WHICH SKILLS FOR THE DIGITAL ERA?

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BETTER POLICIES FOR BETTER LIVES

1. Motivation

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How does the digital transformation affects the skills demanded on the market? Cognitive and non-cognitive skills.

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  - Cross-section, worker-level data for 31 OECD & non-OECD countries, splitting more vs less digital intensive sectors.

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  - 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.
  - What is human capital contribution to productivity? Matching.

1. Contribution of this work

- Returns to both cognitive and non-cognitive skills.

1. In a single dataset, for a representative sample (Deming and Kahn, 2016), with uniform measurement, and across country.
2. Controlling for “innate” competencies (but no assessment pre-labour market – vs Edin et al., 2017).
3. Investigating BUNDLES of skills (as in Weinberger, 2014 or Deming, 2016).
4. Task-approach (e.g. Autor and Acemoglu, 2011) in digital: multiple possible complementarity / substitution patterns.

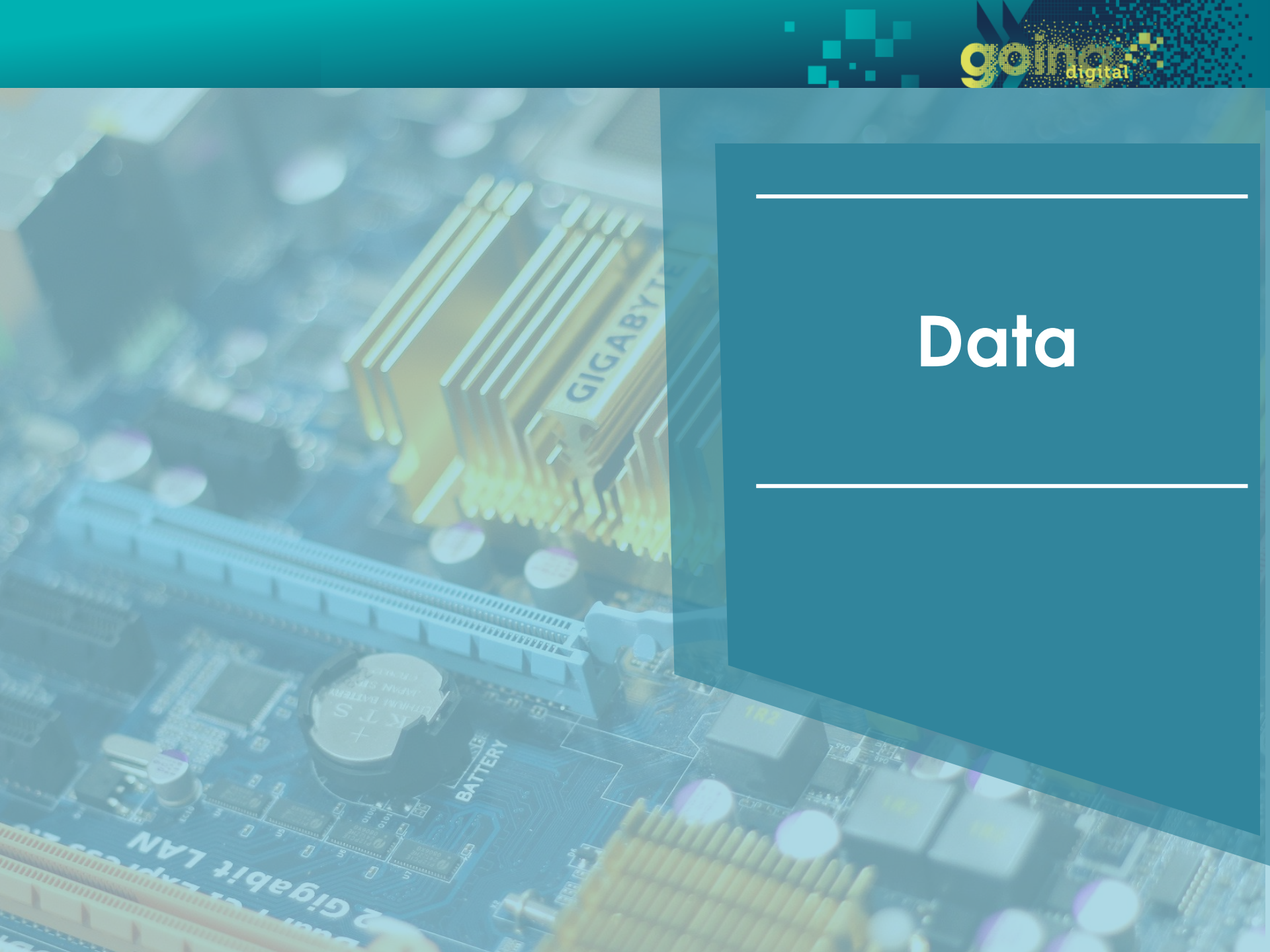
1. Findings

- Cognitive and non-cognitive skills are strongly rewarded by labour markets (Heckman and Kautz, 2012). Not dependent by occupations.

