Which Skills for the Digital Era?

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BETTER POLICIES FOR BETTER LIVES

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).

- Returns to skills in the digitalisation. Goldin and Katz, 2008.
  1. BUT task-approach (e.g. Autor and Acemoglu, 2011): multiple possible complementarity / substitution patterns.
  2. Using new taxonomy of sectors by digital intensity (Calvino et al. 2018).
  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)

Measuring Workers' Skills

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

- **3 cognitive skills:**
  - Literacy, Numeracy and Problem Solving in Technology Rich Environments.
  - 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.
- 2001-03 vs 2013-15.
- 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.

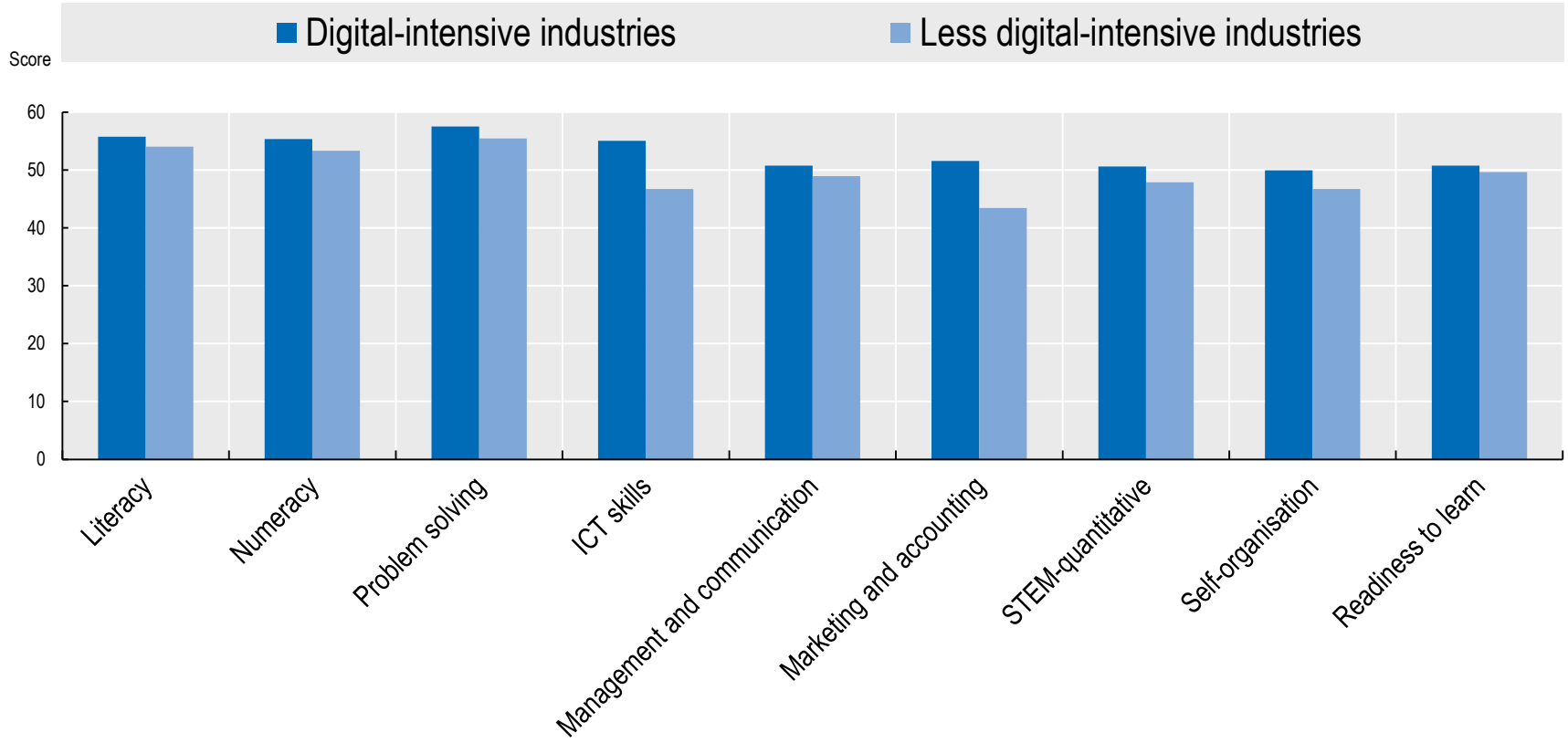
See Calvino et al. (2018)

