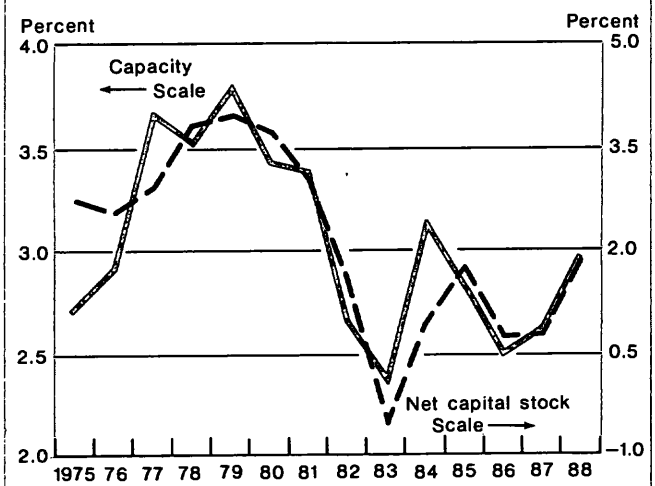
Estimates of investment spending in 1988 and plans for 1989 are presented in the Department of Commerce survey of business capital spending for all manufacturing and for many industries within manufacturing.[4] The survey findings, once adjusted for inflation, indicate that manufacturers stepped up investment spending in 1988 by more than 12 percent over the 1987 level. This represents a significant advance over the sluggish pace of investment that prevailed in the preceding two years and reflects the growing pressure placed on existing capacity by the trade-related rebound in manufacturing. A baseline investment path is constructed using spending plans taken from the survey for 1989, and for 1990 investment is extrapolated on the assumption that continued strong demand for manufactured products will lead to further growth in capital goods spending, although at a rate of advance well below the 1988 pace. The survey results indicate that manufacturing investment will rise 3.6 percent in 1989 in real terms, and it is assumed that investment will grow another 4 percent in 1990. If realized, this pattern of growth would represent a departure from recent investment trends. Not since the period 1978-80 has investment increased in three consecutive years. Because of expanding domestic demand and an improving foreign sector, investment spending in manufacturing rose an average of 4 percent per annum for two years following a 12 percent rise in 1978. The experience of that earlier period closely parallels the baseline investment path through 1990. To measure the sensitivity of capacity growth to investment, an alternative scenario is constructed that assumes a faster rate of growth in investment spending. The rate of growth in spending on capital goods is doubled to 8 percent a year in 1989 and 1990, a change that brings the average annual increase for the three years 1988-90 to its highest level for any three-year period since 1972-74.

The Department of Commerce capital spending survey shows that investment in the primary processing industries, where capacity growth has been relatively slow during the current expansion, grew 16 percent in 1988, compared to 11 percent in the advanced processing sector. For 1989, the survey results indicate that investment will grow 6 percent in the primary processing sector and just 2 percent in the advanced processing sector. Investment is assumed to rise 4 percent in both sectors in 1990 in the baseline case. The Department of Commerce survey of capital spending also provides estimates of investment in 1988 for many disaggregated industries within manufacturing. The survey results are used to project capital spending for individual industries in 1989, and in 1990 investment in each industry is assumed to increase 4 percent.

Chart 4

Capacity and Net Capital Stock in Manufacturing

Percent Change, Fourth Quarter over Fourth Quarter



[4]Survey results from December 1988 are used in this analysis. Updated survey results do not affect the conclusions of this study.

The jump in investment spending in 1988 explains the sharp rise in the value of investment relative to the existing stock of capital, the first of the two ratios from equation 1. For all of manufacturing, this ratio rose from a level of 10.6 percent in 1987 to 11.8 percent the following year, with a larger percentage point rise registered in the primary processing sector. In 1989 and 1990, continued growth of investment ensures that this ratio rises further, although at a much slower pace even when using the higher investment outlook. The rate of depreciation in manufacturing, the second ratio in equation 1, currently stands close to 10 percent per annum, but this rate has been steadily rising over the past 10 years. The projections assume that this upward trend continues through 1990.

The change in the net capital stock for each industry is calculated as the difference between the investment-capital ratio and the depreciation rate. For all of manufacturing, the net capital stock rose an estimated 1.9 percent in 1988, up from 0.8 percent the preceding year and above the 1.1 percent annual pace in the four-year period ending in 1987. This pickup reflects the rise in the investment-capital ratio, which itself was caused by the sharp rise in investment. Moreover, the net capital stock in the primary processing industries rose in 1988 for the first time in the current economic expansion. For 1989 and 1990, the rate of growth of the net capital stock continues to rise, but only marginally under the baseline investment assumptions. For all of manufacturing the projected net capital stock rises just over 2 percent per year, with most of the pickup concentrated in the primary processing sector.

Estimates of capacity growth

Capacity growth for 1989 and 1990 is extrapolated from its 1988 rate by combining projected changes in the net capital stock with the estimated sensitivity of capacity to movements in the net capital stock.[5] For most industries, the rate of growth in the net capital stock over the next two years remains close to the 1988 rate of expansion because growth in investment spending slows in the baseline case. Consequently, capacity growth edges up only marginally. For all manufacturing, capacity growth rises only slightly above the 3 percent pace of 1988, with somewhat greater expansion occurring in the primary processing sector

[5]These extrapolations are based on the coefficient estimates on the net capital stock variable reported in Appendix A for the manufacturing, primary processing, and advanced processing industry groups. For the more disaggregated industries, capacity projections (not reported) are constructed assuming an elasticity of 0.30 between capital stock changes and capacity growth.

