“Technological Change and Earnings Polarization: Implications for Skill Demand and Economic Growth”

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About the Report: The Conference Board has recently undertaken a project on innovation and competitiveness, with funding from Microsoft Corporation. The goal of the project is to provide an overview of the current state of knowledge on the nature of innovation, and its role in stimulating economic growth and improved living standards in the U.S. The project draws on experts across the academic, corporate, and policy arenas, in addition to The Conference Board’s own analysis, surveys, and focus groups of the business community. Such experts met in February 2007 to present and discuss various aspects of the innovation process and measurement thereof. Each presenter wrote a summary piece focusing on his respective area of expertise. These summary documents underpin the content in Innovation and U.S. Competitiveness; however the conclusions drawn are those of The Conference Board alone. These papers are retained for reference in The Conference Board Economics Program Working Paper Series.
Summary of Remarks on “Technological Change and Earnings Polarization: Implications for Skill Demand and Economic Growth”¹

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It is widely understood that there was a historical rise of earnings inequality beginning in the 1980s in the United States and, to a lesser extent, in other advanced countries. This rise is seen in overall inequality (for example, the 90/10 log wage ratio), in ‘between-group’ inequality (often measured as the log college/high-school wage ratio), and in ‘within-group’ inequality (measured, for example, as the 90/10 wage of log wage residuals). A summary of these patterns is given in the following two figures from Autor, Katz and Kearney (2007).

Figure 1 shows that over the period 1963 to 2005, there was essentially a monotone growth of inequality; real wage levels rose by the most at the highest wage percentiles and by the least at the lowest percentiles. Figure 2 shows that the rise of inequality after 1979 is visible in all three metrics mentioned above: overall inequality, between-group inequality and within-group (‘residual’) inequality.
Less well-known, however, is that the era of ‘monotonically’ rising inequality was comparatively short-lived. By the late 1980s (approximately 1988), wage growth began to polarize, with the continued strong growth at the upper tail of the wage distribution and, surprisingly, strong growth at the lower-tail as well. Wage growth stagnated in the middle of the distribution, however. This pattern is shown in Figure 3 (from Autor, Katz and Kearney, 2006, updated with more recent data).

I. Why has wage growth polarized?

A central theme of my remarks at the Innovation and Productivity Growth meeting is that the polarization of wage growth can be understood as a demand-side phenomenon, induced by changes in demands for job tasks throughout the skill distribution. In the ‘task framework’ proposed by Autor, Levy and Murnane (2003, ‘ALM’ hereafter), we argue that the dramatic advance of information technology (understood as a precipitous decline in the price of computing) has had non-monotone impacts on the demand for skill throughout the earnings distribution: sharply raising demand for the cognitive and interpersonal skills used by educated professionals and managers (‘abstract tasks’) and reducing demand for clerical and routine
analytical and mechanical skills that comprised many middle-educated white collar and manufacturing production jobs (‘routine tasks’). Somewhat paradoxically, computerization has probably had little direct impact on the demand for the non-routine manual skills (‘manual tasks’) used in many ‘low-skilled’ service jobs such as health aides, security guards, orderlies, cleaners, servers, etc. Because the interpersonal and environmental adaptability demanded by these manual tasks has proven difficult to computerize (to date), these manual activities may in fact grow in importance as a share of labor input.²

The Autor, Levy, Murnane framework suggests that computerization (among other forces) may have raised demand for skill among higher-educated workers, depressed skill demands for ‘middle-educated’ workers, and left the lower echelons of the wage distribution comparatively unscathed. Goos and Manning (2003) label this process a “polarization of work,” and argues that it may have contributed to a hollowing out of the wage distribution in the United Kingdom during 1975 to 2000. Spitz (2006) and Dustmann, Ludsteck and Shönberg (2007) also report a similar polarization of jobs for the former West Germany during 1979 to 1999.

² This can be understood as a form of “Baumol’s Disease,” in which labor-intensive sectors where there is low productivity growth (such as teaching, nursing or table-waiting) tend to grow faster as a share of GDP than sectors experiencing rapid productivity growth (such as manufacturing or farming).
To illustrate the potential relevance of shifts in task demands for changes in skill demands, I link data on task intensity by occupation from the Dictionary of Occupational Titles to data on skill level by occupation in the 1980 Census (again drawing on Autor, Katz and Kearney, 2007). In this analysis, occupational skill level is measured by the mean years of education of an occupation’s workforce (weighting workers by their hours of annual labor supply). Figure 4 uses a locally weighted smoothing regression to plot task intensity by occupational skill for each of the three broad task categories above: abstract, routine and manual tasks. Task intensities are measured as percentiles of the baseline distribution of job tasks in 1960. Thus, an occupation with the median intensity of ‘routine’ task input in 1960 would receive a score of 50.

