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The Impact of Computers and Globalization on U.S. Wage Inequality

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ABSTRACT. The late 1970s and early 1980s was a time of rising wage inequality in the United States, particularly between skilled and unskilled workers. During this time, there was also a dramatic increase in on-the-job computer use. Many economists blamed the increase in computer use for the increase in wage inequality in the United States. That view became known as the skill-biased technological change hypothesis. But there are problems with the hypothesis in nearly every dimension of wage inequality in the U.S. labor market. A better explanation for the increase in wage inequality is the globalization of the U.S. economy.

I. Introduction

The introduction of the personal computer in the late 1970s led *Time* magazine to make the computer its "Person of the Year" and argue that "the information revolution...has arrived...bringing with it the promise of dramatic changes in the way people live and work, perhaps even in the way they think. America will never be the same" [Card and DiNardo quoted in *Time*, 2002a, 45]. The prediction proved to be true. The fraction of the workforce that used computers at work increased from one quarter in 1984 to over one third in 1989, and to almost one half in 1993—an average increase of 2.4 percent of the workforce per year [Autor et al., 1998, 1187].

During the same period, the wage structure in the United States was also changing. The 1970s and 1980s was a time of rising wage inequality, particularly between skilled and unskilled workers. Many economists concluded that the rapid change in technology was responsible for most of the dramatic changes in the wage structure. The view became known as the skill-biased technological change hypothesis. A complementary story explaining the rising wage inequality focuses on the decline in unions and the falling real value of the minimum wage, but the skill-biased technological change hypothesis has had particular appeal to many labor market analysts [Autor et al., 1998, 1169]. Although many labor economists have accepted this hypothesis as a unicausal explanation for the changes in the wage structure in the 1970s and 1980s, there are many problems with it. A more significant cause of the wage gap between

skilled and unskilled workers in the United States in the past three decades is an increase in globalization. Globalization transferred production activities abroad that were previously carried out by less skilled U.S. workers. The resulting global division of labor meant that the United States specialized in marketing and financial activities traditionally carried out by more skilled workers [Levy and Murnane, 1992, 1363].

Between 1963 and 1989 the average weekly wage of working men increased by about 20 percent, but the wage gains were not distributed equally among workers. Wages for the least skilled, those in the 10th percentile of the wage distribution, fell by 5 percent, while wages for the most skilled, those in the 90th percentile of the wage distribution, increased by about 40 percent [Juhn et al., 1993, 410-411]. The result was a significant increase in wage inequality and is a reason for concern.

The main problem is that growing wage inequality may weaken Americans' sense of social unity. Greater wage inequality has led to wider differences in political influence and legal bargaining power. In 1979, the income of an American at the 95th percentile of the income distribution was 3 times the median income and 13 times the income of an American at the 5th percentile. By 1996, an American at the 95th percentile had an income almost 4 times the median income and 23 times the income of a person at the 5th percentile [Burtless, 1999, 2]. The growing income gap between the rich and the poor and its consequences for the distribution of political influence may contribute to the decline in Americans' confidence that their elected officials care very much about the views of ordinary citizens. In 1960, only a quarter of U.S. respondents agreed with the statement, "I don't think public officials care much about what people like me think." By 1996, the percent of people who agreed climbed to 60 percent [Burtless, 1999, 2].

Wage inequality may also affect public health. It can increase mortality rates and contribute to poor health. Countries and communities with high inequality have higher mortality rates than countries or communities with comparable incomes and poverty rates but lower inequality. According to one public health researcher, low-income Americans have death rates comparable to those in Bangladesh, one of the world's poorest countries, even though income, average consumption, and health care spending are much higher among America's poor than in Bangladesh. The possible link between public health and inequality may help explain why the United States, one of the world's richest countries,

does not have the longest average life span or the lowest infant mortality rate [Burtless, 1999, 2]. If the benefits of U.S. income growth in the last three decades had been more equally shared, the average health and life spans of Americans might have improved faster than they did.

