What's Driving Wage Inequality?

The Effects of Technical Change on the Labor Market

By Aaron Steelman and John A. Weinberg

Most of the time, we assess an economy's performance using broad aggregate measures of output and wealth. In this regard, the United States is doing quite well. It is the richest country in the world. U.S. gross domestic product exceeded $11 trillion last year—roughly $38,000 per capita. And despite the slowdown associated with the 2001 recession, the economy has expanded at an average annual rate of more than 3 percent over the past 10 years. The way people actually feel about the economy's performance is shaped by their individual experiences, however, and here there is always great diversity. Indeed, there remains substantial anxiety about the direction the economy is heading, especially in regard to the growing disparity in income. The gap in real wage rates between those at the higher end of the distribution and those at the lower end has been widening for some time. In addition, the real wages of workers at the lowest part of the distribution were stagnant or falling during much of this extended period of growing wage inequality.

This essay will explain why wage inequality has been increasing in the United States; in doing so, we will draw upon the scholarly literature, including work done by Richmond Fed economist Andreas Hornstein with Per Krusell of Princeton University and Giovanni Violante of New York University. We also will discuss the associated policy implications—that is, what can be done to better assure that all Americans have the opportunity to secure well-paying jobs, as well as which policies may hinder that goal.

Overall, we will argue that technical innovation has significantly affected the wage distribution in the United States. But the direction of that effect has not been uniform. In the early part of the twentieth century, various technical innovations had the effect of compressing the wage structure. Since the 1970s, however, technical innovation—particularly the introduction and widespread use of information technology—has produced wage dispersion.

Another force to which many have attributed recent labor market developments is globalization. We conclude that international trade and immigration, while significant trends, are not by themselves the primary force behind growing wage inequality. To some extent, globalization is itself a result of advances in information technology, which allow the production of goods and services to take place over a broader geographic area.

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As for public policy, research suggests that increased emphasis on education is a sound response to recent trends in wage inequality, particularly education early in life and programs focusing on general, broadly applicable skills. Early skill acquisition yields rewards over a relatively long period of time because individuals can recoup their investment in human capital throughout their working lives. In addition, such training tends to build on itself: acquiring skills early in life makes it easier to acquire additional skills later in life. In contrast, policies that would aim to slow the growth in wage inequality by imposing barriers to globalization, such as trade restrictions, would likely do little to achieve their intended goal, while lowering aggregate income and overall social welfare.

Before discussing why wage inequality has been growing and the steps policy-makers may wish to consider in response, it is necessary to look at the facts. In the next section, we present data on wage inequality from the early twentieth century to the present.

THE FACTS

Most economists agree that wage inequality has been increasing in the United States recently.[1] But this has not always been so. Wage inequality was large during the first part of the twentieth century, decreased during the middle part of the century, and accelerated again toward the end of the century.

During the early part of the twentieth century, several factors contributed to a decline in the demand for less-skilled workers. For instance, the widespread introduction of electricity and new hoisting equipment in the 1910s greatly reduced the need for common laborers who moved goods to and within factories.[2] The lower demand for these workers' services put downward pressure on their wages. At the same time, the rise of large businesses increased the demand for the relatively small subset of workers with higher education to fill managerial roles, thus driving up their wages. As a result, wage inequality grew during the first quarter of the twentieth century.

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By the 1940s, wage structures began to change significantly, however, so much in fact that Claudia Goldin and Robert Margo have called this period "The Great Compression," describing the general decline in wage inequality.[3] On the supply side, the once small number of college graduates began to face increased com-

petition, as thousands of American military personnel came back from World War II and took advantage of the GI Bill. This influx of newly minted graduates most likely helped depress the relative earnings of college-educated workers. In addition, the quality of education at the high school level became less variable during this period, meaning that the skill differentials between high school graduates in different parts of the country probably decreased, thus reducing the disparity in wage rates among this group of workers.

In the 1940s, wage inequality decreased as demand for less-skilled workers grew in the nation's booming manufacturing sector.

On the demand side, more low-skilled labor was needed in the nation's industrial centers to produce goods for the war effort, therefore driving up the relative wages of these workers. In addition, government intervention through the National War Labor Board almost certainly contributed to the compression of the wage structure.[4]

It is interesting to note that there is also evidence of wage compression in the United Kingdom during the Industrial Revolution of the eighteenth and nineteenth centuries. Goods that were once produced by artisans in relatively small numbers over relatively long periods of time were produced in factories following industrialization.[5] This meant that more-skilled workers were replaced by less-skilled workers, who because of the introduction of interchangeable parts and other production techniques could perform their tasks efficiently with little training. The demand for low-skilled workers, then, increased during this period, demonstrating that not all technological innovations are necessarily "skill-biased." Some, in fact, have been "skill-replacing."