A taxonomy of digital sectors

Sector denomination (36 sectors)	Quartile of digital intensity: 2013-15	Sector denomination (36 sectors)	Quartile of digital intensity: 2013-15
Agriculture, forestry, fishing	Low	Wholesale and retail trade, repair	Medium-high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages and tobacco	Low	Accommodation and food service activities	Low
Textiles, wearing apparel, leather	Medium-low	Publishing, audiovisual and broadcasting	Medium-high
Wood and paper products, and printing	Medium-high	Telecommunications	High
Coke and refined petroleum products	Medium-low	IT and other information services	High
Chemicals and chemical products	Medium-low	Finance and insurance	High
Pharmaceutical products	Medium-low	Real estate	Low
Rubber and plastics products	Medium-low	Legal and accounting activities, etc.	High
Basic metals and fabricated metal products	Medium-low	Scientific research and development	High
Computer, electronic and optical products	Medium-high	Advertising and market research; other business services	High
Electrical equipment	Medium-high	Administrative and support service activities	High
Machinery and equipment n.e.c.	Medium-high	Public administration and defence	Medium-high
Transport equipment	High	Education	Medium-low
Furniture; other manufacturing; repairs of computers	Medium-high	Human health activities	Medium-low
Electricity, gas, steam and air cond.	Low	Residential care and social work activities	Medium-low
Water supply; sewerage, waste management	Low	Arts, entertainment and recreation	Medium-high
Construction	Low	Other service activities	High

