Multifactor productivity in household furniture

Multifactor productivity in household furniture manufacturing accounted for approximately one-third of the average annual labor productivity gain in the 1958–91 period; capital and intermediate purchases rose relative to labor

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Multifactor productivity, a measure relating output to the combined inputs of labor, capital, and intermediate purchases, grew at an average annual rate of 0.5 percent between 1958 and 1991 in the household furniture industry. (See chart 1.) Many factors influence movements in multifactor productivity such as technological change, changes in the skill and effort of the work force, and economies of scale.

For more than 10 years, the Bureau of Labor Statistics has published a labor productivity measure for the household furniture industry. In this article, we extend the analysis of the household furniture industry, Standard Industrial Classification (SIC) 251, by presenting a multifactor productivity measure for the industry.

Labor productivity increased at an average annual rate of 1.8 percent over the 1958–91 period. Labor productivity, as measured by output per employee hour, is comprised of the effects of changes in capital per hour, intermediate purchases per hour (materials, fuels, electricity, and purchased business services), and multifactor productivity. The multifactor measure accounts for the influences of capital and intermediate purchases in the input measure and does not reflect the impact of these influences on the productivity residual. It also allows analysts to quantify the effects on labor productivity of changes in capital relative to labor and intermediate purchases relative to labor.

BLS first published multifactor productivity measures in 1983, covering the private business sector, the private nonfarm business sector, and the total manufacturing sector. Since then, BLS has developed and published data for 20 two-digit manufacturing industries and 7 three-digit industries.

Establishments in the industry

The household furniture industry is composed of establishments that produce wood household furniture, upholstered furniture on wood frames, metal home furnishings, mattresses, bed foundations, dual purpose sleep furniture, and plastic, fiberglass, rattan and wicker furniture. The industry also includes the production of recreational (lawn and beach) furniture, except stone and concrete, and cabinets, except wood kitchen cabinets and bathroom vanities. Wood household furniture accounted for more than 40 percent of the output of this industry in 1987, followed by upholstered furniture (28.4 percent), mattresses (13.0 percent) and metal furnishings (11.5 percent). Wood television and radio cabinets and plastic and wicker furniture combined made up less than 5 percent of the value of industry shipments (1.9 percent and 2.2 percent, respectively).

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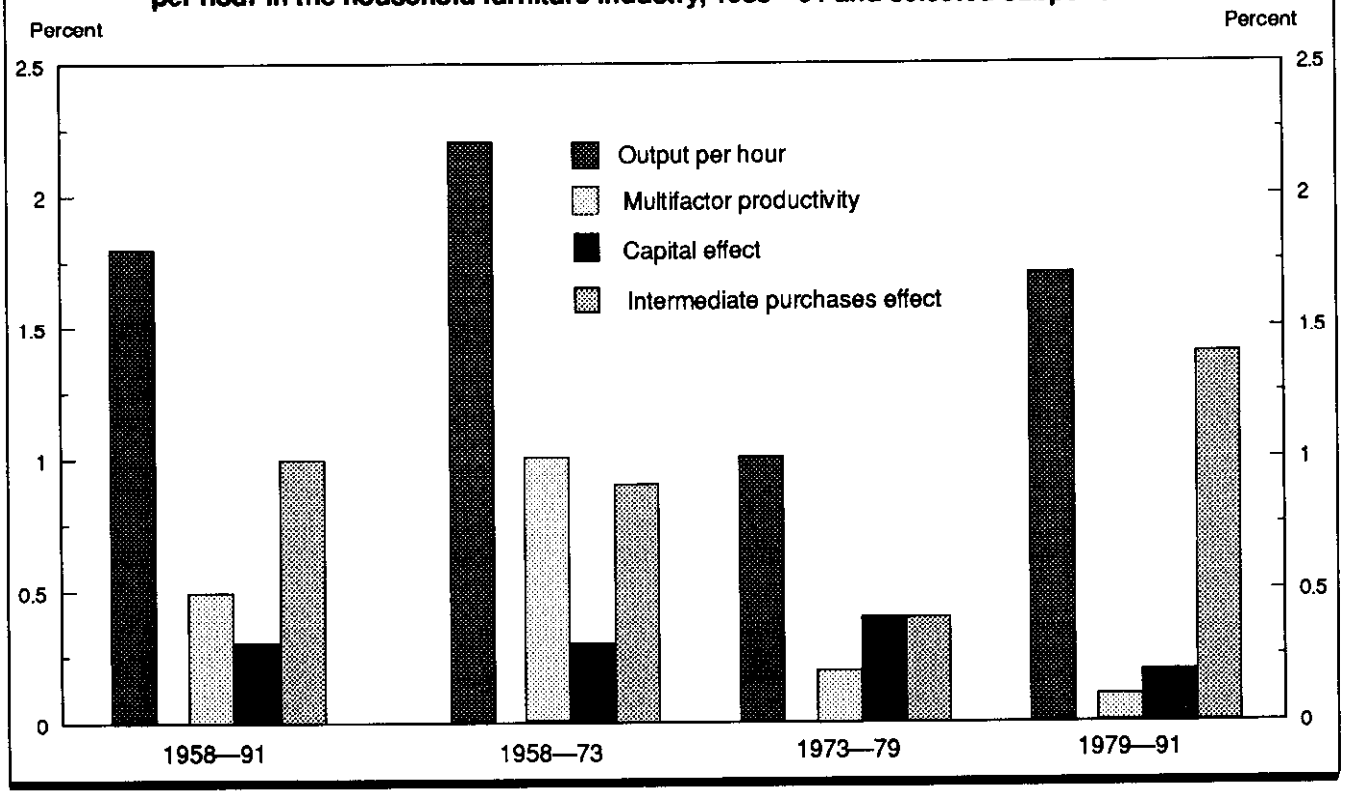
Chart 1. **Contribution of multifactor productivity, capital, and intermediate purchases to output per hour in the household furniture industry, 1958—91 and selected subperiods**



The influence of changes in capital per hour on labor productivity will be referred to in this article as the "capital effect" and is measured by multiplying the change in the capital-labor ratio by the share of capital costs in the total cost of output. The influence of changes in intermediate purchases per hour on labor productivity is described as the "intermediate purchases effect" and is measured by multiplying the intermediate purchases-labor ratio by the share of intermediate purchases costs in the total cost of output.

