Multifactor productivity trends in manufacturing industries, 1987–96

Over the 1987–96 period, multifactor productivity—measured as output per unit of combined inputs—increased in manufacturing as a whole and in most of the 108 published three-digit industries within manufacturing; within the three-digit industries, however, there was wide dispersion in the growth rates

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Labor productivity, the most widely used measure of productivity, can grow as a result of increases in the quantities of capital services and intermediate inputs used in production and as a result of other factors. In order to provide an alternative picture of productivity change focusing on these other factors—such as economies of scale, changes in organizational efficiency, improvements in labor and management skill, changes in capacity utilization, and changes in technology—the Bureau of Labor Statistics recently developed multifactor productivity series for detailed manufacturing industries. These data show that between 1987 and 1996, multifactor productivity, measured as output per unit of combined inputs, rose in a majority of the 108 industries presented here. For more than 85 percent of these industries, however, multifactor productivity did not grow as much as labor productivity (defined as output per hour). The faster growth of labor productivity reflects increases in the contributions of capital and intermediate purchases over the period.[1]

More specifically, multifactor productivity relates an index of output to an index of combined inputs of labor, capital, and intermediate purchases (materials, fuels, electricity, and services). Multifactor productivity is calculated as a residual that measures the change in an industry's output that is not due to measured changes in labor, capital, or intermediate purchases inputs.

The Bureau of Labor Statistics has published multifactor productivity measures for major sectors of the economy since 1983 and for a limited number of detailed industries since 1987. In 2000, multifactor productivity measures were completed for all 140 manufacturing industries at the three-digit Standard Industrial Classification (SIC)[2] level of detail—a major expansion over the 10 multifactor productivity measures previously available.[3] The industry labor productivity and multifactor productivity indexes are developed from secondary data sources that have been compiled for purposes other than productivity measurement. As a result, staff from the BLS Office of Productivity and Technology evaluated the reliability of these measures and their components and developed publication criteria; the industry series that did not meet the criteria are not published.[4] This article analyzes measures for the 108 published three-digit manufacturing industries covering 89 percent of employment in the total manufacturing sector. We analyze changes from 1987 to 1996, the entire period for which the new multifactor productivity series are presently available. Both years are at roughly comparable points in the economic cycle, representing years that were well into the economic expansions of the 1980s and 1990s.

Manufacturing sector overview

Between 1987 and 1996, multifactor productivity at the total manufacturing level increased at an

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average annual rate of 0.7 percent.[5] Within manufacturing, there was significant variation among industries in the average annual rates of change in multifactor productivity. For manufacturing industries classified at the two-digit SIC level, the average annual rates of change in multifactor productivity ranged from a decline of 1.4 percent per year in printing and publishing (SIC 27) to an increase of 4.7 percent per year in electronic and other electrical equipment (SIC 36).

There was an even greater dispersion over the period in the multifactor productivity rates at the more detailed three-digit SIC industry level. Average annual multifactor productivity change ranged from a decline of 3.5 percent per year in newspapers (SIC 271) to an increase of 14.8 percent per year in electronic components and accessories (SIC 367). Table 1 shows the average annual rates of change for multifactor productivity, output, and combined inputs, and for the specific inputs of labor, capital, and intermediate purchases for the 1987–96 period; chart 1 shows the distribution of the changes among the 108 manufacturing industries over the same period. As the chart clearly shows, a large majority (84) of the published industries experienced average annual rates of change in multifactor productivity that ranged from a decline of 0.9 percent per year to an increase of 1.9 percent per year.

Among the 108 published industries, 2 had gains in multifactor productivity between 1987 and 1996 that far exceeded those of all other manufacturing industries—electronic components and accessories (14.8 percent per year) and computer and office equipment (SIC 357, 14.4 percent per year). In addition, 3 other industries recorded gains of more than 3 percent per year: communications equipment (SIC 366, 4.4 percent), ophthalmic goods (SIC 385, 3.2 percent), and pens, pencils, office, and art supplies (SIC 395, 3.1 percent). Another 5 industries experienced gains between 2.0 and 2.9 percent per year: metal cans and shipping containers (SIC 341, 2.4 percent); industrial machinery, not elsewhere classified (SIC 359, 2.4 percent); hydraulic cement (SIC 324, 2.4 percent); tires and inner tubes (SIC 301, 2.1 percent); and sugar and confectionery products (SIC 206, 2.1 percent). An additional 24 industries posted multifactor productivity growth in the range of 1.0 percent per year to 1.9 percent per year, and 33 industries had increases in the range of 0.0 percent to 0.9 percent. A total of 41 industries had declining multifactor productivity over the period. Of the industries with multifactor productivity declines, two-thirds had drops of less than 1 percent per year, on average.

Trends in the 10 largest industries

The multifactor productivity performance was mixed for the 10 largest manufacturing industries (those with more than 300,000 employees in 1996) reported on in this article.[6] Multifactor productivity grew in five of the industries for the 1987–96 period. Two of the industries had no growth while three industries recorded declines. Conversely, labor productivity advanced in 9 of the 10 industries. These 10 manufacturing industries ranged in size from 345,000 employees to 967,000 employees and represented more than 25 percent of employment in the manufacturing sector. (See chart 2.)

It has been noted widely that the computer and semiconductor industries appear to be major contributors to the overall productivity growth of recent years.[7] The electronic components and accessories industry—which includes semiconductors—and the computer and office equipment industry are important not only because they experienced the two greatest annual rates of change in multifactor productivity, but also because they were the third and eighth largest industries, respectively, in terms of employment size. Multifactor productivity rose by 14.8 percent per year in the electronic components and accessories industry, as output jumped 20.3 percent per year, far surpassing the 4.8 percent per year increase in combined inputs. Inputs showed divergent trends, with labor input rising at a low rate of 0.3 percent and capital services surging 8.1 percent, while intermediate purchases were up 6.2 percent. The second largest gain in multifactor productivity (14.4 percent per year) occurred in the computer and office equipment industry. This gain resulted from a strong increase in output of 20.4 percent per year and a rise in combined inputs of 5.3 percent per year. Labor input fell 2.7 percent, while capital input rose 5.7 percent and intermediate purchases grew at a rate of 8.2 percent per year.

