TEXAS BUSINESS REVIEW
Bureau of Business Research • College and Graduate School of Business • The University of Texas at Austin

April 2000

The Vise:
Occupational Restructuring and Earnings Inequality in High-Tech Manufacturing

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High-tech industries are our most strategically important source of new products and processes. These industries generate much, if not most, of the competitive advantages that U.S.-made goods and services enjoy in domestic and international markets. Consequently, news about anything high tech consistently commands the attention of the general public.

The latest high-tech story, however, is less about gadgetry and much more about the effects of accelerating technological change on the working lives of those employed in high-tech industries.[1] The new economic logic associated with increasingly powerful and increasingly cheap microprocessors is shifting the occupational structure of high-technology manufacturing industries. The net affect is a wider—i.e., more unequal—distribution of earnings. With the relentless advance of the microprocessor into the interstices of ever less routine manufacturing and service processes, it is increasingly likely that these occupational shifts will diffuse throughout the economy at large, worsening the nationwide trend toward greater income inequality.

We arrived at this conclusion after examining occupational employment data spanning twelve years (1983-1995) and almost 400 occupations in 32 "R&D-intensive" and "R&D-moderate" high-tech industries, as classified by the Bureau of Labor Statistics (BLS) and the National Science Foundation. These classifications were derived from a 1991 survey of high-tech firms that reported the actual number of employees engaged in research and development activities.[2]

Restructuring Among Nonproduction Workers

There were two major dimensions to occupational restructuring in this set of industries. We encountered the first on the nonproduction side of the employment divide. Here, workers not directly involved in the production of goods manage and supervise projects, product lines, or other nonproduction and production workers; engage in R&D activity; or perform service and support functions. Overall, during the twelve-year period spanned by the data, better educated, therefore more flexibly skilled, and better paid workers took over the positions of the less formally educated, more specialized, and lesser paid workers. We characterize this dimension

as the *professionalization* of nonproduction work.

Professionalization on the nonproduction side occurred within and among four major occupational groups. Within the executive, managerial, and administrative group, professionally educated executives and administrators with formal credentials supplanted less formally educated and lesser paid managerial support workers, so-called "middle managers." High-tech firms added 60,000 of the former positions and abolished about 135,000 of the latter. Within the professional specialists group—among whom are the R&D cadres for which U.S. high tech is so well known—professionally trained computer engineers, scientists, and systems analysts replaced "hard-hatted" single discipline (mechanical, industrial, chemical, and aeronautical) engineering professionals, and less educated, less flexible, and therefore lesser paid science, math, and engineering technicians and computer equipment operators.

Between 1983 and 1995, almost 100,000 computer engineers, scientists, and systems analysts—an astonishing increase of 230 percent—were added to organizational charts, while a combined total of almost 72,000 professional engineers and technicians were eliminated. At the same time, the administrative support category as a whole was decimated—with many workers relegated to contingent employment status—by a loss of more than 13 percent, or 131,000 positions. Computer operators and peripheral equipment operators accounted for 7,300 of these positions, about 25 percent of their total number in these industries.

Much of the movement in these numbers is attributable to defense industry cutbacks, but we did not analyze defense-dependent high-tech industry occupational shifts separately.[3] The net effect of these shifts, however, was to "ratchet up," within and across major occupational groups, the share of positions that require higher levels of formal educational attainment and therefore command higher salaries. This leads to a more skill-intensive nonproduction workforce as the occupational distribution is flattened by the departure of middle managers and administrative support workers.

We think that the critical enabler for this pattern of occupational restructuring was not the geopolitical (defense industry) business cycle, per se, but *computerization*, i.e., the increasing power and functionality of the microprocessor. Managers and administrators, for example, can combine cheaper and ever more powerful computer technology with skills acquired in graduate or professional school to encompass multiple tasks once performed by more narrowly specialized managerial and administrative support personnel. The new information technology thus allows high-tech firms to replace middle managers with computer networks that link front line supervisors more directly with higher level decision makers. Similarly, professional computer specialists trained to use powerful computers more efficiently possess a greater functional range (flexibility) and span of control than the more specialized engineering, science, math, computer technicians and administrative support-class computer equipment operators they replace.

