Technology and the Evolution of Skill Demand: Theory and Evidence

Michael J. Handel
Department of Sociology
Northeastern University
m.handel@neu.edu
[Beginning in the 1980s] firms substituted computers and more-skilled workers for lower-skilled workers whose tasks could now be performed more efficiently with computers.

Insurance companies could lay off file clerks...checkout clerks no longer had to enter prices in the cash register. Inventory control was simplified and reordering could be done automatically.

In these and other ways, technology (or automation) decreased the value of the skills of workers with lower levels of education and increased demand for workers with more education. (Danziger and Gottschalk 1996)
Motivation

We went through the worst crisis since the Great Depression. We are now in a process where the economy is growing again, and we've created 2 million jobs over the last 15 months. But it's not as fast as it needs to be to make up for all the jobs that were lost.

The other thing that happened, though, is there are some structural issues with our economy where a lot of businesses have learned to become much more efficient with a lot fewer workers.

You see it when you go to a bank and you use an ATM; you don't go to a bank teller. Or you go to the airport, and you're using a kiosk instead of checking in at the gate.

--Barack Obama, interview, June 14, 2011
Trends in the Share of Tellers as a Percentage of All Workers in Banking (avg. n=1,075), 1971-97 (March CPS)
Trends in the Share of Cashiers as a Percentage of Workers in Grocery Stores (avg. n=1,460), 1971-97 (March CPS)
Trends in the Share of Secretaries as Percentages of All Workers, 1971-97 (March CPS)
Ratio of Managers and Professionals to All Clerical Workers and Secretaries, 1971-97 (March CPS)
Trends in the Ratio of Managers and Professional to all Clericals, 1971-97 (March CPS)
Trends in the Share of Clerical Workers as a Percentage of Workers in Finance and Insurance Industries (avg. n=2,787), 1971-97 (March CPS)
### Trends in e-commerce (excl. vehicles), 1999-2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Total retail sales</th>
<th>E-commerce</th>
<th>Pct e-commerce</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>2,088,188</td>
<td>13,206</td>
<td>0.63</td>
</tr>
<tr>
<td>2011</td>
<td>3,316,423</td>
<td>173,963</td>
<td>5.25</td>
</tr>
</tbody>
</table>

**Annual abs. change** 0.4
Cutting edge vs. nuts and bolts

Baxter the robot, 2013: low cost flexible visual recognition

Marks & Spencer - Covent Garden 2010: self-checkout in two Kroger stores in 1987—*why are cashiers overwhelmingly more common 27 years later?*

Probably many reasons — but that’s key
Motivation 2

Growing inequality

• Leading explanation based on human capital theory
  o skill-biased technological change (SBTC)
  o Increasing demand for skill outpacing the supply
  o Information technology driving change

Broader discourse (various sources)

• Skills shortage, mismatch
• Educational failure
• Skill demands accelerating, revolutionary
• Converges with post-industrial theories of knowledge society

Focus on worker characteristics, rather than economic structure
Issues and problems

A. Claims about skill levels and trends based on weak evidence
   - Rising education premium (indirect evidence)
   - Preconceptions regarding technology impacts (non-evidence)
   - Limited measures of technology levels
   - To alter wage structure rate of technological change must change (accelerate)

B. SBTC arguments vague or shifting
   1. Demand acceleration vs. supply deceleration
   2. Not clear exactly how IT affects skill demand (within- vs. between-occ shifts)
   3. Skill upgrading vs. polarization
      - First argued least skilled hardest hit
      - After 50-10 pay gap narrowed in late 1990s, argument became middle skilled most impacted by IT

C. Despite progress, still too many problematic black-box correlations
Issues and problems 2

• Alternative institutional forces
  ○ Deindustrialization
    ▪ Decline of institutionally protected, well-paid, low- to mid-skill jobs
    ▪ Rise of service proletariat
    ▪ Industry shifts rather than skill shifts (segmented labor market theory)
  ○ Deunionization
  ○ Trade, offshoring, outsourcing
  ○ Minimum wage trends

○ Macroeconomic strength
  ▪ Deep recessions in early 1980s & now; strong growth late 1990s
  ▪ Did the less-educated cause financial crisis?
  ▪ Is current unemployment level due to skills mismatch?