Average skill levels

31 countries, 2012 or 2015



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

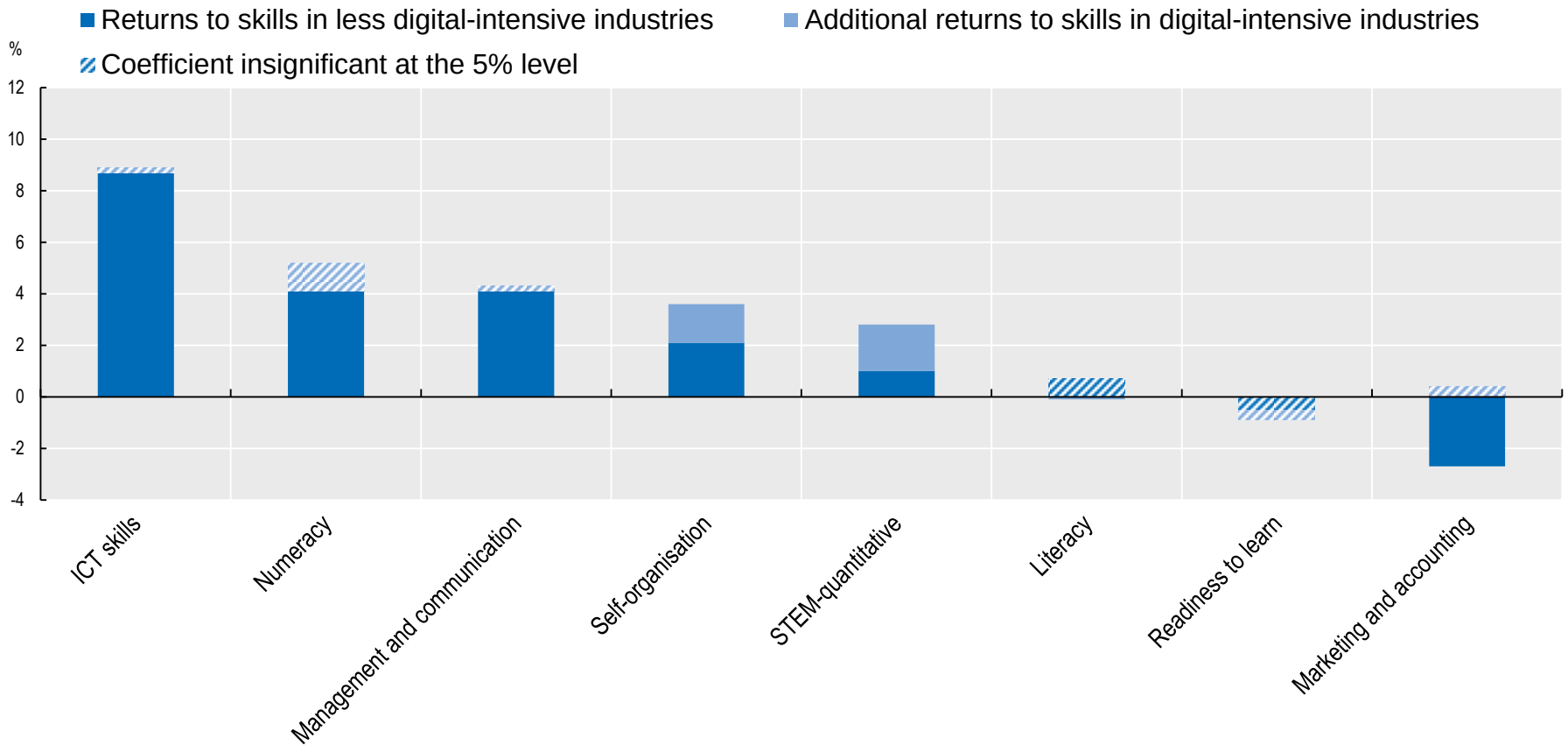
3. Empirical strategy

$$\log(wage)_i = \alpha_0 + \alpha_1 DigInd_k + DigInd_k * \boldsymbol{skills'}_i\boldsymbol{\beta} + \boldsymbol{skills'}_i\boldsymbol{\gamma} + \boldsymbol{x'}_{i,c}\boldsymbol{\delta} + \boldsymbol{\mu_c} + \boldsymbol{\sigma_{sector}} + \boldsymbol{\rho_{isco08}} + \boldsymbol{u_i} \quad (1)$$

- 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)

