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ABSTRACT

This report on the textile industry focuses on the training and education of production-level textile workers--from unskilled factory hands to first-level supervisors. It is part of a larger study of the educational implications of broad economic changes, particularly the spread of microelectronic technologies, growing national and international competition, and the large increase in the number and variety of products and services. The analysis is organized in six chapters. The first chapter is an overview of the textile industry that describes the central trends, including rising imports, modernization, and the proliferation of products. Chapter 2 discusses technological innovations in textiles. Chapter 3 describes innovations in the organization of production and in the training and management of the work force. Chapter 4 summarizes the implications of the technological and organizational changes on the skill demands of the industry. Chapter 5 describes how the changes in technology, organization, and skills have affected the system for training and educating production-level textile workers. Finally, Chapter 6 discusses how that system might change to be more in tune with current needs of the industry and presents generalizations tying this report more closely to other case studies for this project. (KC)

EDUCATION AND THE TRANSFORMATION OF MARKETS AND TECHNOLOGY IN THE TEXTILE INDUSTRY

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Conservation of Human Resources
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PREFACE

The National Center on Education and Employment is funded by the Office of Educational Research and Improvement (OERI) of the U.S. Department of Education. The Center is based at Teachers College, Columbia University, in New York City. The RAND Corporation of Santa Monica, California, and Washington, D.C., is a partner with Teachers College in this enterprise.

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Chapter 1: Introduction

Growing trade deficits, high rates of illiteracy, and stagnant real incomes have all led to a national reexamination of the country's education system. Few people disagree that solving many of these problems requires a skilled labor force, and policy proposals for moving the country ahead all contain at least a ritualistic call for greater investments in the country's human capital. But the consensus that appears so strong at a general level does not survive a shift of focus to more concrete proposals. Some analysts have argued for a return to an emphasis on a common cultural tradition while others have lamented the lack of scientific and technological preparation. Although private firms have the technological expertise and equipment to provide much of the advanced training of a more specific nature, many firms are increasingly reluctant to make the long-term commitments to their employees that would provide the firms with the incentives to offer such training. And vocational schools and junior colleges that are logical places to fill part of this gap are alternately attacked as being, on the one hand, unresponsive to the needs of industry and, on the other hand, too focused on narrow skills at the expense of broader competencies that might better prepare students for a complex and dynamic society and economy.

This report on the textile industry[1] is part of a larger study of the educational implications of broad economic changes, particularly the spread of micro-electronic technologies, growing national and international competition, and the large increase in the number and variety of products and services. The goal of this larger project is to understand how these changes are affecting the skills that employers seek and which institutions--the firm or the various levels of the education system, for example--are the most appropriate for teaching

[1]For this report, the textile industry includes those industries in the Standard Industrial Classification major group 22 (SIC 22). There will be a more detailed discussion of the industry later.

those skills.[2] The strategy of the project is to build up an understanding by examining the changes taking place in particular industries. This report focuses on the training and education of production-level textile workers--from unskilled factory hands to first level supervisors. A report on the banking industry is already completed,[3] and studies of garment manufacturing and business services will be forthcoming.

In analyzing the changing educational needs of the textile industry, this report covers three areas that affect the human resources strategies of the industry. The first concerns the effect of the changes in technology on the skills needed by the industry. The second is the human resource implications of the growing emphasis on flexibility and quick response to changing market demands. And the third concerns the role of the education system in preparing skilled textile workers and the future of the long-standing practice of filling skilled positions almost entirely through internal promotion.[4]

The broad changes that have affected the economy in the last decade have had profound effects on the textile industry in the United States. Although U.S. producers have made large investments in modern technology--some analysts refer to a technological revolution in the industry--imports continue to grow. At the same time, there has been an explosion in the number of styles and fashions that the industry is called upon to produce. Although the training needs of the industry

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[2]We are concerned with the relationship between education and employment and less so with the moral and cultural issues that also play an important role in the discussion of educational reform.

[3]See Thomas Bailey and Thierry Noyelle, "New Technology and Skill Formation: Issues and Hypotheses," Technical Paper No. 1, National Center on Education and Employment, Teachers College, Columbia University, April 1988.

[4]These issues have also generated substantial research and debate in academic circles. See Bailey and Noyelle, note 3, for a discussion and review of the literature.

are changing, industry efforts and those of the education system to work together have met with only sporadic success.

The textile industry competes on the basis of cost, quality, service, and product choice. During most of the post-war era, the industry in the U.S. sought to cut costs through the rationalization of the production of long runs of fabric. During the 1970s, textile manufacturers also increased their emphasis on quality. At the same time, technological innovations developed in Europe and Japan were being widely adapted in the U.S., leading to further reductions in cost and improvements in quality. It has only been in the last decade, and perhaps even the last five years, that textile makers have begun to turn their attention towards service and product choice by developing interactive ties with their customers, through trying to reduce the time it takes to turn an order into a delivery, and through increasing their abilities to produce more varied products in short runs at reasonable costs. As the focus has shifted to service and product, producers have found that the new technology can go only so far in promoting the flexible and responsive manufacturing process that they seek. Indeed, some new processes strengthen incentives for producing long runs of standardized goods. Finding only a partial answer in new machinery, some textile managers have turned to new methods of organizing communications and production and of training and managing the workforce. The innovations in personnel management often involve shifting from traditional techniques in which workers carried out narrow, well-defined tasks to techniques in which there is more group interaction and in which the workforce is expected to operate in a more varied and uncertain environment.

Thus the system of educational institutions and firm-based training that prepares the industry's workforce has been hit by two interrelated yet separate shocks. First, it must train workers to operate, maintain and repair new equipment that is more sophisticated, has greater capacity, and is much more expensive than the old machinery. Second, the shift to stronger orientation towards service, product, and flexible manufacturing processes requires new skills and abilities for the production workers.

There are many studies of the textile industry and textile technology, yet none focus on the interaction between technology and industry training. Indeed the training of production workers has received little attention, perhaps because informal training was so predominant. Therefore the information provided here on the textile training process was developed through open-ended, in-depth interviews with textile executives, personnel managers, plant supervisors, production planners and trainers in six firms in 1985 and six in 1987, three of these were repeated from the earlier interviews. The smallest firm had just over 1,000 employees and the largest had over 50,000. Since the goal was to understand emerging trends, I chose firms engaged in technological or educational innovations. Interviews were also conducted with faculty at the Fashion Institute of Technology, the Philadelphia College of Textiles and Science, and the Institute for Textile Technology. Because of the concentration of textile mills in North Carolina, I interviewed several professors and administrators in the North Carolina Department of Community Colleges including officials in Raleigh, staff at two general community colleges and at the only community college in the state devoted entirely to textile education--the North Carolina Vocational Textile School.

The analysis is organized into six chapters. The rest of this chapter is an overview of the textile industry in which I describe the central trends including rising imports, modernization, and the proliferation of products. Chapter 2 discusses technological innovations in textiles. Chapter 3 describes innovations in the organization of production and in the training and management of the workforce. Chapter 4 summarizes the implications of the technological and organizational changes on the skill demands of the industry. Chapter 5 describes how the changes in technology, organization and skills have affected the system for training and educating production level textile workers. Finally, Chapter 6 discusses how that system might change to be more in tune with current needs of the industry and presents generalizations, tying this report more closely to other case studies for this project.

An Overview of the Textile Industry

The textile industry in the United States employed almost three quarters of a million individuals in 1987. Since it is concentrated in the Southeast, its importance to some states is even greater. In North Carolina, the industry accounted for 25 percent of all manufacturing and 7 percent of total employment.[5]

As is true with most industry aggregates, the textile industry (SIC 22) is a complex agglomeration of diverse sub-industries. Table 1 displays data on employment and output in nine sub-industries, the most important being weaving, knitting and spinning mills.[6] The industry can also be categorized by its output which is usually divided into three broad groups. Apparel fabric accounts for about 40 percent of U.S. textile output. Home furnishings--such as drapes, carpets, sheets and towels, and industrial fabrics--for tires, airplanes, hoses and myriad other uses, make up the other 60 percent.[7]

Although there are several huge multi plant companies, most firms in the industry have one factory--in 1982, the industry comprised 6,630 establishments in 5,376 companies. Sixty-two percent of the establishments had fewer than 50 employees and only 71 (just over 1

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[5]American Textile Manufacturers Institute, Economic Information Division, Textile Highlights, June 1987. Washington, DC: ATMI, p.22; North Carolina Department of Community Colleges, Business Conference Series, Preliminary Reports, Session XI: Textiles and Apparel. Raleigh, NC: Department of Community Colleges, 1986, p.1.

[6]These data understate the importance of spinning since many weaving mills are integrated from spinning through weaving.

[7]American Textile Manufacturers Institute, Economic Information Division, "The U.S. Textile Market in Square Yard Equivalents: 1973-1985." Washington, DC: ATMI, May 1987, pp. 4, 6.

percent) of the establishments had more than 1,000 workers. Although the larger mills of course account for a disproportionately high amount of employment and output, the industry concentration is not high when compared to major durable goods producers such as auto and steel. In 1982, the four largest companies among both cotton weaving and synthetic fiber weaving firms accounted for about 40 percent of total shipments for their respective sectors. But the top four yarn spinning firms only accounted for 22 percent of the market.[8]

The industry's vertical structure is also diverse. For some products, such as some sheets, towels, and socks, one firm produces the goods from raw fiber and sells directly to large retailers or to wholesalers who distribute to small outlets. But for other products, the industry produces intermediate goods used by the garment, automobile, or other industries. Moreover, the spinning, weaving, finishing, and dyeing are often done by different firms. And even within these steps, subcontractors can be used. This creates a vast and complicated network of producers, service firms, middlemen, wholesalers, and retailers that sometimes work together and sometimes compete. There is considerable disagreement about the implications of this structure. On the one hand, Michael Piore and Charles Sabel have argued that this structure promotes innovation in the textile industry in Italy; Ronald Dore arrives at a similar conclusion for Japan. On the one hand, it is more common in the U.S. to blame this fragmentation, because it prevents the concentration of resources required for expensive research and development, for slowing innovation and modernization.[9]

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[8]U.S. Bureau of the Census, 1982 Census of Manufactures, MC82-S-1 (Part 1 and Part 2), Subject Series, General Summary. Washington, DC: U.S. Government Printing Office, 1982, table 3 (for Part 1) and table 1 (for Part 2). U.S. Bureau of the Census, 1982 Census of Manufactures, MC82-S-7, Subject Series, Concentration Ratios in Manufacturing. Washington, DC: Government Printing Office, 1982, table 5.