II. Computer Technology and the Skill-Biased Technological Change Hypothesis

Although computer technology dates back to at least the 1940s, microprocessors were first introduced on a wide scale in manufacturing machinery in the 1970s. Mainframe computers started to be extensively used in business, especially in financial services, in the late 1950s and early 1960s. The diffusion of computer use accelerated in the 1960s and 1970s. With the introduction of the Apple II in 1977 and the IBM PC in 1981, personal computer use increased rapidly in the early 1980s and 1990s and continues to rise today [Autor et al., 1998, 1186-1187]. Computer use at work increased from 24.3 percent in 1984 to 52.5 percent in 1997, but the use was not evenly distributed among workers. In 1997, 74.9 percent of college graduates used a computer at work compared to only 38.6 percent of high school graduates [Borghans and Ter Weel, 2004, 137-138]. Many economists believe that the advent of new technology, particularly the increase in computer use, led to an increase in demand for more skilled workers. Labor economists called this view the skill-biased technological change hypothesis. More specifically, the hypothesis is "the view that a burst of new technologies led to an increased demand by employers for highly skilled workers (who are more likely to use computers) and that this increased demand led to a rise in the wages of the highly skilled relative to those of the less skilled and therefore an increase in wage inequality"[1] [Card and DiNardo, 2002a, 45].

The skill-biased technological change hypothesis is controversial. The main reason that economists believe skill-biased technological change is the primary cause of wage inequality between skilled and unskilled workers is timing. The number of more educated workers employed in the United States in the 1980s and 1990s increased despite the rising relative wages of this group. Also, studies have found that workers who use computers on the job earn more than non-users [Krueger, 1993, 40], and the shift toward skilled workers was greatest in

industries that experienced the greatest rise in computer use. These facts have been used as direct evidence to support the skill-biased technological change hypothesis [Autor et al., 1998, 1170].

A fundamental problem for the skill-biased technological change hypothesis is that wage inequality stabilized in the 1990s despite continuing advances in computer technology. The skill-biased technological change hypothesis also fails to explain the closing of the gender gap, the stability of the racial wage gap, and the effect on returns to different college degrees [Card and DiNardo, 2002b, 733]. These failures illustrate that the skill-biased technological change hypothesis is not a good explanation for the change in U.S. wage structure in the 1980s and 1990s. This is not to say that technology had no effect on relative wages, but rather that the skill-biased technological change hypothesis is not very helpful in understanding the shifts in the structure of wages that have occurred in the U.S. labor market [Card and DiNardo, 2002b, 735].

III. Proponents of the Skill-Biased Technological Change Hypothesis

The main reason that the skill-biased technological change hypothesis has been accepted as a unicausal explanation for wage inequality between skilled and unskilled workers is timing: wage inequality began to rise in the early 1980s, just a few years after the invention of the microcomputer [Card and DiNardo, 2002b, 734]. But this coincidence does not prove causation. There are other things that changed during the same time period including trade, demographics, unionization, regulation and other factors [Richardson, 1995, 34].

The continued increase in the use of more educated workers within industries in the United States, despite the rise in the relative wages of this group during the 1980s and 1990s, indicates strong demand shifts favoring the more educated and is often interpreted as reflecting the skill-biased technological change hypothesis [Autor, et al., 1998, 1170]. In a very influential study, Alan Krueger [1993, 40] found that workers who use computers on the job earn 15 to 20 percent more than non-users. But higher wages of computer users may be a result of differences in unobserved characteristics among workers [Borghans and Ter Weel, 2004, 138]. Although it is difficult to conduct a test that accounts for other employee characteristics, it is very likely that workers who use

computers on the job are more able workers and therefore may have earned higher wages even without computer technology [Krueger, 1993, 42-43].

Autor et al. [1998, 1189] also found that the shift toward more skilled workers and away from less skilled workers was greatest in industries that experienced the greatest rise in computer use. They believe this fact supports the skill-biased technological change hypothesis. But this association between the rise in the proportion of more skilled workers in an industry and the increase in computer use may not represent a causal relationship. It is very likely that the increase in more skilled workers caused the industry to adopt computers, rather than vice versa.

Alan Krueger [1993, 54-55] found that the expansion of computer use in the 1980s could account for one-third to one-half of the increase in demand for more skilled workers between 1984 and 1989. He concludes that technological change—in particular the spread of computers at work—significantly contributed to changes in the U.S. wage structure. But there are many problems with this view. There have been many changes in the wage structure that appear to be inconsistent with the skill-biased technological change hypothesis. The hypothesis needs to be reevaluated.

IV. Problems with the Skill-Biased Technological Change Hypothesis

The recent history of U.S. wage inequality can be divided into three periods. During the late 1960s and 1970s, aggregate wage inequality was relatively constant. The 1980s was a period of increasing inequality, with the biggest rise occurring early in the decade. Finally, in the late 1980s, wage inequality stabilized. There was no noticeable change in inequality between 1988 and 2000. The apparent stability of wage inequality over the 1990s presents a problem for the skill-biased technological change hypothesis because there were continuing advances in computer technology throughout the 1990s that were arguably as skill-biased as the innovations in the early 1980s [Card and DiNardo, 2002a, 51-52].

