WHICH SKILLS FOR THE DIGITAL ERA?

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1. Motivation

THE QUESTION:
How does the digital transformation change the skills demanded on the market? Cognitive and non-cognitive skills.

OUR ANSWER:

- The skills with higher rewards (or returns) in digital industries are particularly needed for the digital transformation of industries
- Cross-section, worker-level data for 31 OECD & non-OECD countries, splitting more vs less digital intensive sectors.

RELEVANCE:

- Digital transformation affects labour markets and jobs (both quantity and quality) and the skills that workers need.
- Tacit knowledge in digital / AI requires skills non-codifiable skills => plurality of skills
1. Contribution of this work

- Returns to both cognitive and non-cognitive skills.
  1. For a representative sample (vs. e.g. Deming and Kahn, 2016).
  2. In a single dataset, with uniform measurement, and across country.
  3. Controlling for “innate” competencies.
  4. Investigating BUNDLES of skills (as in Weinberger, 2014 or Deming, 2016).

  1. BUT task-approach (e.g. Autor and Acemoglu, 2011): multiple possible complementarity / substitution patterns.
  3. Inform policy debate.
1. Findings

- Cognitive and non-cognitive skills are strongly rewarded by labour markets

- Digital intensive industries show higher returns for Stem-quantitative and Self-Organisation skills

- In digital intensive industries the bundling of workers skills seems to be especially important:
  - Self-organisation and managing and communication skills are complementary to STEM-quantitative or numeracy skills

- Focusing only on STEM/Numeracy skills to face the challenges of the digital transformation is short sided (non-cognitive skills matter)
Programme for the International Assessment of Adult Skills

- 22 + 9 countries, 2012 or 2015. Both OECD and non-OECD
- Approx. 2-5,000 adults aged 16-65 in each country.
  - Down to ~104,000 when excluding unemployed, self-employed and individuals with missing salaries.
- Detailed employee information.
  - Occupations (ISCO08, 3-dig) and sectors (ISIC Rev4, 4-dig)
  - Age, gender, education and health of the worker, part timers etc.
  - Size of the firm
- Assessed skills.
- Tasks performed on the job.

Measuring Workers’ Skills
Measuring Workers’ Skills

- **3 cognitive skills:**
  - Assessed through tests

- **6 skill indicators based on information on frequency of tasks performed on the job and individual characteristics**

  Items isolated with Exploratory Factor Analysis (as in Conti et al., 2014):
  - ICT
  - Management and Communication
  - Advanced Numeracy (STEM)
  - Accountancy and Marketing
  - Self-Organisation
  - Readiness to Learn

See [Grundke et al. (2017)](#)
Measuring Digital Intensity of Sectors

- Balanced data for 36 sectors (ISIC4) in 12 OECD countries.
- Multiple dimensions of the taxonomy:
  - **ICT investment intensity**: deflated ICT tangible GFCF / total GFCF;
  - **Software investment intensity**: deflated software GFCF / total GFCF;
  - **Robot intensity**: Stock of robots / employment (manufacturing);
  - **Intermediates ICT goods and ICT services**: deflated purchases of ICT intermediate goods (resp., services) / output;
  - **E-sales intensity**: % of total sales carried out online;
  - **ICT specialists**: # of ICT specialists in all countries / total employment.