○ Shifting wage norms due to more difficult economic conditions and rise of market-based or non-solidaristic governance philosophies
Begin again...

Establish a more compelling framework for understanding

• nature of technologies
• their labor market impacts
• including mediation through skill demand
Skills

**Taxonomy of job skill requirements relatively straightforward**

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Interpersonal</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>3Rs, schooling</td>
<td>Very diverse (e.g., counseling, caring, training, persuading, public presentations)</td>
<td>Skilled tasks (tools, equipment, methods, materials)</td>
</tr>
<tr>
<td>Field of study/training</td>
<td></td>
<td>Simple muscle power</td>
</tr>
<tr>
<td>Job-specific HC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tacit knowledge/skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General cognitive ability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spanning multiple categories

**Management duties:** Cognitive and interpersonal

**Work organization:** Cognitive and interpersonal (autonomy, employee involvement)

**Technology use:** Cognitive and physical (mechanical technology)
## Skills and occupations

Broadly speaking....

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Interpersonal</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use at high level</td>
<td>Use at high level</td>
<td>Skilled physical</td>
</tr>
<tr>
<td>Professionals</td>
<td>Managers</td>
<td>Craft, trades, repair, farm</td>
</tr>
<tr>
<td>Assoc. professionals</td>
<td>Professionals</td>
<td></td>
</tr>
<tr>
<td>Managers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use at medium level</td>
<td>Use at medium level</td>
<td>Muscle power, fingers</td>
</tr>
<tr>
<td>Clerical</td>
<td>Clerical</td>
<td>Operative, laborer,</td>
</tr>
<tr>
<td>Sales (low to medium)</td>
<td>Sales</td>
<td>elementary, service, farm</td>
</tr>
<tr>
<td></td>
<td>Service</td>
<td></td>
</tr>
</tbody>
</table>
Technology taxonomy

Key distinction

Manual/mechanical
- Hand tools
- Powered tools
- Powered machines
- Programmable machines (including intelligent control)

Information/Communication
- Digitization (recording, simple processing)
- Analytics (data analysis)
- Automation
- Networks (voice/data transmission)
- Self-service

Other technologies

Chemical processes and electric power generation

*Humans or machines can mix ingredients or maintain infrastructure, but primary action is microscopic*
Technology taxonomy—hypotheses

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Hand tools</td>
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</tr>
<tr>
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<td>Automation</td>
</tr>
<tr>
<td>Programmable machines</td>
<td>Networks, Self-service</td>
</tr>
</tbody>
</table>

1. The task and technology classes form natural pairs
   a. Mechanical technologies are the main influences on blue-collar tasks
   b. Information technology mostly affects white-collar tasks (not exclusively)

2. More physical labor displaced by shift from hand to power tools/machines than by addition of programmability and intelligent control
   a. Capital-labor substitution a longstanding trend
   b. Implies pre-computer technology effects under-estimated by SBTC theory

3. Effects of digitization and self-service often mistaken for automation
   a. Neither has counterpart in blue-collar world
   b. Easy to overestimate effects of IT on blue-collar work for this reason

4. Slow diffusion rate and unit impact makes it easy to over-estimate IT effects on white-collar work also
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   a. Mechanical technologies are the main influences on blue-collar tasks
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### Explain diffusion

<table>
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<tr>
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</tr>
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<tr>
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<td>Powered tools/machines</td>
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</tr>
<tr>
<td>Programmable machines</td>
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1. **The task and technology classes form natural pairs**
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Technology needs better theory

1. The most novel development receive most attention
   a. **Underestimates** past rate of change based on familiar technologies
   b. **Overestimates** recent/future rates of change based on new technologies

2. Several components of impact: **Total impact = no. of units * impact per unit**
   a. First term implicates literature on **diffusion of innovation** (not instantaneous/universal)
   b. Second term implicates previous discussion of within- and between-occupation effects

3. Critical distinction: **Manual vs. symbolic work**
   a. Mechanical technologies address manual tasks (longstanding)
   b. Information & communication technologies address symbolic tasks (recent)