Another inconsistency with the skill-biased technological change hypothesis is that women are more likely to use computers at work than men, but still earn less on average. In 1984, 29 percent of women used computers at work, compared to only 21.2 percent of men. In 1984, 43.4

percent of women used computers compared to 32.3 percent of men [Krueger, 1993, 36]. According to the skill-biased technological change hypothesis, the technological changes should have led to upward pressure on women's wages relative to men's, but this is not the case. [Ehrenberg and Smith, 2000, 531].

Another problem for the skill-biased technological change hypothesis is that computer-related technology had different effects on college graduates in different fields of study. It seems likely that the computer revolution would have led to a rise in relative demand for college graduates with more "technical" skills like engineers and computer scientists, especially in the early 1980s when microcomputers were first introduced. Instead, relative salaries in more technical fields rose in the 1970s and fell in the 1980s, especially in the two fields most closely related to computers: computer science and electrical engineering. While innovations in computer technology do not necessarily raise the relative demand for workers with specialized computer training, engineers and computer scientists have very high rates of computer use and also earn higher wages than other bachelor degree holders. The decline in the wage premium for engineers and computer scientists over the 1980s is inconsistent with the skill-biased technological change hypothesis [Card and DiNardo, 2002a, 55-56].

Another important dimension of wage inequality is the difference in wages between white and black workers. The trends in the racial wage gap are rather different from trends in other dimensions of inequality. During the 1970s, when the gender gap and overall wage inequality were fairly stable, the wage advantage of white workers fell sharply: from 28 to 18 percent of the mean log wage for men and from 18 to 4 percent for women. During the 1980s and 1990s, the racial wage gap was relatively stable, while overall wage inequality was rising. Like the gender gap, the evolution of the racial wage gap is a problem for the skill-biased technological change hypothesis. In 1984, 25.3 percent of white workers used a computer at work compared to 19.4 percent of black workers. In 1989, 38.5 percent of white workers used computers and only 27.7 percent of black workers did [Krueger, 1993, 36]. Therefore, the skill-biased technological change hypothesis suggests that skill-biased technological change should have led to a widening of the racial wage gap in the 1980s, but instead the gap remained relatively stable [Card and DiNardo, 2002a, 57].

There seems to be problems for the skill-biased technological change hypothesis in nearly every dimension of wage inequality in the U.S. labor market, including the male-female wage gap, the educational wage gap, and the black-white wage gap. The skill-biased technological change hypothesis also fails to explain the stability of wage inequality in the 1990s. In addition, there are two significant studies that have found inconsistencies with the skill-biased technological change hypothesis.

V. Plant-Level Study

Doms et al. [1997] conducted an important study that looked at how plant-level wages, occupational mix, workforce education, and productivity varied with the adoption of new factory automation technologies such as programmable controllers, computer-automated design and numerically controlled machines [253]. Their cross-sectional results were consistent with the view that "high tech" plants employ more skilled workers, especially college educated workers. The positive correlation between the education of workers and technology use was found for both production and nonproduction workers. They also found that technologically advanced plants employed more high-wage production and technical/clerical workers [255].

But their time series results found little correlation between skill upgrading and adoption of new technologies. Plants that adopted a large number of new technologies did not appear to increase their share of high-wage workers compared to plants that adopted a small number of new technologies. They also found that plants that adopted a large number of new technologies employed high-wage workers both prior to and after adopting new technologies. In contrast with the skill-biased technological change hypothesis, Doms et al. concluded that, at the plant level, the correlation between technology use and worker wages is primarily due to the fact that plants with high-wage workforces are more likely to adopt new technologies, and workers using computer technology were already better paid before its introduction [Doms et al., 1997, 255].[2]

VI. German Cross-Sectional Study

DiNardo and Pischke [1997] conducted a study to find out whether the large measured wage differentials for on-the-job computer use are a true

return to computer skills, or whether they just reflect the fact that higher wage workers use computers on their jobs. They used surveys from Germany because the estimated wage differential associated with computer use in Germany is very similar to the U.S. differential. The patterns of on-the-job computer use are also very similar in the United States and Germany. Although the German labor market is more regulated, pay setting more centralized, and the wage structure more compressed than in the United States, they found that the labor markets of the two countries were similar enough that analysis of German data would be helpful in the interpretation of the wage differentials in the United States [295-296].

