Productivity trends in the cotton and synthetic broad woven fabrics industry

Expanding output per hour during the 1972–86 period has come about despite low output growth as the industry attempts to modernize and fend off increased import penetration

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Productivity, as measured by output per hour, grew at an average annual rate of 3.7 percent per year from 1972 to 1986 in the cotton and synthetic broad woven fabrics industry.[1] This rate of increase was significantly higher than the 2.5-percent rate for the average of all manufacturing industries. Advances in industry productivity have been aided by substantial investments in capital and diffusion of technological advances such as shuttleless looms. In response to the recent import surge from low-wage foreign competitors, industry modernization and restructuring are taking place as part of an ongoing attempt to sustain productivity growth.

Trends in productivity

The productivity gain of 3.7 percent per year resulted from a rate of growth in output of 0.3 percent and a decline in hours of 3.3 percent. Output fluctuated sharply during the 1972–86 period. Generally, the industry followed the cyclical pattern of the overall economy, with output declines coincident with the economic recessions of 1974–75 and 1980–82. Peak industry output occurred in 1977, prior to the explosive growth in imports. But while the output of the industry has fluctuated, sometimes rather widely, productivity, nonetheless, has, with a few exceptions, continued to advance. In many industries, sharp declines in output result in corresponding declines in productivity. However, this has not been the case with broad wovens, because the industry has been able to adjust the level of the work force in response to the changes in demand. Thus, even though output tumbled in 8 of the past 15 years, productivity fell in only 3.

Productivity trends in this industry can be divided into two distinct periods. From 1972 to 1976, productivity advanced at a relatively slow rate of 1.5 percent annually, as output fell slightly—down 0.2 percent per year, and employee hours declined 1.7 percent annually. In contrast, from 1976 to 1986, productivity expanded at a significantly higher rate—3.8 percent per year. This latter gain in output per hour also reflected output and employee hour declines. From 1976 to 1986, output declined 1.2 percent and hours fell 4.8 percent annually. (See table 1.)

Industry description and operations

The output of this industry consists of woven fabric more than 12 inches in width, made chiefly of cotton or synthetic fibers or both. Important markets for the industry's output are the apparel, automotive, and home furnishings industries. Many plants in the industry are highly integrated and are capable of transforming bales of the fibers, first, into yarn. Multiple strands of this yarn are then interlaced at right angles in the process of weaving. Additionally, an integrated mill would have the capability to "finish" the woven fabric. Finishing, a term for further treating fabric, may involve one or more of the following operations: bleaching,

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dyeing, printing (of a pattern), or applying permanent press treatment. Weavers lacking the capability to perform these finishing operations may contract with commission finishers to provide these services. (However, these contract finishers are *not* part of this study.) Finally, highly integrated mills may fabricate some of their output of finished fabric into end products such as sheets, towels, and pillowcases.

Traditional production techniques

Transforming fibers into finished fabric requires many complex, integrated operations. The fibers must first be "opened"—a loosening and partial cleaning process which "fluffs" up the fibers which were tightly compacted in the shipping bale. "Blending" assures a proper mix of cotton and synthetic fibers. The "picking" operation transforms the blended fibers into loose sheets of lint-like material (lap rolls) made up of roughly parallel fibers. These "laps" are then "carded" to further parallelize the fibers and reduce the sheet of fibers to a loose, rope-like strand. This rope-like material is then put through the "drawing" operation in which several of the strands are merged and their fibers further combed to increase parallelism among the fibers. The "roving" operation then reduces the "drawn" strand into a much smaller strand of fibers, inserts a slight twist, and winds the strands onto "bobbins." Spinning machinery for the final process in the manufacture of yarn draws out the strands of fiber, twists them into yarn, and again winds the yarn onto bobbins.

In the winding and warping operations, yarn is transformed from the relatively small spinning bobbins onto larger packages for use on the weaving looms. Weaving then consists of interlacing crosswise or "filling" threads with lengthwise or "warp" threads on a loom to form fabric. If the yarn that had fed the looms was already colored or "dyed," the fabric is, for the most part, complete. If the yarn was not dyed prior to weaving, the resulting off-white or "grey" fabric may then be dyed in the finishing operation.