The other three large industries with multifactor productivity gains showed more modest increases. Average annual growth in multifactor productivity was 2.4 percent in industrial machinery, not elsewhere classified, 0.6 percent in metalworking machinery (SIC 354), and 0.5 percent in miscellaneous plastics products, not elsewhere classified (SIC 308).

Multifactor productivity declines were recorded in three of the 10 largest industries. The largest decline recorded occurred in the newspapers industry, where output declined by 3.5 percent and the level of combined inputs was unchanged. An increase in capital services (1.4 percent per year) was offset by a decline in labor input of 0.7 percent and a drop of 0.4 percent in intermediate purchases. The largest industry, motor vehicles and equipment (SIC 371), posted a decline in multifactor productivity of 0.9 percent per year as the increase in combined inputs (3.6 percent) surpassed the gain in output (2.6 percent). Labor and capital inputs rose by similar rates (1.8 percent and 1.9 percent, respectively), while the increase in intermediate purchases was much stronger (4.3 percent).

Multifactor versus labor productivity

One benefit of multifactor productivity analysis is that it provides information about the impact on labor productivity of changes in the use of capital and intermediate purchases. Multifactor productivity is equal to output per hour minus the effects of changes in capital per hour and intermediate pur-

Table 1. Multifactor productivity and related variables for three-digit manufacturing industries, 1987–96

(Average annual percent change)

SIC code	Industry	Multifactor productivity	Output	Combined inputs	Labor	Capital	Intermediate purchases
202	Dairy products	–0.1	0.5	0.7	–1.1	1.6	0.8
203	Preserved fruits and vegetables	–.3	1.7	2.0	.7	2.1	2.2
204	Grain mill products	–.7	1.3	2.0	.5	2.5	2.1
205	Bakery products	–.4	–.7	–.3	–.2	1.9	–1.0
206	Sugar and confectionery products	2.1	1.7	–.5	.2	1.4	–1.7
207	Fats and oils	.3	1.0	.7	–.1	.3	.8
208	Beverages	1.6	2.2	.6	–1.2	–.1	1.3
209	Miscellaneous food and kindred products	.9	2.2	1.3	1.2	1.4	1.1
221	Broadwoven fabric mills, cotton	–.5	–.1	.4	–3.5	–1.9	2.2
222	Broadwoven fabric mills, manmade	1.5	.9	–.6	–3.4	.1	.3
224	Narrow fabric mills	1.9	1.3	–.6	–1.3	.6	–.5
225	Knitting mills	1.9	2.2	.3	–2.3	.8	1.4
226	Textile finishing, except wool	.9	–1.1	–2.0	1.5	–.3	–3.1
227	Carpets and rugs	.8	.3	–.5	.3	.3	–.7
228	Yarn and thread mills	–.3	1.2	1.5	–3.1	1.0	2.9
229	Miscellaneous textile goods	.2	2.2	2.0	–.1	2.3	2.6
232	Men's and boys' furnishings	–.6	–.3	.3	–3.6	.4	2.0
233	Women's and misses' outerwear	1.0	.5	–.4	–3.3	.3	.6
234	Women's and children's undergarments	–.2	–.5	–.3	–6.5	–.6	2.4
235	Hats, caps, and millinery	–1.5	.7	2.2	2.9	2.0	1.7
238	Miscellaneous apparel and accessories	–.3	–.3	.1	–2.3	–.6	1.2
239	Miscellaneous fabricated textile products	.4	2.3	1.9	1.6	2.6	1.8
242	Sawmills and planing mills	1.8	.4	–1.3	–1.2	–1.5	–1.4
243	Millwork, plywood, and structural members	–.3	–.1	.2	.8	1.4	–.2
244	Wood containers	1.0	3.4	2.3	2.6	.1	2.5
245	Wood buildings and mobile homes	–.4	2.5	2.9	2.9	.1	3.5
249	Miscellaneous wood products	–.4	1.7	2.1	.2	1.5	2.9
251	Household furniture	.6	.7	.2	–1.4	.5	.9
252	Office furniture	–.7	–.6	.2	–1.3	2.1	.4
253	Public building and related furniture	.2	11.8	11.6	4.6	5.1	14.2
254	Partitions and fixtures	–.4	1.4	1.8	1.7	2.1	1.9
259	Miscellaneous furniture and fixtures	–.4	1.7	2.1	.3	2.3	2.9
262	Paper mills	–1.1	.4	1.5	–.8	2.9	1.8
263	Paperboard mills	–1.0	1.2	2.2	–.7	2.9	2.6
265	Paperboard containers and boxes	–.1	1.6	1.7	1.0	1.4	2.0
267	Miscellaneous converted paper products	.0	1.8	1.8	.4	2.2	2.0
271	Newspapers	–3.5	–3.5	.0	–.7	1.4	–.4
275	Commercial printing	.0	1.9	1.8	1.0	4.1	1.7
276	Manifold business forms	–3.0	–4.4	–1.4	–1.3	.0	–1.9
277	Greeting cards	–2.6	.9	3.6	2.0	1.6	6.1
278	Blankbooks and bookbinding	–.8	.8	1.7	–.7	2.3	3.6
279	Printing trade services	1.6	1.3	–.3	–1.3	2.6	–.8
281	Industrial inorganic chemicals	.0	.7	.7	–.3	–1.4	1.7
282	Plastics materials and synthetics	.3	2.1	1.8	–.4	2.9	2.0
283	Drugs	–2.1	3.4	5.7	2.1	6.4	6.5
285	Paints and allied products	–.9	.6	1.5	–1.9	.6	2.6
286	Industrial organic chemicals	–2.4	–.4	2.1	–.3	3.3	2.1
287	Agricultural chemicals	.4	1.7	1.3	.6	–.8	2.4
289	Miscellaneous chemical products	–.8	.9	1.8	–.1	2.0	2.3
291	Petroleum refining	.8	1.3	.6	–2.5	1.4	.6
295	Asphalt paving and roofing matrials	.5	1.7	1.2	.3	1.5	1.2
299	Miscellaneous petroleum and coal products	–1.5	.5	2.0	2.0	1.2	2.1
301	Tires and inner tubes	2.1	2.8	.6	–.9	–.5	1.8
305	Hose and belting and gaskets and packing	.2	3.3	3.1	2.5	–.3	4.4
306	Fabricated rubber products, n.e.c.	1.4	2.9	1.5	.7	1.3	2.0
308	Miscellaneous plastics products, n.e.c.	.5	4.8	4.2	2.3	4.7	5.0
314	Footwear, except rubber	–.3	–4.6	–4.3	–7.0	–2.8	–3.4
321	Flat glass	1.8	.8	–1.0	.6	–.8	–1.9
322	Glass and glassware, pressed or blown	1.5	.4	–1.0	–1.7	–.2	–1.1
323	Products of purchased glass	1.1	4.4	3.2	2.1	3.7	3.6
324	Cement, hydraulic	2.4	1.4	–1.0	–1.4	–3.0	.4
325	Structural clay products	1.4	.5	–.9	–1.5	–1.2	–.4
326	Pottery and related products	1.0	2.9	1.9	.9	.6	3.7
327	Concrete, gypsum, and plaster products	.8	1.0	.2	.2	–1.4	.5
329	Miscellaneous nonmetallic mineral products	1.1	1.3	.2	.2	–1.0	.8

