Sourcebook of Labor Markets

Evolving Structures and Processes

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Seven Reasons for Skepticism about the Technology Story of U.S. Wage Inequality

Jared Bernstein and Lawrence Mishel

One of the most important economic developments over the past few decades has been the persistent increase in the inequality of economic outcomes. Though its rise has slowed over the past few years, family income inequality—the gap between the income of families at the bottom, middle, and top of the income distribution—was much greater in the late 1990s than at any other time in post-World War II America. Naturally, inquiring minds have turned to economists for an explanation of this expansion of inequality. Since labor earnings comprise the bulk of most families' incomes, analysts have examined the causes of rising wage dispersion to understand what is driving inequality's inexorable climb since the late 1970s.

One of the most popular explanations offered by economists is what we label the "technology story." This chapter outlines the widely accepted technology story and provides seven reasons why we think this story is not up to the task of explaining the increase in wage inequality. We do not elaborate a competing story, though we have done so elsewhere.[1] Instead, our goal here is to outline the substance and the logic of the technology story. We then offer our critique, which is based on the following type of reasoning: If technology is the best explanation for the increase in wage inequality, a number of facts should be observable. If those facts are not forthcoming, technology is unlikely to be the culprit.

Our motivation is not simply our knee-jerk reactionary desire to oppose the conventional wisdom (although the pull is undeniably strong!). If the technology story is wrong, then the main policy prescriptions of economists (and those

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policymakers whose ears they have) are called into question. Specifically, the uncritical acceptance of the technology story has led policymakers to focus almost solely on skills upgrading to counteract the growth of inequality. In fact, it is fair to say the enhanced education and training of the workforce is practically the only solution offered by economists and contemporary policymakers who are concerned with the increase in inequality.

But if, as argued here, the conventional diagnosis is wrong and technological advances are not the central driver of increased wage inequality, focusing exclusively on educational upgrading is unlikely to be effective. Other explanations, particularly deregulation and the decline in labor market institutions, which formerly ensured that middle- and low-wage workers got a larger slice of the growing economic pie, have been pushed to the wings while the technology story has dominated the debate. These other explanations imply very different policy interventions than skills training, such as raising the minimum wage, creating a supportive environment for union organizing, and pursuing full employment to raise workers' bargaining power. While we support efforts to improve the skills of the nation's workforce (who would not?), in the absence of these other interventions, we do not think education alone will be sufficient to reverse the increase in inequality.

THE TECHNOLOGY STORY

The conventional technology story might be summarized as follows: We are undergoing a transformation into a knowledge-age, computer-driven economy, one in which there is increasing emphasis on the command of knowledge, information, and the ability to harness the power of microprocessors. This transformation has a profound effect on the way our economy produces goods and services, such that the production process now demands more and more highly skilled workers to harness the new technologies. If this technologically driven demand for skills is not accompanied by fast-enough growth among the workers whose education and skills are able to exploit the new technology, then we are faced with a situation where the demand for skills outpaces its supply.

But how does this scenario lead to growing wage inequality? The answer has to do with the concept of "relative factor prices and quantities." Here, the analysis generally reduces the workforce into two groups, the skilled and the unskilled, which, in the economics literature, is further reduced to college graduates and high school graduates.[2] Each group is considered a separate factor in the production process. Now, imagine a technology-induced change in the production process such that the more highly skilled group, or factor, is increasingly more necessary than the other, less-skilled factor. Demand for that factor will rise relative to demand for the less valuable factor, and, all else equal, this increase in relative demand will lead to an increase in the wage of the skilled factor relative to that of the unskilled factor. This increase in "relative factor prices" is at the heart of the technology story, which labels the aforementioned scenario *skill-biased technological change* (SBTC).

Note the ubiquitous "all else equal" clause. It is possible for the relative supply of skilled workers to expand enough to meet the technology-induced increase in relative demand. If the relative share of skilled workers in the workforce grew quickly enough to meet the needs embedded in the new technologies, this could serve to dampen, or even erase, the wage inequality driven by the skill-bias inherent in the new production processes.

Thus, to the proponents of the technology story, the path of wage inequality is the outcome of a race between relative demand—driven by skill-biased technological change—and relative supply.

With this framework in mind, proponents of the technology story point to the well-documented increase in the relative wages of college-educated workers over the 1980s, when the growth in wage inequality accelerated considerably over the previous decade. Since it was generally held that the relative supply of skill had also accelerated over this period, this increase in the so-called "college premium" must be evidence of skill-biased technological change at work, the result of relative demand outpacing relative supply (e.g., Katz and Murphy 1992).

SEVEN REASONS TO QUESTION THE TECHNOLOGY STORY

The rest of this chapter presents countervailing evidence to the scenario just presented. Here, we briefly summarize the seven points.

First, we point out that since SBTC has been with us for countless decades, the technology story is only true if technology has had a greater impact on the wage structure of the 1980s and 1990s than in earlier periods; that is, it is not enough to show that technology is skill-biased in any single period. To explain the *increase* in wage inequality, it is necessary to prove that the impact of technology is greater now than in the past.

Second, the increase in "returns to skill" can explain less than half of the overall growth in wage inequality since 1973, and an even smaller share of more recent trends, meaning that the conventional technology story, even if true, is only addressing a portion of the wage inequality problem.

Third, though the technology story focuses exclusively on relative wages (differences in earnings between workers), trends in absolute wage levels address the question of whether technology is having an identifiable impact on the real wages of workers. We present evidence of stagnant or falling real wages of white-collar workers and college graduates (especially among younger workers and males) over the past 10 years. Such trends are inconsistent with the notion that technology drives wage inequality by "bidding up" the wages of skilled workers.

Fourth, turning back to relative wages, our critique shows that recent wage differentials are also inconsistent with the technology story. Despite the continued diffusion of technological change in our labor market, the relative demand for college graduates grew more slowly in the 1990s than in the 1980s.

Fifth, there has been a flattening, or slowdown, in the employment shift to white-collar (or higher wage) occupations and to non-production-worker employment.