Output per hour showed considerable growth of 2.2 percent per year in the 1958–73 period, but slowed to an average annual increase of 1.0 percent in the 1973–79 period. (See table 1.) This slowdown of 1.2 percentage points reflects the slowdown that occurred in the business sector as a whole. The most substantial influences on the slowdown in labor productivity in the household furniture industry were the falloffs in multifactor productivity and the intermediate purchases effect. Multifactor productivity growth slowed 0.8 percentage point while the intermediate purchases effect declined 0.5 percentage point. Average growth in the capital effect was largely unchanged: it increased from a 0.3-percent average annual growth rate during the 1958–73 period to a growth rate of 0.4 percent in the 1973–79 period.

After 1979, labor productivity (output per hour) rebounded, reflecting the trend in the business sector overall. Between 1979 and 1991, labor productivity in household furniture grew an average of 1.7 percent per year, a jump of 0.7 percentage point from the 1973–79 rate (1.0 percent). This rebound was stronger than that in total business, which accelerated slightly from a 0.7-percent annual average rate to an average yearly increase of 1.0 percent in the 1979–91 period. In household furniture, this rebound was influenced primarily by the 1.0-percentage point jump, from an annual average rate of 0.4 percent to 1.4 percent, in the intermediate purchases effect between the 1973–79 and 1979–91 periods. Multifactor productivity growth fell off 0.1 percentage point per year, while the capital effect fell off 0.2 percentage point from the earlier to the later periods.

Because intermediate purchases comprise a much larger share of the total cost of output—an average of 57 percent over the 34 years of this study—changes in the intermediate purchases-labor ratio had a far greater influence on output per hour than did changes in the capital-labor ratio. The movement in the intermediate purchases effect can be seen by examining the changes in intermediate purchases, labor, and the

intermediate purchases share weight. The intermediate purchases component grew at an annual 4.0-percent rate in the 1958–73 period (See table 2). This growth, combined with the 2.4-percent annual increase in labor hours, yielded an average annual gain of 1.7 percent in the intermediate purchases-labor ratio. Weighting the gain in the intermediate purchases-labor ratio with the cost share of intermediate purchases, which changed little over the study period, results in a 0.9-percent increase in the intermediate purchases effect for the pre-1973 period.

Between 1973 and 1979, the intermediate purchases effect fell from 0.9 percent in the pre-1973 period to 0.4 percent. The intermediate purchases-labor ratio fell to a 0.7-percent per year growth rate during this period, as intermediate purchases declined an average of 0.4 percent and labor hours fell 1.1 percent per year. Since 1979, furniture manufacturers increasingly substituted intermediate purchases for labor. The increased use of intermediate purchases relative to labor appears to be in the form of more finished materials inputs.[1] During the 1979–91 period, the intermediate purchases effect growth accelerated to a rate of 1.4 percent per year. Intermediate purchases grew 0.7 percent per year, while labor dropped 1.7 percent per year on average.

As mentioned earlier, the average growth in the capital effect rose 0.1 percentage point between the 1958–73 and 1973–79 periods, but fell 0.2 percentage point between 1973–79 and 1979–91. These changes in the capital effect can be broken down into changes in capital services, labor, and the capital share weight. During the 1958–73 period, the capital effect grew 0.3 percent on average. Inputs of capital services increased over this period by 4.4 percent and labor by 2.4 percent, boosting the capital-labor ratio by an average of 2.0 percent annually. Weighting this growth rate in the capital-labor ratio with capital's average share in the cost of total output of 14 percent in this period yields the 0.3-percent annual growth in the capital effect.

From 1973 to 1979, the capital effect grew 0.4 percent on average. The growth rate of capital services slowed to an average of 1.8 percent annually while labor fell 1.1 percent per year. Growth in the capital-labor ratio accelerated to an average rate of 2.9 percent. Capital's average cost share weight fell slightly for the period to 13 percent.

Finally, in the 1979–91 period, the capital effect grew 0.2 percent per year on average. Labor input continued to decline, at an average annual rate of 1.7 percent, while capital services fell an average of 0.1 percent annually. This caused the capital-labor ratio growth rate to slow to an average rate of 1.6 percent. The average cost share weight of capital remained at the 13-percent level after 1979.

Shifts in the relative growth of the input prices for household furniture probably influenced the change in relative input use. As mentioned above, the intermediate purchases effect played a part in the 1973–79 labor productivity slowdown, accounting for more than one-third of the 1.2 percentage point falloff. In the 1958–73 period, intermediate purchases prices rose only 2.4 percent annually, compared with the 4.3-percent average annual increase in hourly labor cost. This difference served as an inducement to substitute intermediate purchases for labor in the production process where possible, and indeed, the intermediate purchases effect rose at a 0.9-percent rate over the period before 1973.

During the 1973–79 period, hourly labor costs accelerated to an average annual growth rate of 7.7 percent, but intermediate purchases prices jumped to an annual rate of 8.4 percent. This essentially eliminated the inducement for substitution of intermediate purchases for labor; during the period, average growth in the intermediate purchases effect fell to 0.4 percent.

The rebound in labor productivity in the 1979–91 period was accounted for entirely by the 1.0-percentage point acceleration in the growth rate in the intermediate purchases effect. Relative price movements also could have influenced this jump, as intermediate purchases prices fell off to a rate of 3.1 percent from the earlier 8.4-percent rate, a greater deceleration than hourly labor costs, which dropped to a 5.4-percent annual rate from the earlier 7.7 percent.