Table 1. Continued—Multifactor productivity and related variables for three-digit manufacturing industries, 1987–96

(Average annual percent change)

SIC code	Industry	Multifactor productivity	Output	Combined inputs	Labor	Capital	Intermediate purchases
331	Blast furnace and basic steel products	1.1	3.2	2.1	–1.1	–1.5	4.9
333	Primary nonferrous metals	–1.7	1.0	2.7	–.2	–.2	4.0
335	Nonferrous rolling and drawing	–.6	–.1	.6	–.5	.7	.9
336	Nonferrous foundries (castings)	1.2	3.0	1.7	.7	1.6	2.4
339	Miscellaneous primary metal products	1.6	6.1	4.4	1.5	.5	7.7
341	Metal cans and shipping containers	2.4	.7	–1.7	–4.1	.5	–1.5
342	Cutlery, handtools, and hardware	–.4	1.2	1.6	–.7	.9	3.2
343	Plumbing and heating, except electric	.5	1.2	.7	–.7	.4	1.5
344	Fabricated structural metal products	–.1	1.5	1.6	.8	.5	2.2
347	Metal services, n.e.c.	1.1	4.8	3.7	1.9	3.1	5.0
348	Ordnance and accessories, n.e.c.	–1.8	–6.6	–4.8	–5.2	–1.2	–6.4
349	Miscellaneous fabricated metal products	–.1	2.7	2.8	1.8	1.7	3.6
351	Engines and turbines	.3	2.6	2.4	–.9	2.1	3.7
352	Farm and garden machinery	.5	4.3	3.7	.7	.6	5.6
353	Construction and related machinery	.8	3.8	3.0	1.4	–.1	4.1
354	Metalworking machinery	.6	3.0	2.4	1.4	1.0	3.6
355	Special industry machinery	.9	5.2	4.3	1.9	2.8	6.0
356	General industrial machinery	–.3	2.6	2.9	1.6	1.3	4.3
357	Computer and office equipment	14.4	20.4	5.3	–2.7	5.7	8.2
358	Refrigeration and service machinery	.2	3.6	3.3	2.0	2.1	4.3
359	Industrial machinery, n.e.c.	2.4	5.7	3.3	1.7	2.2	5.2
361	Electric distribution equipment	1.7	1.7	.1	–2.3	.0	1.3
362	Electrical industrial apparatus	1.4	3.5	2.1	–1.3	.7	4.6
363	Household appliances	.8	1.6	.8	–1.1	.3	1.4
364	Electric lighting and wiring equipment	.3	1.1	.8	–.7	.6	1.6
366	Communications equipment	4.4	9.4	4.8	–.2	4.0	8.3
367	Electronic components and accessories	14.8	20.3	4.8	.3	8.1	6.2
369	Miscellaneous electrical equipment & supplies	1.2	1.5	.3	–.8	2.7	.4
371	Motor vehicles and equipment	–.9	2.6	3.6	1.8	1.9	4.3
372	Aircraft and parts	.0	–2.9	–2.9	–4.2	2.4	–3.1
373	Ship and boat building and repairing	–1.3	–1.6	–.4	–1.5	–.9	.5
375	Motorcycles, bicycles, and parts	1.8	9.7	7.7	7.0	2.3	8.5
376	Guided missiles, space vehicles, parts	–1.9	–6.1	–4.2	–8.7	–.9	–2.1
381	Search and navigation equipment	.8	–4.1	–4.9	–7.7	–1.4	–3.3
382	Measuring and controlling devices	.6	4.2	3.5	–.4	3.9	6.5
384	Medical instruments and supplies	.7	6.3	5.6	2.4	6.7	6.9
385	Ophthalmic goods	3.2	6.7	3.4	–.5	6.8	5.3
386	Photographic equipment & supplies	.5	.2	–.3	–2.6	1.0	–1.0
391	Jewelry, silverware, and plated ware	–.7	–.5	.2	–.7	–.5	.8
393	Musical instruments	–1.6	–.4	1.3	2.3	–1.2	1.5
394	Toys and sporting goods	.6	4.0	3.4	1.9	1.6	4.3
395	Pens, pencils, office, and art supplies	3.1	3.4	.4	–.7	1.4	.4
399	Miscellaneous manufactures	1.2	2.5	1.3	1.2	2.0	1.4

chases per hour. These effects are measured as the change in the ratio of nonlabor to labor inputs where the nonlabor input is weighted by its share in the total cost of output. The capital effect, for example, is the change in the capital-labor ratio weighted by capital's share in the total cost of output. Whenever the combination of the capital effect and the intermediate purchases effect is positive, multifactor productivity growth is less than labor productivity growth.

Table 2 shows the relationship between multifactor productivity and labor productivity. Over the 1987–96 period, multifactor productivity changed by less than the change in labor productivity in 93 three-digit manufacturing industries. Also, 65 industries recorded growth in the capital effect over the period, and 95 industries recorded growth in the intermediate purchases effect; some industries recorded growth in both measures.

