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"Technology, Skills, and Education" by Laurie Dougherty

One aspect of inequality that has received a great deal of attention is the large gap in wages between people with higher education and to those with a high school diploma or less. Neoclassical economists attribute this to the dynamics of human capital, claiming that better educated workers are more productive and, therefore, better rewarded in the labor market. In trying to understand the upsurge of inequality in wages in the 1980s, many analysts turned to the burgeoning use of computer technology in the workplace as a contributing factor. An argument widely accepted among labor economists claims that technological change is skill-biased, that is, it raises the demand for workers with sophisticated skills and/or reduces the demand for less-skilled workers.

Other analysts challenge the idea that the relationship between technology and inequality is quite so straightforward. However, it is clear that new technologies raise skill levels in some occupations and reduce them in others; reconfigure the distribution of tasks; create new occupations and render others obsolete. The increasing complexity of living and working at the end of the twentieth century means that access to quality education is ever more important, for reasons that go beyond the returns to education that come in the form of higher wages.

In Volume 4 of this series, *The Changing Nature of Work*, we examined these changes and their implications for the work experience itself. In this section and essay we will review the arguments for and against skill-biased technical change and its implications for wage inequality (the trade and institutional theories are discussed in detail in other parts of this volume). We will also examine inequality in the education system itself.

TECHNOLOGY AND WAGE INEQUALITY

A major problem for economists with respect to the wage trends of the past two decades is that the premium paid for skills in the labor market has grown at the same time that the supply of more highly skilled workers has grown. This pattern emerges regardless of the empirical measure of skill that is used. Some analysts use education levels as a proxy for skills, while others use the broad occupation categories of production vs. non-production (or blue collar vs. white collar workers). By any of these measures, the share of highly skilled workers in employment and in the total wage bill has increased. (Berman, Bound and Griliches, 1994) Given this apparent anomaly, many researchers infer that the demand for higher skilled workers

must have grown enough to offset the difference in cost between high and low-skilled workers. (Acemoglu, 1998)

Table VII.1. Table Educational Attainment by Median Earnings and Gender, 1997

| | Male | | Female | |
|-------------------------------------|--------------------------|------------------------|--------------------------|------------------------|
| | No. with Earnings (000s) | Median Annual Earnings | No. with Earnings (000s) | Median Annual Earnings |
| Total | | | | |
| Less than 9th grade | 50,802 | \$35,715 | 34,611 | \$25,823 |
| 9th to 12th grade (no diploma) | 1,914 | \$18,551 | 791 | \$13,447 |
| High school graduate (includes GED) | 3,548 | \$24,241 | 1,761 | \$15,907 |
| Some college, no degree | 16,220 | \$30,655 | 11,470 | \$21,291 |
| Associate Degree | 9,169 | \$35,087 | 6,628 | \$25,035 |
| Bachelor's degree or more | 15,864 | \$51,198 | 10,425 | \$36,346 |
| —Bachelor's degree | 10,349 | \$46,255 | 7,712 | \$33,432 |
| —Master's degree | 3,228 | \$57,553 | 2,447 | \$41,856 |
| —Professional degree | 1,321 | \$78,290 | 488 | \$54,528 |
| —Doctorate degree | 966 | \$70,706 | 318 | \$50,758 |

Source: Excerpted from Historical Income Tables, p. 21 in March Current Population Survey, U.S. Bureau of Census.

Economic logic predicts that, in the absence of intervening factors, an increase in the supply of something should reduce its price: in this case more skilled workers should lead to a lower wage or salary paid to those with skills. Alternatively, faced with a highly-priced workforce, employers would be likely to substitute lower-priced (i.e., lower-skilled) workers in order to reduce labor costs. (Berman, Bound and Griliches, 1994; Mishel and Bernstein, 1999) In line with this prediction, a surge in college-educated workers in the 1970s was in fact accompanied by a reduction in the premium paid to college graduates; The experience of the 1980s, when both the supply and the wage premium of college graduates increased at the same time, is not as easy to explain. It is the events of the 1980s that gave rise to the hypothesis of a shift in demand for skilled labor.