Table 1

Investment and Capacity Growth

	Average 1984-87	1988	Baseline Investment 1989	Baseline Investment 1990	High Investment 1989	High Investment 1990
All manufacturing						
Investment (percent change)	6.4	12.4	3.6	4.0	8.0	8.0
Investment/capital (ratio)	10.6	11.8	12.0	12.2	12.5	13.2
Depreciation/capital (ratio)	9.6	9.9	10.0	10.1	10.0	10.1
Net capital stock (percent change)	1.1	1.9	2.0	2.1	2.5	3.1
Capacity (percent change)	2.8	3.0	3.0	3.1	3.2	3.3
Primary processing						
Investment (percent change)	2.7	15.5	5.8	4.0	10.2	8.0
Investment/capital (ratio)	8.1	9.6	10.2	10.5	10.6	11.3
Depreciation/capital (ratio)	9.1	9.4	9.5	9.6	9.5	9.6
Net capital stock (percent change)	−1.0	0.3	0.7	0.9	1.1	1.7
Capacity (percent change)	1.7	3.3	3.4	3.4	3.5	3.7
Advanced processing						
Investment (percent change)	9.0	10.5	2.3	4.0	6.7	8.0
Investment/capital (ratio)	13.1	13.8	13.6	13.7	14.2	14.8
Depreciation/capital (ratio)	10.0	10.4	10.5	10.6	10.5	10.6
Net capital stock (percent change)	3.1	3.4	3.1	3.1	3.7	4.2
Capacity (percent change)	3.3	2.9	2.9	2.9	3.0	3.1

Notes: Investment changes are year-over-year, net capital stock and capacity changes are end-year over end-year, and other values are ratios. Net capital stock is the difference between investment/capital and depreciation/capital. Some results may not add exactly due to rounding.

(Table 1). When the high investment assumptions are used, capacity growth is stronger, with annual capacity growth nearing 3½ percent by 1990.

These capacity estimates are used with the output projections taken from the following section to calculate changes in capacity utilization through 1990. These projected changes in capacity must be interpreted cautiously, especially at the detailed industry level. Factors other than investment or changes in the capital stock frequently have affected capacity growth over a short-term horizon. For example, the intensive application of new technology and managers' revised estimates of production possibilities during periods of rapid economic expansion sometimes have caused capacity growth to jump with no corresponding pickup in capital spending. Thus, considerable uncertainty surrounds any given industry estimate of capacity growth. Taken together, however, these estimates provide a general picture of likely capacity trends in the manufacturing sector under the assumed investment environment.

The outlook for manufacturing output

Historically, changes in capacity utilization have been brought on by rapid production shifts more than by movements in capacity (Chart 5). The implications of continued economic growth, and an improving external balance in particular, for manufacturing output are explored in this section. In the approach adopted, two plausible scenarios for the economy over the next two years are developed, with assumed growth paths specified for the major components of GNP. Then the implications of the scenarios for the manufacturing sector are calculated. In later sections these calculations, which may be viewed as conditional forecasts of manufacturing production, are combined with the outlook for capacity growth to determine implied capacity utilization rates. These results are used to evaluate the likelihood that inflationary bottlenecks will develop in the manufacturing sector and to highlight particular pressure points within manufacturing.

The analysis uses two accounting relationships to break down or translate economic activity from one basis of measurement to another. The first holds that total purchases of final goods and services in the economy, the most common measure of GNP, equals domestic demand plus exports minus imports. Exports minus imports, or "net exports," includes international transactions of services. Domestic demand measures U.S. residents' purchases of all final goods and services regardless of national origin. Consumer, investment, and government spending on domestically produced and imported goods and services are part of domestic demand, but exports are omitted. The second accounting relationship used is the input-output table of the U.S. economy. This describes the various intermediate inputs consumed by an industry during production. The input-output table translates purchases of final goods and services into production activity in particular industries or sectors of the economy.

Economic scenarios

Growth rates associated with two economic scenarios are presented in Table 2.[6] Each scenario represents a path the economy could take over the next two years, based on assumed changes in domestic demand, exports, and imports. In the *moderate growth scenario,* real GNP growth falls to a pace consistent with long-run trends and considerably below the rate of economic expansion during the past two years. The *high growth scenario* is designed to highlight the inflation risks arising from continued strong growth in the economy.