4. Results

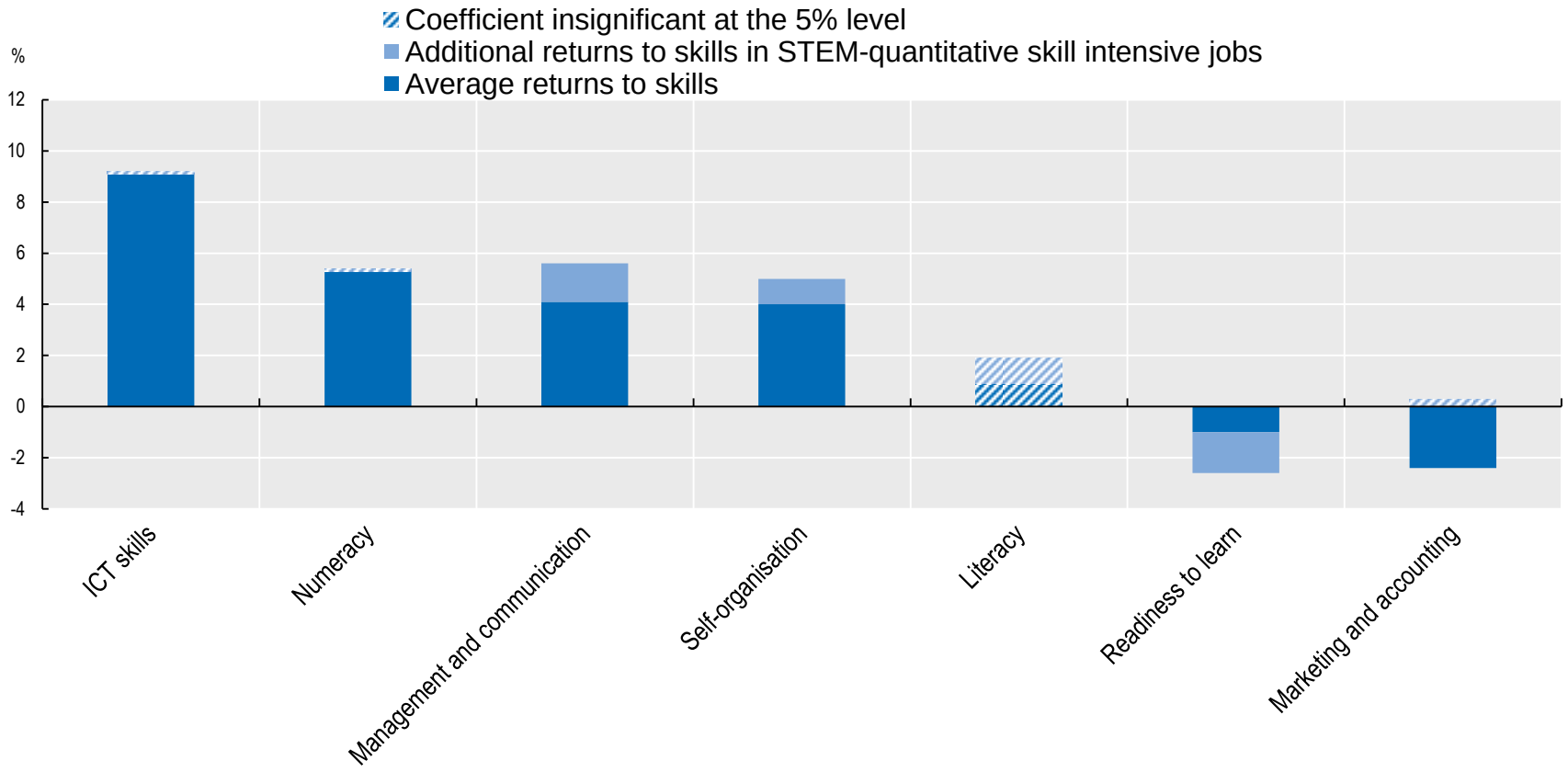
What skills show additional returns in digital intensive industries?



All skills and interaction with digital-sector dummy included at the same time
Full-control specification
N : 104,296. Adjusted R2: 0.576