Looking inside the pay gap between higher and lower-skilled workers we find that real wages for poorly educated workers have fallen sharply since the 1970s, while real wages for most other workers have fallen somewhat or remained stagnant. Only women with a college degree or better and men with advanced degrees have experienced real wage gains. Overall, only the top 10% of the wage distribution experienced substantial real wage gains from 1979-1997. (Mishel and Bernstein, 1999) While mainstream economists generally focus on the relatively higher demand for higher skilled workers to explain increased inequality, their critics emphasize the deterioration of wages for the less-skilled. The former approach leads to investigation of labor demand factors such as technological change or international trade as likely explanations for inequality; the latter leads to analysis of the collapse of wage-setting institutions.

THE MAINSTREAM ARGUMENT FOR SKILL-BIASED TECHNICAL CHANGE

Anne Bartel and Frank Lichtenberg claim that highly skilled workers are best able to use new technologies; therefore workplaces with high proportions of such workers will readily adopt new tools and methods. (Bartel and Lichtenberg, 1987) Making a similar argument but taking the question of causality one step farther, Daron Acemoglu argues that the increase in supply of college-educated workers after World War II, which accelerated after 1970, induced technological change in a manner that is complementary to highly-skilled workers. Technological change need not always be compatible with the skills of the workforce. In fact, as Acemoglu points out, technological change has often replaced rather than complemented workers' skills. He describes the relationship between skills and technology in the postwar era as the "directed technology effect."

Eli Berman, John Bound and Zvi Griliches demonstrate that the share of non-production workers in manufacturing employment has increased over time, and this increase accelerated in the 1980s. "Between 1979 and 1989 the employment of production workers in U.S. manufacturing dropped by 15 percent from 14.5 to 12.3 million, while nonproduction employment rose 3 percent from 6.5 to 6.7 million." (Berman, Bound and Griliches, 1994, p.368) Over two thirds of this shift in employment occurred within finely defined manufacturing industries. Between-industry changes can be attributed largely to the effects of trade and government procurement for defense purposes, but these factors cannot account for within-industry changes in employment share. The authors attribute the residual within industry shifts to technological change that reduces the need for production (vs. non-production) labor. They find this change to be correlated with changes in technology inputs, specifically investment in computers and research and development (R&D) expenditures. They corroborated their econometric results with reference to case studies of a number of industries undertaken by the Bureau of Labor Statistics (BLS). These case studies indicate widespread displacement of production workers by new technologies.

David Autor, Lawrence Katz and Alan Krueger extended the scope of this analysis to a broader set of industries, using data that cover both use of computers by individual workers and industry level investment and technology adoption. They also extended the time frame of their study back to the 1940s to capture the full range of experience with computers in business applications.

Their findings (summarized in *The Changing Nature of Work*) indicate that relative demand for college educated workers has increased over the past five decades, accelerating in the 1980s, and slowing somewhat in the early 1990s. "[W]ithin-industry skill upgrading increased from the 1960s to the 1970s throughout the economy, accelerated further in manufacturing from the 1970s to the 1980s, and remained high from 1990 to 1996." (Autor, Katz and Krueger, 1998, p. 1203) Autor, et al. included several measures of technology such as Current Population Survey (CPS) data on use of a keyboard at work; National Income and Product Accounts (NIPA) data on overall capital investment and high-tech capital intensity; and National Science Foundation data on R&D. They conclude that skill upgrading is greatest in those industries where computer use is heaviest. (Autor, Katz and Kreuger, 1998, 1997: Kreuger, 1993)¹