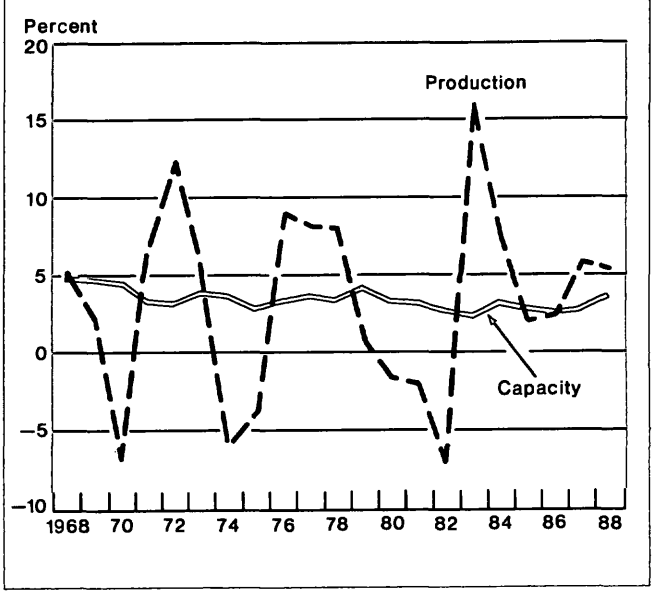
In the moderate growth scenario, both domestic demand and net export growth slow, but their relative contributions to GNP growth do not change significantly. Domestic demand growth drops to about 2 percent per year, well below the pace of the past two

[6]Historical changes in 1988 and projected changes in 1989 are net of the effect of the drought on GNP. The drought reduced GNP and domestic demand growth by an estimated half a percentage point in 1988; it should boost growth in 1989 by a similar amount.

Chart 5

Production and Capacity Growth in Manufacturing

Percent Change, Fourth Quarter over Fourth Quarter



years.[7] Manufacturing export growth decelerates from its recent 20 percent annual rate to 10 percent by 1990 as the effects of past exchange rate changes wear off. Imports grow at slightly under their average pace of the past two years. Exports and imports of advanced processing goods rise more rapidly than primary processing goods, as they have for the past two years. Other components of net exports, such as trade in services and nonmanufactured goods, are assumed to move in line with recent trends. Overall, these assumptions leave real GNP growing at about 2½ percent by 1990, close to many estimates of long-run potential growth in the economy.

The high growth scenario assumes that domestic demand does not adjust to a lower growth path. Instead, domestic demand rises about 3 percent per year over the projection period, only slightly below its average rate of growth over the past two years. Imports of manufactured goods rise at a faster pace than in the moderate growth case because of stronger domestic demand, but export growth is the same in both scenarios. These assumptions leave real GNP growing at just over 3 percent per year by 1990.

[7]Total domestic demand growth averages 2 percent across all sectors, but demand is assumed to be somewhat stronger for the final output of the manufacturing and services sectors than for the output of other sectors.

The input-output structure of the economy

If the demand for all final goods and services produced by an economy were to grow by the same percentage amount, then production in all sectors of the economy also would expand uniformly. But when changes in demand are not the same for all categories of final products, output growth in different sectors may diverge. This section describes the input-output framework and its use in calculating how these

Table 2

Economic Growth Scenarios

(Annualized Percent Changes)

	Historical 1986-IV to 1988-IV	1988-IV to 1989-IV	1989-IV to 1990-IV
Moderate growth case			
Domestic demand	3.7	2.0	2.0
Manufacturing exports	19.8	14.0	10.0
Primary processing	10.3	8.0	6.0
Advanced processing	23.7	16.0	12.0
Manufacturing imports	7.2	3.0	3.5
Primary processing	−0.3	1.5	2.0
Advanced processing	9.4	3.5	4.0
Domestic GNP	4.3	2.7	2.4
Foreign GNP		2.6	2.5
High growth case			
Domestic demand		3.0	3.0
Manufacturing exports		14.0	10.0
Primary processing		8.0	6.0
Advanced processing		16.0	12.0
Manufacturing imports		4.0	4.5
Primary processing		2.0	2.5
Advanced processing		5.0	5.5
Domestic GNP		3.5	3.2
Foreign GNP		2.6	2.5

Notes: Growth rates from 1986-IV to 1988-IV are average annual percent changes. Historical changes and economic scenarios for 1989 exclude the effects of the drought on GNP and domestic demand. Historical changes in exports and imports of manufactured goods are derived from movements in related trade components taken from the National Income and Product Accounts. Changes in the nonmanufacturing components of trade have a negligible impact on activity in the manufacturing sector and are not presented in Tables 2 and 3.

economic scenarios, which assume different rates of growth for various categories of final products, affect output in the manufacturing sector.[8]

Growth of GNP, or purchases of final goods and services, can be determined by summing changes in domestic demand, exports, and imports. However, a similar decomposition cannot be used for most individual industries because they do not produce final products exclusively. Typically, some portion of each industry's output is consumed by other industries as an intermediate input during production. For example, the steel industry produces few final products but many intermediate inputs required for the manufacture of other products such as machinery. The impact that a rise in steel exports has on steel output can be determined directly. However, the steel industry also would receive a boost in demand from a rise in machinery exports or from changes in demand for any other good that uses steel in production. The total impact that a broad-based increase in exports has on any one industry's output will be understated if these indirect effects are not considered.