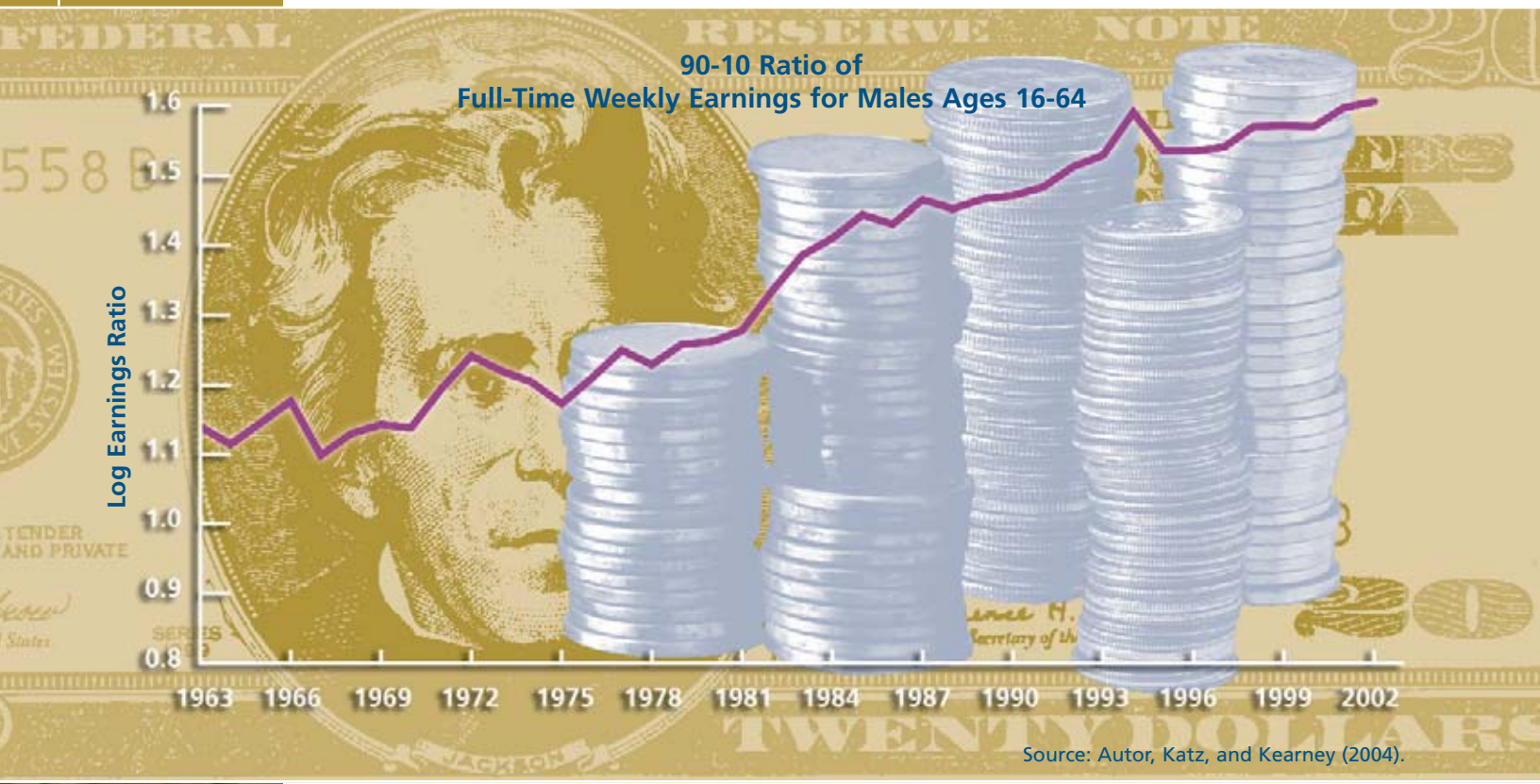
That brings us to the last half of the twentieth century. In particular, we will focus on the period from 1970 onward. As stated earlier, this has been a period of growing wage inequality. Consider the following observations.[6]

- The 90-10 weekly wage ratio, which compares the wages of workers at the 90th and 10th percentiles of the wage distribution, rose from 1.20 to 1.55 for males and from 1.05 to 1.40 for females from 1965 to 1995. Similar growth in inequality was found elsewhere in the wage distribution, though dispersion in the lower wage groups (for instance, the 50-10 ratio) seems to have stabilized recently.

- Average and median real wages have changed little since the mid-1970s. But real wages in the bottom 10 percent of the wage distribution fell sharply during much of this period before experiencing modest growth recently. Meanwhile, the real wages of those at the top of the distribution, especially the top 1 percent, have risen sharply.