CHALLENGES TO MAINSTREAM THEORY: THE ROLE OF WAGE SETTING INSTITUTIONS

Trade and labor economists use different methodologies, and in earlier rounds of analysis often came to mutually exclusive conclusions, i.e., that either trade or technology or institutions account for a significant portion of the polarization of wages. Analysts who favor trade or technology arguments tended to eliminate the alternate theory as a viable explanation, even though both theories leave most of the increase in inequality unexplained. However, this dichotomy may be softening as researchers realize that their favored methods can only account for some part of the recent increase in inequality. Autor, Katz and Krueger point out that their findings of skill-biased technological change leave room for fluctuations in labor supply, globalization and institutional arrangements. (Autor, Katz and Krueger, 1998) Berman, Bound and Griliches point out that the share of manufacturing employment fell in the economy as a whole. This would tend to reduce the share of production workers overall since they are overrepresented in manufacturing. This effect is more susceptible to influence from international trade than the changes within manufacturing that they studied in detail.

Stephen Machin, Annette Ryan, and John Van Reenan, find evidence for skill-biased technological change in a shift toward higher proportions of skilled workers within similar industries in four countries (U.S., U.K., Denmark, Sweden). However, they also find that wages polarized most in the U.K and U.S. where institutional protections for workers are weak. Machin and Van Reenan confirmed these conclusions in a 1998 study of seven OECD countries and offer evidence for skepticism about trade as an explanation. Although they do not investigate labor market institutions, Machin and Van Reenan suggest that such an investigation would provide useful insights into the phenomenon they have described: similar within-industry indications of skill-biased technological change across several developed countries, but dissimilar wage patterns.

David Howell did undertake an analysis of changes in wage setting institutions in the United States. He argues that the changing institutional environment in the 1970s and 1980s led to the collapse of wages for the low-wage labor market. While he gives some credence to the role of globalization (trade and immigration) in increasing competitive pressure on low wage workers, he is critical of the skill-biased technological change hypothesis. Among other things he points out that the major shift in composition from low to high skilled labor occurred in the early 1980s before the upsurge in computer investment.²

Howell also points out that in several highly unionized industries with high-paid but low-skilled labor, from the mid-1970s to 1990 the share in employment of less-skilled workers did fall somewhat, but the share of low-wage workers rose dramatically. One among several examples he presents is the automobile industry in which the share of *low-skilled* employment went from 76% to 71%, but the share of *low-wage* employment went from 17% to 40%. Both Howell and Machin, et al. conclude that trade or technology may exert pressure on labor markets, but the distribution of wages depends on the institutional structure.

TECHNOLOGY IN CONTEXT

Pinning down the effect of technology on labor markets is difficult because the definition and measurement of relevant variables are not precise. Technology plays a complex role in the economy. For example, the availability of labor-saving technology may make the institutions that protect wages and working conditions either more or less effective. On the other hand, when technology raises productivity, wages can also rise without raising prices for goods and services, but here too, institutional factors determine the distribution of productivity gains.

The role of technology is also complicated by the pervasiveness of recent innovations in transportation and in information and communications technology. On the one hand, this allows multinational corporations to move production to low-wage locations. On the other hand it leads to what Adrian Wood calls defensive innovation, ie. using labor-saving technology in high-wage locations in order to compete with low-wage imports.

Autor, et al. have been criticized for concluding that use of computers raises wages, when it may be that computer use is picking up on the influence of other characteristics associated with education or occupation. John DiNardo and Jorn Steffen-Pischke, using a detailed data set of German workers, found that other variables, such as use of pencils or sitting at a desk, also had statistically significant and positive effects on wages. Since they do not believe that use of pencils and chairs lead directly to higher pay, they concluded that a similar analysis does not prove the existence of a causal link between computers and wages. It is equally possible that computers are associated with some as-yet-unobserved skills or that computers were first used jobs that paid more in the first place. DiNardo and Steffen-Pischke do not deny that computer technology has an impact on the workplace, but claim that the mechanism may be complex and indirect. This debate has been carried out over several years in working papers and in *The Quarterly Journal of Economics*. Two major articles, one from each side of the discussion, were summarized in *The Changing Nature of Work*.

