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ABSTRACT

Work force issues regarding technological change, international trade, and changes in job skills were the subject of a series of studies of work force changes in U.S. industries. The studies examined the characteristics of employees in 61 manufacturing industries in 1960, 1970, and 1980 through data obtained from the Labor Demographics Matrices compiled by the U.S. Department of Labor. Differences in wages and education levels were compared with differences among industries with respect to capital equipment and other measurable characteristics. One finding indicated that industries introducing new technologies hired better-educated employees and paid them higher wages. The policy implication of this finding is that since new technologies create work environments that demand more learning, levels of investments in all levels of education must be improved. Another finding was that as international trade expands, the United States is specializing in learning-intensive goods and services. U.S. trade deficits have been concentrated among traditional industries whereas the country's comparative advantage is in skill-intensive goods and services. The policy implication of this finding is that federal and state economic development strategies should shift to a focus on and support for emerging high technology industries. (10 references) (YLB)

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Technological Change, Trade, and the Need for Educated Employees: Implications for Economic Policy

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Introduction

How are the accelerating pace of technological change and the restructuring of the economy affecting the type of employees that United States firms need? How does technological change affect patterns of international trade, and so affect the workforce? These questions are important. For decades, we have feared that new technology and increasing international competition were eliminating many jobs and reducing the skills needed to perform many others. Today we are becoming aware that employers are searching for better educated people, but we need to know why. Is it because of their better preparation for work? Their better technical skills? Or their ability to adapt? As the nation wrestles with ways to improve the quality of education, we must decide whether to emphasize basic educational skills, technical skills, or cognitive and "workplace" skills. Since education curricula and teacher skills cannot be changed quickly, we must attempt to anticipate, to plan for a more highly educated, trained workforce, capable of competing increasingly better in a world market.

These workforce issues were the subject of a series of studies of workforce changes in U.S. industries completed at the National Center on Education and Employment.

Data and Methodology

The studies examined the characteristics of employees in 61 manufacturing industries in 1960, 1970, and 1980 data obtained from the Labor Demographics Matrices compiled by the U.S. Department of Labor, Bureau of Industrial Economics. Differences in wages and education levels were compared with differences among industries with respect to capital equipment and other characteristics that could be measured.

In analyzing the comparative advantage of the U.S., manufacturing industries were divided into two classes: traditional industries and high-tech industries. High-tech industries were those with ratios of research and development to sales in excess of 0.05 percent. They included office computing machines, optical equipment, communications equipment, and electronic components and accessories. Other industries were classified as traditional industries.

Technology and trade are transforming many industries. But how important are these changes to the overall economy? Most of us believe that high-tech industries are highly automated, employing advanced equipment and few people to produce sophisticated products. This image is misleading. High-tech industries are not physical-capital intensive relative to traditional industries. They are human-capital intensive (see Table 1). High-tech industries employ scientists and technicians designing new products and improving production techniques. They also employ people in direct contact with customers to develop markets for new products. Employees in high-tech industries work with an average of only $12,200 of plant and equipment (in 1972 dollars). Employees in traditional industries work with an average of $17,700 worth of capital.

Table 1
Characteristics of High-Tech and Traditional Industries: 1980

	High-Tech	Traditional
Employment	2m	20m
Capital/Labor Ratio	12.2	17.7
Age of Equipment (yrs.)	5.8	6.9
Output ($billion)	73.2	833.5

Source: Bartel and Lichtenberg, "The Skill Distribution and Competitive Trade Advantage of High-Technology Industries," 1987.

Not only do high-tech industries employ more labor relative to capital, the labor that they employ is more educated. In 1980, 20 percent of those employed in high-tech industries had 16 or more years of schooling compared to only 11 percent for traditional industries; 62 percent had 13 to 15 years schooling, compared to 58 percent for traditional industries; and only 18 percent were high school graduates (or less), compared with 31 percent for traditional industries.

For several decades, high-tech industries have experienced patterns of growth quite different from traditional industries, with output per worker, capital stock, and real output growing much faster (see Table 2). With a small overall share of employment, high-tech industries account for a disproportionately large share of the growth in employment opportunities.