- 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



Data

2. 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)
  - Size of the firm
- Assessed skills.
- Tasks performed on the job.

2. Measuring Workers' Skills

- **3 cognitive skills:**
  - Literacy, Numeracy and Problem Solving in Technology Rich Environments.
  - Assessed through **tests**

See Grundke et al. (2017)

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- **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 proficiency
    - Advanced Numeracy (STEM)
    - Accountancy and Marketing
    - Management and Communication
    - Self-Organisation
    - Readiness to Learn

See Grundke et al. (2017)

2. Measuring Digital Intensity of Sectors

- Multiple dimensions of digitalisation, (mostly) official data:
  - *ICT investment intensity*: deflated ICT tangible GFCF / total GFCF;
  - *Software investment intensity*: deflated software GFCF / total GFCF;
  - *Robot intensity*: Stock of robots / employment (manufacturing);
  - *Intermediate consumption of 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 / total employment.

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- Balanced data for 36 sectors (ISIC4).
- 2001-15, balanced for 12 OECD countries.

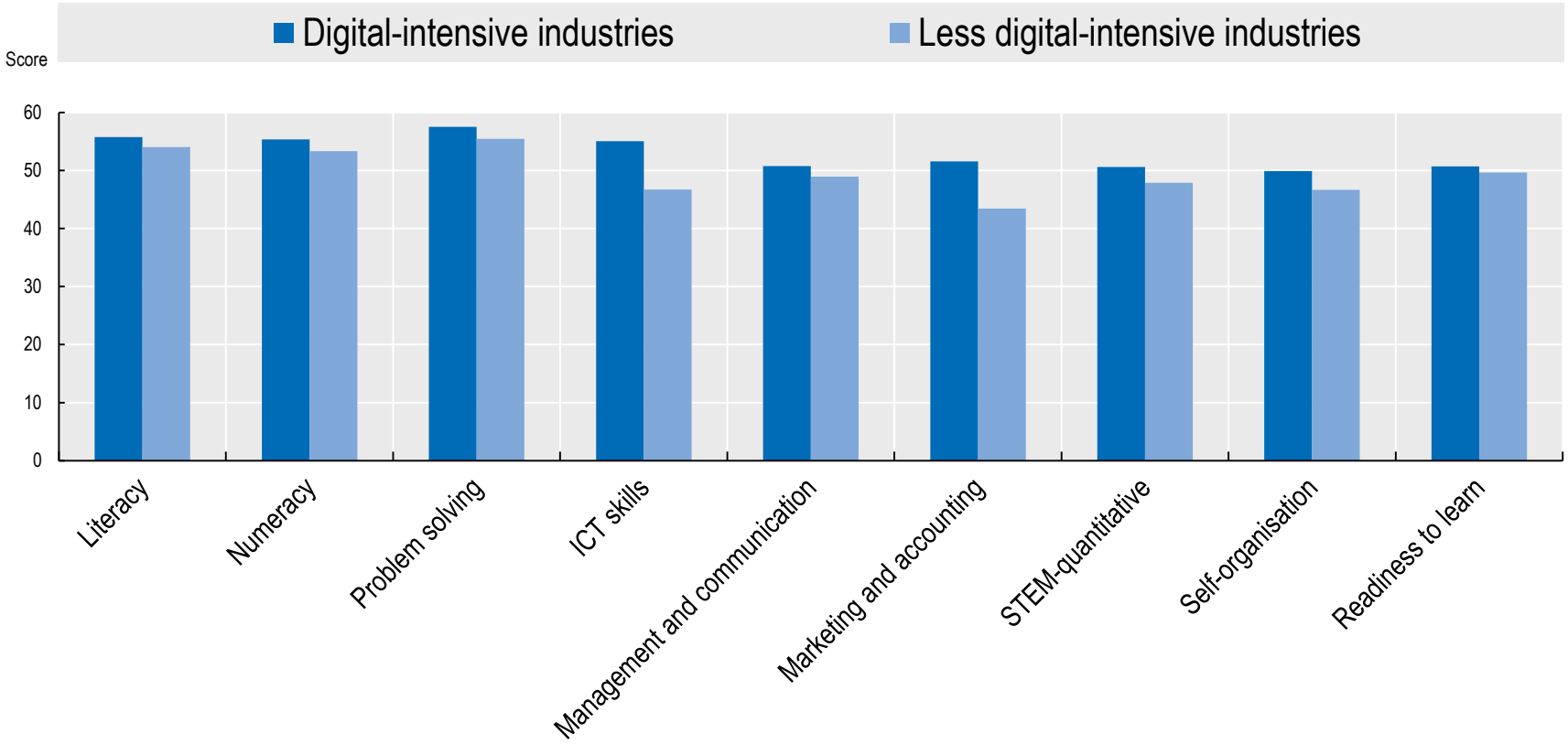
See Calvino et al. (2018)