This figure shows that the intensity of abstract task input is monotonically rising in occupational skill (i.e., education) and, conversely, the intensity of manual task input is falling in occupational skill. Most significantly, there is a distinctly non-monotone relationship between occupational skill and routine task input. Routine task input is highest between the 20th and 60th percentiles of the skill distribution, and falls off sharply on either side of this range. This non-monotonic relationship is highly relevant because, as documented by ALM, routine task input saw the sharpest decline of all task categories over the last two decades (relative to its initial 1960 level). The rapid substitution of information technology for routine tasks might therefore be expected to contribute to polarization by reducing demand for ‘middle-skill’ occupations relative to either high or low skill occupations.

A central implication of the polarization hypothesis is that the twisting of the wage structure observed in recent years is, in significant part, a demand-side phenomenon, induced by rising demands for both high and low-skill tasks. This implication is testable, and I provide a simple evaluation here. Following Goos and Manning’s (2003) analysis for the U.K., I use Census data to explore how employment growth by occupation over the last two decades is related to occupational skill as proxied by educational levels. The working hypothesis is that, if the wage structure changes observed in the 1980s and 1990s are driven in substantial part by demand shifts, wages changes by earnings level and employment changes by skill level should positively co-vary in both decades.
To test this implication, I plot in Figure 5 the change in the share of total hours worked in the economy from 1980-1990 and 1990-2000 by occupation skill percentile, using the education-based occupational skill measure developed above.3 For the decade of the 1980s, we see substantial declines in employment shares at the bottom end of the skill distribution with strongly monotone increases in employment shares as we move up the skill distribution. In contrast to this monotone pattern, employment growth in the 1990s appears to have polarized. There is rapid employment growth in the highest-skill jobs (at or above the 75th percentile), a decline in the employment shares of middle-skill jobs (those at percentiles 30 to 75) and flat or rising employment shares in the lowest-skill jobs, those in deciles one through three.

3 I employ a consistent set of occupation codes for Census years 1980, 1990 and 2000 developed by Peter B. Meyer and Anastasiya M. Osborne (2005). I use a locally weighted smoothing regression (bandwidth 0.8 with 100 observations) to fit the relationship between decadal growth in occupational employment share and occupations’ initial skill percentile in the 1980 skill distribution.
This pattern of job growth corresponds closely with the observed pattern of wage structure changes in each decade, as is shown in the lower panel of Figure 5. Real wage growth was
essentially monotone in wage percentile in the 1980s, with especially sharp wage growth above
the 75th percentile and especially sharp declines below the 30th percentile. In the decade of the
1990s, however, wage growth was noticeably u-shaped. Wage growth was stronger below the
20th percentile and above the 80th percentile of the distribution than throughout the remainder of
the distribution. Thus, despite substantial differences in the evolution of inequality between the
1980s and 1990s, labor market prices and quantities (as measured by wage and skill percentiles)
appear to positively covary in each decade. This is consistent with a demand-side explanation for
observed wage changes.\(^4\)

II. Implications for the Sources of Growth (‘SOG’) Framework

A key implication of the Sources of Growth (‘SOG’) Framework is that U.S. economic
growth is likely to slow due to the decelerating production of college graduates in the U.S.
economy. Figure 6 from Ellwood (2001) depicts the phenomenon of the ‘sputtering’ U.S. labor
force of the 21st century. The college-graduate share of the U.S. labor force is likely to continue
to stagnate in the early 21st century due to a combination of declining cohort size (thus, not much
‘new blood’ to bring up the average) and flattening rates of college attendance among younger
cohorts. This view that the sputtering labor force will slow economic growth, lucidly articulated
by Baart van Ark and Charles Hulten at the Innovation meeting, is widely accepted (see, for
example, Ellwood (2001) and DeLong, Goldin and Katz (2003)).

