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Technological Change and the Labor Market

Ann P. Bartel and
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Economists have long been interested in the effect of technological change on the labor market. Our recent research has focused on how technological change influences the retirement decisions of older workers,¹ the skill acquisition of young workers,² and the interindustry wage structure.³ Since data on the rate of technological change faced by workers in their jobs is unavailable in any non-firm-level dataset, we have used industry-level measures of technological change instead. In our early work on retirement, we studied the manufacturing and nonmanufacturing sectors and used the Jorgenson productivity growth series as a proxy for the industry rate of technological change. In our work on skill acquisition and the interindustry wage structure, we restricted the analysis to the manufacturing sector because of the difficulties in accurately measuring technological change outside the manufacturing sector. We used a number of additional proxies for technological change: the NBER productivity series; the Census of Manufacturers series on investment in computers; the industry's R and D-to-sales ratio; the industry's use of patents; and the number of scientists and engineers employed within the industry. This approach has enabled us to examine the robustness of alternative measures of technological

change, thereby increasing our confidence in the results.

Technological Change and Retirement Decisions

Technological change can affect retirement decisions in two main ways: directly, through its effect on the amount of on-the-job training, and indirectly, through its effect on the depreciation rate of the stock of human capital. Economic theory does not clearly predict the effect of technological change on the optimal level of on-the-job training, though. This relationship depends on the effects of technological change on the marginal return to training, and on the complementarity and substitutability between schooling and training. If technological change and on-the-job training are positively correlated, then human capital theory predicts that workers in industries with higher rates of technological change will retire later.⁴ However, in industries that have higher rates of technological change, human capital will depreciate at a faster rate. These higher rates of depreciation will lead to a lower optimal level of investment, inducing earlier retirement. Hence, from a theoretical perspective, the relationship between the long-run variation in the rate of technological change across industries and the age of retirement is ambiguous. If there is a net positive correlation between on-the-job training and technological change, though, the industries that are characterized by higher rates of technological change will have later retirement ages.

Unexpected changes in the industry rate of technological change can also influence retirement decisions. For example, an unexpected increase in the rate of technological change will produce an increase in the de-

preciation rate of the human capital stock, leading to a revised rate of investment in human capital. If older workers are unlikely to revise their planned investments in human capital, then the higher depreciation rate will induce earlier retirement.

In our empirical work using the 1966-83 National Longitudinal Surveys of Older Men, we find that it is important to distinguish between long-run variations and unexpected changes in industry rates of technological change. Our two main findings are that workers in industries with higher average rates of technological change retire later than workers in industries with lower rates of technological change, and that an unexpected increase in the rate of technological change induces earlier retirement, especially for workers 65 and older.

Technological Change and the Skill Acquisition of Young Workers

Observed investments in training are the outcome of a supply and demand interaction between employers and workers. Technological change influences the incentives of both parties. One argument is that technological change makes formal education and previously acquired skills obsolete. As a result, both workers and firms will find it optimal to invest in on-the-job training in order to match the specific requirements of each wave of innovation. The alternative view is that general education enables workers to adjust to and benefit from technological change. Workers who expect to experience higher rates of technological change on the job therefore should invest more in schooling and rely less on acquiring specific training on the job. Hence it is impossible to predict from theory alone the direc-

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tion of the relationship between technological change and investments in formal company training.

We use the 1987–92 National Longitudinal Surveys of Youth (NLSY) to assess the relative importance of the competing effects. This dataset is particularly well suited to the task because it contains detailed information on all formal training spells experienced by the individual. Our findings indicate that production workers in manufacturing industries with higher rates of technological change are significantly more likely to receive formal company training. This is consistent with the notion that technological change makes previously acquired skills obsolete, thereby inducing workers and firms to invest in training to match the specific requirements of the latest innovation.