The input-output framework details the intermediate inputs each sector produces and uses during production. In general terms, if there are n separate industries, the output of any industry represented by the subscript i can be grouped according to its uses:

$$(2)\quad Q_i = I_{i1} + I_{i2} + \ldots + I_{in} + DD_i + X_i - M_i, \quad i = 1, 2, \ldots, n,$$

where Q_i is the total value of the goods produced by the industry, each I_{ij} measures the value of good i used by industry j during production, DD_i is domestic demand, X_i represents exports, and M_i is imports of good i. The sum of DD_i and X_i less M_i represents all purchases of final goods produced by industry i, while the I_{ij} are demands for output of industry i derived from the production requirements of other sectors. Alternatively, each industry's output can be decomposed according to the inputs required for its production:

$$(3)\quad Q_i = I_{1i} + I_{2i} + \ldots + I_{ni} + VA_i, \; i = 1, 2, \ldots, n,$$

where each I_{ji} is the value of inputs from industry j consumed by industry i during production, and VA_i is the value added to output in sector i during production.

Equation 2 is used to calculate the *direct* impact that changes in the components of final demand taken from the economic scenarios (DD_i, X_i, and M_i) have on each industry's output. Then, the impact that the direct change in each industry's output has on its input requirements is estimated using equation 3, on the assumption that input requirements (and value added) are fixed in proportion to output. This derived demand for inputs is sometimes referred to as the *indirect* demand for goods. The indirect demand for each industry's output is added to the direct demand to arrive at an estimate of the *total* impact on output arising from changes in final demand.[9] In practice, these direct and indirect effects are calculated simultaneously using the input-output framework.

Manufacturing output and economic growth

The input-output table presented in Appendix B is used to estimate the sensitivity of manufacturing output to changes in the main components of final demand (Table 3). These calculations show that a one percentage point increase in domestic demand, broadly based over all sectors of the economy, raises manufacturing output by 1.1 percent.[10] A 1 percent rise in exports of manufactured goods raises manufacturing output by 0.18 percent, and a one percentage point rise in imports of manufactured goods reduces manufacturing output by an estimated 0.27 percent.

The elasticities reported in Table 3 reflect the relative importance of some sectors as suppliers of intermediate inputs. For example, a one percentage point rise in exports of advanced processing goods, when other exports are held fixed, increases output in that sector by 0.17 percent; however, it also raises output in the primary processing sector by 0.08 percent because exports of advanced processing goods require intermediate inputs from the primary processing sector for their production. In contrast, a one percentage point rise in exports of primary processing goods raises output in that sector about 0.11 percent, but output in the advanced processing sector is virtually unchanged because it supplies few intermediate inputs to the primary processing sector. A similar result holds for the import elasticities.

The contribution of the components of final demand to growth in each sector of manufacturing over the past two years can be approximated using the elasticities in Table 3 and the historical data from Table 2. From the end of 1986 through 1988, output in the manufacturing sector rose 11.7 percent, three percentage points faster than GNP. More than half of this growth is directly attributable to the rapid rise in exports of manufactured goods. The rise in exports of the advanced processing industries was the single biggest source of growth for

[8]Further analysis of the input-output structure is presented in Appendix B.

[9]The calculation of all indirect effects is an iterative process because changes in output induced by increased demand for inputs will themselves generate demand for more inputs.

[10]All elasticity calculations are made holding other components of final demand fixed.

that sector. In fact, the rise in advanced processing exports contributed more to growth in the primary processing sector than the rise in primary exports did. Output in the primary processing sector also was boosted by a small decline in imports of primary goods. In the advanced processing sector, rising imports slowed growth.

Under the moderate growth scenario, a decline in export and domestic demand growth leads to a slowing in manufacturing output gains. By 1990 the manufacturing sector is expanding just under 3½ percent per year. The deceleration in growth is somewhat more pronounced in the primary processing sector because of the assumed import developments. Imports of primary processing goods have declined during the past two years, but in the projection period they begin to rise, slowing output growth in that sector. In contrast, import growth of advanced processing goods is assumed to slow substantially. Thus, imports become much less of a net drag on growth in this sector during the projection period than they were during the preceding two years.[11] Manufacturing output rises over one and a half percentage points more in the high growth scenario than in the moderate growth case by the end of 1990. In both scenarios, the continued improvement in the net export sector causes manufacturing output to rise at a faster rate than total GNP.

Capacity utilization in manufacturing

The percent change in the capacity utilization rate is

[11] A different configuration of import growth in the two sectors would affect projected output in each sector, but total manufacturing output growth would not be affected so long as overall import growth was unchanged.

Table 3

Elasticities of Manufacturing Output to Changes in Domestic Demand, Exports, and Imports

	All Manufacturing	Primary Processing	Advanced Processing
Total domestic demand	1.09	1.12	1.07
Manufacturing exports	0.18	0.19	0.18
Primary processing exports	0.04	0.11	0.00
Advanced processing exports	0.14	0.08	0.17
Manufacturing imports	−0.27	−0.32	−0.25
Primary processing imports	−0.07	−0.21	−0.01
Advanced processing imports	−0.20	−0.11	−0.24

Notes: Each entry indicates the percentage change in output of the industry listed at the top of the column to a one percentage point change in the component of final demand named in the row. For example, a 1 percent rise in all manufacturing exports increases output in the primary processing sector by 0.19 percentage point. Elasticities are calculated holding other components of final demand fixed. The sensitivity of industry output to a change in all manufacturing exports (imports) is the sum of the elasticities to a change in primary and advanced processing exports (imports). Domestic demand elasticities are calculated assuming that domestic demand for the final output of all sectors rises 1 percent. Elasticities for the "all manufacturing" column are a weighted average of elasticities for the two sectors, based on relative value added in the sectors. Elasticities may vary over time. Estimates in this table are based on 1988 data.