Finishing, a series of chemical, mechanical, and inspection techniques, completes the process of cloth manufacture in a fully integrated mill. Many discrete operations such as singeing, washing, bleaching, dyeing, printing, preshrinking, calendering, and others may be included in finishing. It is during these finishing operations that the treatments aimed at improving the "wash and wear" property of cloth are performed.

Technology in the 80's

Technological changes taking place in the industry fall into two general categories. One involves the improvement of conventional machines (in speed, capacity, and degree of automation) and the installation of auxiliary equipment (for machine cleaning and materials handling) to increase productivity and improve product quality. Many of these changes have already been adopted by the larger, modernized mills and are being adopted by smaller mills. The other technological change involves more radical modifications, such as integration of two processes or more, instrumentation for process monitoring, and the marriage of computers to this instrumentation for real-time production information.

While in most mills, yarn is still made on a series of discrete machines, many plants have adopted a continuous opening-blending-carding operation, known as direct-feed or chute-feed carding. This eliminates the handling of fiber from machine to machine and actually eliminates an entire process called picking. In the old system, the picking process rolls the fiber into large heavy "laps" which then must be moved manually or mechanically to the carding machine for the next process. Output with direct-feed carding is about 3 to 4 times greater per hour than the older manual system.

Direct-feed carding greatly reduces the need for unskilled and semiskilled labor, compared to the conventional process of opening, blending, picking, and carding. In this continuous system, no picker operators are required nor are the laborers who move the heavy fiber laps. Without the fiber laps, labor for cleaning and maintenance is also greatly reduced. In addition to being considerably more productive than conventional operations, the direct-feed or chute-feed process has also helped meet Federal requirements for lower cotton dust levels, because the opening-to-carding operations are major areas of cotton dust generation. Moreover, the chute system, it is claimed, improves yarn quality by limiting fiber weight variations.[2]

Spinning, the final step in yarn manufacturing, has been sped up by the introduction of open-end or rotor spinning.

Table 1. Output per employee hour and related indexes for the cotton and synthetic broad woven fabrics industry, 1972–86

[1977=100]

Year	Output per employee hour			Output	Employee hours		
	All employees	Production workers	Nonproduction workers		All employees	Production workers	Nonproduction workers
1972	85.8	85.7	86.7	89.4	104.2	104.3	103.1
1973	76.6	76.5	77.1	80.6	105.2	105.3	104.6
1974	79.2	79.4	78.0	79.7	100.6	100.4	102.2
1975	86.7	87.2	83.0	79.5	91.7	91.2	95.8
1976	86.9	86.8	88.8	89.2	102.6	102.8	100.5
1977	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978	93.5	93.6	92.6	90.4	96.7	96.6	97.6
1979	100.7	100.5	102.8	97.5	96.8	97.0	94.8
1980	104.9	105.0	104.1	98.0	93.4	93.3	94.1
1981	107.4	108.0	101.0	94.7	88.2	87.7	93.8
1982	112.5	115.5	89.9	81.2	72.2	70.3	90.3
1983	121.6	122.8	112.3	92.2	75.8	75.1	82.1
1984	119.9	120.7	112.5	90.3	75.3	74.8	80.3
1985	123.9	125.0	114.0	82.5	66.6	66.0	72.4
1986	130.3	130.7	128.4	85.5	65.6	65.4	66.6
	Average annual rates of change(1)						
1972–86 .	3.7	3.8	3.0	0.3	−3.3	−3.4	−2.7
1972–76 .	1.5	1.6	1.2	−0.2	−1.7	−1.7	−1.4
1976–86 .	3.8	3.9	2.7	−1.2	−4.8	−4.9	−3.8
1981–86 .	3.6	3.4	5.6	−1.4	−4.8	−4.6	−6.6

[1]Based on the linear least squares trends of the logarithms of the index numbers.

Conventional ring spinning is a relatively discontinuous operation while the open-end machinery integrates several operations and can produce some of the coarser filling yarns at 4 times or more the speed of ring spinning.[3] Moreover, open-end spinning reduces space, maintenance and cleaning requirements, and downtime. Additionally, automatic doffing machinery can be built onto the new open-end spindles. Because doffing (removal of full bobbins) is one of the most labor-intensive operations in the mills, the successful automation of this process greatly improves productivity.