2. A taxonomy of digital sectors

Sector denomination (36 sectors)	Quartile of digital intensity	Sector denomination (36 sectors)	Quartile of digital intensity
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

2. Average skill levels across individuals

31 countries, 2012 or 2015



Strategy & Results

3. Empirical strategy

- Worker-level, “Mincer” regressions.
- Short-run approach: assume “fixed” L supply and product demand elasticities.
  - 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

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

- 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).
- Standardised skill variables.
- Country (31), industry (18) and occupation (40) dummies.
- Weighted OLS (using final sample weights and giving each country the same weight).

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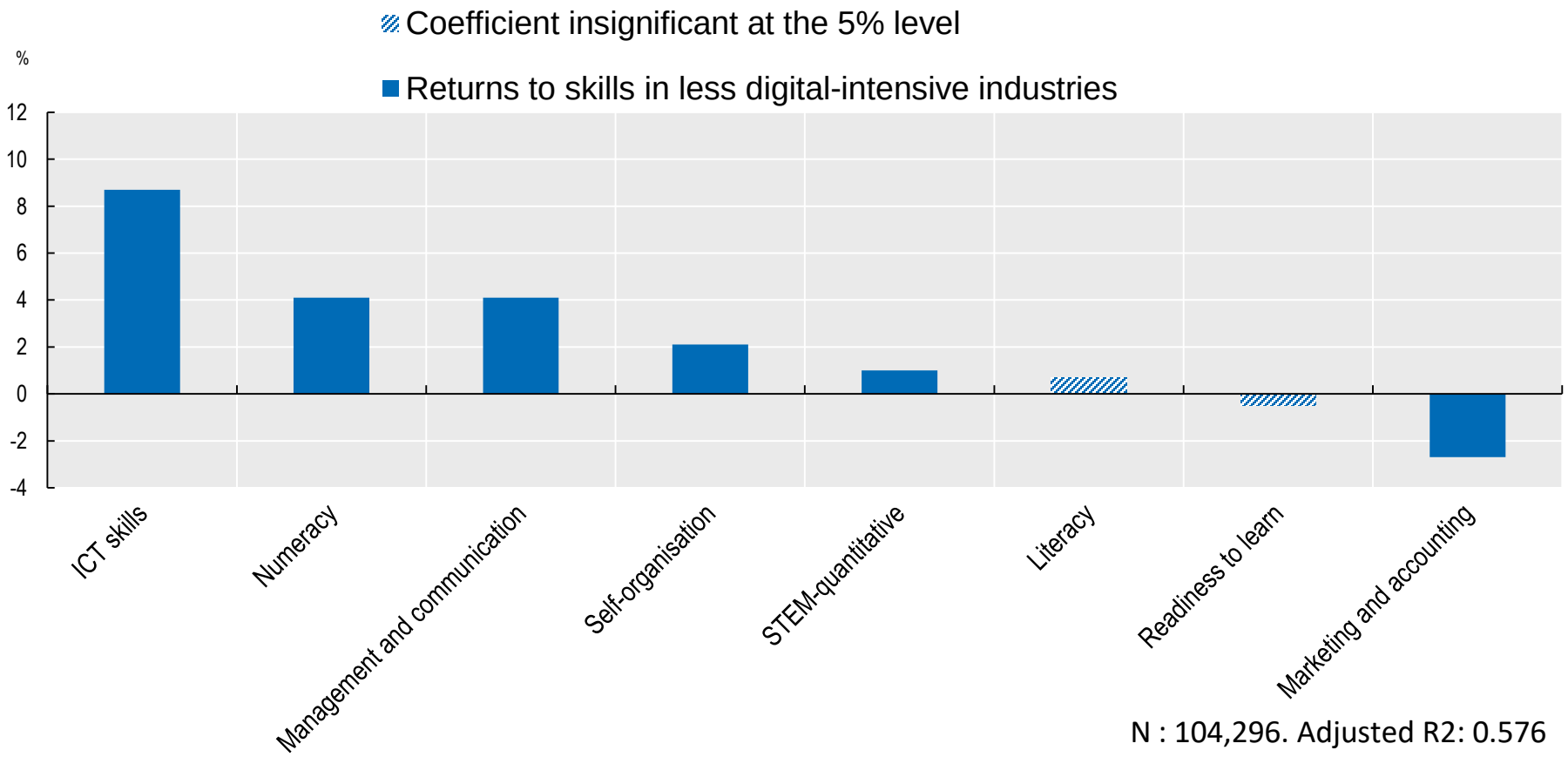
4. Results (I)