Output

Furniture output by manufacturers is affected directly by consumer demand for furniture in

Table 1. **Output per hour expressed as multifactor productivity plus the capital effect and the intermediate purchases effect, household furniture industry**

Measure	1958–73	1973–79	1973–79—1958–73	1979–91	1979–91—1973–79
Output per hour	2.2	1.0	–1.2	1.7	.7
Multifactor productivity	1.0	.2	–.8	.1	–.1
Capital effect[1]	.3	.4	.1	.2	–.2
Intermediate purchases effect[2]	.9	.4	–.5	1.4	1.0

[1]The capital effect is the change in the capital–labor ratio multiplied by the share of capital costs in the total cost of output.

[2]The intermediate purchases effect is the change in the intermediate purchases–labor ratio multiplied by the share of intermediate purchases costs in the total cost of output.

NOTE: Each measure presented in this table is computed independently. Therefore, multifactor productivity, the capital effect, and the intermediate purchases effect might not sum exactly to output per hour due to rounding.

retail outlets that buy directly from manufacturers or are subsidiaries of the manufacturer itself. Therefore, furniture output is dependent on the consumer's confidence in the economy, the consumer's financial situation and, most importantly, how recently the consumer moved to another residence. "According to the U.S. Department of Commerce, the primary purchasers of residential furniture are households headed by persons aged 25–44, who account for the great bulk of households."[2] Factors affecting furniture output include private housing starts, private home resales, and interest rates: 60 percent of all furniture sales are financed on credit.[3]

Output in the household furniture industry has generally moved up over the review period, but with substantial cyclical year-to-year fluctuations. The two greatest declines in output were 14.9 percent in 1974–75 and 11.7 percent in 1981–82, which were recessionary periods that depressed demand in the furniture industry. (See table 3.) Consumer demand fell off when interest rates advanced rapidly between the 1972–74 and 1977–81 periods. The falloff in housing starts and sales reflect this trend. In 1975, furniture plants were operating at 80 percent of capacity and manufacturers were experiencing materials shortages in lumber and fabrics.[4] In addition, the economic slump of the early 1980's caused retailers to keep low furniture inventories as consumers deferred large purchases, slowing demand in the industry.[5]

The industry also has experienced significant upswings in output. One of the largest jumps in furniture production occurred at the very start of the review period, with a 12.9-percent gain between 1958 and 1959. Personal consumption expenditures on furniture grew 6.7 percent in 1959. Furniture and department stores were not prepared for this jump in demand because sales in the previous year were low, keeping down inventory. When demand increased, they placed large orders with furniture manufacturers.[6]

The energy crisis of the early 1970's had a positive influence on the household furniture industry. Consumers cut back on purchases of the larger, expensive, less fuel-efficient automobiles and deferred costly vacations as gasoline prices rose sharply. This led to more time at home, and "a greater portion of consumer disposable income spent . . . on improving the home."[7] From 1970 to 1973, output grew, on average, 10.2 percent per year. Existing and new home sales also were up. The drop of the prime rate between 1969 and 1972 encouraged these investments.

The industry rebounded after the 1974–75 and 1981–82 recessions. Output jumped 12.7 percent in 1976, and continued to grow through 1978. (See table 3.) Again, between 1982 and 1983 industry output grew a considerable 9.7 percent. In both cases, improvements in the economy spurred sales of home furnishings as interest and unemployment rates fell. Because sales in the furniture industry usually lag by between 6 and 12 months behind the housing market,[8] the increase in home sales and housing starts in 1970–71 helped the furniture industry increase output the following year. Housing starts and sales improved somewhat in the 1981–82 period, but furniture output did not increase significantly until 1983. Since 1982, output growth has averaged 2.1 percent per year. This growth was influenced by the increase in the number of new and existing home sales and the forecast that the number of families headed by the 25–44 year-old age group, which is the largest purchaser of furniture, "is rising and should continue to do so through the mid–1990's."[9]

Over the years, concentration of firms in the industry has been low but increasing. In 1987 (the latest year for which data are available), the four largest firms in the household furniture industries (excluding wood television and radio cabinets) accounted for an average of 23 percent of their respective industry shipments and the top 20 companies made up 47 percent, as opposed to approximately 13 percent and 28 percent in 1963.

Until recently, the household furniture industry has been insulated from foreign competition. Low wages, geographic location, and transportation costs borne by distant foreign competitors helped protect the industry.[10] But imports have made inroads recently into the domestic residential furniture market, accounting for 13.2 percent of apparent consumption in 1991, up from 2.8 percent in 1972.[11] Exports as a percent of value

Table 2. **Average annual rates of growth in output per hour, hours, capital, intermediate purchases and related measures, household furniture industry**

Measure	1958–73	1973–79	1973–79—1958–73	1979–91	1979–91—1973–79
Output per hour	2.2	1.0	–1.2	1.7	.7
Output	4.7	–.1	–4.8	.0	.1
Hours	2.4	–1.1	–3.5	–1.7	–.6
Capital	4.4	1.8	–2.6	–.1	–1.9
Capital per hour	2.0	2.9	.9	1.6	–1.3
Capital effect[1]	.3	.4	.1	.2	–.2
Intermediate purchases	4.0	–.4	–4.4	.7	1.1
Intermediate purchases per hour	1.7	.7	–1.0	2.5	1.8
Intermediate purchases effect[2]	.9	.4	–.5	1.4	1.0

[1]Capital per hour multiplied by the share of capital costs in the total cost of output.

[2]Intermediate purchases per hour multiplied by the share of intermediate purchases costs in the total cost of output.

of shipments grew nearly ninefold over the same period, but were only about 35 percent of the value of imports in 1991.