[9] Michael Piore and Charles Sabel. The Second Industrial Divide. New York: Basic Books, 1984; Ronald Dore, Flexible Rigidities: Industrial Policy and Structural Adjustment in the Japanese Economy,

Table 1. The Textile Industry (1982)

SIC Code	Sector	Establishments	Employees (000)	Distribution of Emps.	Payroll (million dollars)	Value Added by Manufacturing (million dollars)	Distrib. of Value Added	Value of Shipments (million dollars)	Distrib. of Shipments	Payroll/ Value of Shipments	Value Added per Emp (000)	Payroll/ Employees (thousand dollars)
	All Manufacturing	358,061	19,094.1		$379,627	$824,118		$1,960,206		0.19	$102.7	$19.9
22	Textile Mill Products	6,630	717.4	100.0%	$9,046.1	$18,550.2	100.0%	$47,515.4	100.0%	0.19	$66.2	$12.6
2211	Weaving Mills, Cotton	269	76.9	10.7%	$946.6	$1,637.5	8.8%	$3,972.0	8.4%	0.24	$51.7	$12.3
2221	Weaving mills, Manmade Fiber	523	140.8	19.6%	$1,815.2	$3,488.6	18.8%	$8,101.2	17.0%	0.22	$57.5	$12.9
2231	Weaving and Finishing Mills, Wool	131	13.1	1.8%	$175.8	$349.4	1.9%	$762.8	1.6%	0.23	$58.2	$13.4
2241	Narrow Fabric Mills	281	17.5	2.4%	$215.5	$464.7	2.5%	$851.8	1.8%	0.25	$48.7	$12.3
225	Knitting Mills	2,334	204.8	28.5%	$2,327.2	$4,985.4	26.9%	$10,986.1	23.1%	0.21	$53.6	$11.4
226	Textile Finishing, Except Wool	753	58.1	8.1%	$834.0	$1,590.3	8.6%	$4,971.9	10.5%	0.17	$85.6	$14.4
227	Floor Covering Mills	505	41.9	5.8%	$603.1	$1,711.7	9.2%	$5,807.8	12.2%	0.10	$138.6	$14.4
228	Yarn and Thread Mills	714	108.6	15.1%	$1,277.8	$2,318.2	12.5%	$7,036.4	14.8%	0.18	$64.8	$11.8
229	Misc. Textile Products	1,120	55.8	7.8%	$832.9	$2,004.5	10.8%	$4,935.4	10.4%	0.17	$88.4	$14.9

Source: U.S. Bureau of the Census, 1982 Census of Manufacturers, MC82-S-1 (Part 1) Subject Series, General Summary, Part 1, table 3.

In the last two decades the textile industry has experienced a number of profound shocks. As is the case with so many other industries in the country, years of prosperity came to an abrupt end in the 1970s.[10] That decade saw a virtual revolution, which continues today, in production technologies, in the nature of demand for the industry's products and in the extent of competition, especially from abroad.

More than for any other industry, advances in textile technology have marked the development first of the industrial revolution and then of modern mass production. Although there were no major technological breakthroughs in textile technology during the middle part of the twentieth century, there have been important advances in the last twenty years. Nevertheless, textile production still requires large quantities of low-skilled labor. Indeed, in 1975 about 75 percent of the industry's workforce is classified in semi-skilled, laborer or service occupations.[11]

The large need for low skilled labor and the widespread diffusion of the basic textile production process has made the industry vulnerable to competition from cheap foreign labor. The data displayed in Table 1 show that the value added per employee in textiles is only about 65 percent of that figure for all of U.S. manufacturing. Indeed, employment and import data reflect the threat of foreign competition. In 1980, the U.S. imported 4.9 billion square yard equivalents of

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1970-80. London, England: The Athlone Press, p. 239; Office of Technology Assessment, The U.S. Textile and Apparel Industry: A Revolution in Progress. Washington, DC: Government Printing Office, 1987, Chapter 2.

[10] Although the growth trend between World War II and the late 1970s was positive, the industry is sensitive to the business cycle and to abrupt fashion changes. Therefore overall growth obscured cyclical and micro-level instability.

[11] Unpublished data provided by the Equal Employment Opportunity Commission, Washington, DC.

textile products (including imported raw fabric and the fabric contained in imported garments and other textile products) which accounted for 17 percent of the textile market. By 1986, imports had risen to 12.9 billion square yards, accounting for 35.6 percent of the market. In that same year, over 50 percent of U.S.-consumed apparel fabric was imported.[12] Between 1980 and 1986, the U.S. textile market grew by over 20 percent while U.S. production fell by about 4 percent. Thus as a result of imports and productivity increases, domestic employment fell 16 percent from 848 thousand in 1980 to 709 thousand in 1986. Industry employment had been as high as 965 thousand in 1974.[13]

Confronted by increasing competition, many marginal firms have closed and the survivors have carried out major modernization and automation programs. In 1960, the textile industry ranked forty-eighth out of 61 manufacturing industries in terms of its average equipment age. (The industry ranked first had the newest equipment.) By 1980, the industry's rank had risen to second.[14] This modernization has led to impressive gains in productivity. While total factor productivity in the manufacturing sector in the United States grew 2.4 percent a year between 1975 and 1985, textile productivity grew by 5.6 percent a year during the same period.[15]

In any case, in many large textile markets, automation alone may not be adequate to compensate for low labor costs abroad--textile producers are particularly worried about imports from China. As the data in Table 1 show, payroll accounts for one half of the industry's value added and in some segments payroll accounts for one quarter of the value of shipments. Moreover, U.S. textile firms have other

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[12]American Textile Manufacturers Institute, note 7, p.4. The import figures include finished goods and imported fabric used to produce U.S. made finished goods.

[13]American Textile Manufacturers Institute, note 5, p. 22.

[14]Unpublished data, based on Census data--provided by Professor Frank Lichtenberg, Columbia University Business School.

[15]American Textile Manufacturers Institute, note 5, p.21.

problems besides wage levels. Domestic garment producers and retailers also complain that U.S. textile manufacturers historically have been reluctant to produce small amounts of special fabrics, preferring to concentrate on large production runs of standardized items. To be sure, in such a diverse industry, there have always been specialty producers, but the bulk of the industry in the U.S. focused on producing standardized products for a mass market.[16] In 1968, the Bureau of Labor Statistics wrote, "until recently, little attention was paid [by the management of textile firms] to developing new products and markets, and little research or advertising was carried on."[17]

But developments in textile markets, and indeed in markets for almost all goods and services, have made the strategy of mass production for a homogenous market much more problematic.[18] The greater segmentation of markets and the faster changing of styles have shrunk the market for large production runs of identical fabric. Even such a staple mass-produced commodity as denim now comes in dozens of weaves, colors and finishes. Faster changing seasons have also had their effect. In apparel, styles become obsolete much more rapidly, thus apparel makers are less likely to order large quantities of the same material. The changes in styles are reflected in increases in stock-outs and markdowns. Forced markdowns, which are necessary when

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[16] Brian Toyne, Jeffrey S. Arpan, Andy H. Barnett, David A. Ricks and Terence Shimp, The Global Textile Industry. London, England: George Allen & Unwin, 1984, Chapter 8.

[17] U.S. Department of Labor, Bureau of Labor Statistics, "Technology and Manpower in the Textile Industry of the 1970's." Bulletin No. 1578. Washington, DC: Government Printing Office, August, 1968, p. 9.

[18] Thomas Stanback and his associates argue that the increasing use of producer services was a by-product of the growing diversity of market demands (Thomas Stanback, Peter Bearse, Thierry Noyelle and Robert Karasek, Services: The New Economy. Totowa, NJ: Rowman and Allanheld, 1981). See Michael Piore and Charles Sabel, note 9, for a discussion of flexibility in manufacturing. See Toyne, et. al., 1984, note 16, and Office of Technology Assessment, note 9, 1987, for specific discussions of textiles.

retailers fail to sell items during the appropriate season, have increased by 50 percent during the last decade. Industry estimates suggest that losses from stockouts, which occur when retailers run out of hot items, amount to 8 percent of sales.[19] Now only 20 percent of the garment output consists of so-called "commodity" products such as men's underwear and socks that are made in large standardized runs and sold all year.[20] Market analysts consider that the market share of commodity goods will continue to fall.

As imports have risen and markets diversified, the domestic textile producers have tried to respond. It has now become an article of faith in the U.S. that the textile industry must become more "market driven"--that is, the industry must be capable of producing shorter runs of many more styles. One strategy pursued by the industry has been to try to develop new markets and to produce for niches where there is less competition. In general as the market for apparel textiles has been threatened by foreign producers, the industry has put more emphasis on producing and marketing home furnishings and industrial fabrics. Indeed, these areas accounted for 60 percent of the textile fabric produced in the U.S. in 1985, up from 52 percent in 1980.[21]

All of the industry segments are now turning out a greater variety of fabric. Managers of every mill studied for this project reported increases in the number of styles that they are handling. For example, one spinning mill increased the number of active styles from 3 to 35 in two years, a plant producing home furnishings increased the number of styles it produced annually from 100 to 300 in five years. And one large denim mill was currently producing 28 styles while ten years ago it typically produced at most three styles at one time.

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[19]Office of Technology Assessment, note 9, pp. 26-7.

[20]Office of Technology Assessment, note 9, p. 16.

[21]American Textile Manufacturers Institute, note 7, pp. 4, 6.

Indeed, in 1987, owing to the modernization programs, the greater attention to the market, the general economic growth and the falling value of the dollar, many of the textile firms that had survived were doing well. The sales manager of one spinning firm said, "this is the best yarn market in history." Employment actually grew from 702,000 to 726,000 between June 1986 and April 1987, and corporate profits on sales grew from less than 2 percent in the second quarter of 1985 to over 4 percent at the end of 1986.[22]

Nevertheless, this hardly justifies complacency. Profits fell again in 1987 and imports continue to grow at 15 percent a year. Modernization and a flexible market-oriented approach are strategies used by foreign competitors as well. Indeed, most of these tricks are themselves imported. The most important recent technological advances were developed in other countries.[23] And the discussion of market response taking place in the mid 1980s echoes earlier discussions abroad. Thus Ronald Dore, in his study of the Japanese textile industry during the 1970s, argues that such phrases as "increasing product differentiation," "getting closer to consumer needs," and "maintaining an advantage in non-price competition," had become virtual cliches in the textile policy debate during that decade.[24]

In any case, textile managers in the U.S. have now embarked on a competitive strategy based on combining advanced technology and responsiveness to an increasingly volatile and varied market. Thus the central question for our purposes is how the education system needs to adjust so that it can most effectively prepare a workforce for a modern and flexible production process.

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[22]American Textile Manufacturers Institute, note 5, pp. 13, 22.

[23]Charles F. Sabel, Gary Herrigel, Richard Kazis, and Richard Deeg, "How to Keep Mature Industries Innovative," Technology Review, April 1987, pp. 27-35.

[24]Dore, note 9, p. 239.

Chapter 2: Textile Production: New Technology and Flexibility

The investments in new textile equipment have had an impact on industry productivity. In 1986, the industry produced as much cloth as it did in 1981, but it employed 15 percent fewer workers.[25] There will always be a market for basic textile products produced in long runs and some mills will prosper filling this demand. Indeed the new production equipment may help these producers stave off some of the competition based on low foreign wages. Nevertheless, the market for standardized goods that can be produced in massive runs is shrinking and textile executives and analysts realize that increasing productivity is not enough. The industry as a whole must also be able to produce a wider variety of goods, on shorter notice, and at a reasonable cost. This chapter describes the new technology in the industry and assesses how much that new technology can contribute to increasing the flexibility of textile production.

The development of flexibility in production is fundamentally a process of reducing the cost differential between standardized goods produced in long runs and a more varied output produced in smaller batches. Custom made products could always be acquired at a price. Ever since Henry Ford mobilized the labor of low skilled factory workers through the assembly line to replace teams of skilled workers, technological innovations, at least in the United States, have almost been synonymous with specialization of labor and mass production. Flexibility has usually been achieved by reversing Ford's process, moving back up the range of skill levels and shifting from specialized to general purpose and more traditional tools and machines.