- The returns gained from education fell in the 1970s, but have increased since. The college wage premium—defined as the ratio between the average weekly wage of a college graduate and a worker with a high school diploma or less—was 1.35 in 1975, 1.5 in 1985, and 1.7 in 1995.

- The returns from experience also grew in the 1970s and the 1980s but flattened in the 1990s. For instance, the ratio of weekly wages between workers with 25 years of experience and workers with five years of experience increased from 1.3 in 1970 to 1.5 in 1995.



Source: Autor, Katz, and Kearney (2004).

- The returns from white-collar occupations relative to blue-collar occupations increased by about 20 percent from 1970 to 1995.

- Inequality across race and gender has declined since 1970. The black-white differential and the male-female differential have both dropped. Also, labor force participation of women increased dramatically during this period.

> **"The evidence strongly suggests that there has been skill-biased technical change that has benefited more-skilled workers over the past 30 years."**

The last three points all involve "between-group" comparisons—that is, comparisons of workers classified by observable characteristics, such as education, experience, occupation, race, and gender. But it is also true that wage inequality "within groups"—that is, among workers with similar education or experience, for instance—has risen. This trend seems to have started about a decade prior to the trend of increasing returns from college education.[7] Looking abroad, recent trends in wage inequality in the United Kingdom tend to resemble those in the United States. Things in continental Europe are quite different, though. There has been almost no increase in wage inequality there. Indeed, wage inequality has even declined in Belgium, Germany, and Norway.