Sixth, by examining historical productivity trends, we point out that there is no evidence of a technology-induced improvement in this key measure of economic efficiency during the time of the greatest restructuring of wages—the 1979-1995 period, especially in 1979-1985.

Finally, if there was ever going to be technology-induced growth in wage inequality, it should have occurred during the technology-led rapid growth of the late 1990s. Yet, although education premiums rose, overall wage inequality and its key components (experience differentials and within-group wage inequality) were either flat or falling.

No Evidence of Acceleration

For technology to be a central factor in the growth of wage inequality in the 1980s and 1990s requires that the growth in the relative demand for skill/education accelerated and that technological change played a major role in this acceleration of relative demand. This logic derives from the technology story, as outlined in the prior section. Given the observed increase in relative wages in the 1980s over the 1970s, either the relative demand for education/skill accelerated or relative supply decelerated. But if a supply-side deceleration (around a steady growth of relative demand) explains the relative wage trends, then it was not technology that drove the sharp increase in wage inequality.[3] A technology story only makes sense if there was a demand-side acceleration, and if technology is responsible for this acceleration.

Note that this argument is by no means inconsistent with the view that technological change and capital accumulation have historically been associated with the need for greater skills and education (i.e., the existence of capital-skill complementarity). The share of our workforce with a college degree or higher has doubled since the early 1970s (to 27 percent in 1998) while the share of the workforce without a high school degree has fallen precipitously (to 11 percent in 1998, from 29 percent in 1973). The average private sector worker had nearly two more years of education in 1997 than in 1973. We are convinced (and have developed evidence; see Mishel and Bernstein 1998) that, decade upon decade, evolving skill-biased technological change has played a central role in absorbing this ever-increasing share of college graduates in our workforce. But for the technology story to explain something new in the 1980s—the sharp increase in wage inequality—its impact must be occurring at a faster rate than in the past.

Much of the discussion of technology's role in growing wage inequality implicitly assumes acceleration, suggesting that we have entered a new era of technological change, signified by the computer revolution. The assumption is that either the rate of introduction of new technologies or the types of technologies being introduced is creating a qualitatively new situation in today's workplace and generating an enhanced demand for cognitive skills. Some analysts have explicitly talked in terms of a "technology shock" (Krugman 1994).

Various studies have looked for evidence of these claims. These researchers have tried to develop ways to measure skill-biased technological change and have examined their correlation with the increase in wage inequality in the 1980s and 1990s over earlier periods. While these analyses find strong evidence of the existence of capital-skill complementarity in any given time period, they find no evidence that technology's impact accelerated in the 1980s or 1990s and mounting evidence against acceleration. Recent research by Autor, Katz, and Krueger (1996) rejected the idea that there was any acceleration in the relative demand for education between the 1970s and 1980s.[4] Machin, Ryan, and Van Reenan (1996) found that there was no increase in the complementarity between research and development (R&D) and skills in manufacturing in four countries.

Our work in this area examines the impact of technological change on the use of more educated, more "skilled" (higher wage) workers within industries in the 1970s, 1980s, and 1990s (Mishel and Bernstein 1998). Our model allows technology's impact to change if there is a shift in complementarities, or if indicators of technological change (equipment accumulation, computerization, and R&D) grow faster. We have found that there was no technology-induced acceleration in the use of more highly educated workers between the 1970s and either the 1980s or the 1990s. There was also no technology-associated acceleration in the use of higher-wage workers or a shift away from the use of low-wage workers. In fact, the skill bias of technological change may have moderated over the last two decades.

Wage Inequality versus Skill Premiums

Recall that the technology story described here purports to explain the growth in relative wages between skill groups, as in the increasing wage gap between college- and high school-educated workers. Much of the literature examining technology's role in this trend claims to be addressing the issue of wage inequality (see, e.g., Berman, Bound, and Griliches 1993). But this is incorrect; growing skill premiums are only one component in the increase in wage inequality, and they cannot, by themselves, serve to explain the growing increase in wage inequality.

In fact, research has consistently shown that the returns to education and experience, frequently labeled "returns to skill," can account for less than half of the growth of overall wage inequality. This is because of the large role played by the growth of within-group wage inequality (WGWI), the growth of inequality among workers of comparable education and experience. Therefore, any analysis that fails to address the growth of WGWI is not addressing the growth in *wage* inequality; it is simply addressing that portion of the growth driven by education (or experience) differentials.

First, let us be clear of the magnitudes involved. In our book, *State of Working America, 1998-99* (Mishel, Bernstein, and Schmitt 1999), we decompose the growth in overall wage inequality (measured by the growth of the 90th percentile wage relative to the 10th percentile wage) into that part determined by skill returns and attributed the rest to WGWI. Between 1973 and 1997, 43.5 percent of the growth in the male 90/10 wage differential, and 52.8 percent of the growth in the female 90/10, was the result of higher returns to skill. Gary Burtless (1995) has found similar results using the March CPS, showing that over the 1969–1989 period, only about one-third of the growth wage inequality is associated with changes in skill returns. In summary, inequality analysts cannot ignore the limited role of changing skill returns and presume to be addressing the growth of wage inequality.

While the conventional skill-biased technological change story purports to explain skill differentials, and not the growth in WGWI, some analysts have argued that the growth in the latter might also reflect technological change. These analysts (Juhn et al. 1993) sometimes label the growth in WGWI as reflecting higher returns to *unobservable* skills (skills other than education and experience). This may be comforting to some, but it is simply labeling a residual,[5] and begs for empirical support, or at least some argument that the growth of WGWI over time, across industries or education groups, fits a pattern one would expect, if it reflects a higher return to unobservable skills.

Second, it is also mistaken to interpret changes in the returns to education and experience as "returns to skills," since other factors also play a role in the expanding wage gap between college and high school workers. For example, the federal minimum wage fell 30 percent in real terms over the 1980s. Since this decline is closely associated with the fall in the wage rates of less educated workers, it will lower the college-high school premium. Similarly, the continued decline in unionization over this period also lowered the relative wages of non-college-educated workers. While both of these trends will show up as an increase in skill returns, they are unrelated to the increasing demand for skill, as explained by the technology story.