Table 4

Percentage Changes in Manufacturing Output Based on Economic Scenarios

	Historical	Moderate Growth Scenario		High Growth Scenario	
	1986-IV to 1988-IV	1988-IV to 1989-IV	1989-IV to 1990-IV	1988-IV to 1989-IV	1989-IV to 1990-IV
All manufacturing	5.7	4.1	3.4	4.9	4.2
Primary processing	6.1	3.7	3.2	4.4	4.0
Advanced processing	5.6	4.4	3.5	5.2	4.4

Note: Growth rates from 1986-IV to 1988-IV are average annual changes.

the difference between the percent changes in output and capacity. Under the moderate growth scenario and the baseline investment case, the operating rate rises to a level just over 85 percent for all manufacturing by the end of 1989 (Table 5). With some further slowing in export growth in 1990, the utilization rate levels off near 85½ percent. In contrast, under the high growth conditions, capacity utilization approaches 86 percent by the end of 1989 and continues rising through 1990 despite the slowing in export growth. Even when the capacity outcomes from the high investment alternative are used, the operating rate continues to climb in 1990 in the high growth case past levels previously associated with accelerating inflation. In both scenarios, capacity utilization increases are greater in the advanced processing industries, a departure from the recent pattern. This reflects both the greater output gains projected in that sector, for the reasons cited in the preceding section, and the relative strength of capacity growth expected among primary processing industries following the strong pickup in investment in that sector during 1988.

Peak levels of capacity utilization from previous business cycle expansions are compared to the projected levels in Table 6. In the moderate growth scenario, the utilization rate does not reach the peak rates realized in the 1973-74 expansion, but it is not far below the highest level from the 1978-80 period. This result holds for both the primary processing and advanced processing sectors. Under the high growth conditions, by

Table 5

Outlook for Capacity Utilization

	Operating Rate	Percent Change — 1989		Operating Rate	Recent Change — 1990		Operating Rate
	1988-IV	Output	Capacity	1989-IV	Output	Capacity	1990-IV
Moderate growth case							
All manufacturing	84.4	4.1	3.1	85.2	3.4	3.1	85.5
Primary processing	88.0	3.7	3.4	88.2	3.2	3.4	88.0
Advanced processing	82.7	4.4	2.9	83.9	3.5	2.9	84.4
High growth case							
All manufacturing	84.4	4.9	3.1	85.8	4.2	3.1	86.8
Primary processing	88.0	4.4	3.4	88.8	4.0	3.4	89.4
Advanced processing	82.7	5.2	2.9	84.5	4.4	2.9	85.7

Note: The percentage change in the capacity utilization rate is equal to the percentage change in output less the percentage growth of capacity.

Table 6

Capacity Utilization Rates
Results from Economic Scenarios and Previous Business Cycle Peaks
(Quarterly Rates)

		Peak Rates		Moderate Growth Scenario	High Growth Scenario
	1988-IV	1973-74	1978-80	1990-IV	1990-IV
All manufacturing	84.4	87.3	86.0	85.5	86.8
Primary processing	88.0	91.6	88.2	88.0	89.6
Advanced processing	82.7	85.5	84.7	84.4	85.6
Paper	94.2	94.0	89.1	92.1	
Chemicals	89.3	87.3	82.1	89.3	
Primary metals	90.0	98.2	94.6	96.7	
Fabricated metal products	84.4	85.7	84.7	85.9	
Nonelectrical machinery	82.9	87.7	84.3	87.3	
Transportation equipment, excluding autos	85.6	76.3	77.2	90.2	

the end of 1990 the operating rate in both sectors of manufacturing rises to a level above the highest utilization rate realized in the preceding economic expansion. The operating rate does not reach the peak rate from 1973-74 during the projection period, but it is still climbing at the end of 1990.

Some major industries likely to experience capacity pressures even under the conditions of the moderate growth scenario are identified using a more detailed input-output table.[12] Simplifying assumptions are needed to work at this level of disaggregation because of data limitations. For example, percentage changes in the components of final demand are assumed equal in most industries, and capacity growth is based on extrapolations of recent changes. Thus, these results indicate where bottlenecks are most likely to develop, but they are not intended to be forecasts of individual industry operating rates.

At the end of 1988, the paper and chemicals industries were operating at utilization rates at or above previous peaks. Capacity pressures do not ease significantly in these industries in the moderate growth scenario, but the industries' strong investment performance raises capacity growth sufficiently to prevent further increases in the operating rate despite continued growth in output. In the primary metals sector, capacity utilization continues to rise despite a sharp slowing in output growth and an end to the cutbacks in existing capacity that characterized this industry in recent years. Only a significant expansion of capacity precludes a rise in the operating rate to peak levels realized in earlier expansions. Capacity pressures on makers of fabricated metal products surpass their historical peaks as a result of continued steady output gains combined with sluggish capacity growth. The relative importance of trade for nonelectrical machinery producers causes this sector to benefit disproportionately from the assumed trade improvement in the moderate growth scenario. Similarly, a strong export performance contributes to growing capacity pressures for manufacturers of aircraft, the dominant subcomponent of transportation equipment excluding autos.