The rate of growth in capital services exceeded that of labor in 80 industries, and the rate of growth in intermediate purchases exceeded that of labor in 96 industries. Changes in the capital-labor ratio and the intermediate purchases-labor ratio can have varying influences on labor productivity depending on the shares of capital and intermediate purchases in the total cost of output. For instance, in aircraft and parts (SIC 372), the capital-labor ratio grew at a high rate of 6.9 per-

Chart 1. **Distribution of long-term trends in multifactor productivity for 108 manufacturing industries, 1987–96**

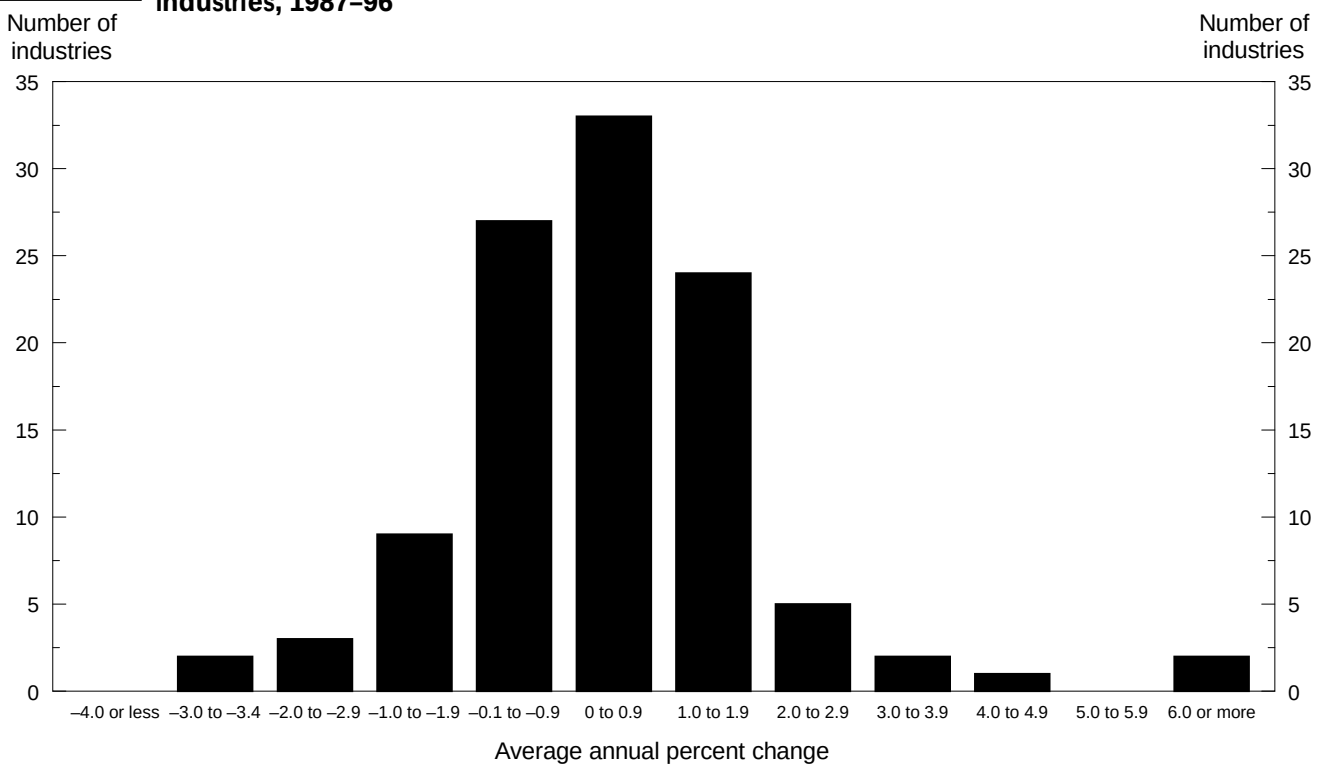
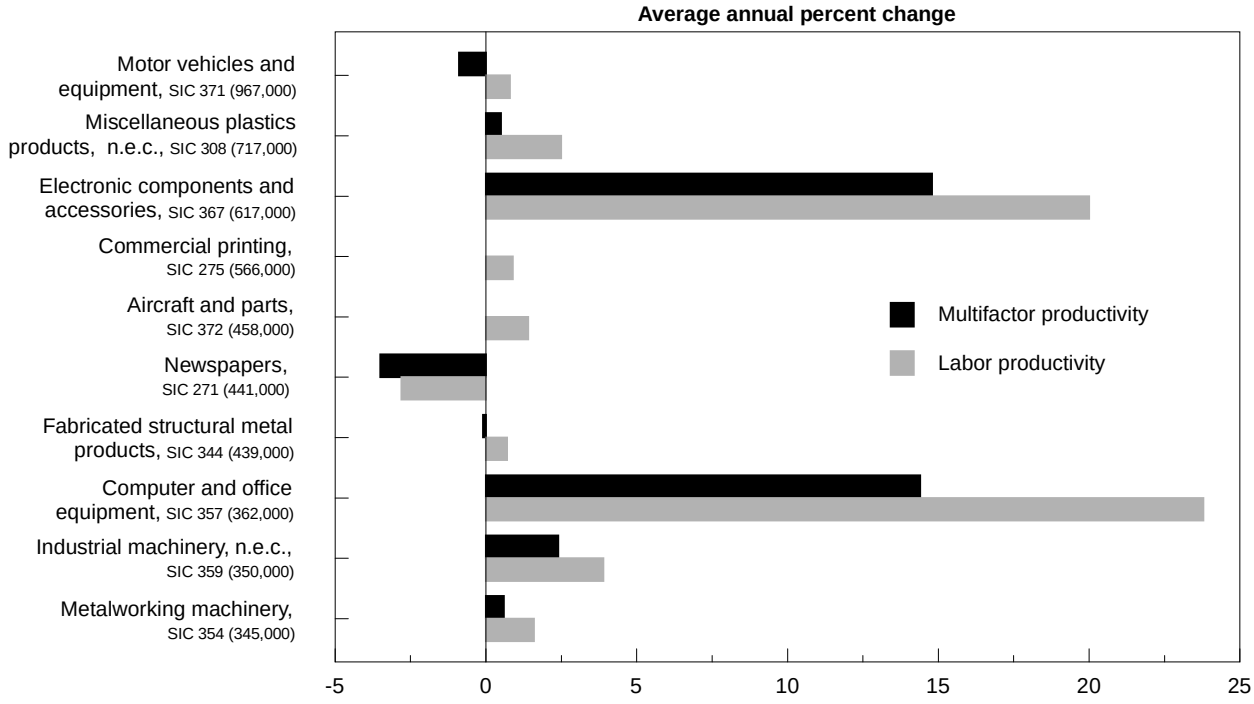


Chart 2. **Trends in multifactor productivity and labor productivity for the 10 largest manufacturing industries, 1987–96**



n.e.c. = not elsewhere classified

NOTE: Employment levels for 1996 are shown in parentheses.