Relative versus Absolute Wages

The technology story rests heavily on the analysis of *relative* wage trends in which the comparison is between the wages of two groups, such as the "skilled" and the "unskilled." This emphasis grows out of conventional microeconomic analysis that typically focuses less on levels and more on how one type of "economic actor" is faring relative to another. But this focus fails to yield insights into one of the implicit claims of the popular version of the technology story: While technological change inevitably leaves some workers behind, those whose skills are complementary with the new technology will prosper. This in turn leads to the prediction that the "winners" in the technology story—white-collar and college-educated workers—have not only done well relative to the less skilled but have also enjoyed real wage increases. If this were not the case, advocates of the technology story would want to change their position from "SBTC raises the economic fortunes of some workers relative to others" to "SBTC prevents skilled workers from doing as badly as the less skilled." As we show in this section, absolute wage trends, even among "skilled" workers, fail to support the technology story.

Among men, white-collar male hourly wages barely rose over the 1979-1989 period (up 0.6 percent) and were essentially unchanged (−0.3 percent) from 1989 to 1997. The hourly wages of male managerial workers rose 7 percent over the 1980s but fell 3 percent in the 1989-1997 period. The real wages of men with four-year college degrees grew only 1.8 percent over the 1979-1997 period and were lower in 1997 than in 1973. Similarly, the real hourly wages at the 90th percentile among men (someone making more than 90 percent but less than 10 percent of all men) grew 2 percent from 1979-1997. This level of growth, over an 18-year period, is another indication that high-"skills," or at least high-wage, men have not benefitted much from the shift to a knowledge-age economy. These high-wage men have also seen a slight erosion in health and pension coverage.

That women's wages, though still below those of men, have grown more than men's wages in every category—by education, occupation, or wage percentile—raises the question of whether SBTC change has favored female, as opposed to male, workers. Our earlier work (Mishel and Bernstein 1994) tests whether this is the case and finds no consistent evidence in favor of this explanation.[6]

Those who believe that computerization is transforming the wage structure might look for evidence to the wage trends of new college graduates, whose skills are presumably more complementary with new technologies than older, college-educated cohorts. However, the real hourly wages paid to new college graduates with 1- to 5-years' experience—the entry level wage—fell over the 1989-1997 period by 7 percent for both men and women. In fact, in 1997, entry level college wages for men and women were 8 percent and 3 percent, respectively, below the 1973 level. Data on the offers made to new college graduates show that, as recently as the spring of 1997, new college graduates were faring worse than those of the late 1980s. This is true for computer science and engineering majors, as well as social scientists.[7]

Recent Trends in Wage Differentials

Do recent trends in wage differentials match what one would expect if technology is the driving force behind wage inequality? Certainly, technology's diffusion has not slowed in the 1990s; on the contrary, the share of the workforce using computers has continued its rapid growth into the 1990s (Autor, Katz and Krueger 1996). Our work (Mishel and Bernstein 1998) shows an acceleration of R&D spending and computerization (but not of equipment accumulation) in the 1990s over the prior two decades. Given these trends, and barring an acceleration in the relative supply of skill, the technology story would predict an acceleration is the pay gap between skilled and unskilled workers in the 1990s over the 1980s. Or in reference to the overall wage distribution, the expectation would be for increased wage divergence across the entire wage range: the pay of high-wage workers (90th percentile) should be growing relative to middle-wage workers (50th percentile), whose pay should be growing relative to low-wage workers (10th percentile). Given the widespread focus on the falling wages of "unskilled" workers, we might especially expect to see the lowest-wage workers doing the worst.

If the 1980s technology trends have continued to accelerated in the 1990s, then (again, barring an acceleration in relative supply) one would expect the college-high school premium to continue to expand. In fact, there has been no acceleration of the relative supply of male college graduates in the 1990s, and a slight acceleration among women. Yet, as shown in Figure 16.1, the male college-high school wage premium grew rapidly in the early 1980s but has *de*celerated considerably in the 1990s.[8] For instance, the college-wage premium among men grew 1.5 points per year from 1979 to 1989, but slowed to 0.3 points annually in the 1989-1997 period. For females, the growth rate of the skill premium fell from 1.5 points per year in the 1980s to 0.6 points per year in the 1990s.[9]

These trends pose a significant challenge for the technology hypothesis. Contrary to the predictions of the technology story, they suggest that the relative demand for education has grown more slowly in the 1990s despite the continued diffusion, and even acceleration, of microprocessor technologies.

In conventional microeconomic theory, hourly wages are considered to be a good proxy for a worker's ability.[10] Thus, to the extent the SBTC is driving relative wages, the technology story would predict a "fanning out" of wage levels throughout the wage distribution, as technology differentiates between low-, middle-, and high-wage workers. Figures 16.2 and 16.3 present the trends in differentials between high (90th percentile), middle (50th percentile), and low (10th percentile) wages over the 1973-1998 period by gender. For both men and women, the 90/50