See Calvino et al. (2018)
## A taxonomy of digital sectors

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing</td>
<td>Low</td>
<td>Wholesale and retail trade, repair</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>Low</td>
<td>Transportation and storage</td>
<td>Low</td>
</tr>
<tr>
<td>Food products, beverages and tobacco</td>
<td>Low</td>
<td>Accommodation and food service activities</td>
<td>Low</td>
</tr>
<tr>
<td>Textiles, wearing apparel, leather</td>
<td>Medium-low</td>
<td>Publishing, audiovisual and broadcasting</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Wood and paper products, and printing</td>
<td>Medium-high</td>
<td>Telecommunications</td>
<td>High</td>
</tr>
<tr>
<td>Coke and refined petroleum products</td>
<td>Medium-low</td>
<td>IT and other information services</td>
<td>High</td>
</tr>
<tr>
<td>Chemicals and chemical products</td>
<td>Medium-low</td>
<td>Finance and insurance</td>
<td>High</td>
</tr>
<tr>
<td>Pharmaceutical products</td>
<td>Medium-low</td>
<td>Real estate</td>
<td>Low</td>
</tr>
<tr>
<td>Rubber and plastics products</td>
<td>Medium-low</td>
<td>Legal and accounting activities, etc.</td>
<td>High</td>
</tr>
<tr>
<td>Basic metals and fabricated metal products</td>
<td>Medium-low</td>
<td>Scientific research and development</td>
<td>High</td>
</tr>
<tr>
<td>Computer, electronic and optical products</td>
<td>Medium-high</td>
<td>Advertising and market research; other business services</td>
<td>High</td>
</tr>
<tr>
<td>Electrical equipment</td>
<td>Medium-high</td>
<td>Administrative and support service activities</td>
<td>High</td>
</tr>
<tr>
<td>Machinery and equipment n.e.c.</td>
<td>Medium-high</td>
<td>Public administration and defence</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>High</td>
<td>Education</td>
<td>Medium-low</td>
</tr>
<tr>
<td>Furniture; other manufacturing; repairs of computers</td>
<td>Medium-high</td>
<td>Human health activities</td>
<td>Medium-low</td>
</tr>
<tr>
<td>Electricity, gas, steam and air cond.</td>
<td>Low</td>
<td>Residential care and social work activities</td>
<td>Medium-low</td>
</tr>
<tr>
<td>Water supply; sewerage, waste management</td>
<td>Low</td>
<td>Arts, entertainment and recreation</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Construction</td>
<td>Low</td>
<td>Other service activities</td>
<td>High</td>
</tr>
</tbody>
</table>
Average skill levels

31 countries, 2012 or 2015

Digital-intensive industries

Less digital-intensive industries

Score

Literacy
Numeracy
Problem solving
ICT skills
Management and communication
Marketing and accounting
STEn-quantitative
Self-organisation
Readiness to learn
3. Empirical strategy

- Worker-level, “Mincer” regressions.

- Retrieve **prices of skills** (returns to skills): they signal whether these skills are in high demand and/or short supply.

- *Individuals have bundles of skills*: prices of tasks need not be the same across occupations (Roy, 1951; Rosen 1978).

- Investigate differences in returns between *digital and less digital intensive* industries.
3. Empirical strategy

\[
\log(wage)_i = \alpha_0 + \alpha_1 \text{DigInd}_k + \text{DigInd}_k \ast \text{skills'}_i\beta + \text{skills'}_i\gamma + x'_{i,c}\delta + \mu_c + \sigma_{sector} + \rho_{isco08} + u_i \quad (1)
\]

- Dependent variable is the log of the hourly gross wage (with bonuses) in PPP USD.

- Only employees.

- Individual control variables: age, gender, years of education, working part time, health, firm size (, parental education).

- Country (31), industry (18) and occupation (40) dummies.

- Weighted OLS (using final sample weights and giving each country the same weight)
What skills show additional returns in digital intensive industries?

- **Results**

<table>
<thead>
<tr>
<th>Skill</th>
<th>Additional returns to skills in digital-intensive industries</th>
<th>Coefficient insignificant at the 5% level</th>
<th>Returns to skills in less digital-intensive industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT skills</td>
<td>-4</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Numeracy</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Management and communication</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Self-organisation</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>STEM-quantitative</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Literacy</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Readiness to learn</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>Marketing and accounting</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
</tr>
</tbody>
</table>

All skills and interaction with digital-sector dummy included at the same time
Full-control specification
N : 104,296. Adjusted R2: 0.576
What skills are complementary to STEM-quantitative skills?

4. Results – Digital Intensive Industries

- Coefficient insignificant at the 5% level
- Additional returns to skills in STEM-quantitative skill intensive jobs
- Average returns to skills
What skills are complementary to numeracy skills?

- Coefficient insignificant at the 5% level
- Additional returns to skills in numeracy skill intensive jobs
- Average Returns to skills
4. Robustness checks

- Use top quartile of sectors in the taxonomy to define digital intensive industries

- Include combined country-industry (18 aggregated industries) fixed effects to control for country-industry specific characteristics

- Including further individual level control variables (parental education)

- Excluding occupation dummies (looking at results across occupations)

- Using old classification. (Digital*numeracy) and (Digital*readiness to learn) now significant.