Table 2
Annual Growth Rates 1960-80: High-Tech and Traditional Industries

	High-Tech	Traditional
Employment	0.89	0.15
Capital Stock	3.30	0.92
Real Output	3.58	0.84
Output per Worker	1.43	0.60
Capital/Labor Ratio	1.27	0.67

Source: Bartel and Lichtenberg, "The Skill Distribution and Competitive Trade Advantage of High-Technology Industries," 1987.

The difficulty with analyzing how new technologies affect the demands for education is that neither the newness of technology nor the responses by employers can be directly measured. Therefore, these studies were forced to rely on proxy measures. The newness of technology was measured in several ways. First, the mean age of equipment in an industry was used on the presumption that industries experiencing rapid technological change purchase new equipment that embodies the new technology. Of course, industries where demand has been growing rapidly will also have purchased new equipment, although they may not have taken on new technology. Therefore, when estimating the effect of the age of the capital stock, the past rate of growth of employment and output by industry were also included.

The second measure of the extent to which industries were adapting to new technologies was the level of investment in research and development expressed as a percentage of total sales—R and D embodied in purchases of new equipment were calculated from input output tables. This measure was based on the assumption that new capital was more likely to embody new technologies in industries investing heavily in research and development. A third proxy measure was the value of each industry's purchase of electronic and computer equipment divided by that industry's total output.

Finding 1: Industries Introducing New Technologies Hire Better-Educated Employees and Pay Them Higher Wages

How are new technologies affecting jobs? What sort of skills are employers demanding to cope with rapid technological change? Answers to these questions are difficult because measuring technology is difficult, but also because our relationship with technology is ambivalent. Like Mark Twain, we applaud *progress*—with its abundance of new products and services—but we oppose *change*—with its mandate to acquire new skills and reorganize the workplace. How should employees perform on new equipment? What skills should managers demand when hiring or retraining workers? How will the shrinking supply of skilled new entrants to the workforce affect our ability to deal with new technologies?

Employers Hire Better-Educated Employees to Cope with Rapidly-Changing Technologies. A comparison of hiring patterns among industries finds that employers in industries with quick changing technologies cope by hiring better-educated workers. The younger the age of equipment, the larger the share of the industry's workforce that has had more than high school education. The effect was strongest among workers between 18 and 34 years old. The combined effect of the age of equipment and spending on research and development raised this share even more strongly, especially for younger workers.

But what is it about these new employees that makes them important assets in dealing with change? Education trains people to receive, sort out, and understand the implications of information they receive on the job. Economist Finis Welch (1970) argued that "educated persons can distinguish more quickly between the systematic and random elements of productivity responses." As they respond to change, they are more likely to make the right moves than people with less education. Learning takes time as employees experiment with different ways of using new machines, diagnose problems, and restructure jobs. It demands strong conceptual skills, not necessarily technical proficiency.

As technologies mature, research by Jacob Mincer (1989) and Lee A. Lillard and Hong Tan (1986) suggests that the need for educated and adaptable people declines. Tasks have become routinized and employees need clearly-specified skills that can be learned more easily on the job.

Employers Pay Well-Educated Employees More to Encourage Higher Performance. Employers in high-tech industries are willing to pay more for employees who are good learners. The studies found that wages paid to employees of all levels of educational attainment were higher in industries with younger capital equipment, with higher ratios of research and development to sales, and higher expenditures on computers—in other words, in high-tech, versus traditional, industries. These higher wages were not a temporary "adjustment." High-tech industries pay more not simply because they need more employees—the analysis took account of differences in growth rates of employment and still found that high-tech industries offered higher wages.

How quickly people learn on the job is determined by the *quality* as well as the *quantity* of the time they invest: the quality of their time is the product of how skillfully employees invest their time and how much effort they devote to the task. To encourage these new hires to work hard, employers must either monitor their performance closely or reward them for making greater efforts. Monitoring is difficult where new technologies have upset the traditional workplace structure. Therefore, employers offer higher wages to workers as incentives. This wage premium persisted over time, and was larger for younger workers between the ages of 18 and 34.