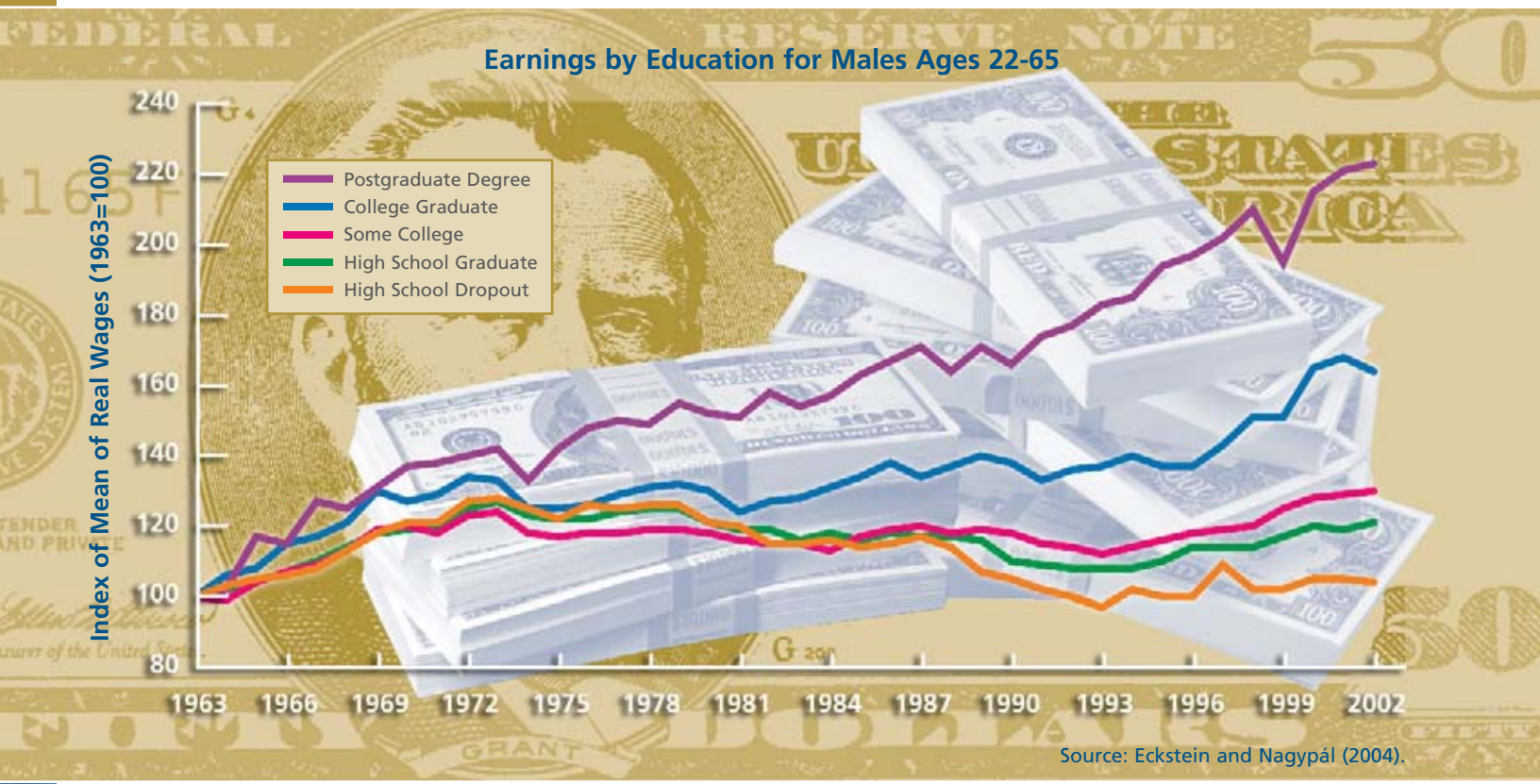
THE ARGUMENT

What is driving the increasing disparity in wages in the United States? The evidence strongly suggests that there has been skill-biased technical change that has benefited more-skilled workers over the past 30 years. By skill-biased change, we mean advancements in technology that have boosted the productivity of skilled labor relative to that of unskilled labor.

To determine why this is the case, it is important to understand that the relative wages of workers at different skill levels are determined by the relative supply of and demand for those types of workers; that supply is determined by the relative number of more-skilled and less-skilled workers; and that demand for those workers' labor is determined by the current state of technology, which in turn largely determines the productivity of different types of labor.

At first, this explanation may appear to fit awkwardly with the facts. After all, the relative supply of more-skilled workers, measured as a fraction of workers with a college education, has risen sharply during this period. Wouldn't this increased supply tend to depress wages, as seemed to happen at mid-century? Standard theory would suggest yes: with a given demand, more supply of a good

would tend to drive down its relative price. And for a while this seems to have been the case with skilled labor. During the 1970s, the number of college graduates rose sharply and effectively flooded the market, driving down the returns gained from education. But by the 1980s, more-skilled workers were able to command a wage premium.



Source: Eckstein and Nagypál (2004).

What accounts for the change? In large measure, the development of new technology. In particular, information technology, which began to make its way into the workplace in the 1970s but did not become widespread until the 1980s, the same time as the returns from skill began to increase. What is it about information or computer technology that increases the demand for skilled workers? According to David Autor, Frank Levy, and Richard Murnane, two mechanisms—substitution and complementarity—are at work:

> Computer technology substitutes for workers in performing routine tasks that can be readily described with programmed rules, while complementing workers in executing nonroutine tasks demanding flexibility, creativity, generalized problem-solving capabilities, and complex communications. As the price of computer capital fell precipitously in recent decades, these two mechanisms—substitution and complementarity—have raised relative demand for workers who hold a comparative advantage in nonroutine tasks, typically college-educated workers.[8]

Autor, Levy, and Murnane conclude that information technology can explain between 60 and 90 percent of the estimated increase in relative demand for college-educated workers from 1970 to 1998. So while the relative supply of more-skilled workers certainly increased during this period—which, all else being equal, would have tended to depress the relative wages of such workers—the demand for such labor increased even more because of technical change.

Consider a few examples that may help to illustrate their point. Advances in manufacturing, such as the introduction of computer-controlled machinery, have often meant fewer workers on the factory floor with those remaining needing a higher level of skill to operate the increasingly sophisticated equipment. A similar process is at work in the division of labor between architects and draftsmen. Before the advent of computer-aided design—or "CAD"—a draftsman would create and revise plans under the guidance of an architect. With CAD, however, the architect can easily generate and manipulate plans on the computer, resulting in the employment of fewer draftsmen, while boosting the productivity of the overall design process.

Some economists have suggested that the increasing supply of skilled workers may have actually induced the development and implementation of new technologies that require higher levels of skills. In short, as Daron Acemoglu has argued, "When developing skill-biased techniques is more profitable, new technology will tend to be skill-biased."[9] Conversely, when developing skill-replacing techniques is more profitable, new technology will tend to be skill-replacing. This, arguably, is what happened in England during the Industrial Revolution. The migration of large numbers of less-skilled workers to the English cities from rural areas and Ireland made the implementation of skill-replacing technologies profitable. "So, it may be precisely the differential changes in the relative supply of skilled and unskilled workers that explain both the presence of skill-replacing technical change in the nineteenth century and skill-biased technical change during the twentieth century."[10]

With the introduction of computer technology into the workplace, the demand for skilled workers increased along with their wages.

Thus, overall, the best explanation for the increase in wage inequality appears to be skill-biased technical change. But there are some potential challenges to this theory.

Trade between the United States and less-developed countries has increased over the last 30 years. But total trade volume arguably remains too small to have greatly affected U.S. wage patterns.