Table 2. Multifactor productivity growth and its relationship to output per hour for three-digit manufacturing industries, 1987–96

(Average annual rate of change) [1]

SIC code	Industry	Multifactor productivity	Output per hour	Capital effect [2]	Intermediate purchases effect [3]
202	Dairy products	–.1	1.7	0.2	1.6
203	Preserved fruits and vegetables	–.3	1.0	.4	.9
204	Grain mill products	–.7	.9	.5	1.1
205	Bakery products	–.4	–.5	.3	–.4
206	Sugar and confectionery products	2.1	1.4	.4	–1.0
207	Fats and oils	.3	1.1	.0	.8
208	Beverages	1.6	3.4	.3	1.4
209	Miscellaneous food and kindred products	.9	1.0	.1	.0
221	Broadwoven fabric mills, cotton	–.5	3.6	.1	4.0
222	Broadwoven fabric mills, manmade	1.5	4.4	.5	2.4
224	Narrow fabric mills	1.9	2.6	.4	.3
225	Knitting mills	1.9	4.6	.6	2.1
226	Textile finishing, except wool	.9	–2.6	–.2	–3.2
227	Carpets and rugs	.8	.0	.0	–.8
228	Yarn and thread mills	–.3	4.4	.4	4.3
229	Miscellaneous textile goods	.2	2.3	.3	1.8
232	Men's and boys' furnishings	–.6	3.4	.8	3.2
233	Women's and misses' outerwear	1.0	3.9	.5	2.4
234	Women's and children's undergarments	–.2	6.4	1.1	5.5
235	Hats, caps, and millinery	–1.5	–2.2	–.2	–.6
238	Miscellaneous apparel and accessories	–.3	2.1	.2	2.2
239	Miscellaneous fabricated textile products	.4	.6	.1	.1
242	Sawmills and planing mills	1.8	1.6	–.1	–.1
243	Millwork, plywood, and structural members	–.3	–.9	.0	–.6
244	Wood containers	1.0	.7	–.2	–.1
245	Wood buildings and mobile homes	–.4	–.4	–.3	.4
249	Miscellaneous wood products	–.4	1.5	.1	1.8
251	Household furniture	.6	2.2	.2	1.4
252	Office furniture	–.7	.7	.6	.9
253	Public building and related furniture	.2	6.8	.0	6.7
254	Partitions and fixtures	–.4	–.3	.0	.1
259	Miscellaneous furniture and fixtures	–.4	1.4	.2	1.5
262	Paper mills	–1.1	1.2	.8	1.5
263	Paperboard mills	–1.0	1.9	1.0	1.9
265	Paperboard containers and boxes	–.1	.7	.0	.7
267	Miscellaneous converted paper products	.0	1.4	.4	1.0
271	Newspapers	–3.5	–2.8	.6	.1
275	Commercial printing	.0	.9	.5	.4
276	Manifold business forms	–3.0	–3.1	.3	–.3
277	Greeting cards	–2.6	–1.1	–.1	1.7
278	Blankbooks and bookbinding	–.8	1.5	.7	1.6
279	Printing trade services	1.6	2.6	.8	.1
281	Industrial inorganic chemicals	.0	1.1	–.2	1.2
282	Plastics materials and synthetics	.3	2.5	.7	1.6
283	Drugs	–2.1	1.3	1.8	1.7
285	Paints and allied products	–.9	2.6	.5	2.9
286	Industrial organic chemicals	–2.4	–.1	.8	1.5
287	Agricultural chemicals	.4	1.1	–.4	1.1
289	Miscellaneous chemical products	–.8	1.1	.4	1.5
291	Petroleum refining	.8	4.0	.3	2.8
295	Asphalt paving and roofing materials	.5	1.4	.2	.7
299	Miscellaneous petroleum and coal products	–1.5	–1.5	–.1	.1
301	Tires and inner tubes	2.1	3.7	.0	1.5
305	Hose and belting and gaskets and packing	.2	.8	–.4	1.0
306	Fabricated rubber products, n.e.c.	1.4	2.1	.0	.7

See footnotes at end of table.

Table 2. Continued—Multifactor productivity growth and its relationship to output per hour for three-digit manufacturing industries, 1987–96

(Average annual rate of change) [1]