3. Non-technology drivers of occupational demand—Final demand
   a. Goods to services
   b. **Healthcare** (population aging)
   c. **Prepared food, leisure** (consumption preferences, female LFP)
   d. Social services
Substantive argument

• Easy to overestimate the level of job skill requirements
  ○ Careful measurement shows common academic skills are not widely used
    ▪ Issues of completeness of measures remain (field of study, IQ)

• Easy to overestimate the skill requirements of information technology
  ○ Most users do not perform complex IT tasks
  ○ Few use automated factory technologies
  ○ IT unlikely to have large direct upgrading effects within-occupations
  ○ Trends suggest probably no large indirect effects within occupations, but analyses remain to be completed

• Between-occ trends show gradual, steady skill upgrading, not acceleration
  ○ slow rate $\times$ long time = high level
  ○ no indication manual jobs returning in future

• Hard to argue recent skill change is exceptionally rapid
• Many reasons for caution regarding tech impacts
• “Knowledge economy” thesis does have some foundation
Data

Survey of Skills, Technology, and Management Practices (STAMP)

- Two-wave, refreshed panel ($N_{wave1} = 2,304$, $N_{wave2} = 2,237$)

- Sample reinterviewed after 3 years ($N=1,160$, 60%), plus new subsample ($N = 1,077$)

- Nationally representative, RDD telephone survey (2005, 2008)

- Employed wage & salary workers, age ≥ 18

- English & Spanish language versions

- 166 job-specific questions, 28 mins. average length
### STAMP Survey Content (N=number of items)

1. **Basic Job and Organizational Information** (N=12)
   - Occupation, industry, organizational position, size
   - Union membership

2. **Skill and Task Requirements** (N=60)
   - Cognitive skills (N=48)
     - Mathematics (n=12)
     - Reading (n=8)
     - Writing (n=6)
     - Forms and visual matter (n=6)
     - Problem-solving (n=3)
     - Education, experience, and training requirements
     - Skill changes in previous three years (n=4)
   - Interpersonal job tasks (n=8)
   - Physical job tasks (n=4)

3. **Computer and Non-computer Technology** (N=49)
   - Computers (n=26)
     - Frequency of use
     - Use of fourteen specific applications
     - Use of advanced program features, occ-specific IT
     - Training times
     - Complexity of computer skills required
     - Adequacy of respondents’ computer skills
     - Computer knowledge and experience in prior jobs among non-users
   - Machinery and electronic equipment (n=18)
     - Level of machine knowledge needed, training time
     - Set-up, maintenance, and repair
     - Automation, equipment and tool programming
   - Other technology (n=5)
     - Telephone, calculator, fax, bar code reader, and medical, scientific and lab equipment
   - Technological displacement measures

4. **Employee Involvement Practices** (N=18)
   - Job rotation and cross-training
   - Pay for skill
   - Formal quality control program
   - Teams activity levels, responsibilities, decision making authority
   - Bonus and stock compensation

5. **Autonomy, Supervision, and Authority** (N=11)
   - Closeness of supervision, autonomy
   - Repetitive work
   - Supervisory responsibilities over others
   - Decision-making authority over organizational policies

6. **Job Downgrading** (N=15)
   - Downsizing and outsourcing
   - Reductions in pay and retirement and health benefits
   - Promotion opportunity, internal labor markets
   - Work load, pace, and stress
   - Strike activity