Implications of the results

In the moderate growth scenario, the capacity utilization rate reaches levels historically associated with increased price pressure but, significantly, those levels are not breached. Instead, operating rates settle into a range from 85 to 86 percent of capacity. Thus, under these circumstances capacity bottlenecks leading to widespread inflationary pressures could be avoided, although such an outcome is not certain because of the high level of utilization reached in many industries. This result assumes that the economy begins to expand at a pace consistent with many estimates of long-run potential growth and that trade improvement, which affects the manufacturing sector disproportionately, remains an important source of growth. The high growth case indicates that, without a slowing in growth from the pace of the past two years, capacity in many manufacturing industries soon will become very strained. The conclusions for both scenarios rest upon an investment climate associated with annual capacity increases of about 3 percent, a growth rate above that of recent years but still below growth rates of earlier periods.

Capacity pressures are not likely to be felt evenly across industries. Even under the conditions of the moderate growth scenario, some basic industries such as paper and chemicals probably will continue to operate at historically high utilization rates despite a recent acceleration in capital spending. Unless capacity growth of primary metals producers reverses its downward trend, pressures on capacity in that sector will continue to increase despite a slowing in output growth. Manufacturers of fabricated metal products also will see a gradual tightening of capacity unless capacity growth rises. A continued strong export performance will place increased pressure on the most export-oriented sectors, such as producers of machinery and aircraft, and on those sectors that provide intermediate inputs to these manufacturers.

At a more aggregate level, utilization rate increases have been especially large in the primary processing sector of manufacturing during the past two years. In the economic scenarios developed in this analysis, the advanced processing sector begins to show more of a buildup in capacity pressures over the next two years. This result rests upon three developments: faster capacity growth in the primary processing sector brought on by a relatively sharp rise in investment first seen in 1988 and expected to continue in 1989; continued strong export growth that benefits disproportionately the more export-oriented advanced processing industries; and a convergence of import patterns in the two sectors that during the past two years tended to place additional pressure on capacity in the primary processing sector while relieving pressure in the advanced processing sector. The failure of any one of these factors to materialize could upset the conclusion that future rises in capacity utilization rates will be more pronounced in the advanced processing sector.

Prompted by the steady rise in operating rates, many observers have voiced concern that capacity bot-

[12] A more disaggregated input-output table, dividing manufacturing into 21 industries corresponding to the two-digit Standard Industrial Classification System, was used for these calculations.

tlenecks could limit improvement in the trade deficit over the next two years. The external adjustment that could be sustained depends upon several factors, including the strength of domestic demand, the pace of capacity expansion, and the utilization rate that can be reached before capacity pressures become widespread; but some of the calculations presented above can be used to address this issue. If 85½ percent is chosen as a benchmark level above which capacity constraints might begin to retard further trade improvement, then the results of the moderate growth scenario indicate that over the next two years the trade deficit on manufactured goods could narrow perhaps as much as $40 billion in nominal terms before the utilization rate reached this critical level.[13] This conclusion assumes that capacity rises about 3 percent a year and that domestic demand growth falls to an annual rate of 2 percent. Of course, with stronger domestic demand or more sluggish capacity growth, considerably less capacity would be available for trade improvement. For instance, if domestic demand were to rise at an annual rate of 2½ percent, then the nominal trade balance for manufactured goods could improve only about $17 billion over the next two years before the operating rate reached 85½ percent. And if domestic demand were to rise at a 3 percent annual pace, capacity utilization could rise to 85½ percent by the end of 1990 even with no further improvement in the nominal trade balance for manufactured goods. These last two results, while only illustrative, underscore the importance of domestic demand for the capacity dimension of external adjustment.

[13]The nominal improvement in the trade balance is valued on a National Income and Product Accounts (NIPA) basis, and the balance of nonagricultural exports and nonpetroleum imports from the NIPA accounts is used as a proxy for trade in manufactures. Changes in trade volumes are taken from the moderate growth scenario, and export and import prices for manufactured goods are assumed to rise 4 percent a year.

Conclusion

During the two years ending in 1988, utilization rates in the manufacturing sector rose from just under 80 percent to about 84½ percent of capacity after having remained nearly unchanged during the preceding three years. This surge in the operating rate was largely the result of an improving U.S. external position and strong domestic demand growth, which combined to boost output in the manufacturing sector well above overall economic growth during this period. Should the pace of manufacturing output growth fail to slow significantly in the near future, inflationary bottlenecks in that sector almost certainly will become widespread regardless of any foreseeable capacity developments. Even with a return to more moderate growth, some specific manufacturing sectors are likely to feel a capacity pinch. However, capacity pressures in manufacturing can remain tolerable while the trade deficit continues to improve if economic growth adjusts to levels consistent with long-run trends.