Most of the imports are in wood home furnishings, particularly living room and dining room furniture. The growth in imports has been influenced by decreases in transportation costs and the development of knock-down furniture technology.[12] Because furniture's value is low relative to its weight, high shipping costs had kept out foreign competition.[13] Today, lower transportation costs stemming from efficiencies in shipping containerization have eradicated much of this U.S. advantage. For example, companies that produce wooden dining room pieces and occasional tables are the hardest hit by imports: These products are the easiest to manufacture and can be shipped with the legs "knocked down" for economical packaging.[14]

Taiwan is the largest exporter of wood furniture to the U.S. In 1983, it exported $223.7 million of furniture pieces to the United States. This is a twenty-fold increase from $10.1 million in exports in 1972.[15] Imports of wood furniture are expected to increase as foreign competition improves production methods, uses better quality materials, and continues using efficient shipping and assembly techniques.[16]

Metal furniture has little import competition, primarily because much of it is too bulky for foreign transport.[17] The bedding industry also is insulated from foreign competition because the bulkiness of its products makes transportation costs prohibitive.

The upholstered furniture industry, because of the size of its product, high transport costs, and special-order requirements that stretch out delivery time, is the most insulated from foreign competition. On balance, the effect of trends in import competition is that some U.S. wood furniture producers will likely drop out of the industry but the upholstered furniture industry will grow.[18]

The trade balance changed in the last several years of this study. The decline in the value of the dollar improved the trade balance. The rate of growth in imports slowed between 1985 and 1988 and has declined since. The value of exports also rose. In 1991, U.S. exports of household furniture set an industry record at $955 million, a 305-percent increase over the 1988 export value. Foreign demand has grown as international import regulations have eased and foreign economies improved. Also, some of the largest exporters of furniture to the United States, such as Taiwan and South Korea, have lost their eligibility to ship furniture duty-free into the United States in the most important furniture categories;[19] as a result, these products are less price competitive in the home furnishing market. The industry's trade prospects in the future will depend on the changing value of the dollar and continued approval of trade liberalization agreements.

Table 3. **Output and input indexes, household furniture industry**

[1987=100]

Year	Output	Combined inputs	Hours	Capital	Intermediate purchases
1958	47.2	57.4	81.4	47.8	50.3
1959	53.3	63.2	90.4	48.7	56.0
1960	50.7	60.8	86.3	49.7	53.5
1961	48.9	59.8	82.7	50.1	53.2
1962	53.4	64.3	88.6	50.8	58.0
1963	56.6	66.2	91.0	52.5	59.7
1964	60.5	70.9	95.0	54.6	65.3
1965	65.0	73.8	99.8	57.4	67.4
1966	68.5	77.3	103.3	61.9	70.5
1967	65.9	76.7	98.1	66.6	70.3
1968	70.5	80.6	102.9	68.4	74.4
1969	72.7	82.0	104.9	71.2	75.1
1970	69.9	80.7	97.8	75.3	74.7
1971	75.2	85.2	101.4	78.0	80.1
1972	88.5	95.0	112.7	83.4	90.7
1973	93.4	97.2	115.4	90.8	91.2
1974	85.4	90.9	107.0	96.6	82.7
1975	72.7	81.2	89.1	97.1	74.5
1976	82.0	88.2	99.2	95.1	81.8
1977	89.1	94.1	106.4	97.2	87.8
1978	95.8	98.7	109.7	99.3	93.6
1979	93.1	95.9	108.1	101.3	89.3
1980	87.4	91.8	101.8	101.4	85.4
1981	87.4	90.3	98.8	101.4	84.2
1982	77.1	81.4	85.9	100.7	75.5
1983	84.6	87.2	92.2	99.6	82.3
1984	89.9	92.9	97.0	100.3	89.4
1985	88.1	92.2	93.7	100.2	89.8
1986	93.5	94.9	92.9	99.2	94.9
1987	100.0	100.0	100.0	100.0	100.0
1988	99.2	99.1	98.5	101.2	98.9
1989	99.4	100.3	96.8	101.5	101.8
1990	97.1	98.5	94.2	101.1	100.1
1991	92.8	94.9	88.0	100.3	97.2
	Average annual rates of change (percent)				
1958–91	2.1	1.5	.2	2.3	2.0
1958–73	4.7	3.6	2.4	4.4	4.0
1973–91	.0	–.1	–1.5	.6	.4
1973–79	–.1	–.2	–1.1	1.8	–.4
1979–91	.0	–.1	–1.7	–.1	.7

Labor

Employee hours in the household furniture industry increased an average of 0.2 percent annually between 1958 and 1991. During the period 1958–73, employee hours grew 2.4 percent annually, fueled by the average annual increase of 4.7 percent in output in the same time period. Over the next 6 years of this study, labor hours declined an average of 1.1 percent. From 1979 to 1991, labor and output growth diverged, with labor input falling at an average rate of 1.7 percent and output remaining constant on average.

In 1991, total employment in the household furniture industry was 258,600, 3 percent above

the 1958 level. Employment in the industry peaked in 1973 at 326,000. The number of employees fell dramatically in the following 2 years, but rose to 316,400 in 1978. More recently, employment has fallen off between 1981 and 1982. During the 1982–88 period, employment in the industry gradually approached its 1981 level, but has fallen off more recently. The industry averaged 51 employees per plant in 1987, up from 44 in 1958.

Production workers averaged 85 percent of all employees in this industry in the 1958–91 period, while nonproduction workers averaged 15 percent. The nonproduction worker proportion was lower in this industry than for total manufacturing. In 1990, the professional, paraprofessional, and technical employees group made up only 1 percent of total employment (mostly engineers and designers) in the industry while this group made up more than 9 percent of employment in the whole manufacturing sector. Average hourly earnings (in constant dollars) increased steadily between 1958 and 1973, but have fallen since 1973. In current dollars, production workers averaged $8.13 per hour in 1991, while in total manufacturing they averaged $11.18.