Technological change is also likely to affect the relationship between education and training. In general, more educated workers receive more training, either because human capital is an input in the production of new human capital or because individuals who are better “learners” invest more in both schooling and training. At higher rates of technological change, however, the training gap between the more and less educated narrows. In addition, we find that the proportion of individuals receiving training increases, and that firms are more likely to train individuals who have not received training in the prior period than those who were trained previously.

Technological Change and the Interindustry Wage Structure

Previous studies have found positive correlations between technological change and industry wages⁵ and between technological change and the ratio of the earnings of more educated relative to less educated work-

ers.⁶ Using the 1979–93 NLSY, we examine the role of observed and unobserved heterogeneity in explaining these positive relationships.

We show that wages in industries with higher rates of technological change are higher, even after we control for a variety of individual characteristics using the AFQT score. This result could reflect wage premiums that are attributable to: industry effects, such as compensating wage differentials or efficiency wages; labor mobility constraints that cause the results of demand shocks to persist; or continuous shocks in the industry. Alternatively, it could reflect the sorting of more skilled workers into industries with higher rates of technological change. We use a number of econometric procedures, based on fixed-effects models, and conclude that sorting is the dominant explanation for higher wages in industries with higher rates of technological change. Although, like other researchers,⁷ we find evidence of an industry wage premium after controlling for individual fixed effects, we show that this premium is not correlated with the industry rate of technological change. In addition, we document higher returns to education in high-tech industries and show that this education premium also results from greater selectivity on individual unobserved characteristics.

These individual unobserved characteristics could reflect innate ability, the home environment and the skills learned there, or school curriculum and school quality. The implications of our findings for wage inequality and its persistence depend on the relative importance of these factors. For example, if the unobserved characteristics largely reflect individuals’ innate abilities, then the wage differentials associated with technological change would be expected to persist over time. Similarly, if these unobserved characteristics capture the

home environment, which is also exogenous to the individual, then there will be a limited role for public policy intervention. If the unobservable characteristics largely reflect school curriculum or school quality, though, then public policy or individual choice could shape the allocation of these resources, thereby mitigating the effects of higher rates of technological change on wage inequality.

¹ A. P. Bartel and N. Sicherman, “Technological Change and Retirement Decisions of Older Workers,” *Journal of Labor Economics*, 11 (January 1993), pp. 162–83.

² —, “Technological Change and the Skill Acquisition of Young Workers,” *Journal of Labor Economics*, 16, (October 1998), pp. 718–55.

³ —, “Technological Change and Wages: An Interindustry Analysis,” *Journal of Political Economy*, 107 (April 1999), pp. 285–325.

⁴ This can be shown using the model in Y. Ben-Porath, “The Production of Human Capital and the Life Cycle of Earnings,” *Journal of Political Economy*, 75 (August 1967), pp. 352–65.

⁵ For example, see W. T. Dickens and L. F. Katz, “Inter-Industry Wage Differences and Industry Characteristics,” in *Unemployment and the Structure of Labor Markets*, K. Lang and J. Leonard, eds. New York: Basil Blackwell, 1987.

⁶ See S. G. Allen, “Technology and the Wage Structure,” NBER Working Paper No. 5534, April 1996; A. P. Bartel and F. R. Lichtenberg, “The Comparative Advantage of Educated Workers in Implementing New Technology,” *Review of Economics and Statistics*, 69 (February 1987), pp. 1–11; E. Berman, J. Bound, and Z. Griliches, “Changes in the Demand for Skilled Labor within U.S. Manufacturing Industries: Evidence from the Annual Survey of Manufacturing,” *Quarterly Journal of Economics*, 109 (May 1994), 367–98; and J. Bound and G. Johnson, “Changes in the Structure of Wages during the 1980s: An Evaluation of Alternative Explanations,” *American Economic Review*, 82 (June 1992), pp. 371–92.

⁷ See R. Gibbons and L. Katz, “Does Unmeasured Ability Explain Inter-Industry Wage Differentials?” *Review of Economic Studies*, 59 (1992), pp. 515–35.