While sticking with their conclusion that computers are implicated in recent increases in wage inequality, Autor et al. also point to research on changes in work organization and a heightened emphasis on customer service as factors raising demand for cognitive skills. Computers play a role in a general restructuring of tools and techniques. “We do not view the spread of computers as simply increasing the demand for computer users and technicians, but more broadly as a part of a technological change that has altered the organization of work and thereby more generally affected the demand for workers with various skills.” (Autor, Katz and Kreuger, 1998, p. 1186) They cite work by other researchers who found information technology associated with higher levels of education and training, greater responsibility and decentralized decision-making.

The Changing Nature of Work we also found much research that emphasized new configurations of skills. Team-based work organization requires that workers learn to perform multiple tasks, participate in decision processes, and negotiate tasks and responsibilities among groups of co-workers. Productivity and quality increases expected with the introduction of new technologies in manufacturing were usually realized only when compatible changes in work organization were undertaken. (MacDuffie and Krafcik, 1992; Ichniowski, Shaw and Prennushi, 1997) Other researchers have noted an increase in the need for “soft” skills. Soft skills

encompass a variety of attributes and attitudes including communications, teamwork, networking, entrepreneurship and managerial potential, motivation and the ability to learn and to adapt to changing technology and forms of work organization. The demand for these kinds of skills is particularly noticeable in situations where the workers are in contact with, or performing a direct service for, a firm's customers, but is also apparent in factory or office situations in which teamwork is prized and initiative is rewarded. [Moss and Tilly, 1996]

EDUCATION AND INEQUALITY

Despite the difficulty in determining exactly the impact of technology on wages, and particularly on our concern in this volume with wage polarization, there is no doubt that new technologies themselves require new skills, or that the diffusion of information and communication technology is changing the way work is done. However, technology is not the only influence on the workplace.

David Howell points out in a summarized article that in many U.S. industries both the share of high skilled employment and the share of low-waged employment have increased concurrently. This indicates a "hollowing out" of employers who had been in the middle region of skills and wages. At the same time as there has been a proliferation of low-wage, low-skilled jobs, there has also been a clear trend toward a greater share in employment for better educated workers over the post war period. This happens when jobs in unionized industries are moved to non-union plants, or when work is contracted to low-wage suppliers or assigned to lower-wage workers within the parent firm through two-tiered pay schedules or use of part-time or temporary workers.

Many of the problems of low-wage employment can only be addressed through the use of wage-setting institutions such as labor unions, a minimum wage adequate for a decent standard of living, and vehicles to bring wages and benefits for part-time or contingent workers in line (on a pro-rated basis) with full-time permanent workers. Social welfare benefits provided by the state, such as health care or pensions can also ease the burden of inequality faced by low-wage workers. However, even if such institutional programs were securely and generously in place, inequalities in the education system would still relegate some workers to more tedious, less rewarding jobs while offering others opportunities for prestige and fulfillment.

In developing countries, education nurtures the skills necessary for using and managing the new technologies that are required for growth (Behrman, Birdsall, Kaplan, 1996). One of the debates surrounding education in the development context concerns the distribution of educational resources. **Ajit Bhalla** cites World Bank research that concludes that widespread basic education is necessary for economic growth. Behrman, et.al, on the other hand argue that a highly educated elite is necessary for economic growth. While Bhalla's argument is egalitarian, it is focused on growth and engagement with market dominated economic forces. A broader discussion would place education in the context, articulated by Amartya Sen, of enlarging the ability of individuals to participate fully in community life as well as achieve economic well-being.

In developed countries, education has been seen as the vehicle for upward mobility. As the skill-biased technological change debate, discussed above, indicates, that is not always the case. The supply of educated individuals can overshoot market demand, or technology can make certain jobs obsolete, among the well-educated as well as among the less well-educated. Still, there is a high correlation between wages and educational attainment in industrialized countries

and justice requires that the opportunities afforded by higher education be distributed fairly. **Michael Hout, Adrian E. Raftery, and Eleanor O. Bell**, found, in studies of three countries (Ireland, U.K. and U.S.), that educational stratification tends to persist over long periods of time. Even while more people are achieving each level of attainment, relative positions will be maintained as long as some members of the upper class have not attained the highest educational levels. Among socioeconomic strata, all but the exceptional few will have to wait their turn. While the analysis put forward by Hout, et al. was directed toward the persistence of stratification, they also found evidence of an emerging underclass in the U.S. Although high school graduation had become almost universal, in recent years there has been an increase in the proportion of high school dropouts, particularly males, among the children of parents who did not themselves graduate from high school. This reverses the trend for later generations to graduate at higher rates than previous generations.