The total number of establishments has increased from 5,413 in 1958 to 5,706 in 1987, or 5.4 percent. Much of this growth was due to an expansion in the wood household furniture industry, which expanded from 2,066 establishments in 1958 to 2,948 in 1987. The number of establishments in the whole household furniture industry peaked in 1977 at 6,160.

Furniture production is a very labor intensive process, affected often by shortages of highly skilled workers or carvers. In large plants, assembly lines are prevalent and are characterized by fewer skilled craftsmen. "Most production is an assembly line technique that breaks down the construction of any piece of furniture into scores of simple individual assembly operations."[20]

Table 4. **Multifactor and related productivity indexes, household furniture industry**

[1987=100]

Year	Multifactor productivity	Output per hour	Output per unit of capital	Output per unit of intermediate purchases
1958	82.2	58.0	98.7	93.8
1959	84.3	59.0	109.4	95.2
1960	83.4	58.7	102.0	94.8
1961	81.8	59.1	97.6	91.9
1962	83.0	60.3	105.1	92.1
1963	85.5	62.2	107.8	94.8
1964	85.3	63.7	110.8	92.6
1965	88.1	65.1	113.2	96.4
1966	88.6	66.3	110.7	97.2
1967	85.9	67.2	98.9	93.7
1968	87.5	68.5	103.1	94.8
1969	88.7	69.3	102.1	96.8
1970	86.6	71.5	92.8	93.6
1971	88.3	74.2	96.4	93.9
1972	93.2	78.5	106.1	97.6
1973	96.1	80.9	102.9	102.4
1974	93.9	79.8	88.4	103.3
1975	89.5	81.6	74.9	97.6
1976	93.0	82.7	86.2	100.2
1977	94.7	83.7	91.7	101.5
1978	97.1	87.3	96.5	102.4
1979	97.1	86.1	91.9	104.3
1980	95.2	85.9	86.2	102.3
1981	96.8	88.5	86.2	103.6
1982	94.7	89.8	76.6	102.1
1983	97.0	91.8	84.9	102.8
1984	96.8	92.7	89.6	100.6
1985	95.6	94.0	87.9	98.1
1986	98.5	100.6	94.3	98.5
1987	100.0	100.0	100.0	100.0
1988	100.1	100.7	98.0	100.3
1989	99.1	102.7	97.9	97.6
1990	98.6	103.1	96.0	97.0
1991	97.8	105.5	92.5	95.5
	Average annual rates of change (percent)			
1958–91	0.5	1.8	–.2	.1
1958–73	1.0	2.2	.3	.6
1973–91	.1	1.5	–.6	–.4
1973–79	.2	1.0	–1.9	.3
1979–91	.1	1.7	.1	–.7

Capital

Capital input in this industry grew in all but 8 of the years covered by this measure. Year-to-year changes ranged from an increase of 8.9 percent in 1973 to a 2.1-percent decline in 1976. Capital services grew an average of 2.3 percent per year between 1958 and 1991. Before 1973, capital showed substantial growth, at 4.4 percent on average annually, but slowed dramatically to an average of 1.8 percent per year during the period 1973–79. From 1979 to 1991, capital services fell at an average rate of 0.1 percent. During the economic upswing of 1970–73, many companies expanded facilities, built new plants, and invested in more efficient technologies. Capital spending did not rebound quickly after the 1974–75 recession due to considerable overcapacity among firms.[21] The overall growth in capital services in the pre- and post–1973 periods almost replicates the overall growth of output, although capital has remained fairly stable year-to-year since 1974 while output has been cyclical over the same period with sizable yearly changes.

Capital input is the flow of services derived from the equipment used in the production of household furniture, structures (primarily buildings housing the production process), finished goods, work-in-process, materials and supplies inventories, and the land on which the plants are located. Over the 1958–91 period, services from equipment grew at an average rate of 2.3 percent per year while capital input from structures

increased an average of 2.2 percent. The inventories input annual growth rate averaged 2.3 percent. Land input grew at a faster annual rate, 2.5 percent.

In the pre-1973 interval, services from all four types of capital expanded at about the same pace as total capital (4.4 percent per year). Input from both equipment and inventories increased 4.9 percent per year. Structures and land input grew at a slower average pace, 4.1 percent.

Although all four inputs' growth slowed over the post–1973 period, their trends diverged. From 1973 to 1979, a period in which output fell 0.1 percent per year, services from equipment declined an average of 0.4 percent and inventories 0.5 percent. Land and structures input growth slowed to average increases of 3.0 and 2.7 percent. In the 1979–91 period, average growth in inventories increased to 0.4 percent while land growth slowed to 0.3 percent. Structures and equipment input declined 0.2 percent from 1979 to 1991.

Intermediate purchases

Intermediate purchases consist of the raw materials, energy (purchased fuels and electricity), and purchased services used in the production of the industry's output. Materials make up an average of 87 percent of intermediate purchases. Between 1958 and 1991, intermediate purchases grew at an average annual rate of 2.0 percent. This figure reflects the rapid growth in the pre–1973 period of 4.0 percent per year, an average decline in intermediate purchases of 0.4 percent from 1973 to 1979, and 0.7 percent average growth over the post–1979 period. Intermediate purchases followed output's cyclical movements over most of the 34 years studied. The two indexes moved in opposite directions only during 1980–81 and 1984–85, and the differences were small.

Lumber and woven upholstery fabric are the largest components of materials consumed by the industry. In 1987, the latest year for which detailed materials data are available, wood products accounted for 18 percent of total materials. Woven upholstery fabric (cotton and artificial fiber) made up 8 percent of materials consumed. The third largest component was plastic products (furniture parts, components, and foam cores) with a 5-percent share, springs and furniture mechanisms—5 percent, wood furniture frames—4 percent, and furniture and builder's hardware—4 percent.