R. Spence Hilton

Appendix A: Estimating the Capital Stock-Capacity Relation

To measure the impact of changes in the capital stock on capacity growth in the manufacturing sector, percentage changes of capacity are used in regression analysis with percentage changes in the net capital stock. Changes are calculated on an end-year to end-year basis for both series. Historical values of the net capital stock in constant dollar terms are provided by the Department of Commerce, and capacity indexes are obtained from the Board of Governors.† Estimates of the coefficient on the net capital stock variable indicate how capacity growth responds directly to changes in the rate of growth of the net capital stock. The constant term captures other influences, including the impact that advancing technology has on capacity growth independent of the size of any change in the capital stock.

All equations are estimated using the ordinary least squares method, and the results appear in the accompanying table. The sample period was restricted to 1975 through 1988. Results using a longer sample period indicate that a substantial shift occurred in the capital stock-capacity relation sometime in the early 1970s. Tests were conducted to determine whether a change in this relation occurred more recently, but no evidence was found of a shift at the aggregate level. For the primary and advanced processing sectors, however, the estimates indicate that a shift in this relation occurred during the current expansion. This is reflected in the estimated coefficient on the dummy variable D85, which takes a value of 1 beginning in 1985 and is 0 in earlier years. Dividing capital stock changes into additions to plant and additions to equipment failed to substantiate the often stated view that capacity growth is more dependent on investment in industrial structures, or "bricks and mortar," than on new machinery. The reason may be that technological advances are embodied

†Capital stock values for 1988 are estimated from investment spending data for that year.

Appendix A: Estimating the Capital Stock-Capacity Relation *(continued)*

more in new equipment than in buildings or plant.

The results for "all manufacturing" indicate that a change of one percentage point in the growth of the net capital stock raises capacity growth by .28 percentage point. The constant term shows that even in periods when the net capital stock is unchanged, capacity rises nearly 2½ percent. This finding reflects the impact that new technology embodied in investment has on capacity. The manufacturing sector was disaggregated into its two major components, primary processing and advanced processing industries, and separate estimates of the capital stock-capacity relationship were made.‡ For both industries, the estimated sensitivity of capacity to changes in the capital stock was near 0.30, a level similar to that found for all manufacturing. Separate equation estimates also were made for 21 disaggregated industries making up the manufacturing sector. The explanatory power of many of these estimated equations was low, and some of the estimated results were found to be unstable. In most cases, however, the estimated sensitivity of capacity to changes in capital stock growth was close to the 0.30 level found at the more aggregate industry level. Consequently, projections of capacity growth for these 21 industries were made using the estimated sensitivity of capacity growth to capital stock changes taken from the aggregate equations.

‡Data for the petroleum refining industry were excluded in the estimation of the primary processing sector because no sensible relation was found between capital stock changes and capacity growth in that industry.

Footnote ‡ continued

Estimated Effects of Capital Stock Changes on Capacity Growth

	Constant	D85	KK	R^2
All manufacturing	2.43		.28	.68
	(18.5)		(5.4)	
Primary processing	1.29	1.12	.33	.80
	(10.4)	(5.4)	(6.5)	
Advanced processing	2.91	—.85	.30	.75
	(11.2)	(3.9)	(4.5)	

Notes: KK is the percentage change in the net capital stock, end-year to end-year, and D85 is a dummy variable with a value of 1 beginning in 1985 and 0 otherwise. Coefficient estimates appear along with corresponding t-statistics in parentheses. R^2 is the coefficient of determination adjusted for degrees of freedom.

Appendix B: The Input-Output Framework

The input-output (IO) structure of the economy is summarized in Tables B1 through B3 for six sectors: agriculture, mining, construction, primary processing manufacturing, advanced processing manufacturing, and services.† These are aggregated versions of tables prepared by the Department of Commerce, and all values in the tables are expressed in constant 1982 dollar terms.

The columns of Table B1 describe the inputs that are required directly for the production of every dollar's worth of industry output. For example,. each dollar of advanced processing manufacturing output uses about 15 cents of inputs originating in the services sector and another 17 cents from the primary processing sector of manufacturing. In total, about 58 cents worth of inputs is needed to produce each dollar's worth of output in this sector, and another 42 cents of value is added directly in production by the labor and capital employed in the industry.

Several modifications were made to the Department of Commerce tables in deriving Table B1 in order to reflect changes in production requirements since 1982. The importance of oil and steel as inputs for most industries is scaled back to reflect declining usage of these two inputs in production in the economy since 1982. For the nonelectrical machinery industry, which includes computer manufacturers, the relation between

†Detailed versions of the latest (1982) input-output tables of the U.S. economy appear in the *Survey of Current Business*, April 1988. A full description of the IO system, including accounting practices, is in *Definitions and Conventions of the 1977 Input-Output Study*, Department of Commerce. For simplicity, several categories of the economy that are treated separately in the input-output accounts are not presented here. These include the household sector, government employee compensation, noncomparable imports, scrap production, and the rest-of-world accounts. Moreover, output data are collected using an "industry" classification system while final demand and trade data are available on a "commodity" classification basis. The IO accounts are designed to resolve discrepancies between the systems that arise when an industry produces more than one commodity, or secondary products, but at the cost of added complexity. The differences between industries and commodities are minor at the six sector level of detail and are ignored in this study.