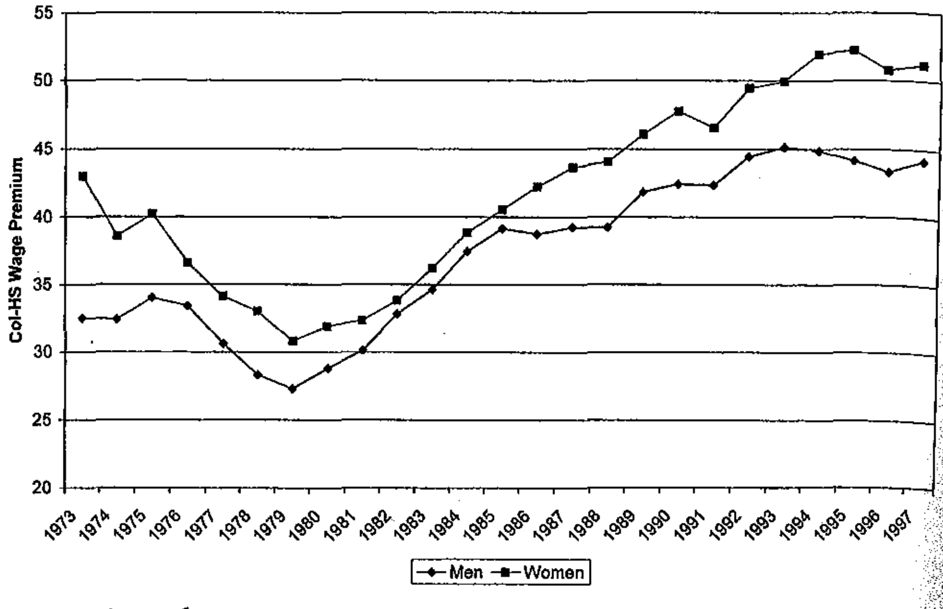

Figure 16.1. Regression-adjusted college-high school wage premium, 1973-1997.

differential grew steadily over the full period (Figure 16.2). The 50/10 differential (Figure 16.3), however, has been flat (females) or falling (males) from roughly the mid-1980s through 1998; that is, in the last 10 years, the lowest wage workers have not fared any worse than middle-wage workers, while high-wage workers have consistently "pulled away from the pack."

This pattern clearly fails to support a technology story in which skill-biased change differentiates workers by wage levels. Perhaps a more nuanced version of the story could be developed, arguing that the skill bias has become more "highly targeted" over time, differentiating the most productive (i.e., highest paid) hourly workers from the rest of the workforce. This seems to us, however, to smack of massaging the interpretation of technology to fit the data trends.

Recent Employment Shifts

The technology story also predicts an acceleration of occupational upgrading; that is, if SBTC is driving employer demands for skilled workers, we should observe an acceleration of the shift into white-collar, and in particular, technology intensive occupations. Note here, again, the importance of acceleration. It is not enough for proponents of the technology story to provide evidence of occupational upgrading—a phenomenon that has persisted in our economy as far back as we have data. Instead, the story requires that such upgrading occurred at a faster rate in the 1980s and 1990s—when wage inequality climbed sharply—than in earlier periods. This section looks for evidence of this acceleration of occupational upgrading. We also examine which occupations were most responsible for the increase in

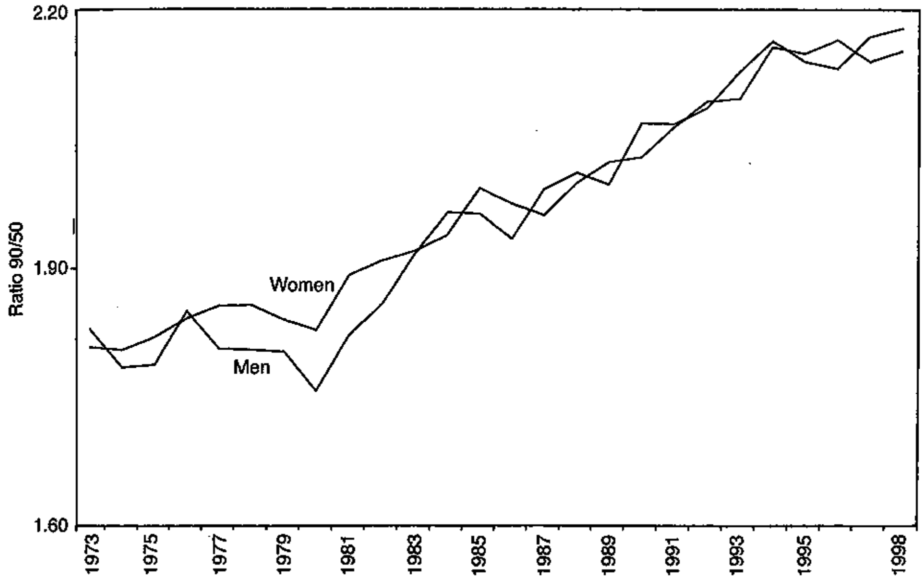

Figure 16.2. Wage inequality, 90/50 ratio, 1973-1998.

education differentials to see if these were the technology-intensive occupations. In both cases, we find the evidence lacking.

First, consider the shift to white-collar and higher-paying occupations. Figure 16.4 presents an index of occupational upgrading for each year over the 1972-1997 period, using employment data on 13 major occupations and the relative compensa-

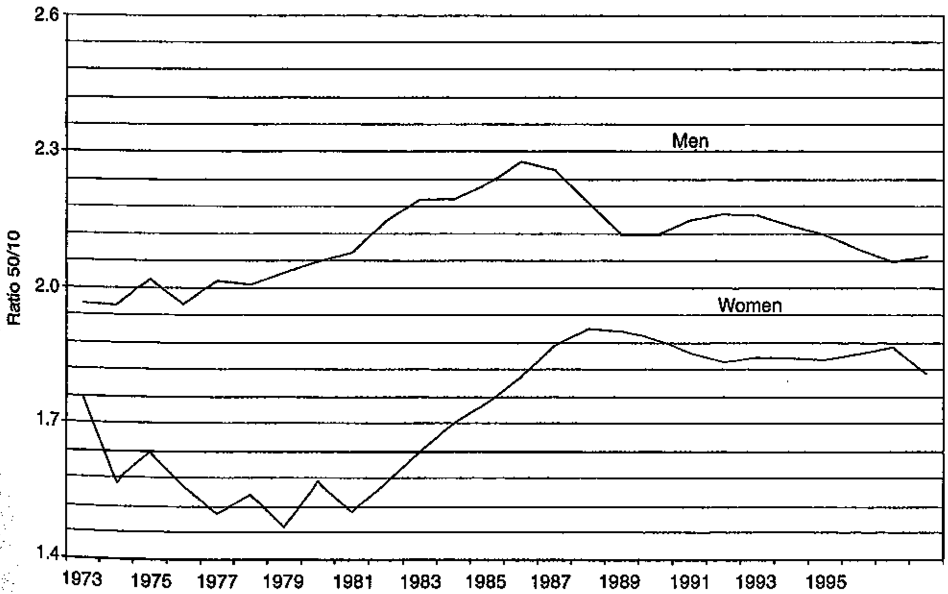

Figure 16.3. Wage inequality, 50/10 ratio, 1973-1998.