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, pooled sample.



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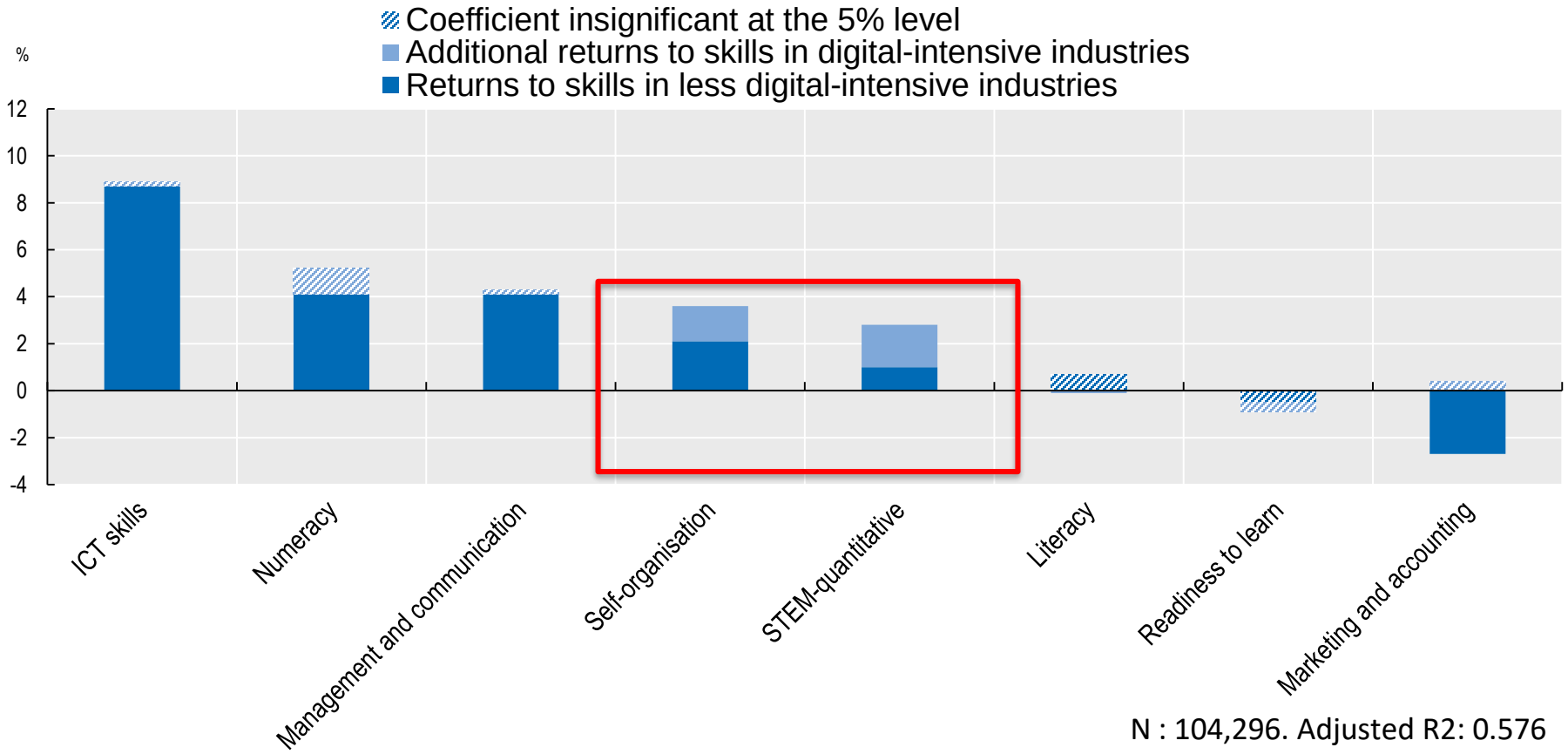