Policy Implications. The studies resolve the debate between those who have argued that technology—new ways of making goods and services, new materials, or new products and services—reduces the skills needed to perform jobs and those who argue that technology increases the skills needed to perform jobs. For the "de-skilling" argument see Braverman (1974). For examples of technology "up-skilling" jobs in the financial industry see Bertrand and Noyelle (1988). New technologies do both. While those technologies are being implemented, the need for better educated workers dominates.

Economists have long recognized that experience on the job makes people more productive. Everyone learns by doing, but not everyone learns at the same rate, and not every job requires the same amount of learning. New technologies create work environments that demand more learning. They are shocks that render obsolete much of the experience accumulated by management and by employees. Everyone, from top management to production employees, must learn new skills.

The pace of technological advance shows no sign of abating. Expenditures on research and development, one of the sources of new technologies, are rising as a share of GNP, from 1.65 percent of GNP in 1971 to 1.88 percent today. The increase has been more rapid in other developed countries: Japan expanded R and D spending from 1.84 percent in 1971 to 2.75 percent in 1985, and Germany increased spending from 2.03 percent in 1971 to 2.60 percent in 1986.

During the 1980s, in a move to strengthen U.S. manufacturing

industries, federal and state policymakers have attempted to encourage investments in research and development and to speed the rate of innovation. The tools include tax credits, changes in antitrust laws to allow industries to form research consortia, expansion of research grants, and the creation of "centers of excellence" at universities. If successful, these measures will accelerate the demand for skilled employees. The effectiveness and perhaps the levels of investments in all levels of education must be improved to meet the growing demands.

State and local governments attempt to stimulate local development by offering subsidies to attract businesses—including tax abatements and exemptions, low-interest rate loans, and grants for the construction of plant and the purchase of equipment (Clark, 1986). But this strategy will appeal to traditional industries more strongly than to high-tech industries because capital costs are a larger part of costs of the former. Their average capital/labor ratio is nearly 50 percent higher.

High-tech industries are likely to be influenced by the level of education of the local labor force and the quality of local schools, colleges, and universities because skilled labor constitute a larger share of production costs. Educated labor is vital for these industries in implementing young technologies. Communities attempting to attract rapidly growing high-tech industries should consider advertising the strengths of their education system rather than the value of their capital subsidies.

Finding 2: As International Trade Expands, The U.S. Is Specializing In Learning-Intensive Goods and Services

Emerging patterns of trade have become a major concern to policymakers. The expansion of exports and imports has meant an inevitable decline in the market share of U.S. manufacturers in world exports, from 13 percent in 1973 to 10 percent today. From approximate balance in 1980, the U.S. current account trade deficit—the difference between the value of U.S. goods and services sold to foreign buyers and the value of goods and services made overseas purchased by U.S. buyers from abroad—has grown to record levels. In May 1989, the deficit was running at an annual rate of over $135 billion (*The Economist*, 1989). About 80 percent of the deficit has been attributed to increased imports since 1979 of manufactured durable goods—electronics, automobiles, steel, and apparel—a development that has caused concern about the ability of the U.S. to compete in foreign markets. (U.S. Office of Technology Assessment, Technology and The American Economic Transition, 1988)

Is the nation's competitiveness in international markets threatened by a poorly skilled workforce?

U.S. Trade Deficits Have Been Concentrated Among Traditional Industries While the Country's Comparative Advantage Is in Skill Intensive Goods and Services. The rapidity with which trade has expanded has led to painful shifts in the U.S. economy. Traditional industries have shrunk—shoes in Maine, steel in Ohio, and copper in Arizona. But shrinking of traditional industries does not reflect the failure of American firms to compete as much as it reflects the exploitation of our comparative advantage. Shrinking industries are those in which the U.S. no longer enjoys a comparative advantage.

Trade occurs because nations differ in the goods and services that they are *relatively* good at producing, not because they are absolutely more efficient than other nations. As the level of international trade expands, *all* nations necessarily produce *more* of those goods and services in which they enjoy a comparative advantage—services and skill-intensive manufacturing in the case of the U.S.—and relatively less of other goods and services in which their trading partners enjoy a comparative advantage. For example, the U.S. imports a growing volume of durable manufactured goods from Japan and South Korea. It is easy to misinterpret the United States' falling share of world markets as the failure to compete. In fact, it may simply reflect the growing specialization from trade.