In their book, The Second Industrial Divide, Michael Piore and Charles Sabel argue that new technology breaks the link between technological innovation and mass production. They say that "what is

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[25]See American Textile Manufacturers Institute, note 7, p. 4, for production levels; and American Textile Manufacturers Institute, note 5, p. 22, for employment.

distinctive about the current crisis is that the shift toward greater flexibility is provoking technological sophistication--rather than regression to simple techniques." A classic example involves steel production in which "computerized process control equipment, for example, allows firms to regulate the carbon content of steel more precisely and to add a sequence of different alloys without interrupting the flow of production."[26] This eliminates a crucial disadvantage for short runs since stopping the flow of production requires an extremely expensive process of cooling and reheating the blast furnaces. Thus with new technology, production flow continues while computer controls adjust the mix of inputs and the characteristics of the processing to produce a wide variety of products without the cost of idle equipment, switch-over and start-up costs or, if a just-in-time delivery system is used, excess inventories.

What is the potential for this type of technologically based flexibility in the textile industry? Answering this question requires a basic understanding of the textile production process.

The Production Process

The textile industry turns fiber into fabric.[27] In traditional cotton textile production, there are four broad steps, each of which may combine several processes. In the first the cotton is blended and cleaned; in the second it is spun into yarn; in the third it is woven or knitted into fabric; and in the fourth it is "finished."[28]

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[26]Michael Piore and Charles Sable, note 9, pp. 207, 209.

[27]See Office of Technology Assistance, 1987, note 9, for a detailed and up-to-date description of the textile production process and technology.

[28]During finishing, the fabric is dyed, treated with chemicals, singed, or manipulated to prepare it for its end use.

Although textiles have been manufactured for millennia and the basic procedures are theoretically simple, the manufacturing process presents some profound barriers to complete automation. Perhaps the key problems are that textile materials are neither rigid nor liquid, and that textile production requires so many discontinuous steps. Thus it is difficult either to push and manipulate the material automatically or to move it from procedure to procedure through pipes or chutes. The reduction of the use of labor in the textile industry has progressed more rapidly in those stages of the manufacturing process at which material can be more easily handled. For example, loose fibers can be blown around and, as a result, labor has been almost eliminated from the early stages of fiber cleaning and processing. Once cotton or synthetic staple is turned into yarn, handling the material becomes much more difficult. But when yarn is subsequently turned into cloth, automation is once again somewhat easier. Thus rolls of fabric can be processed easily in large quantities by few workers during the finishing stages. But the next processing step for apparel fabric, garment making, once again uses large amounts of hand labor. The sharp fluctuations in the mix of labor and capital during the production process can be further illustrated by the variation in the number of machines used at each stage. For example, 50 carding machines can produce the input for 30,000 spindles which in turn feed only one slasher. This single slasher can load the warp beams for hundreds of looms.[29]

The production of some fabrics requires more than fifteen separate processes. Each involves a separate machine and still, for the most part, the material must be moved from machine to machine

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[29]**Carding** machines clean and straighten fibers to prepare them for spinning. A **slasher** treats the yarn with chemicals to help it withstand the friction and tension during weaving. The slasher also winds the yarn onto the **warp beam** which is then mounted on a loom. The **warp** comprises the vertical yarns in the construction of the fabric. In a shuttle loom, filling yarn is passed though the warp yarn by the shuttle to make the fabric. In shuttleless looms, other techniques are used to perform this function.

either by hand, by a robot (still very rare), or by cumbersome conveyors (that are also inflexible). In many cases, the material is accelerated to tremendous speeds--spindles, for example, turn at thousands of revolutions per minute--and then stopped, only to be speeded up again for the next step. Processes that may seem simple and straightforward often use complicated and sophisticated machines. For example, one of the most advanced machines in a spinning mill, called a winder, is used to wind yarn from the small spindles that come off of the spinning frames onto larger packages used in weaving or knitting. In a typical spinning or weaving plant, thousands of small packages must be handled individually several times and millions of tiny threads must be inserted into eyelets and must be knotted or spliced when they break.

This complex process makes changing styles complicated. Variation can enter at any point in the process--blending, spinning, weaving, knitting, or dyeing. Changes often require running out material already on a machine, thorough cleaning of the equipment, some physical adjustments to the control mechanisms, and loading the new material. When fiber content is changed, cleaning is particularly important and difficult since different fibers react differently to the same dye. If a mill changes from cotton to polyester, for example, without thoroughly cleaning the machines used to make the yarn, then some cotton fibers will remain in the yarn. Thus when the fabric into which the yarn is woven is eventually dyed, there will be streaks of odd colors.

All of these problems make "mill balance" extremely important. A mill is balanced if all of its equipment is fully utilized, but frequent style changes make mill balance difficult. For example, changing the size of the yarn changes the quantity of fiber that a given number of spindles can process in an hour, thereby changing the demands on the machines that prepare the fiber for the spindles. Changing styles thus changes the location of bottlenecks in the manufacturing process. This almost always results in either idle machines (which are increasingly expensive) or increased in-process inventories. Abhorrence of idle machines is revealed in the universal move to 24-hour-a-day, 7-day-a-week production. The importance of balance and its implications is demonstrated in the following statement from an analysis of problems of a medium-sized textile mill.

> Mr. Chandler [the mill superintendent] emphasized the importance of correct mill balance. By properly balancing the process flow in the mill, profits were increased rapidly from $200,000 to $1 million. He explained that once the balance had been achieved, it was maintained by accepting orders for only those fabrics that would be appropriate to the balanced flow.[30]

This is hardly a recipe for flexible responses to rapidly changing market conditions, but it does capture the conflict between flexibility and cost in textile manufacturing. The plethora of discreet processes that vary in their mix of labor and capital, the complication of switching materials from process to process, and the problem of mill balance all add important costs to style changes. This does not mean that short runs and specialty products are not made, but rather that they are made at a much higher cost.

Innovations in Textile Technology

In the following pages, I take a more detailed look at the latest innovations in textile technology. While the discussion emphasizes their potential to promote flexibility, it also considers the effects on throughput speeds and output quality.[31]

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[30]Richard Paul Olsen, <u>The Textile Industry</u>. Lexington, MA: Lexington Books, 1978, p. 142.

[31]There are several informative and detailed descriptions of textile production technology. For a picture of the technology during the mid-1960s, see Bureau of Labor Statistics, note 17. The situation during the mid-1970s is described by Olsen, note 30. Toyne, et.al., note 16, covers developments through the early 1980s; see Office of Technology Assessment, note 9, for a description of the state of the art at mid decade.

Opening and Picking: The first stage of yarn production involves opening the bales of cotton or synthetic staple and blending fiber from several bales to achieve a uniform product and the desired mix of cotton and synthetic. With the traditional technology, this was backbreaking work in which a worker was instructed to pick some material from a given sequence of bales and feed it into a machine which broke up clumps, started the cleaning process, and rolled the fiber into thin sheets called laps. The laps were moved by hand to a carding machine that further cleaned the fibers and arranged them into straight and parallel strands. Workers have been eliminated from this process except in the use of a fork lift to maneuver bales of fiber into the proper position on the floor. A computerized machine picks cotton from a programed sequence of bales and the fiber is fed by chutes and blowers through all of the processes up to the carding machine. This innovation speeds up the process and eliminates some of the most unhealthy and unpleasant jobs in the mill. It also improves quality by assuring a more consistent blend of fiber. Although commodity producers adopted this technology before specialty producers,[32] it does appear to have a moderate effect on flexibility, primarily because it restricts the spread of loose fiber. This eases the clean-up necessary for changing the fiber mix.

Spinning: The basic principles of traditional ring spinning technology have changed little in the last several decades. Indeed it is not uncommon to see early twentieth century dates on ring spinning frames used by even technologically progressive firms. To be sure, those frames have been renovated and updated; nevertheless, the basic principles remain the same. But there have been important improvements in spindle speeds and in automatic loading and unloading of the spinning (and roving)[33] frames. Yarn quality has also been much improved. The greatest advances in ring spinning have been in the

[32]Olsen, note 30, p. 11.

[33]Roving starts the twisting process and prepares the fiber for spinning.

winding process. Computerized monitoring and repair systems can spot low quality yarn and cut it out, splicing together the resulting ends without using a knot--knotted yarn hurts quality in subsequent steps. And programmable controls have eliminated the need to make mechanical adjustments to change the size and shape of the take-up package. All of these changes have increased speed and quality. Flexibility is enhanced both through programmable controls and through automatic loading and unloading, but the process is still unwieldy, requiring three separate steps--roving, spinning and winding (sometimes). Thus style changing still requires a lengthy process of running out material on three sets of machines, making some, not very difficult, adjustments, and unloading and loading dozens of input and takeup packages.

The most dramatic changes in speed and flexibility have occurred in a process called open-ended spinning. This was a major step towards totally automated spinning--that is a manufacturing process in which bales of cotton or synthetic fiber are turned into thread or yarn wound onto packages of the appropriate size without being handled by humans. Open ended spinning collapses roving, spinning and winding into one short procedure. It takes the cleaned and straightened fibers, turns them into thread, and winds them onto the appropriate package. This has dramatically reduced labor needs. For example, one spinning mill that converted from ring spinning to open ended spinning more than doubled its output while cutting its labor force in the spinning room by more than half. Furthermore, open ended spinning reduces the number of knots used to join threads together both by reducing yarn breakage and reducing the need to tie together threads from small packages in order to make up larger packages, thereby increasing yarn quality. To be sure, there have been important advances in yarn knotting or splicing that can be used with traditional ring spinning, but they are much less cumbersome with open-ended spinning. Thus in many ways, open-ended spinning increases quality, increases productivity and definitely promotes flexibility since it eliminates much of the switching process that is time consuming for style changes. But in other ways, it reduces flexibility. Higher fashion garment makers often insist on ring-spun yarn, because open-ended spun yarn is heavier and coarser. Thus while it eases changeover within its range, its range is limited. Moreover, it is in the mass produced commodity markets such as denim and underwear that open-ended spinning is most common.

Weaving: One of the best known advances in textile technology has been the shift from shuttle to shuttleless looms. Shuttleless looms have increased loom speeds. Some of them can insert over 600 picks (threads) of yarn per minute, while shuttle looms insert about 150. Moreover, the new looms can weave wider fabric. This permits more efficient use of the cloth and in some cases permits two widths of cloth to be woven on the same loom, which effectively doubles the speed of the loom. But the speed may not be the most important aspect, since shuttleless looms can cost up to 10 times as much. Perhaps more important than speed is that these looms are more efficient and weave better quality cloth with fewer broken ends.[34] Broken ends reduce the quality of the fabric because the knots that are used to repair the breaks become incorporated into the fabric as flaws; the breaks also reduce loom efficiency by idling the machines while the break is repaired. One mill operator reported that his seconds-quality cloth fell from 10 to 15 percent to two or three percent with the introduction of shuttleless looms.

Although shuttleless looms improve speed and quality, their effect on flexibility is not so clear. Indeed, some of the fastest looms have severe restrictions. Air jet looms can still only insert one color of filling yarn and the use of fancy yarns presents problems. Water jet looms are also limited to synthetic filament yarns, and until recently also have only been able to insert one color of filling yarn. Rapier and projectile looms do allow multicolor filling but so did much older box-type shuttle looms. New looms also have programmable weave-

[34]An **end** is one of the threads that makes up the warp.

construction controls (the sequence in which the heddles[35] are raised and lowered) but this was also a feature (called a dobby) available on shuttle looms since the 1950s.