SIC code	Industry	Multifactor productivity	Output per hour	Capital effect [2]	Intermediate purchases effect [3]
308	Miscellaneous plastics products, n.e.c.	0.5	2.5	0.4	1.5
314	Footwear, except rubber	–.3	2.6	.5	2.4
321	Flat glass	1.8	.2	–.5	–1.1
322	Glass and glassware, pressed or blown	1.5	2.2	.5	.2
323	Products of purchased glass	1.1	2.2	.3	.8
324	Cement, hydraulic	2.4	2.8	–.5	.9
325	Structural clay products	1.4	2.0	.0	.6
326	Pottery and related products	1.0	2.0	–.1	1.0
327	Concrete, gypsum, and plaster products	.8	.8	–.2	.2
329	Miscellaneous nonmetallic mineral products	1.1	1.1	–.3	.3
331	Blast furnace and basic steel products	1.1	4.4	–.1	3.4
333	Primary nonferrous metals	–1.7	1.2	–.2	3.1
335	Nonferrous rolling and drawing	–.6	.4	.1	1.0
336	Nonferrous foundries (castings)	1.2	2.3	.0	1.0
339	Miscellaneous primary metal products	1.6	4.6	–.2	3.1
341	Metal cans and shipping containers	2.4	5.0	.4	2.1
342	Cutlery, handtools, and hardware	–.4	1.9	.2	2.0
343	Plumbing and heating, except electric	.5	1.9	.2	1.2
344	Fabricated structural metal products	–.1	.7	–.1	.9
347	Metal services, n.e.c.	1.1	2.8	.2	1.5
348	Ordnance and accessories, n.e.c.	–1.8	–1.5	.9	–.5
349	Miscellaneous fabricated metal products	–.1	.9	.0	1.0
351	Engines and turbines	.3	3.5	.5	2.8
352	Farm and garden machinery	.5	3.6	.0	3.0
353	Construction and related machinery	.8	2.3	–.2	1.7
354	Metalworking machinery	.6	1.6	–.1	1.1
355	Special industry machinery	.9	3.3	.1	2.3
356	General industrial machinery	–.3	1.0	–.1	1.4
357	Computer and office equipment	14.4	23.8	1.7	6.4
358	Refrigeration and service machinery	.2	1.5	.0	1.3
359	Industrial machinery, n.e.c.	2.4	3.9	.0	1.5
361	Electric distribution equipment	1.7	4.1	.4	2.0
362	Electrical industrial apparatus	1.4	4.9	.3	3.2
363	Household appliances	.8	2.7	.2	1.7
364	Electric lighting and wiring equipment	.3	1.7	.3	1.2
366	Communications equipment	4.4	9.7	.9	4.0
367	Electronic components and accessories	14.8	20.0	1.8	2.6
369	Miscellaneous electrical equipment & supplies	1.2	2.3	.4	.7
371	Motor vehicles and equipment	–.9	.8	.0	1.7
372	Aircraft and parts	.0	1.4	.7	.6
373	Ship and boat building and repairing	–1.3	–.1	.0	1.2
375	Motorcycles, bicycles, and parts	1.8	2.6	–.3	1.0
376	Guided missiles, space vehicles, parts	–1.9	2.9	1.9	2.9
381	Search and navigation equipment	.8	4.0	1.2	1.9
382	Measuring and controlling devices	.6	4.6	.7	3.3
384	Medical instruments and supplies	.7	3.8	1.1	2.0
385	Ophthalmic goods	3.2	7.3	.9	3.1
386	Photographic equipment & supplies	.5	2.8	1.8	.5
391	Jewelry, silverware, and plated ware	–.7	.3	.0	.9
393	Musical instruments	–1.6	–2.6	–.7	–.4
394	Toys and sporting goods	.6	2.0	–.1	1.5
395	Pens, pencils, office, and art supplies	3.1	4.1	.4	.7
399	Miscellaneous manufactures	1.2	1.3	.0	.1

[1] The growth rate of multifactor productivity is equal to the growth rate of output per hour minus the growth rates of the capital effect and the intermediate purchases effect. The rates of change used in this table are the commonly used compound average annual rates. Only logarithmic rates of change are strictly additive. Therefore, the compound rates of change for labor productivity minus the rates for the capital effect and the intermediate purchases effect do not exactly equal the rate for multifactor productivity for larger rates of change.

[2] The capital effect is the change in capital relative to labor over the given time period weighted by the share of capital in the total cost of output.

[3] The intermediate purchases effect is the change in intermediate purchases relative to labor over the given time period weighted by the share of intermediate purchases in the total cost of output.

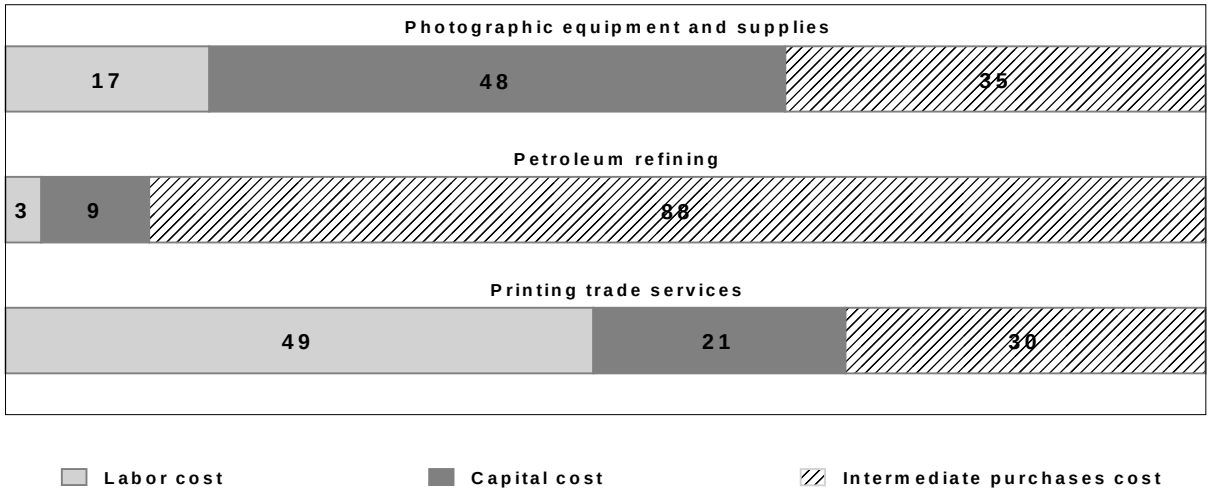
cent per year, but the capital effect grew at a rate of only 0.7 percent, as the value share weight for capital represented only 11 percent of total costs.[8] However, the capital effect grew at 1.7 percent per year, on average, for the photographic equipment and supplies industry (SIC 386), despite a more modest 3.7-percent gain in its capital-labor ratio because the cost share weight for capital averaged 48 percent.

Similarly, the intermediate purchases effect also depends on both the change in the ratio of intermediate purchases to labor and the share of intermediate purchases in total output. In the dairy products industry (SIC 202), for example, the cost share of intermediate purchases averaged 81 percent, and therefore the intermediate purchases effect grew at nearly the same rate—1.6 percent per year—as the 1.9 percent annual growth in the ratio of intermediate purchases to labor. The blankbooks and bookbinding industry (SIC 278), on the other hand, had a much smaller intermediate purchases cost share of 37 percent. In that industry, a much faster 4.3 percent annual growth in the ratio of intermediate purchases to labor resulted in the same growth rate (1.6 percent per year) in the intermediate purchases effect as for the dairy products industry.