THE CHALLENGERS

Not all economists are persuaded that increasing returns from skill were the principal driver of wage inequality during the 1970s. Some have offered competing explanations, many of which are centered around institutional change.[11] One explanation, for example, is the erosion of the real value of the minimum wage and the decline in unionization in the United States. Other theories focus on globalization—specifically, increased trade with less-developed countries (LDCs) and immigration of less-skilled workers to the United States. Finally, some point to evidence from other countries. If skill-biased technical change is causing growing wage inequality in the United States, they ask, why isn't wage inequality also growing rapidly in Western Europe, since all developed countries have access to basically the same technology? We will address those issues in turn.

The nominal value of the minimum wage remained constant throughout much of the 1980s, meaning that as prices rose its real value dropped. Because the minimum wage may be expected to raise the wages of low-paid workers, the decline in its real value could be responsible for increased wage inequality.[12] There are three problems with this hypothesis, though. First, the number of U.S. workers—especially male workers—affected by the minimum wage is quite small, less than 10 percent of all workers between the ages of 18 and 65. Second, the erosion in the real value of the minimum wage occurred in the 1980s, while the *general* trend of rising wage inequality began in the 1970s. One would expect the two to coincide more closely if the decline in the real value of the minimum wage were indeed a significant factor. Third, a large share of the increase in wage inequality is due to rapid gains by workers at the top of the wage distribution. For these people, the minimum wage is not a binding constraint.

Timing is also a problem in theories that focus on declining unionization.[13] The 1950s, as we have discussed, was a time of wage compression, not growing wage inequality. Yet it was during this decade that unionization began its steady decline.

To be sure, the decline of unionization in the private sector picked up pace during the 1970s and 1980s. But at the same time, the public sector workforce became increasingly unionized, compensating for some of the loss in the private sector. In addition, wage inequality has increased quite rapidly in some sectors of the economy that were never highly unionized, such as the legal and medical professions.

There is, however, some evidence that technical change may have been partially responsible for the decline in unionization since the 1950s.[14] Such a decline could have caused the real wages of low-skilled workers to fall (a point that we will return to in the next section), but its effect on increasing wage inequality would have been only indirect, with technical change starting the whole process.

Popular opinion often attributes increased trade with LDCs as the principal cause of increasing wage inequality in the United States—an explanation that some economists have argued is consistent with the data. Indeed, standard trade theory, based on the principle of comparative advantage, would seem to predict just that. Since LDCs have relatively large numbers of unskilled workers, an increase in trade would act like an increase in the relative supply of unskilled workers in the United States, thus potentially increasing wage inequality. And trade between the United States and the developing world has indeed increased substantially during the past 30 years, the period during which wage inequality has been increasing.

The relative price of skill-intensive goods has not increased over the period of rising inequality, however, as one would have expected if trade were a significant factor in wage dispersion. Perhaps more telling, the total volume of trade with LDCs is arguably too small to have had a significant effect on U.S. wages. The effects of trade flows on "relative skill supplies have not been substantial enough to account for more than a small proportion of the overall widening of the wage structure over the past 15 years and have played only a modest role in the expansion of the college-high school wage differential in the United States," conclude George Borjas, Richard Freeman, and Lawrence Katz.[15]

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As for immigration, the total number of newcomers to the United States during the period under review also is probably too small to have had a large effect on the wage structure. For instance, during the 1970s, immigration added 2 million

new workers to the U.S. labor force. But because of the baby boom and the increased participation of women in the workplace, roughly 20 million new native workers also entered the labor force during that period. In addition, even during the 1980s, a period of relatively high immigration, the immigrant share of the total labor supply increased by only one percentage point, from seven to eight percent. "These magnitudes can be taken to mean that immigration is unlikely to have large effects on the overall distribution of wages," concludes Robert Topel.[16]

Finally, some have argued that if technical change is a significant cause of wage inequality, then it ought to have affected the wage structure in Western Europe in the same way that it has in the United States, since those countries have access to much of the same technology and arguably employ it in similar ways to American firms. But, as we know, wage inequality has not increased as rapidly in Western Europe as it has in the United States. Does this cause significant problems for the skill-biased technical change explanation of wage inequality? Some have suggested so. We think otherwise, however. The observations from Western Europe can be explained by factors that do not contradict the skill-biased technical change argument.

As many commentators have noted, Western Europe has significantly less flexible labor market policies than the United States, including more comprehensive employment protection, longer and more generous unemployment benefits, and greater restrictions on wage bargaining. Those policies likely have had the effect of compressing wages. Thus, while similar technical change may have been introduced at roughly the same time in the United States and Europe, different labor market policies have resulted in different effects on the respective wage structures.[17]

In addition, Europe's labor market policies combined with rapid technological change arguably have led to greater unemployment. In the 1960s, the United States and Europe had roughly the same unemployment rates. Since then, Europe's labor market policies have not changed substantially—those policies have been restrictive for many decades—but its unemployment rate has risen sharply. Why?