The most important remaining problem in loom flexibility involves changing the warp yarn (the vertical ends of yarn through which the filling yarn is inserted), not changing the instructions to the machine. A warp beam can contain several thousand ends of yarn and each has to be threaded individually through the beaters (that pack each filling yarn next to the previous one), the heddles, and the contact plates (that stop the loom if an end breaks--there are looms that use different stopping mechanisms that do not require these plates). This can take many hours. Then a loom must be stopped and the new warp beam and harness installed. This can still take several hours. The advantages to long runs are particularly strong here. For very long runs, thousands of yards of warp yarn can be loaded onto the warp beam and the loom can run for many days without stopping. Even when the warp beam runs out of yarn, as long as the style is the same, the new warp yarn can be tied to the end of the yarn from the old warp beam. This can be done mechanically and takes only about one hour.

Shuttleless looms do not represent important innovations in loom changeover. Indeed, since these looms are so much more expensive, there are greater incentives to avoid the style changes that require the loom to sit idle while the new warp beam and harness are installed.

Knitting. Modern technology has made tremendous gains in speed, quality and flexibility of knitting. Knitting machines produce fabric two to ten times faster than looms producing a roughly equivalent

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[35]**Heddles** are the devices that raise and lower the warp yarn so that the filling yarn can be inserted. The construction of the fabric is determined by the pattern in which the warp yarn is inserted into the various heddles and the sequence in which the heddles rise and fall.

fabric.[36] More important, style changes on knitting machines are much easier. Some knitwear can be made from a single thread, and even complicated patterns need at most a few dozen threads. Advanced machines are completely programmable, so a complete style change, including entirely reloading the machine, can take a few minutes, certainly not more than an hour. The main problem, therefore, is in getting the colors and the yarn blends and counts that are necessary. If open-ended spinning can be improved to produce fine yarns, then the entire production process for knitted fabric will be highly automated and flexible. Automated opening and picking combined with chute fed cards, open-ended spinning, and programmable knitting will produce knitted fabric with a minimum of human involvement and a high degree of versatility.

Other Developments: Many of the most important innovations in textile production have involved mundane and incremental changes such as mechanical devices to unload machines, simple improvements to reduce necessary cleaning, suction tubes that travel around the mill on rails removing dust from the air and floor, and better temperature and humidity control. One mill that produced small runs of special fabrics developed a water soluble dye that could be sprayed on fibers to indicate whether there was any contamination from other types of fibers. These small changes have had a major impact on speed and product quality. Those innovations that ease cleaning are particularly important for flexibility.

Computers: So far, the computer has not had a dramatic or revolutionary effect on textile productivity. Indeed, the large majority of the productivity gains that the industry has experienced in the last 15 years have come more from advances in electromechanical technologies, such as loom and spindle speeds, and better quality machines than from computerization. But computers have brought about a series of incremental improvements in textile manufacturing. Newer

[36]Olsen, note 30, p. 49.

machines have electronic controls that can monitor quality and make automatic adjustments. There have been some advances in programmable machine controls, but changing the style settings for looms still requires hardware adjustments. Even with open-ended spinning, a change in yarn size (referred to as yarn "count") requires that a mechanic replace gears that control the speed at which the fiber is fed into the spinning chamber. The automatic knotters that are built into modern open-ended spinning frames also require substantial manual adjustment. Moreover, programmable controls do not remove the formidable barriers to flexibility inherent in the necessary cleaning and in the difficulty of loading and unloading the machines.

The computer has had perhaps its greatest impact in manufacturing control, planning, communication, and record keeping. One plant manager gave an example of the benefits of computerized planning. Before fabric can be woven, hundreds or thousands of ends of yarn must be loaded onto a warp beam. Each end is drawn from an individual package mounted on a frame called a creel. Loading the creel is a straightforward if cumbersome process, but if the pattern of colors that must be loaded onto the beam is changed frequently, then it is easy to imagine the headaches involved with scheduling work through the creel. The process is now done with the assistance of a computer in this manager's plant, and his crew is able to load warp beams adequate to produce 1.2 million yards of fabric a week, sometimes in 300 different styles. Previously, using exactly the same equipment, the plant could produce only about 300,000 yards a week in 100 different styles.

And although most planning is still done with less sophisticated methods, managers and department heads in many mills can get current information on production rates, machine stoppages, output quality and inventories of supplies and output. Indeed, inventory control and communication with suppliers and customers in a system referred to as "Quick Response" at this time is certainly the most talked about use of computer technology. (This will be discussed in more detail below.)

Production planning and inventory control have the potential to increase the efficiency of the use of equipment and to speed up the production process. This will also increase flexibility by helping to determine the least disruptive way to move orders of any size through the mill or in the case of multiplant firms, through the system of mills. Nevertheless, the flexibility of the operation, even with sophisticated planning, is subject to the constraints imposed by the versatility of the machines and labor that are in place.

Conclusions--Continuing Tension Between Cost and Flexibility

Thus the latest textile production equipment has resulted in tremendous gains in speed and quality, especially for long runs. And there is potential for reducing the cost differential between mass produced and more specialized goods. Computerized planning and communications, programmable machines, and advances in loading, unloading and cleaning have all enhanced flexibility.

But profound barriers remain. Indeed, the latest wave of modernization started before the onset of the current preoccupation with flexibility and market response. Some of the most dramatic technological advances have been in machines with restricted uses--water jet looms are restricted to continuous filament and open-ended spinning works best with coarse yarn counts. All of the equipment is now much more expensive and an individual machine now represents a greater proportion of the production capacity. This increases the cost of shutting down the equipment for style changes which in turn creates incentives to restrict the variety of output and increase the length of production runs. Thus the industry is a long way from achieving a continuous flow process with minimal cost differentials between long and short runs and there will continue to be tension between cost and flexibility. Ironically, just as the market demanded more variety and faster service, the industry was perfecting a process to produce large quantities of standard goods.

Moreover technological progress will make only slow progress in resolving that conflict. But changes in the way that firms organize and manage labor can also reduce the tradeoff between cost and flexibility. These changes will involve new management practices and new ways of organizing production within the same technological setting, and this has profound implications for the procedures for recruiting and training workers.

Chapter 3: Organizational Innovation

New technology is not the only road to production that is more responsive to the market. Textile producers have a variety of options that include changes in the structure of the industry as a whole, communications and interactions among the firms and institutions that make it up, the organization of production at the factory level, and the management and utilization of labor working with a given technology. These alternatives all have different implications concerning the most appropriate training for the industry.

Industry Structure

Ronald Dore has argued that in Japan the textile industries have achieved great flexibility through their extensive networks of small specialized firms that carry out specific steps in the production process. For example, in the early 1980s, there were about 16,000 cotton weaving enterprises (there were an additional 34,000 that wove synthetic fiber) in Japan and the modal firm had only 2 or 3 employees other than family members. (In contrast, in 1982 there were 269 cotton weaving establishments in the U.S. with an average of just below 300 employees each.[37]) Other firms specialized in warping, slashing and other specific tasks. This network was held together either by a large firm, usually a yarn maker, or a trading company operating through a middle man. The small operators had long-term relationships with the dominant firms which not only provided the contracts, but also technical assistance to keep the small contractors up to date with the latest technology. In this way, the Japanese textile industry achieved both flexibility and technological sophistication. Moreover, far from disappearing, the market share for small weaving firms is growing. "The proportion of cotton looms operated by the generally

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[37]Since many U.S. weaving mills are integrated operations, the workers in these plants are also engaged in spinning.

large-scale cotton spinning companies was 25 percent in 1952, down to 16 percent in 1969 and to 13 percent in 1979."[38]

Benetton, the Italian garment producer and marketer, uses a similar system for much of its production, subcontracting about one half of its knitting to over 200 small firms.[39] And Piore and Sabel describe extensive and shifting contracting and subcontracting relationships among large numbers of small textile firms in the Prato region of Italy. They point out that the vertically integrated textile mill has virtually disappeared from the region.[40]

One of the most important sources of flexibility in this system is the labor and knowledge of the small entrepreneurs and their families. They can usually operate and repair all of the machines in their establishment, their hours of work can expand or contract according to the strength of their business, and they accept sharp fluctuations in their incomes. Textile officials in Japan refer to these owners as "our Viet Cong."[41]

Although industry analysts have been enthusiastic about this structure for textile production in Italy and Japan, it is unlikely that a structure based on networks of small weavers will emerge in the

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[38]It is a mistake to view the entire Japanese textile industry as uniformly made up of tiny firms. Although most weaving firms are indeed small, the yarn spinning segment of the industry in Japan is more concentrated than it is in the U.S. According to Dore, in Japan nine firms control 75 percent of the cotton and cotton mixture spun yarn market, while in the U.S. the 20 largest yarn mills had only 56 percent of the market in 1982. Ronald Dore, note 9, p. 158-159, 190. U.S. Bureau of the Census, 1982 Census of Manufactures, MC82-S-1 (part 1), General Summary, 1982, table 3 and MC82-S-7, Concentration Ratios, 1982, table 5.

[39]Fiorenza Belussi, "New Technologies in a Traditional Sector: The Benetton Case." BRIE Working Paper. Berkeley, CA: Berkeley Roundtable on the International Economy, March 1986, p. 29.

[40]Michael Piore and Charles Sabel, note 9, pp. 213-216.

[41]Dore, note 9, p. 189.

United States. Indeed, the most technologically progressive weaving firms in this country are the large integrated operations, and there is no apparent move among them towards vertical disintegration. If anything, many firms appear to be strengthening their vertical structure within narrow product fields. Thus they are specializing in market segments rather than in production processes. For example, J.P. Stevens recently sold off its worsted and woolens divisions in order to concentrate in its traditional market areas. And although much may have changed in the last five years, industry concentration in weaving was stable or growing between 1972 and 1982.[42]

Finally, a weaving sector based on thousands of tiny enterprises would require a cadre of technologically sophisticated small owners that could operate and repair modern equipment and run the businesses. This implies a relatively high level of basic education and a system for rapid diffusion of knowledge and information. Thus the viability of this type of industrial structure would depend on whether or not the educational system were able to provide the appropriate skills.

Quick Response

Since 1985, textile and garment producers and retailers have been working together to develop a program, called "quick response," designed to help strengthen the textile complex in the United States. Although the "quick response" campaign is closely linked to computerization in the industry, it is as much an organizational innovation, at least at this stage. The goal of quick response is to minimize the length of time between an order at the retail level and the final delivery of the goods. Traditionally, many months, even up to a year, elapsed between the times that a retailer ordered and

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[42]The total shipments accounted for by the four largest firms grew from 31 to 40 percent for cotton weaving mills but fluctuated around 40 percent during the same period for manmade fiber weaving mills. U.S. Bureau of the Census, 1982 Census of Manufactures MC82-S-7, Subject Series, Concentration Ratios in Manufacturing. Washington, DC: Government Printing Office, 1982, Table 5.

received textile products. In a fashion sensitive industry, this created tremendous risks. Materials had to be ordered months before a fashion season and once the season started, there was no time to reorder hot items. Moreover, the long lead time tied up capital in inventory. During the months of waiting, the material was actually being worked on for a few hours at most. And except for foreign goods shipped by sea, including even essential travel time would only increase the total by a few days. Ideally, quick response would allow retailers to order only small quantities before the season, and then reorder popular styles, thus avoiding both stock-outs and mark-downs. And for the domestic industry, this has the added advantage that a long sea voyage is out of the question in a quick response strategy, although air freight could be used for foreign production, even in a quick response regime.