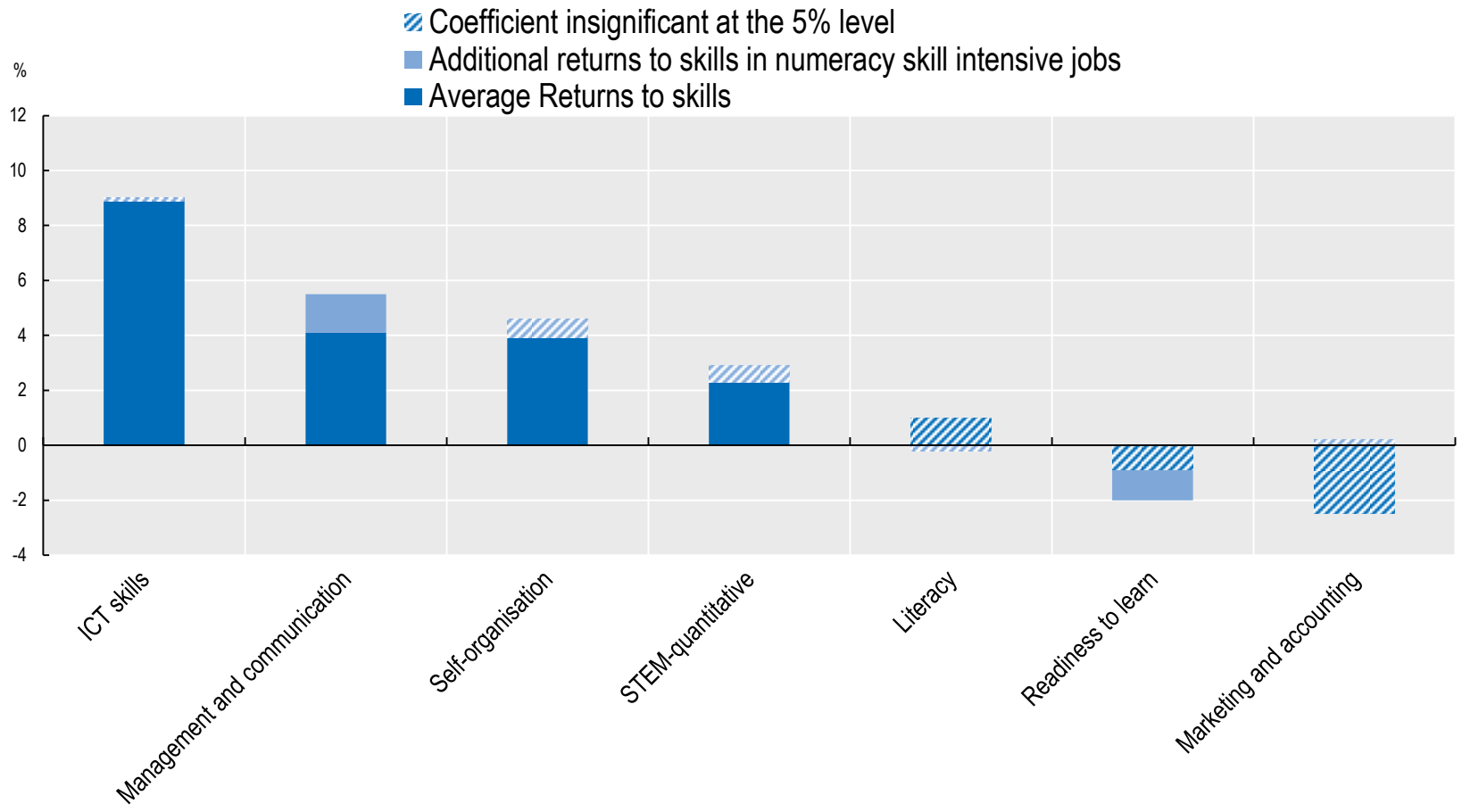
4. Results – Digital Intensive Industries

What skills are complementary to STEM-quantitative skills?



4. Results – Digital Intensive Industries

What skills are complementary to numeracy 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:

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Thank you !

BACK-UP

Components of task-based skills 1

ICT Skills	G_Q05e Frequency of excel use G_Q05g Frequency of programming language use G_Q05d Frequency of transactions through internet (banking, selling/buying) G_Q05a Frequency of email use G_Q05c Frequency of simple internet use G_Q05f Frequency of word use G_Q05h Frequency of real-time discussions through ICT Computer G_Q01b Frequency of Reading letters, emails, memos G_Q02a Frequency of Writing letters, emails, memos G_Q06 Level of Computer Use required for the job F_Q06b Frequency of working physically over long periods
Readiness to learn and creative problem solving	I_Q04j I like to get to the bottom of difficult things I_Q04m If I don't understand something, I look for additional information to make it clearer I_Q04h When I come across something new, I try to relate it to what I already know I_Q04b When I hear or read about new ideas, I try to relate them to real life situations to which they might apply I_Q04d I like learning new things I_Q04l I like to figure out how different ideas fit together
Managing and Communication	F_Q04b Frequency of negotiating with people (outside or inside the firm or organisation) F_Q03b Frequency of planning activities of others F_Q02b Frequency of instructing and teaching people F_Q02e Frequency of advising people F_Q04a Frequency of persuading or influencing others

Components of task-based skills 2

Self-Organisation	D_Q11a extent of own planning of the task sequences
	D_Q11b extent of own planning of style of work
	D_Q11c extent of own planning of speed of work
	D_Q11d extent of own planning of working hours
Accountancy and Selling	G_Q01g Frequency of Reading financial invoices, bills etc.
	G_Q03b Frequency of Calculate prices, costs, budget
	G_Q03d Frequency of using calculator
	F_Q02d Frequency of client interaction selling a product or a service
Advanced Numeracy	G_Q03f Frequency of preparing charts and tables
	G_Q03g Frequency of Use simple algebra and formulas
	G_Q03h Frequency of Use complex algebra and statistics