Most notable among the technological advances in the production of woven fabrics has been the introduction of shuttleless looms. Conventional fly-shuttle looms use a wooden projectile (a shuttle) to carry the filling or crosswise yarn back and forth between the alternating sets of lengthwise or warp threads. The shuttle is "slam" driven from one side of the loom to the other by wooden bars. To move the filling yarn back and forth, the newer shuttleless looms use a variety of techniques and are of several types: Rapier (the largest number in place), missile, water jet (restricted to 100-percent synthetics), and air jet (currently very popular). As an example of the operation, air jet looms weave the cloth by propelling the filling yarn by means of high-pressure streams of air.

Finally, electronic instrumentation and its extensive diffusion is an integral part of the industry's changeover to a more capital-intensive system. Instrumentation systems along with microprocessors are reducing labor requirements for machine operators, maintenance personnel, and unskilled laborers. They are reducing downtime and improving quality, but at the same time are upgrading requirements for skilled repair technicians and electricians. For example, in the dyeing and finishing operation, laser fabric inspection equipment can detect flaws in the grey woven fabric, while color monitoring devices check for dyeing irregularities.

However, many of the productivity gains enjoyed by U.S. mills as a result of installing this new equipment and the advantage this gave domestic manufacturers over imports from developing countries may be only temporary. Much of the new equipment has allowed domestic fabric manufacturers to undercut imports by producing specialty fabrics, thereby partially removing themselves from the low-end, undifferentiated fabric markets. However, because most of this equipment is also available to foreign manufacturers, any competitive advantage that U.S. mills might hold can potentially be quickly eroded. This problem for the U.S. mills is aggravated by the fact that the domestic textile machinery industry is shrinking and, in some respects, nonexistent. The United States, for example, produces none of the shuttleless looms that are revolutionizing weaving.[4]

Employment trends

Total employment in the cotton and synthetic broad woven fabrics industry declined at an average annual rate of 3.1 percent from 1972 to 1986. This decline is significantly greater than the 0.2-percent decline in employment measured in the total manufacturing sector over the same period. Employment in this industry increased from 288,000 in 1972 to 293,000 in 1973, but fell during the recessionary years of 1974 and 1975. An improved economy help to boost employment to a peak of slightly over 293,000 in 1976. Since 1976, however, employment has, with the exception of 1984, declined steadily. Average annual employment, as of 1986, was 185,000. Total employee hours declined, falling at a rate of 3.3 percent, also higher than the 0.2-percent decline registered by the total manufacturing sector. The number of production workers declined at an average annual rate of 3.2 percent. Production worker employment peaked at 264,000 in 1976 and fell thereafter. In 1986, 166,000 production workers were employed.

The proportion of production workers to the total number of employees remained fairly stable over the period. In 1972, this proportion was 90 percent and in 1986 it was 89 percent. Average hourly earnings of production workers in the cotton and synthetic broad woven fabrics industry are lower than those in all manufacturing. In 1972, average hourly earnings in this industry were \$2.75, compared to \$3.82 for all manufacturing. By 1986, the industry's average of \$7.33 was still below the all-manufacturing average of \$9.73, although the gap, in percentage terms, had narrowed.

Structural changes and capital spending

The U.S. weaving industry has historically been fragmented and is still characterized by many firms, both large and small. However, between 1972 and 1986, industry structure changed significantly. Competition and Federal regulation led to increased capital expenditures. The industry was also affected by two major recessions which resulted in the closing of less efficient plants and a reduction in the work force of 36 percent. These changes have resulted in a smaller but more competitive industry, operating at a high level of capacity.

One of the factors which led to changes in the industry's structure was its response to increased competition. Domestic competition has been fierce for the better part of the last decade because of somewhat sluggish demand. The recent surge in imports has only intensified this competition.[5] In the low-growth markets in which these firms (both foreign and domestic) compete, expanding market share for one firm generally means a decreased share for others.[6] Despite international agreements to control their growth, imported goods continue to gain market share. The growth in imported, uncut fabric has been accompanied by the influx of fabricated apparel products, resulting in the further shrinkage of the domestic apparel industry. Thus, imported fabric and apparel products now make up nearly one-half of the apparel and apparel fabric market and one-third of the total textile market.[7]