Materials prices increased in each year of the review period except four. Much of this increase stemmed from the increase in the price of lumber: most wood furniture production uses hardwood that has fewer acres on which to grow, and less land is suitable for hardwood production.[22] Most furniture frames are made of kiln dried hardwood, although to reduce costs plywood is now used in "nonstress bearing" parts of the frame.[23]

Total energy consumed accounted for an average of 1.7 percent of intermediate purchases consumed. Electricity made up 1.2 percent, while fuels averaged 0.5 percent. Energy consumption grew an average of 2.0 percent over the review period. This masks the sharp falloff between the periods before and after 1973. The quantity of energy consumed before 1973 increased an average of 5.2 percent per year while, during the next 6 years, energy consumption shrunk an average of 2.7 percent annually. From 1979 to 1991, energy consumption grew 0.3 percent per year.

Services purchased outside the firm include items such as telephone communications, legal services, and advertising. These services accounted for about 12 percent of intermediate purchases. The quantity of services increased 3.1 percent per year on average between 1958 and 1991.

Technological change

Technological innovation over the review period in the household furniture industry stems mostly from the advent of computer technology and the introduction or creation of materials used to produce whole pieces or parts of furniture. Many of the industry's producers are small, family-owned and family-controlled firms: in 1987, 65 percent of wood and upholstered furniture manufacturers had fewer than 20 employees. These producers are often unable to justify the expense of new machinery and equipment and the high overhead associated with the fixed cost of capital. Even when demand is high, many manufacturers are not inclined to take on the risk of purchasing new machinery.[24] As a result, the industry is relatively labor intensive.

The changes in technology relevant to furniture manufacturing that have occurred over the period of this study have not diffused widely or rapidly into the industry. However, the largest companies have built new and expanded plants and invested in innovative technology to achieve more efficient production and remain competitive in the international furniture industry. Some of those changes in technology are examined here.

In the late 1950's, the leading furniture manufacturers were manufacturing products in an assembly-line fashion.[25] Producers now may use computer numerical controls to guide much of the production in certain machine or transfer lines using special purpose machinery. Robots replace human labor in finishing lines and for materials handling. Furniture soon will be produced increasingly by flexible manufacturing systems

that are "computer controlled machine tools served by automated material handling devices, all linked to and controlled by a central computer."[26] These systems have little human interaction in the production process.

Furniture producers often wait until new technology is proven useful in other industries before employing it in their own production facilities. CAD/CAM systems—computer aided design/computer aided manufacturing—were first used in industries such as automotive and appliance manufacturing. Today, more than half the routers (machinery using high speed vertical cutting heads for milling wood or metal) sold to household furniture industry producers use CAD/CAM systems.[27]

CAD has shortened the initial step in the production of household furnishings—the creation of a design of a finished product. CAD allows a designer to sketch a design on a 3-D screen, and experiment with detail and scale.[28] This technology saves time, labor, and materials because the CAD design shows the piece complete with covering, eliminating the need to manufacture a prototype, and allows changes to be made on the screen.

Because styles are becoming more complicated and patterns change rapidly, there is a need for small and accurate production runs. Computer numerical controlled machinery, a CAM system, can fill that need quickly. Such machinery helps reduce or eliminate manual operations, manufacture products to closer tolerances, or closer to specification, shorten setup time, provide consistent and improved quality, and reduce important lead time for custom work.[29] An increasing number of producers are purchasing computer numerical controlled machinery equipment as computer technology becomes more affordable and improved yield saves on material costs. Equipment often can be modified at a reasonable cost, and computer numerical controlled machinery can eliminate production steps and handling.

Cutting tools used in the manufacture of wood furniture have changed over the period of review. The tools were once made of carbon steel, which slowed production for frequent sharpening. Later, the cutting edges were carbide tipped, which dulled at a slower rate and produced a far cleaner cut. Currently, the use of diamond tools virtually eliminates downtime because sharpening is rarely needed. However, the diamond tools are damaged easily if the cutting machine is out of alignment.

In addition to advances in mechanical blades, other new technologies are used to cut wood and its derivatives. Lasers can accurately reproduce very detailed patterns and produce no dust. This helps producers comply with Environmental Protection Agency and Occupational Safety and Health Administration standards. Water jets that pump water at three times the speed of sound can be used to cut laminates and gypsum less than 3/8-inch thick. This energy efficient method is fast, leaves no dust, has minimal material loss, and can make precision cuts. Lasers and water jets have no downtime due to setup and sharpening and are computer controlled.[30]

All types of furniture manufacturers, particularly those specializing in wood and metal furniture, use robots for finishing work. Robots replace one or two workers per operating spray booth, and are usually used for jobs that spray hazardous materials or require repetitive and monotonous finishing.[31] An operator will manually guide the robot through the motions necessary to finish a part or piece. The robot "remembers" these movements and repeats them precisely each time.[32] Robots can finish a piece with less overspray and fewer emissions, often using between 10 percent and 30 percent fewer materials. The use of robots can reduce production costs because they require less downtime—between 1 percent and 2 percent of hours used—than other machinery.[33]

The finishing technology itself has changed over the last 30 years. Airless and electrostatic finishing have been used since the 1950's. The most recent development is low pressure–low volume air atomization. This system reduces overspray, allows spraying in hard-to-reach areas, and provides a higher transfer efficiency than compressed air atomization. Not only does it meet government emissions regulations, but it is inexpensive to install because only the spray gun from the compressed air atomization system needs to be changed.[34]