There was a wide range of production technologies among the three-digit manufacturing industries, as exhibited by the variation in the input share weights of labor, capital, and intermediate purchases. (See exhibit 1.) The most capital intensive industries include the photographic equipment and supplies industry, with a capital share of 48 percent in 1996, the drugs industry (SIC 283), with a capital share of 42 percent, and the greeting cards industry (SIC 277), with a capital share of 35 percent. The public building and related furniture industry (SIC 253) had the lowest capital share (5 percent). Industries that are the most intermediate purchases intensive include petroleum refining (SIC 291), with an intermediate purchases share of 88 percent in 1996, the fats and oils industry (SIC 207), with an intermediate purchases share of 86 percent, and the dairy products industry with an intermediate purchases share of 81 percent. The printing trade services industry (SIC 279) had the lowest intermediate purchases share (30 percent). Labor cost shares were highest in printing trade services, with a labor share of 50 percent, the search and navigation equipment industry (SIC 381), with a labor share of 42 percent, and industrial machinery, not elsewhere classified, with a labor share of 41 percent. The petroleum refining industry had the lowest labor share (3 percent).

Within the three-digit manufacturing industries, 65 recorded growth in the capital effect, while 18 industries had no change and 25 reported declines. Guided missiles, space vehicles, and parts (SIC 376) had the highest capital effect growth (1.9 percent per year). The intermediate purchases effect grew for

Exhibit 1. **Input cost shares can vary greatly among industries: percent distribution of average cost shares for selected industries, 1987–96**



95 industries, while one industry experienced no change and 12 experienced declines. Public building and related furniture recorded the highest rate of growth in the intermediate purchases effect (6.5 percent per year).

In some industries, the capital and intermediate purchases contributions are so small that multifactor productivity change accounts for a large portion of the change in labor productivity. In 17 industries, multifactor productivity growth accounts for more than half of the change in labor productivity. In 7 of these industries, multifactor productivity growth accounted for 70 percent or more of the change in labor productivity. In miscellaneous manufactures (SIC 399), for example, 1.2 percentage points of the 1.3-percent annual growth rate in output per hour were accounted for by multifactor productivity growth. Similarly, in miscellaneous food and kindred products (SIC 209), of the 1.0-percent annual growth rate in labor productivity, 0.9 percentage points were a result of multifactor productivity growth.

Other industries show a different pattern. For example, in public building and related furniture, only 0.2 percentage points of the 6.8-percent average annual gain in labor productivity were due to multifactor productivity growth. In 28 industries, the change in multifactor productivity was negative, while the change in labor productivity was positive. In these industries, the combined changes in the capital effect and the intermediate purchases effect were greater than the change in labor productivity. Multifactor productivity change was higher than labor productivity change in only 11 industries, indicating that the combined effects of capital and intermediate purchases were negative. In each of these industries, the ratio of intermediate purchases to labor declined during the period; in 6 of 11, the ratio of capital to labor also declined.

As shown in table 2, large variations in the capital effects and intermediate purchases effects exist among industries. As a result, there is no consistent relationship between the multifactor productivity growth rates and the labor productivity growth rates. Among the industries with the 20 highest multifactor productivity growth rates, only 11 were also in the group having the 20 highest labor productivity growth rates. The same held true for the industries with the 20 worst multifactor productivity performances—only 9 were in the group having the 20 worst labor productivity growth rates. For example, at 2.1 percent per year, the sugar and confectionery products industry ranked 9th in multifactor productivity growth, but in terms of labor productivity growth, it ranked 63rd, at 1.4 percent. Guided missiles and space vehicles had the 6th worst multifactor productivity growth rate, with a decline of 1.9 percent per year (trailing 102 other industries), but it had the 29th *best* growth rate in labor productivity, at 2.9 percent.

Output growth was related to gains in multifactor productivity. Among the 88 industries with output gains, 61 recorded multifactor productivity gains. In contrast, of the 20 industries with average annual declines in output, 17 had declines in multifactor productivity. The largest multifactor productivity gains of 14.8 percent and 14.4 percent per year were recorded by the industries with the largest output gains of 20.3 and 20.4 percent—electronic components and accessories, and computer and office equipment. Ordnance and accessories, not elsewhere classified (SIC 348) recorded the sharpest drop in output (6.6 percent per year), while at the same time recording a substantial decline in multifactor productivity (1.8 percent per year) over the study period.

MULTIFACTOR PRODUCTIVITY IN MANUFACTURING as a whole grew at a rate of 0.7 percent per year, on average, for the 1987–96 period. The multifactor productivity series for the 108 three-digit SIC manufacturing industries presented in this article document the wide dispersion of growth rates around that average. While labor productivity measures include the effects of changes in capital per hour and intermediate purchases per hour, multifactor productivity measures do not. Because these effects vary widely from industry to industry, there is no predictable relationship between labor productivity growth rates and multifactor productivity growth rates. □

Notes

[1] Published indexes for multifactor productivity and related series are available at **http//stats.bls.gov/iprhome.htm**. Series for unpublished industries are available upon request. E-mail requests for information may be sent to **dipsweb@bls.gov**. BLS is planning to extend the industry multifactor productivity series to 1999 in the latter part of 2001.

[2] For more information on the Standard Industrial Classification (SIC) system, see *Standard Industrial Classification Manual: 1987* (Office of Management and Budget, 1987).

[3] The Bureau of Labor Statistics also produces measures of labor productivity, as measured by output per employee hour, for individual manufacturing industries at the 2–, 3–, and four-digit SIC level. The number of industries for which labor productivity series are maintained has steadily increased. By 1998, all 457 four-digit manufacturing industries and 140 three-digit industries were covered.

[4] Publication criteria included employment size, variability of annual labor productivity changes, and an evaluation of capital compensation measures for each industry.

[5] The multifactor productivity data for manufacturing and the two-digit manufacturing industry groups are available at **http://stats.bls.gov/mprhome.htm**.