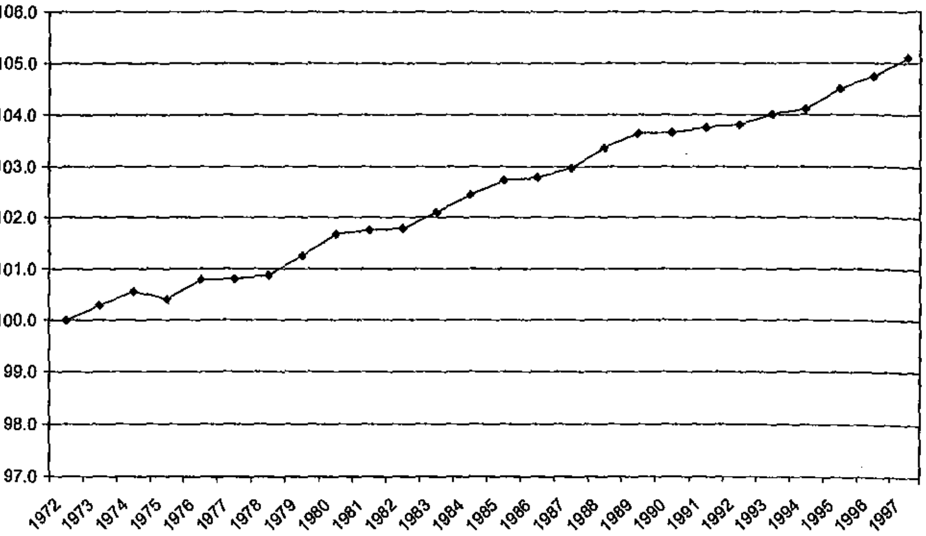

Figure 16.4. Effects of occupational employment shifts on compensation, 1972-1997.

tion structure.[11] This index captures the degree to which employment is shifting toward higher-paying and presumably more skilled occupations. While Figure 16.4 shows clear evidence of steady occupational upgrading, it reveals no obvious evidence of acceleration. The numbers show the annualized growth rates of the index over business cycle peaks (1973, 1979, 1989, and the last year of data, 1997). These rates reveal an acceleration in the 1980s over the 1970s, but a *de*celeration back to the rate of the 1970s in the most recent period. This 1990s deceleration is inconsistent with the notion of SBTC driving persistent increases in the need for "more skill." The historically high levels of dislocation of white-collar workers in the 1990s, which also runs counter to the technology story (see Farber 1996), may lie behind this slowing of occupational upgrading.

Numerous influential studies that purport to prove the technology story have focused on broad occupational upgrading—the growth in the ratio of nonproduction (white- or pink-collar) to production (blue-collar) workers—within the manufacturing sector.[12] Besides ignoring the acceleration argument, these studies fail to note that the shift toward the increased utilization of nonproduction workers in manufacturing seems to have only taken place in the early 1980s, with no shift occurring in the late 1980s and early 1990s, and an actual decline in the share of nonproduction workers in the last few years (see Schmitt and Mishel 1996; Howell 1994). Moreover, the shift toward nonproduction worker employment was slower over the 1979-1989 period than in either the 1960s or 1970s.

Finally, we examine whether the occupations that made the largest contributions to the growth in the college wage premium are the occupations typically considered to be technology intensive. For example, if sales workers, as opposed to those in computer science and engineering professions, were driving the college premium, this would seem to us to cast further doubt on the technology story.

In Mishel et al. (1999), we decompose the growth in the college premium into the share explained by each occupation. We find that for men, 71 percent of the growth between 1979 and 1997 was due to the increase in relative wages and employment of male workers in the managerial and sales occupations.[13] Engineers, math and computer scientists, natural scientists, and other technicians accounted for the rest of the growth, but most of the growing college premium occurred in relatively lesser technologically oriented occupations. For female workers, virtually all of the increase in the college wage premium, 1979-1997, was accounted for by managerial, sales, and health-related occupations. The technologically oriented professions noted here accounted for 9 percent of the growth.

Taken together, these occupational-employment shifts and their contribution to the growth in the "skill premium" offer little evidence to support the technology story. The occupational employment shifts at best fail to show anything other than the continuance of ongoing upgrading (i.e., no acceleration); in manufacturing, they reveal a decline in the share of nonproduction relative to production workers. Additionally, the occupations most responsible for the increase in college wage premium, 1979-1997, were managerial and "low-tech" sales, not the technologically intensive occupations.

The Productivity Paradox

Nobel laureate and macroeconomist Robert Solow raised a profound challenge to the technology hypothesis by noting that "computers are everywhere except in our productivity accounts." Solow's point was based on the observation that the growth rate of productivity (defined below) had failed to accelerate over the period when technology was supposedly improving economic efficiency. Since then, however, one of our important productivity series has been revised, leading to somewhat of an acceleration, particularly in the 1990s.

Nevertheless, even with these revisions, there remains a productivity paradox with regard to a technology story of wage inequality. As the evidence below shows, in the newly revised series, productivity growth accelerated only slightly in the 1980s (by 0.1 percent), when wage inequality was growing most quickly. There is evidence of a productivity acceleration in the (late) 1990s, but, as we have stressed, inequality growth decelerated over this period. The timing of this pattern is inconsistent with the SBTC explanation for growing wage inequality.

Productivity—economic output divided by the number of labor hours it took to create the output—is a broad measure of efficiency. Its growth rate is particularly relevant to the technology story. If we create $100 dollars worth of widgets in 10 hours in one period, while in the next period, adjusted for inflation, we create $110 dollars of widgets in 10 hours, we have higher productivity (10 percent higher), reflecting more efficient production (i.e., something must have changed, since those 10 hours of work generated more widgets in the second period than in the first). In the technology story, that "something" is typically assigned to technological gains that enhance the production process such that the same number of inputs, in terms of hours and quality, leads to more output, as in the aforementioned example. Solow's quip is generated by the fact that despite clear evidence that microprocessor technology is much more diffuse now than in the past, our productivity growth rate has failed to accelerate.