Cutting the in-process time can be done by reducing the delay between the emergence of a trend and the order to the supplier, by reducing the time it takes to produce the goods or by reducing the time that they sit around on loading docks and in warehouses. So far, the main thrust of quick response has not been focused on production time. Certainly for standardized items this makes sense. Given past advances in productivity, by far the greatest savings in time could be realized by reducing ordering and warehouse time.

Most attention has so far been given to inventory control at the retail level and inventory generated orders to suppliers. Ideally, an order to a sheet producer would be generated automatically when the sheet inventory at a department store falls below a given level. Ironically, the key here is the buyer's inventory control. The communication to the producer may be a convenience, but the <u>sine qua non</u> of the system is the information on sales. Another key aspect of this system is the development of a universal nomenclature and the use of computer readable labels (bar codes) on product packages to facilitate inventory tracking. Other important aspects involve timing of production to minimize waiting and more attention to quality in order to cut down on inspection and to reduce the need for back-up inventories. According to the more ambitious quick response scenarios, trucks will be loaded and deliveries will be timed to minimize handling upon delivery.

Although quick response, by reducing inventory costs, may reduce the cost of short runs, its effect on flexibility is not yet obvious. Quick response to market demand works best if large producer inventories are available, but this is precisely the problem that the strategy is designed avoid. If it does favor variety, it encourages variety at the latest stages of production. If the major barrier to flexibility in textiles occurs at the weaving stage, then the logic of quick response leads to production and storage of undyed fabric that can be dyed and finished in response to changing market demands. But this still requires inventories of undyed cloth and reduces flexibility with respect to fiber content and weave construction. There is no question that quick response can cut down on buyer inventory costs and reduce the production cycle, but, just like sophisticated production planning (which is closely linked to quick response), it must operate within the parameters set by the existing machines and labor.

The fundamental goal of flexible manufacturing is to reduce the cost differential between goods produced in long runs and more specialized items. But it is possible that quick response could have almost as much effect on basic commodity items or basics items with small variations as on more specialized goods. Indeed, the biggest advances in quick response have been among the more standardized producers, for example between denim mills and blue jean makers. One yarn mill that used a commodity strategy, producing cotton yarn for underwear and sweatshirts, had already implemented a bar coding system, while a spinning mill that took a short-run-production approach did not have computer readable packaging. Thus, unless flexibility can be enhanced in the production process itself, quick response may be another factor than pushes the industry towards mass commodity production.

Although the discussion of quick response emphasizes the role of the computer, the new technology can go only so far in implementing quick response and in integrating it with a system of flexible production. At the same time, many of the organizational and process innovations can be implemented without the latest technology. One medium-sized textile firm had taken a short-production-run strategy in the early 1960s and had used many quick-response-type procedures without computers. The firm's workers developed simple automatic cleaning devices to reduce the cleaning necessary to change fiber content. The firm set aside a special department to produce short run and sample fabrics in which the workers were specially prepared to work in this changing environment, it worked closely with clients to suggest new types of fabric for production, and it hand-delivered to garment makers in New York detailed descriptions of shipments of fabric before they arrived, allowing the garment maker to be prepared to cut the fabric as soon as it was received. The firm's strategy, which was successful at the time, was to reduce the cost differential between commodity and specialized goods. The primary technological components of the strategy were suction devices for cleaning, the shuttle loom, the teletype and the bicycle messenger. The keys to its success were the two-way interaction between client and producer and active involvement of workers and technicians in the development of simple innovations and alterations to existing technology and work processes.

Internal Factory Organization

In the 1980s, firms have also experimented with a variety of forms of internal organization. Traditionally, plants have been organized into functional departments. For example, a spinning mill would have carding, drawing, spinning and winding departments and there would be a sequential flow of material through the plant. Of course if the plant produces only one product, then this organization works very well, but once the number of products increases and, in particular, the speed with which those products need to be processed varies, then the organization by functional departments becomes less efficient. Firms that are working towards more flexible production tend to organize their plants along product lines. Departments now include the entire production process, for example, in a spinning mill, from bale opening to spinning or winding. This allows some departments to specialize in short runs and fast changes. Faster orders can now be pushed through the plant without disrupting the production process of longer run commodity products. Thus one firm had 13 plants which it divided into 32 separate operating units. But a completely product-oriented organization may not be the best. Some products may require a more intensive use of a particular process than others. Thus it makes sense to allow some crossing between product-oriented departments in order to balance the use of the equipment. Some processes that require extremely expensive equipment, such as some types of slashing and dying, must be centralized. Nevertheless, a product oriented organization allows more flexibility to vary products and through-put speeds.

The Division of Labor

A typical post-war textile mill had a division of labor characteristic of a mass production industry. The production process was broken down into many small steps and semi-skilled machine operators were assigned to carry out one or a small number of repetitive tasks. Workers labored alone carrying out their routine jobs and reacting to problems as they arose. But when the cost, speed, and capacity of the equipment rose, this reactive orientation became more problematic. As machine stoppages become more expensive and disruptive, prevention becomes more important. Now in some mills, instead of simply reacting, workers are expected to anticipate problems and to work with others to find solutions. Increasing flexibility and the frequent style changes that that can imply make it even harder to occupy most workers on a narrow range of simple and repetitive activities.

Textile analysts estimate that perhaps a quarter of the mills in the U.S. are making some effort to reshape their division of labor. Four of the six textile firms visited in the summer of 1987 had some type of experiment in work organization going on; the exception was a firm that continued to follow explicitly a commodity mass-production strategy. All of these efforts involve changing the orientation of production away from extreme divisions of labor to one in which teams of employees work together to accomplish a joint project. Not surprisingly, many of these innovations in weaving mills involve the central bottleneck to flexibility in fabric formation--the warp change. For example, one plant was involved in experimentation that had eliminated the division of labor within the warp change team. In order to reduce the warp-out time, the plant has now moved to a system in which each member of the team can do several of the required operations.

In open-ended spinning, the main barrier to flexibility is the cleaning process. In one small open-ended department that makes frequent changes in the fiber that it spins, the most important issues of work organization arose precisely in the cleanup operation. A team of workers was assigned to the cleanup job and the manager pointed out that the most important determinant of their efficiency was the experience that the team members had working together.

Another spinning firm is experimenting with changes in the traditional form of compensation. Instead of receiving individual piece rates, the employees now receive a bonus each month depending on the total productivity of the plant. Each worker, except the plant manager, but including the clerical workers and even the nurse, gets exactly the same bonus for every hour that they worked during the month. This has increased the firm's productivity by 15 percent without changing any spindle speeds. Maximizing individual output did not necessarily coincide with a maximization of plant output. For example, an operator might do something that increases the output from one operation but compromises the quality of the material produced by that operation. Moving to a system of group bonuses removes this type of perverse incentive. But it also introduces flexibility, because it encourages the labor force to fill in on different machines as the balance of demands change.

Conclusion

Although many firms are experimenting with innovations in production organization and in the management and training of their employees, these steps are still tentative. Quick response was started by the largest firms and has not spread to many smaller and medium sized establishments. And even in the firms in the sample that were trying new ideas, the experiments often include one department or, in a multi-plant firm, one mill. Nevertheless, managers who have experimented with changes in the division of labor believe that improvements in efficiency throughout the plant can be made by switching from a narrow, task-oriented conception of the worker's role. The benefits of this are especially important in the crucial changeover operations when the machines must be stopped. Moreover, as technology continues to automate the routine tasks, as the capacity and cost of equipment continue to rise, as just-in-time systems spread, as the number of styles proliferates, and as firms try to push quick response techniques further down the production pipeline, then opportunities to employ workers in narrowly-defined repetitive tasks will diminish.

Chapter 4: Skills in the Textile Industry

Production in the textile industry has undergone two basic changes. First, the industry has many new machines. Although these new machines are often easier to operate, they have sophisticated and intricate mechanical and electrical components. Moreover, they are many times more expensive than machines that they replaced, and, because of their higher through-put speeds, each machine represents a larger proportion of a given level of output. Second, these new machines are being used in a new environment--one in which customer service, quality, and flexibility are much more important. To some extent, the technological modernization and the flexibility come into conflict. As a result of this and other problems, some firms have begun to change their organization of production and personnel. What implications do these changes have for the skills that the industry needs?

The relationship between skill changes and new technology is usually discussed within the context of the deskilling controversy. That is, does new technology increase or decrease the skills required by production workers? Indeed, many textile managers and analysts continue to have this conception. Articles on new machines in the industry press often report that the machines "deskill" the jobs, presumably saving the employer the trouble of finding skilled workers.[43]

Occupational Distribution

One factor that affects the overall skill level in a firm is the occupational distribution. In this industry, the changes in this distribution suggest that skill needs are rising--the ratio of operators and laborers to more skilled workers is falling. The textile

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[43]See for example, "What's Ahead for Weaving Technology," Textile World, November 1984, p. 86.

industry has traditionally used large quantities of unskilled and semi-skilled labor; even basic literacy or arithmetic ability was not necessary. To begin with, there were many jobs that simply involved moving material from one place to another. Many of the jobs that required physical strength but made few demands on the intellectual or physical abilities of the workers have been eliminated. For example, automatic opening machines, chute fed cards and devices for loading and unloading machines and moving material among them have cut the number of unskilled manual jobs. At the same time, the increased sophistication of the machines and the higher quality which results in fewer broken threads and machine stops have reduced the number of operators relative to more skilled maintenance and repair personnel. Thus in 1975, there were 4.2 operatives, laborers, or service workers for every craft and technical worker, but by 1985, this ratio had fallen to 3.5 to one.[44] In some departments, the ratio is much lower. In one open-ended spinning operation that we visited, there were two technicians for every three operators.

Low-Skilled Jobs: But the occupational shift obscures changes that are taking place within each job category. At first blush, it appears that the new textile machinery, at least in spinning and weaving, requires less demanding operator skills than the machines that they replaced. The machines and the input material are of higher quality and the temperature and humidity of the environment are much more controlled. Knotting broken threads was one of the most difficult tasks performed by the operators, but now many machines have automatic knotters or splicers. Previously, good operators could have a sense of the quality of the output--for example, the weight of material coming out of cards or drawing frames--but now automatic sensors can do that job with more consistency and accuracy. Suction devices have

[44]Data for 1975 come from Equal Employment Opportunity Commission, 1975, Table 1. Unpublished data for 1985 provided by the Equal Employment Opportunity Commission.

simplified the process of loading bobbins onto winding machines. Programmable knitting machines also require slightly reduced skills.[45]

Nevertheless, although each particular task is easier, considering the jobs task-by-task is a narrow and misleading way of looking at the problem. For a variety of reasons, not generally considered in a narrow conception of skills, many operator jobs are more demanding.

First, modern looms, winders, open-ended spinning frames, programmable knitters and other machines are much more expensive than the equipment that they replaced. Thus errors in those tasks that the operators still must do are more costly. The same point applies to the greater emphasis on quality, especially since machine stoppages, and the broken yarn that usually results, have a direct impact on quality. Although textile firms have long realized that preventive maintenance is important, now the operators must be oriented towards avoiding machine stoppages rather than towards starting up the machines once they have stopped. An emphasis on quality and prevention requires not only the ability to work with others, but also a broader understanding of the production process within which the operator works. It is not enough simply to understand the particular task to which the individual is assigned.

