The Impact of Automation on the Demand for Skills – and Potential Education Systems Responses

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Labor Market Polarization

1. **Two inertial forces on a collision course**
   - Polarization of job opportunities, reducing opportunities for middle-educated workers (high school grad esp)
   - Stagnating educational attainment

2. Males are adapting particularly poorly

3. Social consequences beyond the labor market

4. **Why job opportunities are polarizing**
   - The role of Information Technology
   - Trade also appears an important factor

5. Limits to polarization

6. Are there implications for education?
Employment Polarization, 1979 – 2010
Percent Growth in Employment by Occupation

- 1979-1989
- 1989-1999
- 1999-2007
- 2007-2010
Changes in Employment Share by Job Skill Tercile, 1993-2006
Comparison of U.S. and European Union Countries

EU Nations Ordered by Growth in High Skill Occupation Share

Source: Goos, Salomons and Manning (2009)
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Actual versus Predicted College Wage Premium: 1915 to 2005

Figure 2

Actual values for college wage premium
Predicted college wage premium, col. (2)
Predicted wage premium, col. (3)

Sources and Notes: The actual values for the college wage premium are from the series used in the regressions in Table 2 and documented in the notes to Table 2. The two series for the predicted college wage premium are the values of the college wage premium predicted from the regressions in col. (2) and col. (3) of Table 2, as noted in the figure.

Goldin and Katz 2007 (Race between Education and Technology)
Mean Years of Schooling by Annual Birth Cohort, Native-Born Workers, 1876–1980

Goldin and Katz 2007 (Brookings)
Post-Secondary Degree Completion Ages 55-64 in OECD Countries 2007: U.S. Rank 4 of 32

Percentage of 55- to 64-Year-Olds with an Associate Degree or Higher, 2007

Source: Organisation for Economic and Co-operative Development, 2009
Post-Secondary Degree Completion Ages 25-34 in OECD Countries 2007: U.S. Rank 12 of 24

Percentage of 25- to 34-Year-Olds with an Associate Degree or Higher, 2007

Source: Organisation for Economic and Co-operative Development, 2009
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Fraction of Males and Females Ages 25-34 with a Four-Year College Degree, 1940-2008
Ratio of Female to Male College Completion Rates in 2009 by Country and Birth Cohort

US v. EU Averages

European Union Nations

Ages 45-54 in 2009
Ages 35-44 in 2009
Ages 25-34 in 2009

United States
E.U. (10 Countries)
Germany
Netherlands
Greece
Spain
United Kingdom
Ireland
Italy
France
Denmark
Portugal

Source: Eurostat, U.S. Census Bureau
Male College Completion Rates as of 2009 by Country and Birth Cohort

US v. EU Averages

European Union Nations

U.S. Male High Water Mark

Source: Eurostat, U.S. Census Bureau
U.S. High School Graduate Rate by Year 1930-1991: Overall and by Sex

Graduation rate

Goldin and Katz 2007 (Race between Education and Technology)
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Male Earnings Growth 1973 – 2009: Lackluster Except Among Post-College Educated

Percent changes in real hourly earnings by education, 1979–2007

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school dropout</td>
<td>-0.16</td>
<td>-0.01</td>
</tr>
<tr>
<td>High school graduate</td>
<td>-0.12</td>
<td>-0.06</td>
</tr>
<tr>
<td>Some college</td>
<td>-0.04</td>
<td>-0.12</td>
</tr>
<tr>
<td>College graduate</td>
<td>0.10</td>
<td>0.29</td>
</tr>
<tr>
<td>Postcollege education</td>
<td>0.26</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Source: May/OR CPS data for earnings years 1973-2009. The data are sorted into sex-race-age-education groups of two sexes (male/female), three race categories (white, black, nonwhite other), four age groups (16-24, 25-39, 40-54, 55-64), and five education groups (high school dropout, high school graduate, some college, college graduate, and greater than college). The mean log wage for each gender-education group presented in the figure is the weighted average of the relevant cells using a fixed set of weights equal to the average employment share of each group. The percent change is calculated using exponentiated mean log wages for 1979 and 2007.

See Data Appendix for more details on treatment of May/OR CPS data.

Autor 2010 (Hamilton Project paper)
Emp/Pop Falling for Less Educated Males, Rising for all but Least Educated Females

Changes in employment to population rates by education and sex, 1979–2007

Percentage change in employment to population rate

<table>
<thead>
<tr>
<th>Education Level</th>
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<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school dropout</td>
<td>-0.12</td>
<td>-0.02</td>
</tr>
<tr>
<td>High school graduate</td>
<td>-0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>Some college</td>
<td>-0.02</td>
<td>0.10</td>
</tr>
<tr>
<td>College graduate</td>
<td>-0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>Postcollege education</td>
<td>-0.05</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Autor 2010 (Hamilton Project paper)
The percentage change in occupational employment shares from 1979 to 2007 for males and females is shown in the figure. For low-wage occupations, the change was positive for both males and females. For medium-wage occupations, the change was negative for males and slightly positive for females. For high-wage occupations, the change was significantly negative for both males and females. The data suggests a polarization of employment into low- and high-skill jobs over the past two decades.
Incarceration Rate of Males Ages 25 - 39 by Race
1970 - 2008

White Men

Black Men

Hispanic Men

Less Than H.S.  
High School  
More than H.S.