Table 16.1. Productivity: Labor and Multifactor, Annualized Growth Rates, 1959–1997, Nonfarm Business Sector

	Labor productivity		MFP
	Unrevised	Revised	(unrevised)
1959–1973	2.9%	2.9%	1.9%
1973–1979	1.1%	1.3%	0.4%
1979–1989	1.0%	1.4%	0.0%
1989–1997	1.1%	1.7%	0.3%

Source: Bureau of Labor Statistics.

Table 16.1 presents the trends in the two main indicators of productivity fo the private, nonfarm business sector (such trends are most appropriately measure as annualized changes from one business cycle peak to the next, in order to contro for the impact of economic downturns). The first two columns show the growth o labor productivity, described earlier, in the revised (as of October 1999) and in th "old" prerevision series; the last column shows multifactor productivity (MFP growth (unrevised), a measure of output growth that factors in the use of capital a well as labor. MFP is a more accurate measure of technological change, since i accounts for increased quantity and quality of capital investment, along with th increased skill (education and experience) of the workforce.

As mentioned earlier, recent changes in our national accounts have led to a revised productivity series. Specifically, in the most recent revisions of U.S. gross domestic product (GDP), computer software was changed from a business expense (and thus omitted from output) to investment, thus raising both the level and trend of output and productivity in the 1980s and 1990s. Unfortunately, this revision has not yet been made in the MFP accounts, which is why we present the "old," prerevision series for comparison. What is more, while we could be certain that including software would lead to an acceleration in the growth of labor productivity, the amount is not a forgone conclusion for MFP, since investment in software will not only be added to the numerator (output) but also to the denominator, since it is a capital input. Despite this inconsistency, there is still much to learn from these important trends.

Clearly, productivity growth has been slower since 1973, even in the revised labor productivity series (column 2), but the important point here, again, is in regard to acceleration. From 1973 to 1979, revised output per hour grew 1.3 percent per year. Prior to the revisions, it appeared that this measure of productivity had decelerated by 0.1 percent over the 1980s, when technology was becoming more diffuse and wage inequality was rising sharply. In the revised data, it accelerated slightly, from 1.3 percent to 1.4 percent. In our view, neither the old 0.1 percent deceleration nor the new 0.1 percent acceleration solves the Solow paradox. The 1990s (1989–1997) have seen a greater acceleration, by 0.3 percent, and this may be related to the further diffusion of technology. However, recall from the earlier sections that the growth of inequality, particularly education differentials, slowed in the 1990s relative to the prior decade. Thus, this increase in the growth rate of labor productivity in the 1990s may well reflect technological change, but in the context of the technology explanation for the growth of wage inequality, it would appear that this change is less skill biased than that of the 1980s.[14]

MFP trends, shown in the last column, also decelerated notably in the 1970s and again in the 1980s, when they failed to grow at all. It is likely that once revised output is incorporated into this series, MFP will show some slight acceleration in the 1980s over the 1970s, but since the value of software will also be included as an input, the increase is likely to be less than that of the labor productivity series. Even without the revisions, there is an acceleration in MFP growth of 0.3% in the 1990s over the 1980s, but as noted, this increase coincides with a *de*celeration of the growth of wage inequality. A consistent technology story would seem to require that the technology-induced acceleration of efficiency gains coincides with increasing wage inequality.

One could argue that the timing of SBTC need not be coincident with that of a technology-led productivity acceleration. But one would expect technological change to precede the bidding-up of wages of the "skilled" workers required to work with the new technology. In the recent period, wage inequality and education differentials grew rapidly over the 1979–1986 period—the early 1980s—while productivity accelerated after 1996. It would seem difficult to argue that the forces leading to the productivity growth of the late 1990s caused the wage inequality growth of the early 1980s, unless, of course, the technology was implemented earlier but took time (a decade or more) to start "paying off" in productivity gains. Although there has been speculation that such a lag could occur, there is no evidence that the faster recent productivity growth is related to payoffs to much earlier investments. It is more likely that the recent surge of investments in computer equipment and software, coupled with persistent low unemployment, is responsible for recent productivity trends.

Last, it should be noted that it is logically possible that there can be rapid SBTC with no accompanying faster growth in productivity, although this is not the tale being told in the public debate. If there are no accompanying productivity gains, then the technological change is not making us "better off," suggesting that we have the pain of growing inequality but no corresponding "gain."

Wage Patterns in the New Economy

Productivity growth accelerated in 1996 and the latter 1990s in large part because of an acceleration of information technology investments and applications. If the same technology patterns assumed for the 1980s were still prevalent in the late 1990s (skill-biased technological change), then one would have expected a surge in wage inequality. In fact, although education wage differentials expanded, there were offsetting trends in other wage differentials so that overall wage inequality was flat or declining. This clearly contradicts the conventional technology story.

We have summarized the trends in the various dimensions of wage inequality over the 1973–1999 period in Tables 16.2 and 16.3.[15] This includes the trends in the 50/10 and 95/50 wage gaps, reflecting the growth of wage gaps, respectively, overall, at the "bottom," and at the "top." Key education and experience indicators of between-group inequality are also presented, the wage gaps: between college and high school workers, between high school and "less than high school" workers,

Table 16.2. Changes in Dimensions of Men's Wage Inequality, 1979–1999

			1989-1999		
Wage differentials	1973-1979	1979-1989	1989-1995	1995-1999	1989-1999
Total wage inequality	Flat	Up***	Up*	Flat	Up*
Top half (95/50)	Flat	Up***	Up***	Up***	Up***
Bottom half (50/10)	Up**	Up**	Flat	Down**	Down**
Between-group inequality	Down*	Up***	Up*	Flat	Flat
Education					
College/high school (HS)	Down**	Up***	Up*	Up**	Up**
High school/less than HS	Down*	Up*	Up*	Flat	Up*
Experience					
Middle/young	Flat	Up*	Flat	Down**	Down*
Old/middle	Up**	Up**	Flat	Down**	Down*
Within-group inequality	Up*	Up***	Up*	Flat	Up*

between middle-aged and young workers; and, between older and middle-aged workers. Last, trends in within-group wage inequality, the inequality among workers of similar education and experience, is also listed.