Henry Levin supports the view promulgated by John Dewey that education ought to be the leveling agent that eliminates the effects of disadvantage. To that end, fairness demands that educational resources be distributed according to need. He goes so far as to argue that where discrimination persists in society, those discriminated against will need superior education in order to compete adequately. Levin also argues that inequality in education has social costs in health, welfare, correctional institutions and lost productivity that far outweigh the costs of providing quality education to all.³

Recently several state-level challenges have been made regarding inequalities in the US public school funding. Since public schools in most states (California has been an exception) are operated by local districts, and funded mainly from local sources - usually property taxes - funding is highly unequal. These cases, often in the form of lawsuits claiming that local funding is unconstitutional, seek state-level funding to equalize resources across districts. Several have been successful and reform efforts are underway in several states. David Card and Alan Krueger, have also investigated questions related to the school funding equity debate. While some critics of funding reform object outright to the redistribution of resources from richer to poorer districts, others question whether increasing resources to school districts can actually improve student performance. Card and Krueger found evidence that increased resources improve both educational attainment and earnings. (Card and Krueger, 1996)

These issues concern equity in education for children and have important consequences for their ability to meet the 21st century on a level playing field. At the same time rapid changes in technology and work organization mean that many adults are also faced with the need for education and training. **Birgit Mahnkopf**, addresses this need in a critique of the German system of apprenticeship and training. This system is widely praised for its capacity to train young Germans, particularly young men, with appropriate skills and to integrate them into employment. However, as Mahnkopf points out, the programs are less successful at bringing women into desirable jobs, and have not been able to address fully the need for retraining adults with obsolete skills.

Martin Carnoy and Manuel Castells, in an article summarized in *The Changing Nature of Work*, call for a new outlook on employment which incorporates the need for periodic retraining and shifts of career emphasis at various stages of the life cycle. They envision a collaborative effort among businesses, governments, communities and families to ensure that innovation and flexibility can be accommodated, that skills are available when and where they are needed by

the economy, and that people are supported in their efforts to upgrade their skills and during periods of transition.

CONCLUSION

Equality in access to education and the application of educational resources is an important justice issue in a society where education is heavily rewarded. However attention needs to be directed toward the context in which those rewards are determined. There are many roles in society which do not require advanced education. People who fulfill these roles should not be excluded from the benefits of technological progress. There also needs to be more attention to aspects of education that are not solely productivity oriented, such as individual fulfillment and citizenship.

Notes

1. Berman, Bound and Griliches pointed out, without further analysis, that computerization is more extensive in service industries than in manufacturing. [Berman, Bound and Griliches, 1994] Autor, Katz and Krueger indicate that, historically, computers affected skill demands in services earlier than in manufacturing.
2. William Greider makes the point in *Secrets of the Temple*, his account of the role of the federal Reserve Bank in the U.S. economy, that recessions generate employment changes, but following the recession investment does not simply reproduce the old situation but uses new, often labor-saving, technologies. Therefore, technology preserves the drop in demand for less- skilled labor first created by recession. I have seen this at first hand, and also been told the same thing by the personnel manager of a large company whom I interviewed in conjunction with previous research.
3. In a critique of the *Bell Curve* by Hernstein and Murray, a group of sociologists from the University of California/Berkeley claim that inequalities in education, not deficiencies in intelligence, are responsible for the relatively poorer performance of blacks and other disadvantaged groups on standardized tests. [Fischer, Hout, Jankowski, Lucas, Swidler and Voss, 1996] Their critique is addressed in more depth in Section 8, but it has relevance here.