Strict employment-protection laws make it difficult for companies to terminate workers in Europe. But over time some workers will leave voluntarily, perhaps encouraged by generous social-welfare benefits. Those workers' skills become dated quickly as technology changes, just as they do for unemployed workers in the United States. But the principal difference is that the strict European employment-protection laws that made those same workers difficult to terminate in the first place also have the effect of keeping them out of the workforce longer than they would have been otherwise. Employers, knowing that all new hires are

possibly lifelong employees, will look very carefully for a good match. Those workers whose skills are not up-to-date will have difficulty finding new employment. And the longer they are out of work, the more difficulty they will have, because multiple generations of technology will have been introduced and replaced during their absence from the workforce. Also, the generous welfare benefits those workers receive reduce their incentives to acquire new skills on their own.

In the United States, where it is easier to terminate workers, employers do not have to be as careful when hiring new employees. The cost of taking a chance on a worker whose skills may be somewhat dated is potentially much smaller than in Europe. As a result, the U.S. unemployment rate has not risen steadily over the past 30 years, as it has in most European states.[18]

By the mid-1980s, production processes were highly automated and personal computers were commonplace.

THE PROBLEMS

We have argued that the most compelling single explanation for the rise of wage inequality in the United States since the 1970s has been skill-biased technical change. In addition, we have argued that other proposed explanations—such as institutional change and globalization—do not appear very persuasive. Yet there remain two unresolved issues.

First, as we previously noted, the growth of wage inequality within groups, sometimes referred to as "residual inequality," is quite large and may not be adequately explained by skill-biased technical change alone. Second, and also mentioned earlier, real wages for those at the lowest end of the distribution declined during much of the last 30 years. Yet, as Acemoglu has argued, it is unclear how "sustained technological change can be associated with *an extended period* of falling wages of low-skill workers."[19] How can these developments be explained?

Perhaps the most compelling explanation for the increase in residual inequality is that there are unmeasured differences in the skills among workers within groups. Consider, for example, two economists that have nearly identical profiles: both are 50-year-old, white males; hold graduate degrees from similar institutions; and have worked as university professors for 20 years. To an outside observer, it is impossible to distinguish between the two workers. But to their colleagues and students, there may be very substantial differences. One economist simply may have more natural talent than the other, producing innovative research across a number of fields. Or he may be a more gifted teacher who inspires students in the classroom. In either case, he is a more valuable worker than his counterpart and consequently may receive a higher wage. We should not be surprised by such a wage differential, but according to our measures of worker characteristics, both economists fall into the same group—thus leading to an increase in residual inequality. Skill-biased technical change increases the premium paid to skilled workers, even if skills are not well-measured by such characteristics as education or experience.

Unmeasured differences in skill between workers with similar demographic profiles are largely responsible for the growth in residual inequality.

Also, rising residual wage inequality may be possible even without unmeasured skill differences. One possible explanation of this phenomenon involves the role of vintage capital. Close examination of the data suggests that the pace of technological advancement has been accelerating since the mid-1970s. Yet different firms have adopted new technologies at different times and at different levels; that is, firms employ technologies of different vintages. This has important implications for the wage structure. In a model that includes labor market frictions—meaning that the labor market is not fully competitive because, for instance, it is costly to switch jobs—workers with the same skills can be expected to earn different wages. More specifically, their wages will increase as the productivity of

the technology with which they are working increases. As a result, it is plausible that technological acceleration may increase wage dispersion within groups, since with more rapid technical change you have more vintages of technology in operation simultaneously.

But what about the drop in real wages of less-skilled workers? In a world of relatively slow technical change, many skills are easily transferable. Workers can move from one company to another with little trouble adapting to the machinery at their new firm. In a world of rapid and accelerating technological change, however, such moves are more difficult since fewer skills are transferable. Upon separation—that is, when workers leave a firm—those workers can expect to suffer wage losses. This scenario is especially true of workers who have been using the oldest technology, because they find that the skills they have acquired through experience are even *more* outdated than those of workers in similar industries who have been exposed to more modern technology. Thus, accelerating technological change may help us explain both the rise in residual inequality and the decline in real wages at the bottom of the distribution.[20]

> **"Skill-biased technical change increases the premium paid to skilled workers, even if skills are not well-measured by such characteristics as education or experience."**

It is important to note, though, that such conclusions are only tentative. Whereas there seems to be overwhelming evidence and an emerging consensus about the role of skill-biased technical change on the wage structure, there remains a good deal of uncertainty about the cause(s) of residual inequality and the declining real wages of less-skilled workers.