We have summarized these trends for each of the last three business cycles (1973-1979, 1979-1989, 1989-1999) and for the "early new economy" (1989-1995) and "new economy" (1995-1999) subperiods of the current business cycle, we have characterized the trends as up, flat, or down and applied up to three asterisks to denote magnitudes—the more asterisks, the stronger the trend. This presentation enables an overall view of wage patterns in each period and a contrast of the late 1990s to earlier periods.

It is worth starting with the 1980s as a benchmark for examining the late 1990s trends since the wage patterns of the 1980s have been interpreted as being technology driven. The easy way of summarizing the 1980s trends is that wage inequality increased strongly overall and in nearly every dimension—by education, by experience, and within-group. This was true for both men and women. In any case, the

Table 16.3. Changes in Dimensions of Women's Wage Inequality, 1979–1999

			1989-1999		
Wage differentials	1973-1979	1979-1989	1989-1995	1995-1999	1989-1999
Total wage inequality	Down**	Up***	Up**	Flat	Up*
Top half (95/50)	Flat	Up***	Up***	Up***	Up***
Bottom half (50/10)	Down***	Up**	Down**	Down**	Down**
Between-group inequality	Down*	Up***	Up*	Flat	Up*
Education					
College/high school (HS)	Down***	Up***	Up**	Up*	Up*
High school/less than HS	Flat	Flat	Up*	Flat	Up*
Experience					
Middle/young	Up*	Up**	Up**	Down**	Flat
Old/middle	Up*	Up*	Up**	Up*	Up**
Within-group inequality	Down*	Up***	Up*	Down*	Up*

widening wage disparities of this period are considered by many to reflect a heightened demand for skills including education, experience, and skills not captured by measured variables (but reflected in within-group wage inequality).

Interestingly, the late 1990s wage patterns bear almost no resemblance to those of the 1980s: for men and women overall wage inequality was flat, between-group inequality was flat, and within-group wage inequality was flat. Thus, there has been no overall growth of wage inequality in the "new economy" era. However, the overall trend masks offsetting changes beneath aggregates of "overall, between, and within." For instance, there has been a continuing strong growth in the wage gap between high-wage and middle-wage workers (at the median) over the entire 1979–1999 period, including the late 1990s (see Figure 16.2). Offsetting the growing wage inequality at the top has been a decline in the wage gap at the bottom (reflected in the 50/10 wage gap, as seen in Figure 16.3). Similarly, there was a growth in the college wage premium in the late 1990s, although the high school premium, relative to noncompleters, fell. Thus, if technology is having a consistent effect, it must be in driving a wedge between the top and the middle. Low wage workers have not been disproportionately affected, relative to middle wage workers,[16] over the last twelve years or so. In fact, the wage gap at the bottom has shrunk in recent years. Unless there has been a dramatic improvement in skills among low wage workers[17] it would seem that technology has not had a "skill bias," especially disadvantageous to the "least-skilled," in the 1990s (or since about 1987).

It is also interesting to reiterate that the college wage premium grew more slowly in the 1990s (particularly in the early 1990s but also in the later 1990s) than in the 1980s. Given that the supply of college graduates did not grow more quickly in the 1990s, this implies a deceleration in the growing relative demand for a college graduate in the 1990s. This deceleration, in our view, does not correspond to the conventionally told technology story. After all, the pace of the information technology (IT) revolution is thought to have picked up in the early 1990s and particularly in the late 1990s. Yet, rather than an accelerated demand for college graduates, there was a deceleration.

The evidence shows that the late 1990s technology-led boom has not produced a corresponding surge in overall inequality. However, some measures of wage inequality have grown—the college wage premium and the 95/50 wage gap)—while others have been flat or have declined. It is apparent that there is no consistent technology story that can explain the pattern of wage growth in the 1980s and 1990s. How should these facts be interpreted?

One interpretation could be that the "skill-bias" of technology has only raised demand in the 1990s for those in the upper 10 percent of the wage distribution relative to other workers and that the technical change of the 1980s had a similar character. The widening of the wage distribution at the bottom in the 1980s, in this interpretation, would be due to factors such as the decline in the real value of the minimum wage.

Another interpretation is that the skill-bias of technical change may have shifted such that it was disproportionately adverse to low-skilled workers in the 1980s but not in the 1990s. This could be because the use of technology and computers became pervasive in the 1990s and the skill-bias became more neutral.

It is also possible that technology had no substantial impact on wage inequality in either the 1990s or the 1980s. Given that technology's impact was not greater in the 1980s or 1990s than in the 1970s, it would seem that computerization and other technologies of the last two decades have continued but not accelerated growing demand for more college-educated workers. This is our interpretation. T failure of the "new economy" to generate a surge in the relative demand for "sk casts doubt on the interpretation of the earlier growth of wage inequality as be technology-driven. The countervailing story is that other forces are having a c tinuing effect in generating wage inequality between the top and the middle (su as globalization, deunionization, and industry shifts). Furthermore, the combi tion of low unemployment and minimum wage growth at the bottom to keep pa with the wage growth of the medium worker.