Lumber drying technology has been improved to speed up the process by nearly 80 percent. Instead of air drying for up to 6 months to reduce moisture by approximately 70 percent, which was prevalent up to the early 1980's, a pre-dryer can now be used. The air circulating room reduces drying time to 4 weeks. For the final drying procedure to make the lumber ready for machining—for example, routing, cutting, planing—an ultraviolet quick-cycle drying oven is used instead of a kiln and performs this step in one-third the time a kiln once required. A faceplaner is sometimes used before drying. Using faceplaning, a "green board" is trimmed to uniform thickness to also reduce drying time.[35]

Although furniture manufacture is often a custom production procedure, bar coding has provided the industry a way to efficiently keep track of production, inventory, orders, shipping, and other business requirements. This allows for the use of the just-in-time production method, in

which the firm maintains relatively small inventories and relies on very short response times to orders. This gives the firm "instant control" over the process from the delivery of raw materials to the shipping of the finished product, and the tools needed to change setups. A firm was able to reduce its order shipping time and finished goods inventory because it knew immediately when production of an order was complete. Orders were in inventory within 36 hours instead of a week to 10 days.[36]

The technology used specifically for upholstered furniture production also has improved. Computer controlled pattern making and cutting have increased to up to 60 percent the yield from each roll of fabric. In domestic production of upholstered furniture, manufacturers more often are using webbing suspension systems, which are as efficient as springs, but are less expensive, require less time to install, and require a much smaller materials inventory.[37]

Firms that manufacture mattresses may take advantage of automated production systems. Spring production is now fully automated, which has led to an increase in the production of springs 6 times faster than 30 years ago.[38] With computerized quilting, sewing is controlled by a microprocessor. This allows for more pattern choices, instant pattern change, better stitch appearance, and processing that is 20 percent faster than the former CAM system. Border machines also are controlled by microprocessors that automatically punch holes, position and attach handles, and measure and cut the borders. Mattress wrapping machines are computer controlled to automatically adjust for different mattress and foundation sizes.[39]

The materials used in the manufacture of furniture also have changed. Because quality woods are scarce and expensive, new materials are replacing traditional furniture grade wood and veneers,[40] and some of the new materials are more versatile. Plastics, because they are synthetic, may be produced to fulfill any need of the furniture manufacturer. Because the material is uniform, it is much easier to fully automate the production process. Plastic parts and trim often are attached to wood furniture (disguised by a wood grain finish) for ornate decorative work, which reduces labor content, cost, and the number of skilled carvers a manufacturer needs.[41] Some detailing and ornate patterns may not be reproducible in wood, while they can be made easily in plastic.

The other popular material is medium density fiber board, which is made with a "thermal-mechanical pulping process" that reduces wood chips to fibers. Medium density fiber board machines better than particleboard, can be made in various thicknesses more cheaply than solid wood, and can be covered in a wood grain vinyl wrap to simulate solid wood or veneer.[42]

IN SUM, output per hour in the household furniture industry increased at an annual average rate of 1.8 percent between 1958 and 1991. (See table 4.) Multifactor productivity growth accounted for 0.5 percent of this gain, while the capital effect increased 0.3 percent and the intermediate purchases effect contributed 1.0 percent. Output per hour fell off 1.2 percentage points between the 1958–73 and the 1973–79 periods, from an average annual growth rate of 2.2 percent to 1.0 percent. But it rebounded in the later 1979–91 period to an average annual gain of 1.7 percent. The decline in multifactor productivity growth (by 0.8 percentage point) and the intermediate purchases effect (by 0.5 percentage point) between the first two periods influenced the falloff in output per hour, while the 1.0-percent acceleration in the intermediate purchases effect accounted for the increase in labor productivity in the later 1979–91 period.

The level of imports is becoming an important issue to furniture manufacturers, particularly firms that produce wood furniture, which accounts for nearly 41 percent of the industry. Most of the other sectors of the household furniture industry have been insulated from foreign competition because of the low "value to bulk" ratio of their products. The technological changes that have been introduced, such as computer numerical control and automation have contributed to savings in labor and materials and have improved the domestic industry's competitiveness in world markets. However, the employment of "advanced manufacturing and automation technologies" has been concentrated in the larger producers of household furniture "because only they have an adequate 'capital base' and the production volumes needed to justify the investment."[43] □

Footnotes

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APPENDIX: Multifactor productivity—measurement

The following is a brief summary of the methods and data underlying the multifactor productivity measure for the household furniture industry. A technical note, describing in more detail the procedures and data, is available from the Office of Productivity and Technology, Bureau of Labor Statistics, Washington, DC 20212.

Methodology and data definitions

Output. The output measure for the household furniture industry is based on the weighted change in the deflated value of shipments of various types of household furniture as reported in *Censuses and Annual Surveys of Manufactures*. Deflated five-digit primary product shipments were Tornqvist aggregated, using value of product shipments as weights. This measure is in turn benchmarked to Tornqvist indexes of constant-dollar production calculated from detailed quantity and value data published in the *Census of Manufactures* for 1958, 1963, 1967, 1972, 1977, 1982, and 1987.

For multifactor measures for individual industries, output is defined as total production, rather than the alternative of value added. For a value added measure, intermediate inputs are subtracted from total production. Consequently, an important difference between the multifactor productivity indexes BLS publishes for individual industries and those for aggregate sectors of the

economy is that the latter measures are constructed in a value added framework. For major sectors of the economy, intermediate transactions tend to cancel out. Intermediate inputs are much more important in production at the industry level.

Further, output in the measures for individual industries is defined as total production that "leaves" an industry in a given year in the form of shipments and net changes in inventories of finished goods and work-in-process. Shipments to other establishments in the same industry are excluded, when data permit, because they represent double counting that could distort productivity measures.

Labor. Employee hours indexes, which represent the labor input, measure the aggregate number of employee hours. These hours are the sum of production worker hours from the BLS establishment payroll surveys and nonproduction worker hours, derived by multiplying the number of nonproduction workers from BLS by an estimate of nonproduction worker average annual hours.