Source: Census and American Community Survey

White Men
Black Men
Hispanic Men

Source: Census and American Community Survey

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Automation of ‘Routine Tasks:’ Jacquard Loom (1801)

Figure 3
THE PROGRESS OF COMPUTING MEASURED IN COST PER COMPUTATION PER SECOND DEFLATED BY THE PRICE INDEX FOR GDP IN 2006 PRICES

Notes: The larger circles are estimates that have been judged relatively reliable, while the small circles are estimates in the literature that have not been independently verified. The vertical line is placed at 1944, which is the estimated breakpoint in productivity growth.

Source: As described in the text.

Computation has become cheaper by a factor of $7.3 \times 10^{13}$ compared to manual calculations. Given the enormous decrease in computational cost relative to labor cost, it can hardly be surprising that there has been a rapid increase in the computer-intensity of production (as measured by the ratio of computer capital to output or computer capital to labor), a point I return to in the final section.
Plate 1. Comparison of Manual Calculation with Manual Calculator

This photograph shows a comparison of manual calculators and computations by a clerk in adding up a column of numbers such as might be found in a ledger. The calculator has an advantage of a factor of six. (Source: Burroughs Adding Machine Company, *A Better Day's Work at a Less Cost of Time, Work and Worry to the Man at the Desk in Three Parts Illustrated*, Third Edition, Detroit, Michigan, 1909, pp. 153-154.)
<table>
<thead>
<tr>
<th>Task Description</th>
<th>Example Occupations</th>
<th>Potential Impact of Computerization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routine Tasks</strong></td>
<td>• ‘Rules-based’&lt;br&gt;• Repetitive&lt;br&gt;• Procedural</td>
<td>• Bookkeepers&lt;br&gt;• Assembly line workers</td>
</tr>
<tr>
<td><strong>Abstract Tasks</strong></td>
<td>• Abstract problem-solving&lt;br&gt;• Mental flexibility</td>
<td>• Scientists&lt;br&gt;• Attorneys&lt;br&gt;• Managers&lt;br&gt;• Doctors</td>
</tr>
<tr>
<td><strong>Manual Tasks</strong></td>
<td>• Environmental Adaptability&lt;br&gt;• Interpersonal Adaptability</td>
<td>• Truck drivers&lt;br&gt;• Security guards&lt;br&gt;• Waiters&lt;br&gt;• Maids/Janitors</td>
</tr>
</tbody>
</table>

Source: Autor, Levy, Murnane 2003
“Once our edge in natural resources has been made irrelevant by giant Hong Kong ships and dirigibles that can ship North Dakota all the way to New Zealand for a nickel… There's only four things we do better than anyone else: music, movies, microcode (software), and high-speed pizza delivery.”

-- *Snow Crash*, Neal Stephenson (1992)
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Trade Shocks (‘China Syndrome’): Change in Import Exposure per Worker and Fall in Manufacturing Employment

Change in Manufacturing Emp by Commuting Zone, 1990-2007

coef = -.33976267, (robust) se = .07116474, t = -4.77

Autor, Dorn and Hanson 2011
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Moravec’s Paradox

• “It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.”

Rodney Brooks’ Lament

• Give me a robot with the visual recognition skills of a two-year old, the language recognition skills of a four-year old, the motor dexterity of a six-year old, and the common sense of an eight-year old.

(MIT Roboticist Rodney Brooks, 2011)
1. **Feasibility of unbundling**
   - Medical paraprofessionals
   - Classroom teachers
   - Production supervisors

2. **Some high-skill jobs could become middle-skill jobs**
   - Dental specialists, Nurse practitioners

3. **Intrinsic cumulativeness of education**

4. **The Bohr-Fiedler theorem**
   - Prediction is very difficult, especially if it's about the future
     - Neils Bohr
   - If you have to forecast, forecast often
     - Edgar R. Fiedler
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The Mystery of Human Capital: Educated People Earn More at Everything

Figure 4: LIFETIME EARNINGS BY EDUCATION AND OCCUPATION, 2009 DOLLARS

Carnevale et al., "The College Payoff" 2009
Making the most of what we have

- Many kids of recent vintage will not complete college—esp. males
- There are *some good jobs* for non-college workers with right skills
- Also *many fair-to-poor jobs* for non-college workers w/o these skills

Unlikely that non-college workers are investing optimally

- Problem is too hard
- Education does not provide right signals (Career Academies good example, Kemple et al. 2008)
- Traditional career tributaries for non-college drying up

*Can do better for non-college-bound youth*
For-Profit College Enrollment Booming: For-Profit Share of Total, 1997-98 versus 2007-08

Figure 1
For-Profit Institution Share of Total Title IV Fall Enrollment: Total and by School Type, 2000 to 2009

Source: Integrated Postsecondary Education Data System (IPEDS).
Conclusions and Implications

1. Education is the only thing that has consistently worked
   - We don’t know why entirely
   - Appears to create its own demand

2. Worst case economic scenario
   - Horses

3. Worst case policy scenario
   - Do something entirely different

4. Many more opportunities for innovation in the post-secondary education sector