Aggregate trade data hide important sources of strength. The U.S. has enjoyed a stronger balance of trade in high-tech industries than in traditional industries. In 1984, exports of high-tech goods of $29.1 billion exceeded imports of $26.3 billion. Traditional industries experienced a deficit of $39 billion (on imports totaling $77.5 billion). Although high-tech industries accounted for 9 percent of manufacturing employment in the U.S. in 1980, they accounted for 44 percent of manufacturing exports. Less than 5 percent of the output of traditional industries was exported while 40 percent of high-tech output was sold overseas.

New technologies and the evolution of worldwide capital markets mean that many less developed countries are able to produce "capital-intensive" goods such as steel and automobiles whose production technologies are relatively mature, demanding large investments in plant and equipment and using a relatively unskilled workforce. The U.S., on the other hand, is specializing in the production of goods and services whose technology is rapidly changing and where it can profitably deploy its well-educated workforce.

In 1980, among developed countries, the U.S. had a labor force with, by far, the most years of education. (The quality of that education is another issue.) One in nine members of the civilian labor force had reached what UNESCO calls the third level of education, defined as "the successful completion of education at the post-secondary level." The nations with the next highest shares with third level education include the Netherlands (5.3 percent), Sweden (4.7 percent), Japan (4.5 percent) and the United Kingdom (2.0 percent).

The problems of workers displaced by trade, that some observers have attributed to the "failure" of the U.S. to compete in foreign markets, are due in part to the fact that the U.S. has established leadership in producing goods that demand well-educated employees, and in part to the

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corollary, a comparative disadvantage in producing goods that demand greater investments in physical capital.

Policy Implications. The emerging patterns of international trade will reinforce the growing need for better-educated workers caused by the increased pace of technological change. The U.S. enjoys a comparative advantage in exporting the products of its high-tech industries and of other activities that rely on "thoughtware" rather than hardware.

The U.S has created this comparative advantage over many years of investing in education. While Western Europe was rebuilding its physical plant after World War II, the U.S. created the G.I. Bill that extended participation in post-secondary education. States have rapidly increased spending on post-secondary education and training institutions. Today, government, households, and employers invest over $600 billion each year on education and training, more than is invested in plant and equipment (Vaughan, 1989).

Yet federal and state economic development strategies still concentrate on supporting traditional industries, through tax benefits, import tariffs and quotas (voluntary and involuntary), capital subsidies, customized training programs, and other means (Mackenzie, 1988; Clark, 1986). If these measures are successful, they will delay the movement of resources—human and physical capital, and management—into more productive uses in emerging high-tech industries.

Conclusion

Making full use of new technologies is possible only with workforce people who are good learners. The continued growth of high-tech industries is vital for the creation of new opportunities and for the United States' ability to pay for its imports of goods and services from abroad. Yet this sector depends heavily on a growing supply of better and better educated people.

Better-educated people, therefore, are needed not simply to *develop* new technologies but to speed their *introduction* to the workplace and to help employers *exploit* their full benefits. High-tech employers offer higher wages, not only to compete with other firms, but to encourage employees to adapt fast and to work hard in environments where performance cannot easily be monitored.

Because the United States has a more educated workforce than that of many trading partners, the rapid expansion of international trade is leading it to specialize in the production of goods that require highly-educated employees. The corollary of this growing specialization in knowledge-intensive activities is that the U.S. is also importing a growing volume of goods that require heavier capital investments and relatively larger numbers of unskilled or semi-skilled employees. The U.S. is, in effect, "exporting" low skill jobs.

Producing goods that are both knowledge-intensive and characterized by rapid advances in technology demands highly educated employees and uses little physical capital. Therefore, state and local development agencies will not attract high-tech firms with subsidies for physical capital—tax abatements, low-interest rate loans, or direct grants.

The relationship between earnings and education is likely to become stronger over time as trade continues to expand and as industry continues to exploit new technologies. A major challenge to policymakers will be to deal with a labor market in which economic success demands higher and higher levels of education.

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