IMPLICATIONS FOR PUBLIC POLICY

What lessons should policymakers draw from our discussion of the causes of wage inequality in the United States? We might start with a general principle that is often associated with the medical profession but is applicable to public policy as well: first, do no harm. There is understandably a great deal of anxiety among the public about the changing nature of the American economy. Those forces which create economic growth for us all also cause disruptions for some.[21] As Joseph Schumpeter famously noted, capitalism is characterized by "the perennial gale of creative destruction."[22] And to many people, that gale—at least for the moment—is associated with globalization.

Yet, as we have argued, increased trade with LDCs and immigration from abroad likely have had little effect on wage inequality, while almost certainly adding to the strength and vitality of the American economy.[23] Efforts to slow the growth of foreign goods or labor coming to our shores would be costly to Americans as a whole, as well as to those people who seem to be hurt by globalization at the present. As Jeffrey Sachs and Howard Shatz have written, "U.S. labor market experience … teaches that the labor force will respond to the premium on education by increasing the investment in education, thereby narrowing the gap in inequality in the future."[24] Insofar as barriers aimed to slow globalization dampen the incentive to build skills, those barriers will tend to perpetuate wage inequality.

In addition, we should be wary of proposals to extend the duration of or expand the generosity of unemployment insurance benefits to those workers who have lost their jobs due to technical change. Such proposals would tend to increase the time that displaced workers remain unemployed. Instead, we ought to encourage those workers to reenter the labor force as quickly as possible. The problem, of course, is that the jobs that such workers will be able to secure will likely pay significantly less than their former positions. "Workers not only lose income when they are unemployed, but many often suffer a drop in their earnings after finding new jobs. Older workers—who tend to be less flexible adapting to new production techniques or who lack the educational background to transfer to well-paid service economy jobs—bear the greatest losses," write Lori Kletzer and Robert Litan.[25]

> **"The evidence seems increasingly clear that there is a relatively high level of return on investments in education early in life."**

An alternative way to assist displaced workers may be a simple transfer program that subsidizes their wages upon reemployment.[26] This policy would boost recipients' incomes, while allowing them to allocate their financial resources toward the mix of training opportunities and general consumption they deem most beneficial. Such a program would certainly have problems of its own, and policymakers would need to implement it in a way that would minimize distortions to labor market conditions as much as possible. As we noted earlier, in the case of Europe, government involvement in the labor market often can have undesirable effects.

Perhaps an even more promising option would be to increase public investment in skill acquisition. As we have argued, the principal factor driving wage inequality is skill-biased technical change. Thus, the most direct and arguably most effective way to reduce such inequality would be to reduce the disparity in skills between workers.

Investments in skill acquisition early in life may lead to a reduction in wage inequality.

What type of skills should we attempt to provide through public investment? The evidence seems increasingly clear that there is a relatively high level of return on investments in education early in life. As Pedro Carneiro and James Heckman write, "Skill and ability beget future skill and ability."[27] Also, we might expect those investments to yield larger benefits if they are directed toward broadly generalizable skills. The ability to think critically, for instance, is crucial to analyzing and adapting to a number of situations. In contrast, the return on educational investments later in life, especially remedial education or compensatory investments, tend to be smaller. This is true for at least two reasons. First, without a basic level of knowledge on which to build, it will be difficult for individuals to effectively acquire new skills. Second, by definition, older workers have less time to recoup the investment in education than younger workers.

While this may make perfect sense analytically, it still may be difficult to accept. Such reasoning implies that the people hurting the most now—those who have been displaced from their jobs—may also have the most trouble building their skills. What should we do to help those people? A good argument could be made that the government should act as a clearinghouse of information about job training programs, though we should be cautious about expanding such training programs given their limited success.[28] Similarly, we should be skeptical about providing greater financial assistance to displaced workers seeking education at community colleges and four-year institutions. There are already numerous educational subsidies in place, which have substantially reduced potential credit constraints for low- and middle-income people.[29]

Still, increased investment in skill acquisition is a policy option worth significant consideration. If done properly, it may be an effective tool in reducing wage inequality and could yield additional benefits to the economy, such as increasing workers' productivity.

CONCLUSION

Wage inequality in the United States is large and has been growing during the past 30 years. The main cause, it appears, is skill-biased technical change. Those workers with high skill levels have experienced more rapid wage growth than less-skilled workers, some of whom have seen an actual decline in their real wages.

This development is cause for concern to many people who fear that a large share of the workforce no longer has a reasonable chance of achieving its goals, monetary and otherwise. Such concern is understandable. Indeed, the evidence suggests that, at present, less-skilled workers face formidable challenges in the labor market. As a society, we ought to consider investing more funds in skill development—especially early skill development—to ensure that as many people as possible have the basic tools necessary to succeed.