7. **Job Satisfaction** (N=1)
### Table 8. Computer use

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Hi WC</th>
<th>Lo WC</th>
<th>Hi BC</th>
<th>Lo BC</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data entry most of time</td>
<td>0.14</td>
<td>0.14</td>
<td>0.31</td>
<td>0.00</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>Spreadsheets</td>
<td>0.40</td>
<td>0.64</td>
<td>0.44</td>
<td>0.13</td>
<td>0.18</td>
<td>0.14</td>
</tr>
<tr>
<td>Spreadsheet macros, equations</td>
<td>0.12</td>
<td>0.21</td>
<td>0.11</td>
<td>0.02</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Databases</td>
<td>0.19</td>
<td>0.32</td>
<td>0.20</td>
<td>0.07</td>
<td>0.07</td>
<td>0.03</td>
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<tr>
<td>SQL queries</td>
<td>0.03</td>
<td>0.08</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>CAD</td>
<td>0.07</td>
<td>0.10</td>
<td>0.05</td>
<td>0.05</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Science/engineering tasks</td>
<td>0.07</td>
<td>0.14</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Programming</td>
<td>0.04</td>
<td>0.08</td>
<td>0.02</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Special software</td>
<td>0.47</td>
<td>0.61</td>
<td>0.59</td>
<td>0.23</td>
<td>0.29</td>
<td>0.24</td>
</tr>
<tr>
<td>New software in last 3 years</td>
<td>0.16</td>
<td>0.24</td>
<td>0.16</td>
<td>0.11</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>No. of applications (0-15)</td>
<td>4.02</td>
<td>6.06</td>
<td>4.68</td>
<td>1.68</td>
<td>1.91</td>
<td>1.41</td>
</tr>
<tr>
<td>Computer skill level(^a)</td>
<td>4.21</td>
<td>5.91</td>
<td>5.06</td>
<td>1.95</td>
<td>2.43</td>
<td>1.77</td>
</tr>
<tr>
<td>Inadequate skills (users only)</td>
<td>0.23</td>
<td>0.26</td>
<td>0.18</td>
<td>0.30</td>
<td>0.23</td>
<td>0.22</td>
</tr>
<tr>
<td>Affected pay/promotion</td>
<td>0.08</td>
<td>0.03</td>
<td>0.05</td>
<td>0.10</td>
<td>0.18</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**Note:** All statistics calculated from total sample unless noted.
<table>
<thead>
<tr>
<th>Machine technology</th>
<th>All</th>
<th>Hi WC</th>
<th>Lo WC</th>
<th>Hi BC</th>
<th>Lo BC</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Machinery</td>
<td>0.20</td>
<td>0.07</td>
<td>0.11</td>
<td>0.65</td>
<td>0.46</td>
<td>0.12</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0.10</td>
<td>0.03</td>
<td>0.01</td>
<td>0.41</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>Repair</td>
<td>0.08</td>
<td>0.03</td>
<td>0.01</td>
<td>0.35</td>
<td>0.16</td>
<td>0.07</td>
</tr>
<tr>
<td>Set-up</td>
<td>0.12</td>
<td>0.04</td>
<td>0.04</td>
<td>0.41</td>
<td>0.29</td>
<td>0.08</td>
</tr>
<tr>
<td>Machine tools</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
<td>0.12</td>
<td>0.14</td>
<td>0.02</td>
</tr>
<tr>
<td>Use NC/CNC</td>
<td>0.02</td>
<td></td>
<td></td>
<td>0.03</td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td>Program NC/CNC</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Industrial robots</td>
<td>0.01</td>
<td></td>
<td>0.01</td>
<td>0.02</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Program robots</td>
<td>0.01</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programmable logic controller</td>
<td>0.02</td>
<td>0.01</td>
<td></td>
<td>0.06</td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>Computerized process control</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.14</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Program CPC</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
<td>0.04</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Automated equipment</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.09</td>
<td>0.19</td>
<td>0.01</td>
</tr>
<tr>
<td>Assembly line</td>
<td>0.02</td>
<td></td>
<td>0.01</td>
<td>0.05</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>New machinery in last 3 years</td>
<td>0.10</td>
<td>0.04</td>
<td>0.04</td>
<td>0.32</td>
<td>0.23</td>
<td>0.06</td>
</tr>
<tr>
<td>Training time &gt;1 week</td>
<td>0.04</td>
<td>0.01</td>
<td>0.02</td>
<td>0.13</td>
<td>0.12</td>
<td>0.01</td>
</tr>
<tr>
<td>Mechanical Skill Level&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.50</td>
<td>1.73</td>
<td>1.38</td>
<td>5.97</td>
<td>4.55</td>
<td>2.12</td>
</tr>
<tr>
<td>Electronics Skill</td>
<td>0.13</td>
<td>0.12</td>
<td>0.08</td>
<td>0.33</td>
<td>0.15</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Note: Blank cells have values less than 0.01.

a. Mechanical skills: 0=very basic, 10=very complex
Occupational trends—conclusions