Second, because of the increase in the number of styles produced by each mill, many operators are likely to be engaged in a greater variety of activities and in more of the activities necessary for changing styles. As a result, in addition to a greater emphasis on prevention, some firms are experimenting with broader job definitions and teamwork strategies; workers in the industry now have less well-defined jobs in a more uncertain environment.

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[45]Office of Productivity and Technology, "Technological Change and its Labor Impact in the Hosiery Industry." Washington, DC: Bureau of Labor Statistics, May 1983.

Third, textile firms are also becoming more actively involved with working jointly with clients in developing new styles and fabrics. So far, at least in the firms visited for this project, this strategy does not seem to have had much of an impact on the shop floor, but forward-looking firms might consider how the operators could contribute. The same could be said for on-going technological innovations. Many of the most important changes have been small adaptations of existing machines, and operators could make important contributions to these efforts.

Skilled Jobs: The higher level positions also need greater skills and educational preparation than they did in the past. In the textile industry, the skilled occupations involve machinery repair. In the past, textile machinery was intricate, but in principle it was not complicated and the type of experience that many workers had in their own homes working on automobiles or farm machinery was a useful background. Loom fixers and mechanics in spinning and knitting mills were almost always promoted from the ranks of machine operators. Working around the machines had already given them a feel for what was necessary and the additional training needed to become a fixer was acquired on the job with little or no formal instruction. This situation has now changed. Most machines now have microprocessors and other electronic components as well as sophisticated sensors and yarn splicers and knotters. This equipment is well beyond the experience that workers might get in their homes, and operating the machines does not provide much of a sense of what it takes to repair and maintain them. Now, technicians must be able to follow complicated manuals and updates provided by the manufacturers. For example, the maker of popular open-ended spinning equipment provides a school (for a fee) to teach technicians to repair the equipment. The course lasts about six weeks and graduates say that the basic goal of the course is to teach the students to use the manuals. Obviously literacy is much more important. Indeed, the director of a textile school that granted one- and two-year degrees in various textile fields said that one of his most important roles was to raise the basic literacy skills of experienced textile workers to a level adequate for them to absorb the knowledge and information necessary to work on the new equipment.

Technicians and fixers are also very much affected by the types of organizational and work process changes discussed above. For example, if mills are organized along product-oriented lines instead of functional lines, then it may be more difficult for fixers to specialize on one machine. Either the fixer will have to have knowledge of more machines or, in order to be fully utilized, will have to work in more than one department, making supervision and management more difficult. Certainly the increasing demands as a result of greater style changes, more involvement with product development, and practical innovations, all apply even more to technicians than they do to operators.

Finally, given the traditional training system in the industry, which will be discussed in more detail below, the nature of the skills of the technicians and fixers have implications for the characteristics of the entry-level workers. It is still the predominant practice in the industry to fill almost all of the skilled positions from the internal promotion of production workers originally hired as unskilled workers or operators. Viewed in this dynamic perspective, increasing the demands for the skilled positions will, in the long run, affect the preparation required for entry level workers.

Conclusion: The Concept of Skill

Conclusions about the skill impact of changes in the technology and markets of the textile industry depend on the definition of skill. Much of the discussion about deskilling has been based on a narrow conception of skill which involves an individual's ability to work with a particular technology in a well-defined environment. Especially for blue collar work, this focuses on the amount of experience and training necessary to operate or repair the relevant machines. According to this view of skills, textile operators' jobs require no more skill and probably less than they did previously, but technician and repair jobs require more skill.

The research carried out for this case study as well as others suggests that a broader concept of skill is necessary for understanding current changes in employment.[46] This concept includes not only the mastery of particular machine but also the ability to interact with others, to anticipate problems, to have a broader understanding of the production process and of the individual worker's role in that process, and to operate in a more uncertain and variable environment. The distinction between these two concepts of skill also has to do with the difference between a concrete and an abstract understanding of the tasks and functions that must be carried out. A concrete grasp of a problem allows specified reactions to known stimuli, while an abstract understanding is necessary in a more uncertain and variable environment. According to this broader conception of skill, forward-looking textile employers are looking for more skilled workers to fill operator as well as technical positions. Finally, the argument for higher entry-level requirements will be even stronger if the industry continues to expect to fill skilled positions through internal promotion.

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[46]See Bailey and Noyelle, note 3, for a review and discussion of this research.

Chapter 5: Textile Education

The education systems that prepare the textile workforce have responded only slowly to the technological developments in the industry. Indeed, the traditional training patterns still predominate, but strains are developing. Firms are beginning to experiment with solutions to these problems, and the new circumstances are opening up new opportunities and challenges for the school system. Challenges that have so far only been met sporadically.

The traditional employment structure in most firms comprised two well-defined job ladders. Unskilled workers would be hired for service jobs--cleaning and moving material around. They would then move up to progressively more complex operator jobs. Those with aptitude and interest were then trained as fixers or foremen and supervisors and sometimes even plant managers. Although large firms did provide some vestibule training, most training was informal. With the exception of generic occupations, such as air conditioning mechanic and electrician, skilled textile workers had no specialized training and usually were not high school graduates.

Upper level managers and higher level technical and sales personnel were usually college graduates, or at least they were not normally products of the internal promotion system. The managerial positions were often filled by family members, but when outsiders were recruited, they entered at management trainee positions. Trainees were usually graduates of general colleges or one of the specialized textile schools, such as those at the Philadelphia College of Textiles and Science, the Institute for Textile Technology, the North Carolina State School of Textiles, Clemson University, Auburn University, and the Georgia Institute of Technology.

The internal promotion system filled two important functions in the textile employment structure. Internal promotion was a crucial component of the paternalist employment system rooted in the traditional mill town. Even today textile managers see the opportunities that internal promotion provide as an important benefit to working in the industry; all of the mills visited for this project had job bidding systems to regulate promotion through the ranks. Workers have come to see these opportunities as rights. For example, one manager who believed that none of his semi-skilled workers would be able to handle a skilled position for which there was an opening advertised for recruits without using the name of the firm in order at least to postpone the antagonism that this would cause within the mill.

While providing benefits to the employees, the internal promotion system also gave the firm more control over its skilled workforce. The knowledge and skills that they learned were very specific to the textile industry and the many unskilled and semi-skilled workers provided a large and ready source of recruits for the skilled positions. The unskilled workers were often high school dropouts or, in any case, had no more than rudimentary literacy skills; the skilled workers too had little education. This further restricted their mobility outside the industry.

Workers with a broader technical or mechanical background would have more options outside of the industry. And the skills of workers with specific and narrow skills were adequate in an industry in which technological change was slow. Moreover, as long as firms produced long runs of standardized goods using large numbers of identical machines, skilled workers could be fully utilized on one or only a few types of equipment. All of these factors tended to keep down the differential between the wages of skilled and unskilled workers.

One implication of this system is that there is very little role for a junior college or vocational education system in the training of skilled workers for the basic textile jobs, although the industry does draw on community college graduates for the small number of generic jobs, such as electrician and air conditioning mechanic.[47] Thus in North Carolina, the state with the most textile jobs in the country as well as one of the most extensive vocational education systems, there is little interaction between the industry and the community colleges.

There have been many attempts to foster relationships between the community colleges and the textile industry. Some of the colleges have tried to develop curricula and programs that would serve the industry. For the most part, these have not been successful. Programs start up, attract a few students, and then fade away. Indeed, in the 1985-86 school year, of the 75,000 students enrolled in technical degree programs (leading to a two-year associates degree) in North Carolina community colleges, only six individuals were enrolled in programs directly for the textile industry (textile technology and management). About 2,000 students were enrolled in programs that were more broadly related to textiles--1,000 in manufacturing management programs.[48] The one-year vocational programs which enrolled fewer than 40,000 students do provide more training for blue collar jobs, but none specifically for textiles and there were only about 5,000 students in occupations that might be drawn on by the textile mills and 60 percent of those were in air conditioning and electrical installation and maintenance.[49]

In working with textile managers, the vocational schools in the South have to overcome the legacy of the historical relationship between the education system and the textile industry and of the social

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[47]One spinning mill had three machinists and two electricians and one air conditioning mechanic out of 131 workers. In the rest of the workforce, there was one fixer or technician for every three to four workers.

[48]The other programs included air conditioning mechanic, fashion marketing and design, industrial engineering, manufacturing engineering and manufacturing resource planning.

[49]The system also enrolled about 60,000 technical students and 9,000 vocational students in unspecified "special study" programs. North Carolina Department of Community Colleges, Annual Enrollment Report: 1985-1986, Volume 21. Raleigh, NC: Department of Community Colleges, 1986, Table 4.

structure that developed to supply the mills with labor. Through the 1950s, textile mills drew on a labor supply residing in the local community. The mill was often the only major business in the area and opportunities outside the mill or one like it were limited. Although education was also limited, the mill could draw on a heterogenous labor force that was for all intents and purposes confined to the mill town. The management in the mill could quickly spot the ambitious and energetic workers who would be promoted to the skilled and supervisory positions. The technology and lower-level managerial practices were such that the educational preparation required as a base for this career progression was modest. Thus most mill workers did not have or need high school degrees. In fact, the formal education system was seen as a threat. As one economic historian of the South put it, "cotton mill managers knew that a high school diploma was as good as a ticket to leave the mill village."[50]

There are remnants of this attitude. North Carolina community college professors at two colleges in counties with many mills and officials at the state level remarked that some mill owners had complained that graduates of the community college programs expected wages that were above what the owners thought that the graduates should be earning. No manager I talked to sought to recruit young vocational school graduates, with no textile experience, to skilled or even trainee positions, other than in such generic occupations as electrician. Managers expressed their reasons in different ways. One said that the wage expectations of community college graduates were too high. Others simply said these graduates did not want mill jobs.

Indeed, the establishment of the North Carolina Community College System in the 1960s represented a movement away from the low-wage strategy on which the competitive position of the southern

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[50]Gavin Wright, "The Economic Revolution in the American South," The Journal of Economic Perspectives ., Summer 1987, p. 170.

manufacturing industries had been based.[51] It signalled the shift towards other industries in the southern economic base. And this broad shift is reflected in the attitudes of current students. Just as the state set up the colleges to reduce its dependence on the low-wage manufacturing industries such as textiles, today's students go to the community colleges precisely to launch careers outside of the mills. The image of a low-wage declining industry that has to be protected from foreign producers is hardly conducive to industry recruitment. And the South's growing service industries offer alternatives with better images, if not necessarily better wages. While 5,000 of the 75,000 technical-program students in the community colleges in 1985-86 were studying for occupations that might be useful for the textile industry, 35,000 were preparing for jobs directly related to office work in service functions--accounting, business administration, business computer programming, general office technology, or executive secretarial training programs.[52]

Therefore, the mill owners are probably correct in their perception that they would have to raise wages substantially to attract graduates of junior college degree programs for their skilled positions or even to give high school graduates an incentive to enroll in such programs. This would not only increase costs, but also disrupt the existing wage structure, creating resentment among skilled workers who had worked their way up through the ranks but who were earning lower wages than the new recruits.

In addition to these social issues, technological problems stand in the way of more interaction between the textile industry and the community college or vocational education system. Paradoxically, although the community colleges represent a new era in southern

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[51]This argument is developed in Gavin Wright, Old South New South: Revolutions in the Southern Economy since the Civil War. New York: Basic Books, 1986.

