Preface: Technology, Growth, and the Labor Market

DONNA K. GINTHER AND MADELINE ZAVODNY

Ginther is an associate professor of economics at the University of Kansas and a former research economist and associate policy adviser at the Atlanta Fed. Zavodny is an associate professor of economics at Occidental College and is currently on leave from her position as a research economist and associate policy adviser at the Atlanta Fed. *They extend many thanks to presenters and discussants (whose names appear in this preface) as well as conference participants at the January 2002 "Technology, Growth, and the Labor Market" conference. The views expressed in the conference proceeding papers presented in this issue of the Economic Review are the authors' and should not be attributed to any institutions in the Federal Reserve System or any other institutions with which the authors are affiliated.*[1]

In 1998, Federal Reserve Board Chairman Alan Greenspan posed the provocative question, Is there a "new economy"? He described the new economy's characteristics as including technological innovations that raise productivity and that have, accordingly, removed pricing power from the world's producers on a more lasting basis (Greenspan 1998). Although the 2001 recession quelled the discussion about whether the United States, and perhaps even the world, had entered a new era characterized by sustained high levels of economic growth, researchers continue to investigate the effects of technological change on the economy.

This issue of the *Economic Review* contains four papers that examine the underpinnings of the new economy—technology and its effects on macroeconomic growth and the labor market. These papers were among those presented at the "Technology, Growth, and the Labor Market" conference sponsored by the research department of the Federal Reserve Bank of Atlanta and the Andrew Young School of Policy Studies at Georgia State University in January this year. This introduction summarizes all the speeches, papers, and discussant comments presented at the conference.[2]

Researchers were quick to examine the new economy, but many of their early conclusions remain open to debate. Macroeconomists, including Martin N. Baily (2001), Stephen D. Oliner and Daniel E. Sichel (2000), and Kevin Stiroh (2001), argued that the technological change embodied in increased computer investment contributed substantially to the surge in productivity growth experienced in the United States between 1995 and 2000. Although productivity traditionally declines during recessions, labor productivity remained high during the recession that officially began in March 2001, perhaps because the large investments in equipment and software made during the late 1990s continued to boost output for several years after the purchases were made. However, the advent of the 2001 recession and research by skeptics, such as Robert J. Gordon (2000), indicate that the effect of technology on current and future productivity growth remains an open question.

Labor economists have also investigated technology's impact on the wage structure. The generally accepted hypothesis among labor economists is that skill-biased technological change has increased the relative demand for skilled workers, causing the observed increase in earnings inequality in the 1980s (Council of Economic Advisers 1997; Katz and Autor 1999). Articles by, among others, Alan B. Krueger (1993), Eli Berman, John Bound, and Zvi Griliches (1994), and Ann P. Bartel and Nachum Sicherman (1998) noted an association between computerization and higher wages for skilled workers. However, the skill-biased technological change hypothesis has been difficult to prove because of the paucity of data on workers' use of technology in the workplace.

Other research has attempted to forge a link between human resource practices, computerization, productivity, and the returns to skill. Casey Ichniowski and Kathryn Shaw (1995, 1999, and 2000) argued that innovative human resource practices raise worker productivity in a variety of contexts. Peter Cappelli and William Carter (2000) evaluated the relative contributions of computerization and high-performance workplace practices, concluding that higher wages are associated with both technology (as represented by computers) and high-performance workplace practices. This research suggests that, in addition to technology, human resource practices may be contributing to higher productivity growth.

Productivity and the Macroeconomy

The conference included two plenary talks by economists with firsthand experience in determining how productivity, inequality, and other such factors should be taken into account when setting monetary policy. The speeches by Edward M. Gramlich and Alice M. Rivlin framed the questions addressed by conference participants. Gramlich discussed why understanding the role of technology in the economy is important to economists and monetary policymakers. He raised many issues, including what stage of an "information transformation" the U.S. economy is in, why productivity defied past patterns by holding up during the 2001 recession, the relative merits of public versus private investment, and why the United States experienced a much larger productivity spurt during the late 1990s than Western European nations that had access to the same technologies.

Rivlin discussed the relevance of the new economy paradigm and whether the economic recovery in the United States will continue to feature high productivity growth and low inflation and unemployment. She indicated that the Internet, combined with a number of advances in business practices, has led to an increase in economic potential. One of the key implications of being in a new economy is that inflation has become less of a concern for monetary policymakers because employers are able to raise wages without passing higher labor costs along via price increases. Instead, excessive investments and overvalued equity markets are central concerns going forward. Unfortunately, she noted, monetary policymakers have less influence over such factors than over inflation.

Productivity Growth and Technology: What the Future Holds

The conference included two papers, printed in this *Review,* that discussed the sources of the surge in labor productivity growth during the latter half of the 1990s and presented forecasts of labor productivity growth rates during the next few years. The two papers are similar in their methodologies and findings and also dovetail with recent research by Baily (2001).

Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh reviewed recent studies on the sustainable rate of labor productivity growth and quantified the source of growth, focusing on information technology (IT). Using an augmented growth accounting framework, they concluded that the resurgence of labor productivity growth during the late 1990s remains intact despite the 2001 recession. They projected that trend labor productivity growth during the next decade will be about 2.2 percent per year, with a range of 1.3 percent to 2.9 percent, and output growth will be about 3.3 percent per year, with a range of 2.3 percent to 4.0 percent. Jorgenson, Ho, and Stiroh found that IT, particularly semiconductors, played a large role in growth during the second half of the 1990s, a trend that is expected to continue but is nonetheless uncertain.

Stephen D. Oliner and Daniel E. Sichel used a similar growth accounting framework to explore the role of IT in labor productivity growth. They also analyzed the steady-state properties of a multisector growth model in order to estimate the long-run rate of labor productivity growth and to calculate to what extent technical progress drives productivity improvements. Oliner and Sichel concluded that the likely annual rate of labor productivity growth is about 2 to 2.75 percent, depending on the pace of technological advances in the semiconductor industry. This conclusion implies that the rates of labor productivity growth achieved in the United States during the second half of the 1990s are sustainable.

The discussion of these two papers by John Fernald noted that the estimates of labor productivity growth might be on the conservative side because the papers do not account for adjustment costs. The high levels of investment in IT during the second half of the 1990s presumably led to sizable adjustment costs, which lowered both output growth and productivity growth. Fernald also pointed out that much about the role of IT in future growth is unknown at this point, raising questions such as, Will the rate of technical change slow? How elastic is the demand for IT? Will the relative price of IT goods continue to fall? What will happen in the non-IT sector, which accounts for 94 percent of the economy?

Skill-Biased Technological Change and Wage Inequality

The conference also included two papers about the role of technological advances in changes in inequality in the labor market. The authors examined whether inequality should be viewed as a causal result of skill-biased technological change or whether there is a missing link—or perhaps no link—between changes in technology and changes in wage inequality.

David H. Autor, Frank Levy, and Richard J. Murnane began by examining the contributions of changes in labor supply and labor demand to wage inequality during the 1940s through the 1990s. The authors discussed why computers increase the demand for more educated workers, arguing that computers have transformed the importance of manual versus cognitive tasks and routine versus nonroutine tasks. The data they used indicate that demand shifts are an important contributor to recent trends in inequality although supply shifts also exerted considerable influence during the entire period. The authors then explored several pieces of indirect evidence that computerization is responsible for the higher growth in relative demand for skilled workers during recent decades, including the timing of increases in computerization compared with the timing of the rise in wage inequality and trends in educational upgrading within industries.

Several puzzles emerge from Autor, Levy, and Murnane's paper, such as whether relative demand for skilled workers began accelerating during the 1970s or during the 1980s and why the growth in relative demand for skilled workers decelerated during the 1990s. As Donna Ginther's discussion noted, the major contribution of Autor, Levy, and Murnane's work is that it provides a mechanism by which computers and information technology could lead to skill-biased technological change.

David Card and John E. DiNardo, in a paper printed in this Review, examined whether the increase in wage inequality during the 1980s was caused by skill-biased technological change. They focused on the merits and limitations of the skill-biased technological change hypothesis, namely, that an increase in demand for skilled workers has led to an increase in wage dispersion between skilled and unskilled workers. Card and DiNardo noted that the supply of skilled workers has increased, so there must have been a more-than-offsetting change in demand to account for the observed rise in wage inequality during the 1980s. They investigated whether different aspects of the wage structure are consistent with the possibility that technical change underlies the changes in demand that must have occurred.

Card and DiNardo pointed out many inconsistencies that make it difficult to reconcile all of the observed trends with the skill-biased technological change hypothesis. As the discussion by Ginther noted, Card and DiNardo provide a good start at critically examining the skill-biased technological change hypothesis; however, she argued that it is an oversimplification to suggest that skill-biased technological change is a "unicausal" explanation for the many changes in the wage structure since 1980.

Technology and Productivity in the Firm

John Haltiwanger presented a paper that complements those by Autor, Levy, and Murnane and Card and DiNardo. The latter two papers used data on wage inequality from the perspective of workers while Haltiwanger's paper used data from wages on the establishment side.

Haltiwanger discussed the correlation between technology investments and wage dispersion and productivity dispersion, both of which increased since the 1980s. He found that both phenomena occurred at the between-plant, within-industry level, suggesting that the changes in economic forces were not industrywide but occurred at a more micro level. Another implication of Haltiwanger's findings is that workers have become more segregated by skill level, a proposition directly tested in a related paper by Lengermann (2001). Haltiwanger concluded that changes in plants' investments in computers and other forms of capital account for a substantial proportion of the increases in wage and productivity dispersion.