- Excluding bonuses (misreporting?).
5. Next steps

- **ENDOGENEITY.**
  - Individual-level unobservables correlated to wages and skills:
    - Individual’s ability or productivity on the job: assessed skills.
    - Firm-specific wages… If linked to being in digital sector, controlled for.
  - Of sectoral dummies: better-paying sectors attract minds and can innovate more.
    - BUT innovation take times VS contemporaneous specification
    - Controlled for with lagged industry classification.

- **SELECTION into occupation**
5. Conclusions

- Cognitive and non-cognitive (or task-based) skills are strongly rewarded by labour markets.

- Digital intensive industries show higher returns for Stem-quantitative and Self-Organisation skills.

- In digital intensive industries the bundling of workers skills seems to be especially important:
  
  Self-organisation and managing and communication skills are complementary to STEM-quantitative or numeracy skills.

- Focusing only on STEM/Numeracy skills to face the challenges of the digital transformation is short sided (non-cognitive skills matter).
Thank you!
BACK-UP
<table>
<thead>
<tr>
<th>Components of task-based skills</th>
<th>ICT Skills</th>
<th>Readiness to learn and creative problem solving</th>
<th>Managing and Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G_Q05e Frequency of excel use</td>
<td>I_Q04j I like to get to the bottom of difficult things</td>
<td>F_Q04b Frequency of negotiating with people (outside or inside the firm or organisation)</td>
</tr>
<tr>
<td></td>
<td>G_Q05g Frequency of programming language use</td>
<td>I_Q04m If I don't understand something, I look for additional information to make it clearer</td>
<td>F_Q03b Frequency of planning activities of others</td>
</tr>
<tr>
<td></td>
<td>G_Q05d Frequency of transactions through internet (banking, selling/buying)</td>
<td>I_Q04h When I come across something new, I try to relate it to what I already know</td>
<td>F_Q02b Frequency of instructing and teaching people</td>
</tr>
<tr>
<td></td>
<td>G_Q05a Frequency of email use</td>
<td>I_Q04b When I hear or read about new ideas, I try to relate them to real life situations to which they might apply</td>
<td>F_Q02e Frequency of advising people</td>
</tr>
<tr>
<td></td>
<td>G_Q05c Frequency of simple internet use</td>
<td>I_Q04d I like learning new things</td>
<td>F_Q04a Frequency of persuading or influencing others</td>
</tr>
<tr>
<td></td>
<td>G_Q05f Frequency of word use</td>
<td>I_Q04l I like to figure out how different ideas fit together</td>
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<tr>
<td></td>
<td>G_Q05h Frequency of real-time discussions through ICT Computer</td>
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<tr>
<td></td>
<td>G_Q01b Frequency of Reading letters, emails, memos</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G_Q02a Frequency of Writing letters, emails, memos</td>
<td></td>
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<tr>
<td></td>
<td>G_Q06 Level of Computer Use required for the job</td>
<td></td>
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<tr>
<td></td>
<td>F_Q06b Frequency of working physically over long periods</td>
<td></td>
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</tr>
<tr>
<td>Component</td>
<td>Description</td>
<td></td>
<td></td>
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<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td><strong>Self-Organisation</strong></td>
<td>D_Q11a extent of own planning of the task sequences</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D_Q11b extent of own planning of style of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D_Q11c extent of own planning of speed of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D_Q11d extent of own planning of working hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accountancy and Selling</strong></td>
<td>G_Q01g Frequency of Reading financial invoices, bills etc.</td>
<td></td>
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<tr>
<td></td>
<td>G_Q03b Frequency of Calculate prices, costs, budget</td>
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<td></td>
<td>G_Q03d Frequency of using calculator</td>
<td></td>
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<td></td>
<td>F_Q02d Frequency of client interaction selling a product or a service</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Advanced Numeracy</strong></td>
<td>G_Q03f Frequency of preparing charts and tables</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>G_Q03g Frequency of Use simple algebra and formulas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G_Q03h Frequency of Use complex algebra and statistics</td>
<td></td>
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</tbody>
</table>