[6] One large industry, meat products (SIC 201), did not meet publication standards and therefore is not included in this discussion.

[7] See Robert J. Gordon, "Does the 'New Economy' Measure up to the Great Inventions of the Past?" Journal of Economic Perspectives, Volume 14, Number 4, Fall 2000, pages 49–74.

[8] Data for three-digit industry value share weights for labor, capital, and intermediate purchases are available upon request.

Appendix: Measurement of multifactor productivity

Multifactor productivity indexes relate the change in output to the change in the combination of labor, capital, and intermediate purchases inputs consumed in producing that output. Because they incorporate a measure of combined inputs, multifactor productivity measures are not influenced by the substitution of capital and intermediate inputs for labor, as are measures of labor productivity. Multifactor productivity is calculated by dividing a Tornqvist index of output by a Tornqvist index of combined inputs.[1]

Output. Output quantities for most industries are based on the value of output adjusted for price change. The value of shipments of primary products—wherever they are made—for each product class is taken from the Annual Surveys of Manufactures (ASM) conducted by the Bureau of the Census. These product class values are deflated with matching BLS producer price indexes (PPIs) and are Tornqvist aggregated to the four-digit SIC industry level. For each year, special coverage ratios for the industry are used to adjust the wherever-made indexes to an industry basis. The resultant industry indexes are further adjusted to reflect changes in inventories to yield a measure of production during the given year.

Every 5 years, benchmark output indexes are prepared that incorporate data from the Censuses of Manufactures (CM) and that are more detailed than those available in the ASMs. Adjustments are prepared from these data to remove resales and intra-industry transactions to avoid double counting of output. The annual output indexes based on ASM data are adjusted to the quinquennial benchmark levels using linear interpolation.

Each four-digit industry output index is Tornqvist aggregated to the three-digit industry level. In the process of this last aggregation, adjustments are made to remove a second level of double counting—those transactions between four-digit industries within the same three-digit industry.

Combined inputs. The index of combined inputs is a Tornqvist aggregate of separate indexes of labor input, capital input, and intermediate purchases input. The labor share weight is based on the total value of labor compensation including fringe benefits. The intermediate purchases share weight is based on the total value of materials (adjusted to remove intra-industry transactions), fuels, electricity, and purchased services. The capital share weight is a residual calculated as the value of net production minus the value of labor compensation minus the value of intermediate purchases.

Labor input. The labor input indexes are developed by dividing the aggregate employee hours for each year by the base-period aggregate. Because of data limitations, employee hours are treated as homogeneous and additive with no distinction made between hours of different groups of employees. Annual hours of all employees are derived by summing the aggregate hours for production workers and the estimated hours for nonproduction workers. Data on employment and hours are based on BLS surveys.

Capital input. The measure of capital input is based on the flow of services derived from the stock of physical assets. Physical capital is composed of equipment, structures, land, and inventories. Capital services are estimated by calculating capital stocks; changes in the stocks are assumed to be proportional to changes in capital services for each asset. Stocks of different asset types are Tornqvist aggregated using estimated rental prices to construct the weights for assets of different types. Capital stocks are calculated using the perpetual inventory method, which takes into account the continual additions to and subtractions from the stock of capital as new investment and retirement of old capital occur. The perpetual inventory method measures stocks at the end of a year equal to a weighted sum of all past investments, where the weights are the asset's efficiency relative to a new asset. A hyperbolic age-efficiency function is used to calculate the relative efficiency of an asset at different ages.

Price change must be removed from the investment data before calculating stocks. Industry-specific price deflators for each asset category are constructed by combining detailed price indexes (mostly PPIs) with weights based on the capital flow tables from the Bureau of Economic Analysis (BEA). These deflators are used to convert the current-dollar investment to constant dollars. The various equipment, structure, inventory, and land stock series in constant dollars are aggregated into one capital input measure using implicit rental prices to construct the weights.[2]

Intermediate purchases input. The index of intermediate purchases input is constructed as a Tornqvist aggregate of separate indexes of change in the quantity of materials, services, fuels, and electricity consumed by an industry. Except for electricity, for which direct quantity data are available, quantities are derived by deflating current dollar values with appropriate price deflators. Annual current dollar values of total materials consumed for each industry come from the ASM and CM.

To avoid double counting, the materials estimates exclude, whenever possible, the value of intra-industry purchases. Estimates of materials purchased from other establishments within the industry are subtracted from the gross measure of materials costs to derive estimates of "net" materials consumed.

Constant dollar net materials consumed by each industry are derived by dividing the annual current dollar values by an industry-specific materials price deflator. To construct the materials price deflator, detailed producer price indexes are weighted together with weights based on the values of specific materials consumed by each industry. Data to construct these weights come from the CM and the BEA benchmark input-output tables.

Annual data on the total value of all fuels consumed by industry (which also come from the ASM and CM) are deflated with industry-specific price deflators. Producer price indexes for six types of fuel are aggregated using weights based on the nominal values of specific fuels consumed, by industry. Data for estimating the weights are from the ASM and the Department of Energy. Because both the value and the quantity of purchased electricity are available annually by industry from the ASM and CM, electricity is treated as a separate component of intermediate purchases. Estimates of price and quantity of electricity are derived directly from the ASM and CM data.

The data for annual cost of materials does not include the value of purchased services. As a result, current dollar services purchased by each industry are estimated based on proportions from the BEA benchmark input/output tables. Because of a lack of historical data on price indexes for services, the aggregate, fixed-weight materials deflator is used for deflating current dollar services as well as materials.

[1] A Tornqvist index of output is developed by computing a weighted average of the growth rates of the various industry products between two periods, with weights based on the products' shares in industry value of production. The weight for each product equals its average value share in the two periods. For a more complete discussion of the Tornqvist methodology see Kent Kunze, Mary Jablonski, and Virginia Klarquist, "BLS modernizes industry labor productivity program," *Monthly Labor Review*, July 1995, pp. 3–12.

[2] For a more extensive discussion of the measurement of capital, see *Multifactor Productivity Measures for three-digit SIC Manufacturing Industries,* Report 948 (Bureau of Labor Statistics, December 2000).