Table B1

Direct Input Requirements

(Direct Value of Inputs Required to Produce One Dollar of Industry Output, at Producers' Prices)

	Agriculture	Mining	Construction	Primary Processing	Advanced Processing	Services
Agriculture	0.249	0.000	0.002	0.009	0.058	0.003
Mining	0.001	0.055	0.007	0.176	0.004	0.015
Construction	0.008	0.036	0.001	0.007	0.003	0.019
Primary processing	0.105	0.031	0.281	0.297	0.168	0.037
Advanced processing	0.085	0.025	0.064	0.028	0.194	0.040
Services	0.156	0.115	0.227	0.161	0.148	0.259
All inputs	0.605	0.262	0.581	0.687	0.581	0.376
Value added	0.395	0.738	0.419	0.313	0.419	0.624
Output	1.000	1.000	1.000	1.000	1.000	1.000

Table B2

Output and Final Demand

(Billions of Dollars at Producers' Prices, 1988-IV)

	Total Output	Intermediate Usage	Final Output	Exports	Imports	Domestic Demand
Agriculture	204	164	40	18	6	28
Mining	184	240	−57	6	60	−3
Construction	469	89	380	0	0	380
Primary processing	940	835	104	61	126	169
Advanced processing	1563	528	1035	196	312	1151
Services	3683	1495	2188	103	0	2085

Appendix B: The Input-Output Framework *(continued)*

input usage and value added in production is changed to reflect the declining quantity of inputs required to produce a given value of output measured in constant dollar terms. These changes do not have a major impact on calculations made at an aggregate level.

Values of industry output and components of demand estimated for the fourth quarter of 1988 are presented in Table B2. To estimate the output produced in each sector, Commerce Department statistics on value added in each industry in 1987 are updated to 1988-IV levels using various sources of data describing industry activity over the past two years. These estimated levels of value added in 1988-IV are then translated into output levels using the historical ratio between output and value added derived from the bottom two rows in Table B1. The value of each industry's output that was used as production inputs in other industries is determined by multiplying the first six rows of the matrix formed by Table B1 and the vector representing industry output. This product is the column labeled "intermediate usage." The difference between total output and intermediate uses represents the final goods produced in each sector.

Final output is decomposed into its export, import, and domestic demand components. Export and import data are obtained for each industry, and domestic demand is calculated as the difference between demand for final goods and net exports (exports less imports). In accordance with IO accounting practices, transportation and other costs incurred in the movement of goods from the factory to the port of exit are recorded as services exports.

Table B3, commonly called the total requirements table, describes the total value of output from all industries that is required directly and indirectly to produce one dollar's worth of final goods produced in each sector. In addition to including the inputs required directly for production (listed in Table B1), total requirements include all inputs needed to produce these direct inputs. Table B3 is derived from Table B1 in the following manner. As noted above, final demand can be calculated as:

$$(1)\quad f = q - Aq,$$

where f is the vector of final demand or output, q is the vector of total industry output, and A is the matrix formed by the first six rows of Table B1, that is, the input requirements of each industry. The product of A and q is the vector of intermediate inputs originating in each industry. Equation 1 can be algebraically manipulated to show:

$$(2)\quad q = (I - A)^{-1}f,$$

where I is the identity matrix with 1's on the diagonal and 0's in the off-diagonal elements, and the superscript -1 indicates the inverse function.

The matrix formed by $(I - A)^{-1}$ is Table B3. Each column shows the total output from all sectors that is needed to produce final goods in the sector labeled at the head of that column. For example, each dollar's worth of final goods produced in the advanced processing manufacturing sector requires directly or indirectly about 37 cents worth of output from the services sector and 35 cents worth of output from the primary processing sector.

Changes in manufacturing output associated with the economic scenarios presented in Table 2 of the text are calculated by multiplying Table B3 by the changes in final demand assumed in each scenario. These projected changes in manufacturing output are compared to the initial level of output presented in Table B2 to derive percentage changes. Because the structure of the IO system is linear, the impact of changes in domestic demand, exports, and imports on industry output can be calculated separately and summed to measure their

Table B3

Total Input Requirements

(Total Inputs Required to Produce One Dollar of Industry Final Output, at Producers' Prices)

	Agriculture	Mining	Construction	Primary Processing	Advanced Processing	Services
Agriculture	1.350	0.006	0.020	0.027	0.106	0.014
Mining	0.061	1.078	0.102	0.285	0.077	0.043
Construction	0.023	0.043	1.017	0.028	0.017	0.029
Primary processing	0.277	0.088	0.467	1.492	0.353	0.107
Advanced processing	0.175	0.051	0.125	0.086	1.287	0.078
Services	0.395	0.211	0.458	0.400	0.373	1.406

Appendix B: The Input-Output Framework *(continued)*

total effect on output. In both economic scenarios, it is assumed that growth of domestic demand is concentrated on the final output of the manufacturing and services sectors. Thus, in the moderate growth case, domestic demand rises a bit over 2 percent per year for final services and manufactured goods and somewhat less than 2 percent in other sectors, but total domestic demand growth averages 2 percent exactly. This represents a continuation of recent historical patterns. Export and import growth rates for manufactured goods are specified in Table 2. Trade changes in other sectors are assumed to remain in line with recent experience, and in any event they have little impact on output in the manufacturing sector.