Production Worker Restructuring

To some observers, our story about the professionalization and computerization of the nonproduction side of high-tech manufacturing is old news. It lends added credibility to the argument that technical change precedes higher skill requirements ("skill-biased technical change") in U.S. workplaces and is a major contributor to the higher returns to education enjoyed by many American workers over the last two decades. In turn, of course, these returns are believed to be helping fuel the increasingly large disparities in the distribution of earnings, income, and wealth.

What *is* news can be found in the second major dimension of occupational restructuring, which occurred among production occupations. Our data provide more explicit detail than has been seen to date about the actual character of the processes transforming high-tech production work. The raw numbers tell the story: production occupations declined by 252,000 between 1983 and 1995, and 158,000 (63 percent) were in the precision production, craft, and repair group. Within that group, the precision production occupations themselves—encompassing the largest concentrations of the most highly skilled production workers in U.S. manufacturing, machinists and tool and die makers—experienced the largest numeric decline (73,000) of any detailed production occupation examined. It was equal to almost half (46 percent) of all the 158,000 precision production occupations eliminated over the twelve years spanned by the data.

We looked closer within the precision production occupations, focusing on the most metalworking-intensive industries in our high-tech set, i.e., industrial equipment and machinery (SIC 35), to see what was happening to the mix of high-skilled metalworking positions versus those in intermediate-skilled machine operating, tending, and setting. Between 1983 and 1995, 4,400 tool and die maker positions were eliminated, while 11,400 new positions (a 46 percent gain) were created for computer numerically controlled (CNC) machine tool operators and tenders. This gain was particularly striking because it coincided with the elimination of more than 62,000 other machine operator position, the group within which CNC machine tool operators are classified.

The Shape of High-Tech Occupational Change

We see now that occupational restructuring in high-tech manufacturing acts like a vise, squeezing lower skilled occupations from above and higher skilled ones from below. Certainly, nonproduction restructuring acts as the upper jaw of the vise. The routine and not-so-routine functions performed by the less skilled and more specialized are transferred *up* the hierarchy of education and training, encompassed by better educated workers in more highly paid positions. Production-side restructuring is the jaw that presses from below. More highly skilled and better paid workers are pushed out of the occupational mix as the relentless increase in the functional range of the microprocessor allows routine and ever-less routine functions to be computerized and transferred *down* the hierarchy of training and experience to new classes of less skilled and lesser paid machine operators and tenders.

These findings, combined with newly available wage data, indicate that occupational restructuring in U.S. high-tech manufacturing is a mechanism that produces not only widening wage inequality *between* but also *within* the nonproduction and production spheres.[4] This image does not merely lend weight to the skill-biased technical change argument mentioned earlier, but gives it a new critical specificity. One area of ambiguity has been whether firm-level technological advance leads to an undifferentiated increase in skill levels for *all* workers. Our findings show the strikingly different effects that technological change in high-tech industries has on occupational classes differentiated by levels of training, education, and experience.

Because ever more powerful microprocessors are being applied to ever less routine manufacturing and service processes, we think that the vise of occupational restructuring in high-tech will squeeze a broad swath of “middle-waged” workers throughout the economy at large, worsening the national trend toward greater earnings inequality. Clearly, more research is needed, but more importantly,

legislators must incorporate this picture into their deliberations about the kinds of active labor market policies most appropriate for our new economy in the 21st century.

Notes

1.Bill Luker, Jr. and Donald Lyons, "Occupational Restructuring in U.S. High-Tech Manufacturing, 1983-1995." Presented at the 3rd International Conference on Technology and Policy Innovation, LBJ School of Public Affairs, University of Texas-Austin, September 1999.

2. Our high-tech industry list comprised all or part of the miscellaneous textile goods, paper, chemicals, petroleum refining, ordnance and ammunition, and nonferrous metalworking industries; engines, turbines, computers, and special and miscellaneous industrial equipment; electronics and electrical equipment, including semiconductors and search and navigation equipment; autos, aircraft, missiles and spacecraft, and military/outdoor vehicles manufacturing in the transportation equipment group.

3. Because the series ends in 1995, the data cannot reflect new positions that may have been created in these occupations after the rate of job creation began to surge midway through the current national expansion.

4. The wage implications of this shift are now calculable in rough terms, thanks to new BLS occupation-by-wage datasets at the national level. A recent estimate of 1996 hourly wages for CNC operators was $13.84/hr, 80 percent of the $17.36/hr wage commanded by tool and die makers (BLS, 1997).

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April 6, 2000
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