But we also need to remember that technical change is not necessarily skill-biased. There have been significant episodes where technical innovation appears to have been skill-replacing. From today's vantage point, it seems unlikely that we will return to such a world, but developments may lead us in that direction. Market economies, though highly efficient, often move in surprising and unpredictable directions.

Source: DeLong (2000).

Perhaps most important, we ought to focus not just on the distributional effects of technical change—important as they may be—but also on aggregate well-being. Technical change has fueled much of the economic growth of the past two centuries and raised living standards to levels once unimaginable.

J. Bradford DeLong has calculated that real GDP per worker grew from roughly $13,700 in 1890 to about $65,000 in 2000. That's nearly a five-fold increase. And as DeLong has noted, that significantly understates our improvement in living standards. In 1890, people "could not buy modern entertainment or communications or transportation technologies." There were "no modern appliances, no modern buildings, no antibiotics, no air travel. An income of $13,700 today that must be spent exclusively on commodities already in use in the late 19th century is, for all of us, worth a lot less than $13,700."[30]

"Despite the pain that technological change can cause workers in certain segments of the labor force, we should remember that, on net, technical change is good for the economy and good for people."

It's useful to consider the alternative to embracing technology. By 1400, China had invented many of the technologies that triggered the Industrial Revolution of the eighteenth century, such as moveable-type printing, the water-powered spinning machine, and the blast furnace. Tight state controls impeded the spread of those technologies, however, preventing them from being used to their full potential and inhibiting further innovation.[31] We are not suggesting that others are seriously proposing blocking the development and distribution of new technologies in the United States as China did centuries ago. But we do think it is important to understand how powerful a force technology can be for human well-being—and how counterproductive it can be to curtail its growth.

Despite the pain that technological change can cause workers in certain segments of the labor force, we should remember that, on net, technical change is good for the economy and good for people. We should not discourage or lament it.

Andreas Hornstein, Tom Humphrey, Ned Prescott, John Walter, and Alice Felmlee contributed valuable comments to this article.

ENDNOTES

1. For an exception, see Lerman (1997).
2. Goldin and Katz (1999), p. 9.
3. Goldin and Margo (1992).
4. The National War Labor Board was created in 1942 in an effort to stabilize wages during World War II. According to two authors who worked at the agency, "no changes in wage rates could be made except upon approval of the National War Labor Board; and … the Board could approve wage increases only on four narrowly circumscribed grounds, and wage decreases on only two grounds." See Henig and Unterberger (1945), pp. 319–20.
5. For more on the introduction of new technology in England during the Industrial Revolution, see Mokyr (1994).
6. These observations are taken from Hornstein, Krusell, and Violante (2004), which surveys empirical work up to 1995. Recently, Eckstein and Nagypál (2004) and Autor, Katz, and Kearney (2004) have updated some of these observations. Instances in which the more recent observations differ from the older observations are noted in the text.
7. Juhn, Murphy, and Pierce (1993), p. 412.
8. Autor, Levy, and Murnane (2003), p. 1322.
9. Acemoglu (2002), p. 9.
10. Ibid., p. 12. Also, see Acemoglu (1998).
11. See, for instance, Card and DiNardo (2002).
12. Lee (1999) argues that this has, in fact, occurred.
13. For a recent paper that argues there is a significant relationship between unionization and wage inequality, see Card, Lemieux, and Riddell (2003).
14. See Acemoglu, Aghion, and Violante (2001).
15. Borjas, Freeman, and Katz (1997), p. 67.
16. Topel (1997), p. 62.
17. See Krugman (1994).
18. For a complementary explanation, see Ljungqvist and Sargent (1998).
19. Acemoglu (2002), p. 13.
20. This section draws on Violante (2002).
21. Fears about the effect of technical change on the job market—in particular, the belief that technical innovation is a net destroyer of jobs—are not new. David Ricardo and other classical economists addressed the issue. See Humphrey (2004).
22. Schumpeter (1942).
23. See Burtless, Lawrence, Litan, and Shapiro (1998) for a discussion of the benefits of open trade. See Simon (1999) for a discussion of the benefits of liberal immigration policies.
24. Sachs and Shatz (1996), p. 239.
25. Kletzer and Litan (2001), p. 2.
26. Kletzer and Litan outline such a proposal that would work as follows. Once displaced workers found new jobs, they would receive a subsidy to increase their current lower wage to a level more closely approximating their former higher wage. The wage subsidy would be available for only a limited period of time following reemployment and there would be an annual cap on payments. Ibid., p. 4.
27. Carneiro and Heckman (2003).
28. See Kletzer (1998), pp. 131–33.
29. See Carneiro and Heckman (2002).
30. DeLong (2000), pp. 14–15.
31. See Landes (1998), especially pp. 51–59.

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