In an effort to remain competitive, domestic firms are modernizing by investing in capital equipment. Industry specialists believe that capital investment will boost U.S. productivity, thereby reducing the price advantage of imports.[8] This price advantage is largely attributable to the differing wage structure between the United States and other nations. U.S. textile wages, for instance, are more than 8 times higher than wage rates in Korea, a country whose textile products are an increasing source of U.S. imports.[9]

Capital expenditures per employee have been increasing in the broad woven fabrics industry. Although expenditure levels have been below the all-manufacturing average (1972–85), capital expenditures per employee have grown substantially since 1972. In fact, over the period 1972–85, current-dollar capital expenditures per employee grew at an average annual rate of 12.2 percent (from $771 in 1972 to $3,817 in 1985). This rate outpaced the all-manufacturing rate of 9.5 percent, with expenditures growing from $1,356 in 1972 to $4,430 in 1985.

A significant portion of these capital outlays has been allocated to safety and health equipment in an effort to meet the standards of the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). For some operations, particularly those in which dust levels are high, Federal regulations have been difficult to meet without new or overhauled equipment. Although these equipment outlays have been expensive, some industry specialists believe that Federal health and safety regulations have "contributed to the increased pace and intensity of modernization."[10] These expenditures may have a negative short-term effect on the industry because many foreign competitors do not incur such costs. However, the new equipment may "increase worker productivity and manufacturing efficiency, and therefore improve international competitiveness."[11]

Although there has been some dispute regarding the productivity-enhancing effect of the health and safety equipment, spending for it is expected to decline in future years, leaving larger allotments for new and more productive operating equipment.[12] This is especially important in an industry where technological change has caused the rate of machinery turnover to grow more rapidly from year to year.[13]

Tremendous resources are required by those firms that wish to take advantage of these technological changes, and ultimately remain competitive. Larger firms have been in a better financial position to expend the huge sums required for new plant and equipment. The 10 largest firms in the industry accounted for 85 percent of new machinery purchases.[14] These large firms, reaping the benefits of modernization have increased their dominance over smaller firms. This dominance is illustrated by the concentration ratio, which represents the percentage of sales of a given industry accounted for by its largest companies. The weighted concentration ratio of the eight largest firms in the industry rose from 52 percent in 1972 to 58 percent in 1982.

Although spending on new plant and equipment has played a significant role in increasing the domestic industry's competitive stature, it has not been the sole factor. In general, successful firms have adopted more competitive strategies. Some of these strategies have been: identifying emerging market niches which foreign manufacturers might not have the capacity or incentive to supply, cutting response and production times, and stressing a commitment to quality.

Outlook

Textile demand will continue to be heavily reliant on the basic strength of the economy, especially the apparel, automobile, and housing markets. However, demographic changes will also play a major role. For example, the number of persons in the age group 35–54 years old, who typically have rising incomes and high rates of consumption, are a key element in the growth of demand for textile products. In addition, new industrial products are being developed; some of these replace older products, but some involve new applications; for example, soil-stabilizing "geotextiles" that are used in erosion control.

The productivity advances made by the industry to date, will, at a minimum, need to be maintained in the future if the industry is to have a chance at fending off increased market penetration from foreign textile products. Many industry analysts believe that "the only way to alter the international competitive balance is to drastically shorten the production cycle."[15] Thus, fabric manufacturers would be more closely tied to the apparel and other end-use manufacturers and retailers under a "quick-response" system. Consumer retail preference readings, based on bar-coded end products, would be electronically transmitted to apparel and textile manufacturers, which would be able to respond rapidly by shifting production based on those readings. This would avoid the long lead times (now as much as a year or more) between yarn spinning and ultimate fabrication into finished textile end products.[16]

A quick-response system may allow domestic manufacturers to capitalize on the advantages of market proximity and shortened delivery times—even in the face of low-wage foreign competition. Of course, this system would require that the entire chain of production, from yarn spinning to end product fabrication and ultimately retailing, be "wired" into the network. Although several limited quick-response programs have apparently met with success, the organizational effort to expand such a system nationwide, throughout the textile and apparel manufacturing and retailing industries, remains a major hurdle.[17] □

—*FOOTNOTES*—

[1] The cotton and synthetic broad woven fabrics industry includes both SIC 2211 and SIC 2221 (see *Standard Industrial Classification Manual*, 1987 Edition, Office of Management and Budget). Establishments in these industries are primarily engaged in weaving fabrics more than 12 inches in width. Those establishments classified in SIC 2211 weave fabrics that are wholly or chiefly cotton. Fabrics produced by establishments classified in SIC 2221 are composed wholly or chiefly of silk and manmade fibers including glass.