One inescapable conclusion, it seems, is that technology is not working agai the "less educated" or "low-skilled" workforce in the new economy (or in t post-1987 period, for that matter). The wage gap between the middle and t bottom has been flat or falling for at least a decade. Among men, the 50/10 wage g is now back to its 1979 level; plus, the wage gap between high school graduates a those with less education has not grown appreciably since 1973. Thus either the was a significant improvement in skills at the bottom in the 1990s (unlikely, giv the increase in the numbers of low-skill workers due to immigration and welfa reform) or technical change has not been especially adverse for low-skilled worke

CONCLUSION

The technology story is not simply an intellectual curiosity debated by ec nomic elites. In fact, it serves as the philosophical underpinning for important shi in our approach to economic policy. Since the 1980s, when wage and incor inequality began to grow sharply, the theme of our economic policy has been deregulate the economy in the name of "market forces." Once these forces we released, they would take advantage of the new technological advances just comi on line. With the handcuffs removed, Adam Smith would boot up his person computer, and with his invisible hand guiding the mouse, our economy would rea the gains of accelerated, technology-induced growth.

To meet this goal, industries such as transportation (trucking, inter-city buse railroads, airlines) and communications have been deregulated. Management h actively pursued the weakening of union protections as well as the right to organi unions and to collectively bargain, goals accommodated by policymaking bodie Social protections have been weakened, including reduced safety and health ar environmental regulations, a lower minimum wage, reduced government cas assistance, and a weaker, less generous, unemployment insurance system. I creased globalization, including greater international capital mobility and intern tional trade, has also given greater scope to market forces and managerial discr tion. Taxes on businesses and the well-off have been reduced, including th taxation of capital and the average and marginal tax rates on high-income famili and business. Plus, we have had the low inflationary environment preferred b investors, Wall Street, and the bond market. In summary, there has been a consciou and continuing national policy designed to unleash market forces and empowe management decision makers.

The promise of all of these policies was to raise living standards and to generat more overall income growth. As with all policies and economic transformation there were expected to be, and have been, losers, as the large redistribution of income since 1979 attests. But have the benefits of this growth strategy outweighed the costs? Is there any reason to believe that technological gains are facilitating a transition to a better economy?

As we have shown, there is no evidence that technology has led to more efficiency or faster growth. This is, however, a great deal of evidence that the growth strategy just described has led to a vast upward redistribution of economic resources. In the name of technology, labor market institutions and regulations that formerly either protected workers from the vicissitudes of market forces or ensured that they had a better chance of reaping their fair share of the benefits of economic growth have been diminished or removed. Predictably, the result has been the observed increase in inequality.

None of this is to deny the important and salutary role of those technological changes that continue to transform our lives. We can now entertain ourselves with magnificent electronic gear, from virtual reality games to 3-D visuals and compact disks. Satellites, computers, and the Internet provide fascinating new possibilities for communication. These changes, however, do not necessarily have any impact on wage and income inequality.

The technology story maintains that technological change affects the wage structure only insofar as it changes how we produce goods and services and, specifically, if it generates greater demand (in excess of supply) for high-wage or educated workers. For as long as we have had an organized economy, technological change has been a strong force driving up the demand for a more skilled workforce. There is no evidence, however, that technological change over the past few decades has been either qualitatively or quantitatively different in terms of its impact on the wage structure.

We need to look elsewhere for the source of wage inequality. Part of the answer relates to globalization and the shift to low-wage service employment. Another part of the answer is the weakening of key labor market institutions such as the minimum wage and unions. Even with the tighter labor market of the late 1990s, it is not hard to identify a large segment of our workforce, both blue- and white-collar, whose living standards have been significantly reduced by these developments. The growth strategy outlined here has led to their disempowerment, ultimately breaking the link between economic growth and the economic fortunes of working families. Repairing this linkage must be the focus of our future research and policy deliberations.

NOTES

1. See especially the introductory chapter of Mishel et al. (2001).
2. Much of the literature divides the workforce into so-called college and high school "equivalents." High school equivalents includes all high school graduates and a portion of those with less than a high school education and some college. The college group is analogous.
3. This conclusion is challenged in a recent paper by Card and Lemieux (undated), which argues that the deceleration in relative supply of college-educated workers, not a technology-induced increase in demand, drove up the college wage premium over the 1975–1996 period.
4. These authors do, however, argue that evidence of acceleration exists for the 1970s and 1980s (combined), over the 1950s and 1960s.

5. In fact, since the growth in WGWI is typically measured by examining the changes in residuals from human capital wage regressions, it is labeling a residual that by construction is orthogonal to both education and experience.
6. We find some evidence that technology's impact was more skill-biased against low-wage females in the 1990s than in the 1970s. However, technology was less favorable to the highest-wage woman and more favorable to middle-wage women in the 1980s and 1990s (again, relative to the 1970s).
7. Authors' analysis of National Association of Colleges and Employers Salary Survey data.
8. These figures plot the coefficient on the college variable from a standard human capital log wage regression, with high school as the omitted education category. Data are from the CPS Outgoing Rotation Group files (see Mishel and Bernstein 1998).
9. As noted earlier, since there was an acceleration in the relative supply of college-educated females in the 1990s over the 1980s, this deceleration is consistent with the technology story.
10. This theory is expressed in the concept of marginal productivity (i.e., a worker's hourly wage is considered to be equal to the value of his or her contribution to the firm's output in that hour). Thus under this theory, higher paid workers make a greater hourly contribution to firm output than lower paid workers.
11. The index measures occupational employment shifts, wherein each occupation's employment share is weighted by the average rate of hourly compensation over the full period. For more details see Mishel and Bernstein (1998).
12. See Berman, Bound, and Griliches (1993) and Berman, Machin, and Bound (1998).
13. In order to assure that we were not capturing "high-tech" sales workers (such as stockbrokers) in our sales category, we removed financial sales occupations from this category.
14. Gordon (1999) poses an interesting challenge to the belief the computerization is behind the recent acceleration in productivity. He decomposes the recent growth in productivity by industry and finds that the only industries with any significant growth in productivity are those that *make* computers, not those that *use* them. According to this work, we have become significantly more efficient at producing computers, but efficiency gains from computer usage still elude us. Baker (1999) questions whether the large gains in output in computer manufacturing are real or an artifact of the very sharp declines in computer prices (which then lead to higher measured real output).
15. These are based on data in Tables 2.17, and 2.24 in Mishel et al. (2001).
16. With welfare reform and a recovery, the opposite is probably the case.

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