Long-run trends show clear stages

- **Farm occupations** decline steeply when ≥ 20% of workforce
  - Austria, Finland, Greece, Ireland, Japan, Korea, Portugal, Spain, and, to a lesser extent, France and Norway—very rapid transition to non-farm economy in several post-war OECD countries

- **Production jobs** dominate next phase—advanced countries:
  - peak 45% (1950s-1960s) and now <25%, some still in this phase
  - Declines 25% in 50 years, usually predates computers

- **Professionals/assoc profs/managers** predominate now
  - 10% in 1960 and 35% now
  - Mostly overtaken production workers (not Greece, Portugal, Spain, Japan, Korea, Austria)

- **Clerical and sales** grew from 1960-1990, now flat or small decline
  - clerical most affected by computers so far...

- **Service occupations** growing, but not quickly (7-10% in 1960 to 9-18% today)

Projections show no acceleration to 2020
O*NET SKILL MEASURES—summary

1. Job’s required education (years)  
   Cognitive—overall academic skills

2. * Math

3. * Verbal (reading, writing)  
   Cognitive—finer dimensions

4. * General cognitive demands

5. * People skills  
   Interpersonal skills

6. * Craft skills (install, maintain, repair)  
   Manual skills

7. * Gross physical requirements

8. Repetitive motions (time spent)

* Measures 2-7 are composite scales in standardized metric (U.S. 1992 = 1.0)
<table>
<thead>
<tr>
<th></th>
<th>Required education</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>Math requirements:</strong> (1) mathematics skills; (2) mathematics knowledge; (3) mathematical reasoning; (4) number facility ($\alpha=0.92$)</td>
</tr>
<tr>
<td>3</td>
<td><strong>Verbal requirements:</strong> (1) reading comprehension; (2) writing skills; (3) writing comprehension; (4) writing ability; (5) knowledge of English language rules; (6) frequency of using written letters and memos ($\alpha=0.95$)</td>
</tr>
<tr>
<td>4</td>
<td><strong>General cognitive demands:</strong> (1) analytical thinking; (2) critical thinking; (3) complex problem solving; (4) active learning; (5) analyzing data or information; (6) processing information; (7) thinking creatively; (8) updating and using relevant knowledge; (9) deductive reasoning; (10) inductive reasoning; (11) fluency of ideas; (12) category flexibility ($\alpha=0.97$)</td>
</tr>
<tr>
<td>5</td>
<td><strong>People skills:</strong> (1) persuasion; (2) negotiation; (3) speaking skills; (4) frequency of face-to-face discussions; (5) frequency of public speaking; (6) communicating with persons outside organization; (7) dealing with external customers or public; (8) performing for or working directly with the public; (9) customer and personal service knowledge; (10) service orientation; (11) dealing with angry people; (12) dealing with physically aggressive people; (13) frequency of conflict situations; (14) resolving conflicts and negotiating with others; (15) instructing skills; (16) training and teaching others; (17) education and training knowledge; (18) interpreting the meaning of information for others; (19) social orientation; (20) social perceptiveness ($\alpha=0.94$)</td>
</tr>
<tr>
<td>6</td>
<td><strong>Craft skills:</strong> (1) controlling machines and processes; (2) repairing and maintaining mechanical equipment; (3) repairing and maintaining electronic equipment; (4) equipment maintenance; (5) repairing machines; (6) troubleshooting operating errors; (7) installing equipment, machines, and wiring ($\alpha=0.95$)</td>
</tr>
<tr>
<td>7</td>
<td><strong>Gross physical requirements:</strong> (1) handling and moving objects; (2) general physical activities; (3) static strength; (4) dynamic strength; (5) trunk strength; (6) stamina; and time spent (7) sitting, (8) standing, (9) walking, (10) twisting body, (11) kneeling, crouching, stooping, or crawling ($\alpha=0.98$)</td>
</tr>
<tr>
<td>8</td>
<td><strong>Repetitive motions</strong> (time spent making repetitive motions)</td>
</tr>
</tbody>
</table>
Mean job skill demands for US and a panel of European countries, 1997-2009