The discussion by Robert A. Eisenbeis cautioned that some of the paper's findings are sensitive to the time periods analyzed and that the empirical model

1. The authors also thank Lynn Foley, Peter Hamilton, Vanessa Jordan, C. Anitha Manohar, Elizabeth McQuerry, Pierce Nelson, Nancy Pevey, Avani Raval, Vivian Wilkins, and especially Jess Palazzolo for their invaluable assistance with organizing the conference. Finally, they thank Jack Guynn, president of the Federal Reserve Bank of Atlanta; Roy Bahl, dean of the Andrew Young School of Policy Studies at Georgia State University; and James Alm, chair of the economics department at Georgia State University, for making the funds available to host the conference.

2. Presentations included seven papers by distinguished economists, discussant comments on those papers, and speeches by Edward M. Gramlich, a member of the Board of Governors of the Federal Reserve System, and Alice M. Rivlin, a senior fellow at the Brookings Institution and former vice chair of the Federal Reserve Board. The entire conference proceedings, including the papers published in this *Economic Review,* will be published later this year by Kluwer Academic Publishers.

does not explain much of the wage and productivity dispersion between plants. Eisenbeis also noted that the role of macroeconomic cyclical forces versus secular changes is unclear.

Edward N. Wolff, in the final paper from the conference printed in this Review, used industry-level data to examine the relationships between productivity and the computerization, educational attainment, and skill levels of workers at the industry level. Perhaps surprisingly, he found no evidence that education is linked to productivity growth. However, cognitive skills—as measured by job-skill requirements from the *Dictionary of Occupational Titles*—are related to productivity growth, albeit modestly. Wolff's results also indicate that computers and related IT investments are not significantly associated with productivity growth at the industry level. Paula Stephan's discussion of Wolff's paper questioned whether the failure to find a relationship between computerization and productivity would be robust to including data from the 1990s and whether other measures might better capture skill, particularly with regard to IT skills.

Kathryn Shaw investigated the roles of investment in IT and changes in human resource management practices in corporate performance. Using traditional case study techniques, Shaw documented the relationship between changes in human resource practices and productivity gains in the steel industry. The paper argues that IT lowers the costs of providing information to workers as well as greater problem-solving capacities on the part of skilled workers. In her discussion, Stephan noted that Shaw's paper makes an important contribution by linking the literature on IT and performance with the literature on workplace practices and performance.

The papers presented at the conference add to our understanding of the role of technological change in the economy, both in recent years and in the decades ahead.

REFERENCES

Baily, Martin N. 2001. Macroeconomic implications of the new economy. In *Economic policy for the information economy*. Kansas City: Federal Reserve Bank of Kansas City.

Bartel, Ann P., and Nachum Sicherman. 1998. Technological change and the skill acquisition of young workers. *Journal of Labor Economics* 16, no. 4:718–55.

Berman, Eli, John Bound, and Zvi Griliches. 1994. Changes in the demand for skilled labor within U.S. manufacturing: Evidence from the Annual Survey of Manufactures. *Quarterly Journal of Economics* 109, no. 2:367–97.

Cappelli, Peter, and William Carter. 2000. Computers, work organization, and wage outcomes. National Bureau of Economic Research Working Paper 7987.

Council of Economic Advisers. 1997. *Economic report of the president.* Washington, D.C.: Government Printing Office.

Gordon, Robert J. 2000. Does the "new economy" measure up to the great inventions of the past? *Journal of Economic Perspectives* 14 (Fall): 49–74.

Greenspan, Alan. 1998. Question: Is there a new economy? Presented at the University of California-Berkeley, September 4, 1998. <www.federalreserve.gov/boarddocs/speeches/1998/19980904.htm> (June 5, 2002).

Ichniowski, Casey, and Shaw, Kathryn. 1995. Old dogs and new tricks: Determinants of the adoption of productivity-enhancing work practices. *Brookings Papers: Microeconomics,* 1–65.

———. 1999. The effects of human resource systems on productivity: An international comparison of U.S. and Japanese plants. *Management Science* 45:704–22.

———. 2000. TQM practices and innovative HRM practices: New evidence on adoption and effectiveness. In *The quality movement in America: Lessons from theory and research*, edited by Robert Cole and Richard Scott. New York: Russell Sage.

Lengermann, Paul A. 2001. Is it who you are, where you work, or with whom you work? Reassessing the relationship between skill segregation and wage inequality. University of Maryland. Photocopy.

Katz, Lawrence F., and David H. Autor. 1999. Changes in the wage structure and earnings inequality. In *Handbook of labor economics*, vol. 3, edited by O. Ashenfelter and D. Card. Amsterdam, New York City, and Oxford: Elsevier Science.

Krueger, Alan B. 1993. How computers have changes the wage structure: Evidence from micro data, 1984–1989. *Quarterly Journal of Economics* 108, no. 1:33–60.

Oliner, Stephen D., and Daniel E. Sichel. 2000. The resurgence of growth in the late 1990s: Is information technology the story? *Journal of Economic Perspectives* 14 (Fall): 3–32.

Stiroh, Kevin. 2001. Information technology and the U.S. productivity revival: What do the industry data say? Federal Reserve Bank of New York. Photocopy, December (*American Economic Review,* forthcoming).