Capital. A broad definition of capital input, including equipment, structures, land, and inventories, is used to measure the flow of services derived from the stock of physical assets. Financial assets are not included.

For productivity measurement, the appropriate concept of capital is "productive" capital stock, which represents the stock used to produce the capital services employed in current production. To measure the productive stock, it is necessary, for each type of asset, to take account of the loss of efficiency of the asset as it ages. That is, assets of different vintages have to be aggregated. For the measures in this article, a concave form of the age/efficiency pattern is chosen (efficiency declines more slowly during the earlier years).

In combining the various types of capital stock, the weights applied are cost shares based on implicit rental prices of each type of asset. They reflect the implicit rate of return to capital, the rate of depreciation, capital gains, and taxes. (For an extensive discussion of BLS capital measurement methods, see *Trends in Multifactor Productivity, 1948–81*, Bulletin 2178, Bureau of Labor Statistics, 1983.)

Intermediate purchases. Intermediate purchases include materials, fuels, electricity, and purchased business services. Materials measured in real terms refer to items consumed or put into production during the year. Freight charges and other direct charges incurred by the establishment in acquiring these materials also are included. The data from which the intermediate inputs are derived include all purchased materials and fuels, regardless of whether they were purchased by the individual establishment from other companies, transferred from other establishments of the same company, or withdrawn from inventory during the year.

Annual estimates of the cost of services purchased from other firms also are required for multifactor productivity measurement in a total output framework. Some examples are legal services, communications services, and repair of machinery. An estimate of the constant-dollar cost of these services is included in the intermediate purchases input.

Capital, labor, and intermediate purchases cost shares. Weights are needed to combine the indexes of the major inputs into a combined input measure. The weights for this industry are derived in two steps. First, an estimate of cost in current dollars for each input is derived, and the cost of each input is divided by the total cost of all inputs.

Conceptual framework

The multifactor productivity measure presented here is computed by dividing an index of output by an index of combined inputs of capital, labor and intermediate purchases. The framework for measurement is based on a production function that describes the relation of output to the inputs and on an index formula that is consistent with this production function.

The general form of the production function underlying the multifactor productivity measures is postulated as:

$$(1) \qquad Q(t) = Q\big(K(t), L(t), M(t), t\big)$$

where $Q(t)$ is total output, $K(t)$ is input of capital services, $L(t)$ is input of labor services, $M(t)$ is input of intermediate purchases, and t is time.

Differentiating equation (1) with respect to time, we obtain after some algebraic manipulations, the sources of growth equation:

$$(2) \qquad \frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + w_k \frac{\dot{K}}{K} + w_l \frac{\dot{L}}{L} + w_m \frac{\dot{M}}{M}$$

where $\dot{Q}/Q$ is the rate of change of total output, $\dot{A}/A$ is the rate of change of multifactor productivity, $\dot{K}/K$ is the rate of change of capital services, $\dot{L}/L$ is the rate of change of labor hours, $\dot{M}/M$ is the rate of change of intermediate purchases, w_k is output elasticity (percentage change in output due to a 1 percent change in input) with respect to the capital input, w_l is output elasticity with respect to the labor input, and w_m is

output elasticity with respect to the intermediate purchases input. A dot over a variable indicates the derivative of the variable with respect to time.

Equation (2) shows the rate of change of output as the sum of the rate of change of multifactor productivity and a weighted average of rates of change of capital, labor, and intermediate purchases inputs. Now, if output and input markets are assumed to be competitive and in long run equilibrium, each input is paid the value of its marginal product. The output elasticities in equation (2) can be replaced by factor cost shares:

$$w_k = \frac{P_k K}{P_q Q}$$

$$w_l = \frac{P_l L}{P_q Q}$$

$$w_m = \frac{P_m M}{P_q Q}$$

where P_q is the price of output, and P_k, P_l, and P_m are the prices paid for the capital (K), labor (L), and intermediate purchases (M) inputs, respectively. Furthermore, if constant returns to scale are assumed, then $w_k + w_l + w_m = 1$.

Equation (2) can be rewritten as:

$$(3) \qquad \frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - w_k \frac{\dot{K}}{K} - w_l \frac{\dot{L}}{L} - w_m \frac{\dot{M}}{M}$$

In this expression, the growth of multifactor productivity can be seen as a measure of economic progress; it measures the increase in output over and above the gain due to increases in inputs.

Equation (2) also can be transformed into the contribution equation that allows for an analysis of the change in output per hour. First subtract $\dot{L}/L$ from both sides of equation (2).

Because the weights sum to one, apply the term $(w_k + w_l + w_m)$ to the $\dot{L}/L$ term inserted on the right hand side. Next, gather the terms with the same weight and derive the following equation:

$$(4) \qquad \frac{\dot{Q}}{Q} - \frac{\dot{L}}{L} = w_k\left[\frac{\dot{K}}{K} - \frac{\dot{L}}{L}\right] + w_m\left[\frac{\dot{M}}{M} - \frac{\dot{L}}{L}\right] + \frac{\dot{A}}{A}$$

The left side of equation (4) is the growth rate of output per hour. The terms in brackets are the rates of change in the capital-labor ratio and the intermediate purchases-labor ratio. Thus, the rate of growth in output per hour can be broken down into the weighted sums of changes in these ratios in addition to the change in multifactor productivity.

Equations (2), (3), and (4) describe aggregation in continuous form. The BLS multifactor indexes are constructed according to a Tornqvist formula that represents aggregation at discrete points in time and is consistent with a translog production function. The rate of change in output or an input is calculated as the difference from one period to the next in the natural logarithms of the variables. For example, $\dot{Q}/Q$ is calculated as $ln\ Q(t) - ln\ Q(t-1)$. Indexes are constructed from the antilogarithms of this differential. The weights w_k, w_l, and w_m are calculated as the arithmetic averages of the respective shares in time periods t and $t-1$.