A controversial argument advanced during my remarks is that the human-capital-induced
growth picture is less bleak than the SOG analysis would suggest. Based on the ALM
polarization view, I argued that demand has recently been (and may continue to be) strongest for
very high and very low educated workers, with only limited growth in demand for middle-
educated workers who (increasingly) are the college-educated group. Some evidence supporting
this claim is found in Figure 7 (from Autor, Katz and Kearney, 2007). This figure shows that
after 1987, wage growth has been particularly rapid for workers with a post-secondary education.
By contrast, wage growth for pure college-educated workers has been comparatively modest
since the late 1980s. Consistent with the evidence in Figure 5, these patterns are consistent with

\(^4\) Notably, this pattern appears inconsistent with the hypothesis that a declining minimum wage played a leading role
in the expansion of lower-tail inequality in the 1980s. A decline in a binding wage floor should have lead to a
(modest) rise in low-wage employment rather than a sharp contraction.
(though not proof of) a polarization of labor demand, with greater demand at the tails of the distribution and slackening demand in the middle.

The significance of these patterns for economic growth is that, unlike for pure college-graduates, there is abundant supply of very-high and very-low educated workers to the United States. Both are in vast supply due to the role of immigration in the U.S. economy, which provides a highly bimodal distribution of skills; many low-skilled immigrants take low-education service sector positions and many high-skilled immigrants bring (or acquire) Ph.D. level skills to the U.S. workforce. For example, Borjas (2006) shows that immigrants workers provide 25 to 55 percent of the new Ph.D.’s to the fields of Biology, Chemistry, Physics/Astronomy, and Electrical Engineering. While immigration flows are always subject to political pressures and therefore can change precipitously, these observations demonstrate that there is no intrinsic shortage to the supply of highly-demanded skills to the U.S. economy (a point made forcefully by Freeman, 2006).

The fact that immigration supplies appear capable of meeting the changing shape of labor demand in the U.S. economy leaves me more optimistic than the average labor economist that
the predicted slowdown in economic growth due to the decelerating supply of college-educated labor will be less severe than the canonical SOG analysis suggests. Based on clarifying discussions with Profs. van Art and Hulton during the Innovation meeting, I believe that I can (at last) articulate my reasoning in language consistent with the SOG framework. The SOG model is based on a first-order approximation to the aggregate production function. In this model, factors earn their marginal products and so a growth in the supply of a factor contributes to economic growth in proportion to the wage paid to that factor multiplied by the factor’s share in aggregate production. Thus, a high-wage (relative to other labor groups) factor like college educated labor that also constitutes a substantial minority of the labor force is a ‘high leverage’ factor for economic growth. A percentage point growth of college-educated labor makes a significant contribution to aggregate output, and similarly, a slowdown in the production of college-educated labor makes a non-trivial dent in economic growth. The SOG analysis therefore suggests that the slowdown in the production of college educated labor augurs a flattening or even fall-off in the quality of U.S. labor supply and thus a deceleration of economic growth.

What leads me to differ slightly from this conclusion (recognizing that I’m going out on a limb) is that the SOG framework does not make specific provision for factor-augmenting technical change (though of course it can accommodate any technological change as a residual). If, hypothetically, there were a technological change that boosted the productivity of the highest-skilled workers (those with post-secondary education), and if there were simultaneously an influx of supply of these workers, this would augur well for economic growth.

I think that there is initial evidence that we have entered such an era over the last 15 years—that is, one in which, due to changing task demands, the productivity of very highly educated workers is rising rapidly (as evidenced by the combination of rising wages and rising supplies). Simultaneously, there is some initial evidence that factor augmenting technological progress has not been as favorable towards pure college-educated labor (as seen in the combination of stagnating supply and stagnating wages).

In summary, based on my view of the changing nature of job tasks and the empirical evidence on changes in employment and wage levels by skill over the last 15 years, it is my tentative (and, as I readily admit, unconventional) hypothesis that we are entering a period in which the slowdown in the production of college-educated labor will prove less negative—and the growth of post-secondary labor more positive—for economic growth than the SOG
framework would suggest. While, all else equal, it would be better to also have a rapidly increasing supply of college-educated labor, the growing centrality of post-secondary educated labor to U.S. productivity growth appears to be an important counterweight to the ‘sputtering’ of college-educated labor supply.

Figure 7. Trends in Real Log Weekly Full-Time Wages by Gender and Education, 1963 - 2005 (March CPS)
Selected References