[52]North Carolina Department of Community Colleges, note 49, Table 4.

economic history, it is unlikely that they will be in the vanguard of technological or organizational developments in a rapidly changing industry. It is almost impossible for most schools to have the latest equipment. Neither can the relatively low paid teachers with heavy teaching loads be expected to keep abreast of the latest innovations in the industry, especially since most of those innovations are imported. For example, "quick response" is similar to the just-in-time inventory system used in Japan.[53] Even if it cannot teach the very latest trends, which in any case are only used by a minority of textile firms, the post high school system could offer a technical education at a more general and theoretical level. But once again, the historical tradition of training in the industry, which has emphasized narrow and very concrete training for particular machines, leaves little room for this more general mission, at least for its production level workers.

The education system for production level workers that developed was in tune with the technological requirements of the industry in an earlier era and consistent with the social structure in which that industry was located. Two factors were fundamental to the operation of this system: a labor force with limited alternatives and a technology that could be operated, maintained, and repaired by a workforce with little formal education, usually not even a high school degree. The emphasis on producing long runs of standardized goods was particularly conducive to keeping the skill requirements down.

Both of these conditions have now changed. Although there continue to be some mill towns and some areas that are dominated by textile employment, the industry can hardly count on a labor force with

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[53]At the time of one of our visits to a community college in July, 1987, the apparel marketing professor had only recently learned about "quick response." This was at least two years after the concept was extensively covered in the industry press. A professor at another North Carolina school who taught a textile sequence while he also taught other courses in the business school and took courses himself to upgrade his credentials knew very little about the latest developments in textile technology and organization or about textile programs in other parts of the state.

limited options. Indeed, a North Carolina community college official reported that a mill owner had complained to him about the state's programs to attract new business, precisely because it intensified competition for the local labor force. And the discussion in Chapter 4 argues that for several reasons the high school dropout is less adequate as the industry's technology and organization evolves.

The old system of entry-level hiring and internal promotion is increasingly problematic. Employers argue that they are having difficulty finding employees among their unskilled and semi-skilled workers who can be promoted to skilled and supervisory positions. Thus the personnel director of one large plant argued that he had run out of "promotable" semi-skilled workers. As long as three years ago, one mill in South Carolina emphasized that it was finding it increasingly difficult to find appropriate lower-level workers to promote. Other firms have begun to take steps to solve the problem internally. For example, one firm has begun to place a strong emphasis on improving the literacy skills of their workers. They estimate that at least one quarter of their employees are functionally illiterate. The CEO told the training director that "if you spent all of your time driving employees to reading classes, you would earn your salary." Staff members at the only vocational school in North Carolina that serves the textile industry exclusively (the North Carolina Vocational Textile School) emphasize that students often arrive with such weak basic skills that they cannot absorb the technical training that they need.

Current Trends in Textile Education

Three trends are beginning to emerge in textile education, at least in North Carolina--an increasing concern for the quality of secondary school education, a small increase in the use of the community college system to upgrade current textile employees, and an increase in training by the textile firms and equipment manufacturers. There is no trend towards hiring community college graduates with no textile experience directly into skilled production level jobs.

High Schools: Although there continue to be many employees in the textile industry who have not graduated from high school--indeed, none of the firms in our sample required a high school degree for many of their production level jobs--employers are working with local high schools and encouraging their workers to strengthen their literacy and to work towards a high school equivalency diploma. Every manager we talked to complained about the low quality of the education received by the labor force on which they draw for their entry-level workers.

Upgrading and the Community Colleges: The second important trend involves training and upgrading of experienced workers. In this area, the North Carolina community college system has had some success in working with the industry. The system's most successful program is run by the North Carolina Vocational Textile School (NCVTS). This school offers two-year programs for technicians and repair personnel, one-year programs for machine operators and extension programs usually carried out at mills.[54] The total student count for this school rose from 563 in 1982 to 1,143 in 1987.[55] The school is engaged almost exclusively in upgrading current textile employees. Fewer than ten of the students in 1987 came directly from high school.

The staff at the school emphasize that they provide a practical education whereby students spend a great deal of time operating and repairing the machines that they will work on at their jobs. The school also provides a more theoretical foundation, but always in the context of the actual job functions. For example, workers training to work in a dyeing and finishing plant also do projects in the school's lab so that they get an understanding of the processes their firms must go through to design the dye workers' functions.

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[54]Some employers prefer on-site programs because they fear that their employees might be recruited by other textile firms if the students are all thrown together.

[55]Data provided by the school.

Since the school is devoted entirely to textile education, it has been able to focus its resources on acquiring up-to-date equipment; and the school's president has arranged for his faculty to visit the most modern plants, some abroad, so that they will be knowledgeable about the latest innovations. And in contrast to some faculty in the general community colleges, the faculty at NCVTS was knowledgeable about recent organizational trends such as "quick response." Recently, in fact, the instructors have begun to emphasize the skills and knowledge necessary to carry out style changes quickly and efficiently.

The few successful programs at the 58 other schools in the state's community college system have also been either direct extension programs or upgrading programs for current employees. This type of upgrading education is attractive to the industry because it is consistent with the industry's historical pattern of internal promotion and does not require the direct hiring of educated workers for the skilled production positions which might cost more and might disrupt traditional pay structures. On the other hand, the current financing system for the community colleges discourages extension programs. Schools are funded based on the full-time-equivalent enrollment from the previous year, but they receive less than half as much for a full-time-equivalent extension student as for a full-time student enrolled in a one- or two-year degree program.

Internal Training: Finally, according to personnel officials, there is an increase in training provided by the firm and by the machinery manufacturers for a fee, especially for open-ended spinning frames and shuttleless looms. The manufacturers obviously have the appropriate equipment and they provide very specific information about the machines that the mills actually have. A typical program will last a few weeks and take place at a centralized site. But there is no special program for much of the new equipment. One spinning mill had developed its own courses for many of its machines. Just the growth in the number and variety of machines that they are using has forced them to increase their training. The manager of a home furnishing mill reported that there had been a large increase in what he referred to as efficiency training--short courses to teach employees to use new machines and techniques.

<u>An Example</u>: The contrast between the training systems in two firms in our sample is suggestive. One firm with 14 plants explicitly followed a commodity production strategy. All of its plants were similar except for the differences between open-ended and ring spinning processes. Style variation was limited to changes in the fiber blend and yarn count and the firm never produced a yarn type for which it did not have at least two customers. It also set a minimum order size of 25,000 pounds. This firm had no formal internal training, although every year it might send one or two students to the NCVTS and a similar number to a manufacturer's training course.

In contrast, a nearby firm, also with 15 plants, followed a completely different strategy, producing yarn for a variety of different markets including apparel and carpets. It emphasized its willingness to produce short runs and fill-in orders. One of its plants was designated as a "shift" plant that could be used for very different types of products. It had organized its plants into smaller departments. Though each firm included all of the manufacturing processes from carding to winding, the commodity firm still used large functionally oriented departments. In addition to sending some students to the NCVTS and the machinery manufacturers, this firm had its own special training department with an extensive formal training system. It placed a strong emphasis on upgrading the basic literacy and numeracy of its workforce and had separate training cycles for 85 different jobs. The firm brought in local community college faculty to teach more general courses including textile mathematics, computer fundamentals and leadership development. The more extensive training effort in this firm was not a result of more advanced technology; the commodity firm was at least as up to date.

This example is suggestive of how different organizational and training systems are appropriate for different production strategies. The commodity firm was, at the time of this research, in a strong market position and was widely know to produce an excellent product; yet it used a traditional organizational approach, invested heavily in new technology, and did not emphasize employee training and education. The other firm, also profitable and growing, emphasized flexibility and sought out small orders, but correspondingly used an entirely different production strategy, emphasizing training and searching for more efficient forms of work organization.

The Emerging Pattern

The basic outline of an emerging pattern can be seen in these developments. First, although there are still many jobs in the mills that require few skills, and high school dropouts are still hired, employers would like to recruit entry level workers with at least a good basic education. Thus they are increasingly concerned about strengthening the secondary school system that should provide that basic preparation. Second, despite the increasing skill needed to maintain and repair the equipment, the industry has not moved towards direct hiring of workers with higher levels of initial education; instead, they are trying to incorporate the additional educational demands into the traditional internal promotion system either through internal training or through using the community colleges for upgrading.

Chapter 6: Conclusions: Future Directions for Textile Education

Although the textile industry has important particular characteristics, the technological and market changes that are the focus of this report have had profound effects throughout the economy. A case study of the banking industry[56] carried out in conjunction with the textile project and studies of other industries have arrived at similar findings about the skill and educational implications of those changes. In this chapter I will review the main conclusions of the report in light of the results of that previous study and of other research on technology and skills. I will then discuss the particular educational implications of those conclusions for the textile industry.

Technology, Flexibility and Work Organization

As in the banking industry, the relationship between new technology, particularly programmable micro-electronics, and flexible production is ambiguous. In textiles the modernization drive was well underway before the industry started its current efforts to promote flexibility and quick response. Moreover, there are limitations to a purely technologically based flexibility and firms hav had to turn to organizational changes in order to squeeze more flexibility out of their production technology. The relationship in banking is different. Micro-electronics has been a crucial factor in the explosion of products and services available from financial institutions; nevertheless, without organizational innovations, banks have been unable to take advantage of much of the potential of the new technology.

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[56]See Bailey and Noyelle, note 3.

Skill Changes

The effect of new technology on the nature of required skills continues to generate controversy. Many analysts argue that modern micro-electronic technology is generally used to lower skill requirements and there are frequent discussions in the textile press about the potential for "deskilling."[57] In the textile industry, the skilled jobs in the plants--machine repair and maintenance positions--require more training and higher skills. Furthermore, there is no proliferation of low skill jobs in either the textile and banking industries; rather, there is a shrinkage of lower-level, unskilled jobs in both industries, although this trend has been stronger in banking. Nevertheless, it is true that in textiles many of the tasks previously done by the lower level workers, particularly the machine operators, require no more skill and in many cases less skill than previously. In this sense it could be argued that there is deskilling in the industry.

But this does not take account of the changes in production organization that are also taking place in many industries. As a result of these changes, for many textile and banking firms, the role of lower level workers has changed in such a way that their jobs are more demanding than they were previously. These jobs require not only aptitude in a broader set of tasks, but also require a more abstract understanding of those tasks and their relationships to the production processes and markets of the firm. Some case studies of other industries in both the manufacturing and the service sectors have found

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[57]For reviews of this debate, see Barbara Baran and Carol Parsons, "Technology and Skill: A Literature Review," prepared for the Carnegie Forum on Education and the Economy, Berkeley Roundtable on the International Economy, University of California, Berkeley, CA, 1986; Patricia Flynn. Facilitating Technological Change: The Human Resource Challenge. Cambridge, MA: Ballinger Publishing Company, 1988, Chapter 3; Henry Levin and Russell Rumberger, "Educational Requirements for the New Technologies: Visions, Possibilities and Current Realities," Unpublished, Palo Alto, CA: Stanford University, 1986; and Kenneth Spenner, "Upgrading and Downgrading of Occupations," Review of Educational Research 55, Summer 1985, pp. 125-154.

this type of skill broadening.[58] In the end, even those executives who look forward to the day when their new machines will deskill the operator jobs would balk at using the same labor force as the fast-food industry.