Using their detailed German data, DiNardo and Pischke looked at on-the-job use of other office tools, such as pencils, calculators, and telephones and compared it to the use of computers. The literacy rate in Germany was 99 percent, so they assumed that almost every worker should be able to use a pencil productively. Since the tool was used by only about 60 percent of the workforce, the skill was not scarce. They concluded that using a pencil in Germany substitutes for writing skills, and a regression of wages on the use of pencils should therefore have yielded a coefficient of zero. Instead, the coefficient was 13 percent in 1991, which showed there was selection in who used pencils at work: they were used predominately by higher paid workers. DiNardo and Pischke argued that if this is true for pencils and other office tools, it is equally true for computers [1997, 301]. They concluded that the wage differentials for on-the-job computer use only reveal that higher wage workers use computers on-the-job and are not a true return to computer skills.

VII. Globalization and the United States

A more significant cause of the rise in wage inequality in the 1980s and 1990s is globalization. Globalization has reduced the demand for less skilled labor in the United States. This is because the United States imports goods that make heavy use of low skilled labor and exports goods that make heavy use of high skilled labor. The effect has been an increase in wage inequality in the United States [Freeman, 1995, 23].

One thing that distinguishes the 1980s and 1990s from earlier decades following World War II is the increase in globalization due to improved transportation, better technology, and the absence of major wars.

Globalization has allowed a wide range of manufactured goods to be imported at a price lower than the same goods produced domestically [Johnson, 1997, 46]. The most commonly used indicator of globalization is the ratio of exports plus imports to gross domestic product. In the United States, the ratio rose from .12 in 1970 to .22 in 1990 [Freeman, 1995, 19]. In 2004, the ratio rose to .25 and continues to rise.[3]

Another reason for the increase in globalization is that barriers to trade between the United States and developing countries have fallen over the past couple of decades. The trend is partly due to the fact that international transport and telecommunications have become much cheaper, quicker and of better quality, and partly because of changes in trade policies in developing countries [Wood, 1995, 61]. U.S. imports from less developed countries were .4 percent of GNP in 1970 and rose to 2.5 percent of GNP in 1990 [Freeman, 1995, 16]. The United States has also seen a dramatic increase in outsourcing by many manufacturing firms. Many unskilled labor functions are being carried out in low-wage countries, leaving only their "headquarters" functions in the United States [Johnson, 1997, 46].

VIII. The Impact of Globalization on Wage Inequality

The increase in globalization has caused the economic position of less skilled workers in the United States to fall. If the increase in earnings inequality in the 1980s had coincided with rapidly growing real earnings, there would have been no reason for concern. But in the past two decades real earnings for all workers grew slowly at best and fell for men on average. The real average hourly wages of males with 12 years of schooling dropped by 20 percent from 1979 to 1993. The real average hourly earnings of all men in the bottom portion of the earnings distribution fell by a similar percent in the 1980s, while that of men in the upper portion rose modestly. The result was a huge increase in wage inequality [Freeman, 1995, 18].

The main reason globalization has affected wage inequality is because low wage workers overseas have taken away job opportunities and have driven down the wages of unskilled American workers. Competition from cheap unskilled labor abroad has forced American employers to reduce the wages, or make less intensive use, of unskilled labor if they wish to remain in business. Employers who continue to rely heavily on unskilled workers will go bankrupt, will move production overseas, or

will adopt new technologies that displace some of their unskilled workers. Others will specialize in new products where relative wages and prices favor production in the United States. No matter what alternative employers choose, the demand for less skilled workers in the traded-goods industries will fall. Shrinking demand will reduce the relative wage of less skilled workers compared to highly skilled workers [Burtless, 1996, 29]. Between 1969 and 1993, traded-goods industries reduced the percentage of less educated workers they hired. In 1969, 42 percent of male and 45 percent of female workers in traded-goods industries had no high school degree. By 1993, those figures had fallen to only 18 percent of males and 17 percent of females [Burtless, 1996, 30]. The labor markets of less-developed countries have also changed dramatically. The less-developed country share of the world workforce increased from 69 percent in 1965 to 75 percent in 1990, and the less-developed country share of world manufacturing employment grew from 40 percent in 1960 to 53 percent in 1986 [Freeman, 1995, 16]. These trends certainly seem consistent with the view that trade has taken away job opportunities for less skilled workers in the United States and moved them overseas.