[2] "Special Report: Chute Feeding," *Textile World*, September 1981, pp. 58–81.

[3] *The Impact of Technology on Labor in Four Industries* (Bureau of Labor Statistics, May 1985), p. 2; and "Mills in U.S. Continue O-E Expansion," *American Textiles International*, April 1987, pp. 21–24.

[4] U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, OTA-TET-332 (Washington, Government Printing Office, April 1987), p. 5.

[5] National Academy of Engineering and National Research Council, *The Competitive Status of the U.S. Fibers, Textiles, and Apparel Complex: A Study of the Influences of Technology in Determining International Industrial Competitive Advantage* (National Academy Press, August 1985), p. 57.

[6] Office of Technology Assessment, *U.S. Textile and Apparel Industry*, p. 59.

[7] *Ibid.*, pp. 4, 80.

[8] National Academy of Engineering and National Research Council, *Competitive Status of the U.S. Fibers, Textiles, and Apparel Complex*, p. 16.

[9] "Hourly Compensation Costs for Production Workers, Textile Mill Products Manufacturing," (U.S. SIC 22), 26 Countries, 1975–1986 (Bureau of Labor Statistics, September 1987).

[10] Brian Toyne and others, *The U.S. Textile Mill Products Industry: Strategies for the 1980's and Beyond* (University of South Carolina, Center for Industry Policy and Strategy, 1983), pp. 3–12; and Ruth Ruttenberg, *Compliance With the OSHA Cotton Dust Rule, the Role of Productivity Improving Technology*, for Office of Technology Assessment, March 1983, p. 103.

[11] National Academy of Engineering and National Research Council, *Competitive Status of the U.S. Fibers, Textiles, and Apparel Complex*, p. 53.

[12] *Impact of Technology on Labor*, p. 5.

[13] Office of Technology Assessment, *U.S. Textile and Apparel Industry*, p. 95.

[14] *Ibid.*

[15] "Getting Competitive," *National Journal*, June 7, 1986, p. 1363.

[16] *Ibid.*

[17] "Apparel Makers Shift Tactics," *The New York Times*, Sept. 21, 1987, p. D5.

APPENDIX: Measurement techniques and limitations

Indexes of output per employee hour measure changes in the relation between the output of an industry and the employee hours expended on that output. An index of output per employee hour is derived by dividing an index of output by an index of industry employee hours.

The preferred output index for manufacturing industries would be obtained from data on quantities of the various goods produced by the industry, each weighted (multiplied) by the employee hours required to produce one unit of each good in some specified base period. Thus, those goods which require more labor for production are given more importance in the index. Often, however, as an alternative, unit value weights are used when unit labor requirement weights are not available.

Because neither unit labor nor unit value weights are available for all of the industry's products, an alternative technique was used to derive the output index for this industry. Therefore, real output for the industry was estimated by a "deflated" value technique. Changes in price levels were removed from current-dollar values of production by means of appropriate price indexes at various levels of subaggregation for a variety of products in the group. To combine segments of the output index into a total output measure, employee hour weights relating to the individual segments were used, resulting in an output index that is conceptually close to the preferred output measure.

The annual output index series derived from the above discussed deflated value technique was then adjusted (by linear interpolation) to the index levels of the "benchmark" output series. This benchmark series (also utilizing the deflated value technique) incorporates more comprehensive but less frequently collected Economic Census data.

The indexes of output per employee hour relate total output to one input—labor. The indexes do not measure the specific contribution of labor, capital, or any other single factor. Rather, they reflect the joint effects of factors such as changes in technology, capital investment, capacity utilization, plant design and layout, skill and efforts of the work force, managerial ability, and labor-management relations.

The average annual rates of change presented in the text are based on the linear least squares trend of the logarithms of the index numbers. Extensions of the indexes will appear annually in the BLS bulletin, *Productivity Measures for Selected Industries and Government Services*. A technical note describing the methods used to develop the indexes is available from the Office of Productivity and Technology, Division of Industry Productivity and Technology Studies.