Preparing the Skilled Workforce

Since World War II, many industries, including textiles, have relied on internal training and promotion to fill many of their skilled positions. Over the last five years, there have been growing indications that there is a trend away from this traditional pattern of promotion. The banking study as well as case studies of the insurance, telephone, department store, and restaurant industries suggest that firms have been reducing their long-term commitments to workers, reducing internal job ladders, and increasing the number of ports of entry to which access is determined by educational credentials, and relying more on short-term and part-time workers at lower levels and specialized professionals at more skilled levels.[59]

In the textile industry as well, there are serious problems with the traditional system of internal promotion. These result primarily from the increases in skill requirements for technical jobs in the

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[58]Paul Adler, "Rethinking the Skill Requirements of New Technologies," in High Hopes for High Tech, Dale Worthington, (ed.). Chapel Hill, NC: University of North Carolina Press, 1986; Baran and Parsons, note 7; Larry Hirschhorn, Beyond Mechanization: Work and Technology in the Industrial Age. Cambridge, MA: The MIT Press, 1984; and Olivier Bertrand and Thierry Noyelle, The Development and Utilization of Human Resources in the Context of Technological Change and Industrial Restructuring: The Case of White Collar Workers, Expert Report. Paris, France: OECD/CERI, 1984.

[59]Eileen Applebaum and P.S. Albin, "Computer Rationalization and the Transformation of Work: Lessons from the U.S. Insurance Industry," in The Transformation of Work? S. Wood (ed.). London, England: Hutchinson, 1988 forthcoming; Thomas Bailey, Immigrant and Native Workers: Contrasts and Competition. Boulder, CO: Westview Press, 1987; Bailey and Noyelle, note 3; Thierry Noyelle, Beyond Industrial Dualism: Market and Job Segmentation in the New Economy. Boulder, CO: Westview Press, 1987.

plants. Thus it is much more difficult for industry's traditional unskilled workforce to acquire the skills for those jobs entirely through informal on-the-job training.

If the textile employers follow the pattern developing in other industries, one solution would be to shift away from the emphasis on internal promotion, separating the lower level employees from the skilled workers and supervisors, and creating a new port of entry in the industry at the level of the technician or skilled worker. Thus the skilled workers would be hired directly from vocational schools or community colleges. This would alleviate the problem of hiring promotable workers at the lowest levels.

From the point of view of the firm, this approach has several attractive characteristics. It reduces the pressure on wages for lower level workers, and much of the training burden would also be removed from the firm. The technicians would be well trained and have a broad theoretical background that would give them greater ability to adapt to the inevitable technological innovations. Textile technicians would become professionalized much like accountants--that is their careers would depend on the quality of their skills and less on their attachment to a particular firm. At the same time, the firm's investment in and commitment to individual skilled workers would be reduced. This might make it easier to expand or to contract the firm's workforce (since less of a commitment is made to the employees) as market and technological conditions change.

But there is no discernable trend away from internal promotions. There are several practical reasons for this. First, students go to community colleges to find jobs outside of the mills, rather than to prepare themselves for skilled mill jobs. Substantial wage increases might overcome this problem, but employers are reluctant to offer them both because doing so would disrupt traditional wage relationships and because they want to keep costs down. In addition to upsetting traditional wage relationships, this strategy would also reduce the promotion opportunities available for the lower level workers, opportunities that have traditionally been open to them. Another serious problem is that individual community colleges cannot make the capital expenditures necessary to keep their equipment up-to-date.

Thus the textile case seems in contrast to evidence from other industries. Indeed, by increasing emphasis on internal training to facilitate promotion of their unskilled workforce, the industry appears to be strengthening rather that weakening its internal labor market.

Implications for Textile Education

Changes in the textile industry's markets and technology have implications for both the content of education and for the place where education takes place, in particular, the changing roles of the firm and the outside system of schooling in providing education and training. Each of these areas will be discussed below.

Three Suggestions for Educational Content: **1)** Perhaps the most straightforward and uncontroversial implication of this analysis is that the industry needs a workforce with better basic literacy and technical skills. Whether the skilled workers are trained by community colleges or by the firms, that training needs to build on a basic secondary-level educational background in math, electronics and computers. And in the new textile environment, operators too, I have argued, have more demanding jobs, although the relationship between the broader conception of skill on which this conclusion is based and the content of education is not well understood yet. From this point of view, the textile industry has a very large stake in the quality of the secondary education system in the regions where textile production is concentrated. The particular problem for a low-wage, declining industry such as textiles is that, as long as these adequate basic skills are not universal, those few workers who do have them are likely to go elsewhere for employment.

2) In many firms, workers at all levels are expected to operate in a more uncertain and less well defined environment. This suggests that they need to have a more abstract understanding of their role within the production processes and market strategies of the firm. Thus, educators need a better understanding of how they can promote an orientation among their students at all levels that would better prepare them for a work environment in which abstract thinking is increasingly important.

3) As work moves from a mass production focus to one that emphasizes flexibility, group interaction and social skills become more important for skilled and less-skilled workers alike. We need to strengthen students' abilities to work cooperatively as part of a group.

Since Japan seems to have had more success at this than the United States, there may be some useful lessons in that country's education system. A recent report by the U.S. Department of Education on Japanese education described the importance of small cooperative study and work groups called han in the elementary school classroom. The han is also the core unit for discipline and classroom chores. Japanese teachers also rely on rotating student monitors for classroom mana_ nent and discipline. The report concludes that,

> Through the use of han and monitors, teachers delegate much responsibility for classroom management and discipline to the students themselves. Through frequent rotation of roles and responsibilities, all students have the opportunity to gain leadership experience and develop first-hand understanding of the importance of cooperation and mutual effort in achieving a smoothly run classroom.[60]

Of course it is not obvious that this teaching technique would have the same effect in the social and cultural environment in this country.

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[60]U.S. Department of Education, Japanese Education Today. Washington, DC: Government Printing Office, January 1987, p. 27.

After all, in Japan this experience with group autonomy and individual leadership is carried out in the context of classrooms and schools that are ultimately much more authoritarian than schools in the U.S.[61] Nevertheless, schools could certainly place a greater emphasis on group work and learning and take a more conscious approach towards developing their students' ability to interact with others and to work together.

Internal and External Education and Training: Although the textile industry does not appear to be moving away from its traditional system of internal promotion, that may not necessarily be the optimal strategy for the industry. The two most important barriers to a more open system were the unwillingness of post-secondary school graduates to work in the mills and the high cost of the modern equipment needed for the schools to provide up-to-date training. But there are possible solutions to these problems. Substantial wage increases might attract the labor supply; and the establishment of specialized schools within the community college system, such as the North Carolina Textile Vocational School, could concentrate resources, allowing for the purchase of modern equipment. Nevertheless, there are two good reasons why the industry should continue to promote its policy of internal promotion.

First, one reason that reducing the industry's reliance on internal promotion seems attractive is that the gap in the skill requirements for operators and for technicians appears to be growing. Thus if a good source of skilled workers could be found, then there would be less need to find lower level workers who could potentially be promotable. Although the tasks of the low level workers are now easier

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[61]The conditions in the Japanese schools may be a closer match with conditions in the factories in the sense that managers, whether in Japan or the United States, may want their production workers to be more autonomous and take more initiative, but they want that behavior to be contained within the limits of the firm's authority. Thus transferring the han concept to the U.S. in order to better prepare the production workforce might work best if the overall school system were made more authoritarian. But in U.S. society, this is unlikely as there would be many social and cultural objections to this type of reform.

(lower skilled in the narrow sense), the environment in which they are working has changed. In this new environment, marginal, high turnover workers with little education probably will not be effective. Therefore, the growth of the skill gap between operators and mechanics may be more apparent than real. To be sure, higher level positions do require specialized instruction that is difficult to provide through the industry's traditional system of informal on-the-job training. Nevertheless, if the industry does improve the general educational preparation of its lower level workforce, as this analysis suggests, that labor force could once again serve as an adequate pool of recruits for the skilled positions.

Second, the textile industry still has many entry level jobs, although they are declining. In many industries, those unskilled jobs are disappearing even more rapidly, but the barriers to automation in textiles will at least slow down the replacement of low skilled workers by automated systems. The industry also has a job ladder that can still, albeit with the aid of significant training, bridge the distance between the unskilled and skilled textile positions. As a matter of public policy, it seems appropriate to try to preserve the industry as a locus of opportunity for those workers who do not have post-high school degrees. A strong extension program could counteract some of the incentives firms have to move to higher points of entry, and the robust tradition of internal promotion should strengthen the possibilities that this strategy could be successful.

Thus, rather than focus on means to hire skilled workers from the outside labor market. the long-run interests of the textile industry would be better served by strengthening the basic preparation of the industry's workforce and developing appropriate measures to promote internal upgrading. This builds on the strengths of the current system of internal promotion, and addresses directly its weaknesses.

The Role of the Community Colleges: The internal training strategy appears to leave little role for the community college or vocational education system since the industry would still take entry workers without post secondary education and subsequently upgrade them. But rather than bypassing the vocational education system, this strategy changes its role from pre-employment preparation to educational extension or to mid-career upgrading. This is consistent with the past successes of the community college system in North Carolina. At least in that state, this suggests that the vocational education system might be better able to serve the textile industry if the Department of Community Colleges moved away from a system of incentives that encourages the use of one- and two-year degree programs and discourages educational extension.[62]

A few of the largest firms already provide extensive training. But there are several reasons why a closer involvement of the vocational system might benefit even the large firms. The educational system has more experience in teaching basic skills and may therefore be in a better position to integrate the strengthening of basic skills into the teaching of more specific skills. The large firms also have a stake in the health of small and medium sized firms. The large firms may use, or want to move towards, a strategy of using smaller firms as subcontractors, but this requires a technologically sophisticated cadre of entrepreneurs. Finally, it is the large firms themselves that are in fact providing training for the smaller firms. For example, the personnel manager of a textile firm with about 1,000 employees said that Burlington and J.P. Stevens, two giant textile firms, were his best sources of trained technicians and supervisors.

From the point of view of the large firms, a stronger vocational system might save them the cost of training workers who end up in other firms. From the point of view of the industry as a whole, with the current system, many managers and workers in smaller firms are trained and socialized in the culture and production processes used by huge

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[62]The schools in the system receive higher compensation from the state for full-time-equivalent students in degree programs than they do for full-time-equivalent extension students.

corporations. The industry might be more flexible and innovative if there were stronger two-way interaction, but this will not happen unless sophisticated training is available in the smaller firms.

Finally, a strengthened community college textile program should be better integrated into the innovation and research orientation more characteristic of universities. Just as progressive firms should want to encourage their shop floor workers to be more actively engaged in responding to the often idiosyncratic needs of the customers, then the institutions in which they are trained and prepared should start the process of integrating them into an active culture of innovation and flexibility.

In many ways, the education system faces the same problems as the country's employers. If we must move from mass production to flexible production, can we also move from mass education to what might be called flexible education. Mass education has brought literacy to all social classes, just as mass production brought the Model T to the family farmer. The mass producer has looked to technology, the reorganization of production, changing relationships with customers and suppliers, and new types of skills in order to make the high quality, styled or customized goods previously only available to the rich affordable for many levels of society. The question we must face is what tools and strategies do educators need to develop and deliver to the widest possible segment of the population a flexible and innovative education more appropriate for the emerging economy.

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