<table>
<thead>
<tr>
<th></th>
<th>Education</th>
<th>Cognitive</th>
<th>Math</th>
<th>Verbal</th>
<th>People</th>
<th>Craft</th>
<th>Physical</th>
<th>Repetitive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>13.53</td>
<td>0.05</td>
<td>0.05</td>
<td>0.04</td>
<td>0.06</td>
<td>0.01</td>
<td>-0.00</td>
<td>3.09</td>
</tr>
<tr>
<td>2009</td>
<td>13.68</td>
<td>0.12</td>
<td>0.08</td>
<td>0.11</td>
<td>0.17</td>
<td>-0.05</td>
<td>-0.02</td>
<td>3.04</td>
</tr>
<tr>
<td><strong>Δ 1997-2009</strong></td>
<td>0.15</td>
<td>0.07</td>
<td>0.03</td>
<td>0.07</td>
<td>0.11</td>
<td>-0.06</td>
<td>-0.02</td>
<td>-0.05</td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>13.38</td>
<td>-0.06</td>
<td>-0.06</td>
<td>-0.09</td>
<td>-0.12</td>
<td>0.14</td>
<td>0.15</td>
<td>3.17</td>
</tr>
<tr>
<td>2009</td>
<td>13.59</td>
<td>0.05</td>
<td>-0.04</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.04</td>
<td>3.13</td>
</tr>
<tr>
<td><strong>Δ 1997-2009</strong></td>
<td>0.21</td>
<td>0.11</td>
<td>0.10</td>
<td>0.12</td>
<td>0.11</td>
<td>-0.14</td>
<td>-0.11</td>
<td>-0.04</td>
</tr>
<tr>
<td><strong>Europe-US gap</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>-0.15</td>
<td>-0.11</td>
<td>-0.11</td>
<td>-0.13</td>
<td>-0.18</td>
<td>0.13</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>2009</td>
<td>-0.09</td>
<td>-0.07</td>
<td>-0.12</td>
<td>-0.08</td>
<td>-0.18</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>gap shrink</strong></td>
<td>0.06</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.00</td>
<td>0.08</td>
<td>0.09</td>
<td>0.01</td>
</tr>
</tbody>
</table>

European panel: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Switzerland, Sweden, and UK
O*NET conclusions

• O*NET shows very slow (between-occupation) change for 1997-2009
  o all due to change in 1-digit occupations
  o skill composition of 1-digit occupations remain constant for 1997-2009
  o supports validity of first exercise using long-term trends in 1-digit occupation

• Possible that O*NET masks changes within 3-digit occupations
  o but ISSP and ESWC don't show such changes
Conclusions

Clear evidence of stages

- Dominant occupation shifts from
  1. Farm
  3. Professional/Assoc. Professional
- Less action in other occupations (but aggregation issues)
- Transition from Industrial to Post-industrial economy often slower
  - Specific detailed occupations might change more rapidly
  - Skills from farm may be more transferable to production jobs than from production to professional/technical

Trends in job task content

- **Direction:** skill upgrading
- **Rate and timing:** not rapid or discontinuous in past and future (projections)
  - No clear acceleration since computers introduced
  - *Slow rate X long time = high level* in late-stage countries
  - No indication manual jobs returning in future
Remaining issues

- Modeling effects of IT use on other skills and wages
- Modeling occupation time series
- Causal models
- Understanding Asian occupation distributions
- Lots of data cleaning
Key points and additional thoughts

1. The most novel development receive most attention
   a. **Underestimates** past rate of change based on familiar technologies
   b. **Overestimates** recent/future rates of change based on new technologies

2. General trend is **gradual, steady upgrading** of job skill requirements, but no acceleration
   a. slow rate $\times$ long time = high level
   b. no indication manual jobs returning in future

3. Evidence
   a. All OECD countries show smooth trends in occupation and job skill requirements
   b. All project similarly smooth future trends
   c. Firms and workers rarely cite technology as cause of job losses

4. Neglects other sources of job and wage dynamics
   a. **Aggregate demand** (did less-educated cause financial crisis?)
   b. **Changing spending patterns** (e.g., healthcare, market purchases vs. household production)
   c. **Trade, offshoring**
   d. **Unions, minimum wage, competition/rent destruction**
   e. Openings due to replacement demand exceed those due to net additions
   f. Is the quantity of university jobs entirely a response to number of university grads?