IX. Globalization Studies

Many more studies have been conducted on the impact of globalization on wage inequality than will be discussed in this paper. Adrian Wood argues that a standard factor content analysis study understates the effect of trade on employment.[4] He argues that once the proper corrections are made, trade becomes the root cause of the fall in demand for less skilled workers in advanced countries. Wood finds that most factor content calculations are biased downward because of the way in which the labor content of imports is calculated [1995, 64]. He also argues that factor content studies ignore the contribution of trade to technical progress and the estimates are confined to manufacturing. Standard factor content analysis studies conclude that trade can account for 10 to 20 percent of the overall fall in demand for unskilled labor. Adjusting the factor content study, Wood finds that trade accounts for about half of the fall in demand for labor [Freeman, 1995, 25]. As a final step, Wood assumes that trade-induced technological changes spill over to non-traded sectors where most unskilled workers are employed. The final assumption leads him to conclude that increased trade with less-developed countries

accounts for all of the rise in inequality in the United States [Freeman, 1995, 25-26].

Richard Freeman [1995] looks at a price effects study along with a factor content analysis study. He finds that price effects studies have weaknesses like factor content studies. He finds that price data is subject to measurement problems. Import prices exist for few industries and cover only some goods in those industries [28-29]. Like the factor content studies, price effects studies provide a clue to how trade could affect relative wages of unskilled workers, but Freeman argues that neither study comes up with a "smoking gun". He concludes that trade matters, but it is not the primary cause of observed changes in the U.S. wage structure [1995, 30].

Feenstra and Hanson [1996] concentrate on outsourcing in manufacturing firms. They find that certain industries have a much higher propensity to outsource than others. The industries, most of which produce semi-durable consumer goods, share two characteristics that make them more amenable to outsourcing. First, the production process can be separated into self-contained stages. Second, production stages vary in the intensity with which they use labor of different skill types [242]. Feenstra and Hanson reestimate their regressions from past research including outsourcing as an explanatory variable. They conclude that outsourcing has contributed to an increase in relative demand for skilled labor in the United States [1996, 240-241].[5]

X. Conclusion

The wage gap between skilled and unskilled workers in the United States increased dramatically in the 1970s and 1980s. At the same time, the microcomputer was introduced and on-the-job computer use was steadily increasing. This led many economists to assume that technological change is a unicausal explanation for the increase in wage inequality in the 1970s and 1980s. Labor economists also support this idea because the demand for more educated workers in the 1970s and 1980s increased in the U.S. during this time despite rising relative wages of this group, and because workers who use computers on the job were found to earn more than non-users. But there are problems with this analysis in nearly every dimension of wage inequality in the U.S. wage structure. The skill-biased technological change hypothesis fails to explain the closing of the gender gap, the stability of the racial wage gap, and the returns to different

college degrees. The hypothesis also fails to explain why wage inequality stabilized in the 1990s despite continuing advances in computer technology. Also, after conducting plant-level and cross-sectional studies, Doms et al. [1997] and DiNardo and Pischke [1997] concluded that computer use and wages are unrelated.

A more significant cause of wage inequality during the 1970s and 1980s was an increase in globalization. The main reason globalization has affected wage inequality is because the United States imports goods that use low skilled labor and exports goods that use high skilled labor. Therefore, trade with developing countries has reduced the demand for less skilled workers in the United States, increasing overall wage inequality.

It is important to note that technology and trade are not independent of one another. Trade and technology are complementary, and both have contributed in some part to rising wage inequality in the United States. Economists generally agree that there are a variety of links between trade and technology.

For example, new technology, such as improvements in transport and communications, have reduced trade barriers and contributed to the increase in globalization. However one looks at it, trade and new technology are intertwined [Wood, 1995, 62].

Wage inequality in the United States is not a problem that should be overlooked. Growing wage inequality has weakened Americans' sense of social cohesion by creating wider differences in political influence and bargaining power. Wage inequality has also affected public health. Low-income Americans have shorter average life spans and high infant mortality rates. If the growth in earnings over the past few decades had been evenly distributed among workers, most Americans would be better off.

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Endnotes

1. Several economists who have come to view technological change as an explanation for changes in the wage structure have highlighted the computer revolution as the prototypical example of such technological change [Krueger, 1993, 34].
2. It is important to note that the results need to be interpreted as being descriptive of the technology-employment patterns in large, surviving, manufacturing plants in a few select industries. However, Doms et al. Feel the data provided valuable new insights into the plant-level relationship between technology and employment [1997, 283].
3. I calculated this statistic using 2004 data from the Bureau of Economic Analysis.
4. A factor content study involves figuring out how much skilled and unskilled labor is used in producing a country's exports and how much would have been used to

produce its imports. The differences between exports and imports are then interpreted as the impact of trade on the demand for skilled and unskilled workers–by comparison with what it would have been in the absence of trade [Wood, 1995, 64].

5. This paper is just an overview of the effect of globalization on wage inequality. There is much more detailed literature on the subject.