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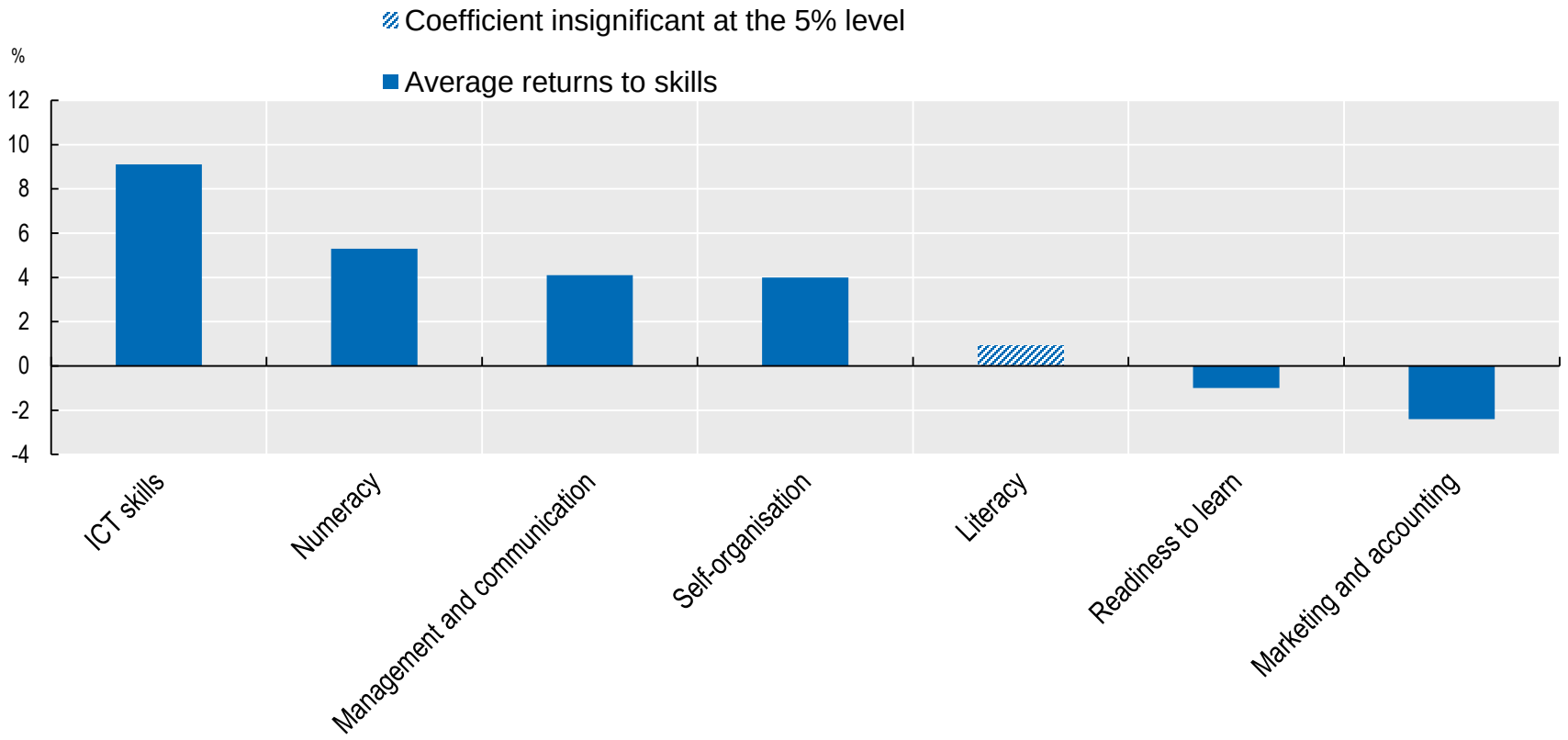
4. Results (II) - Digital Intensive Industries

What skills are complementary to STEM-quantitative skills?



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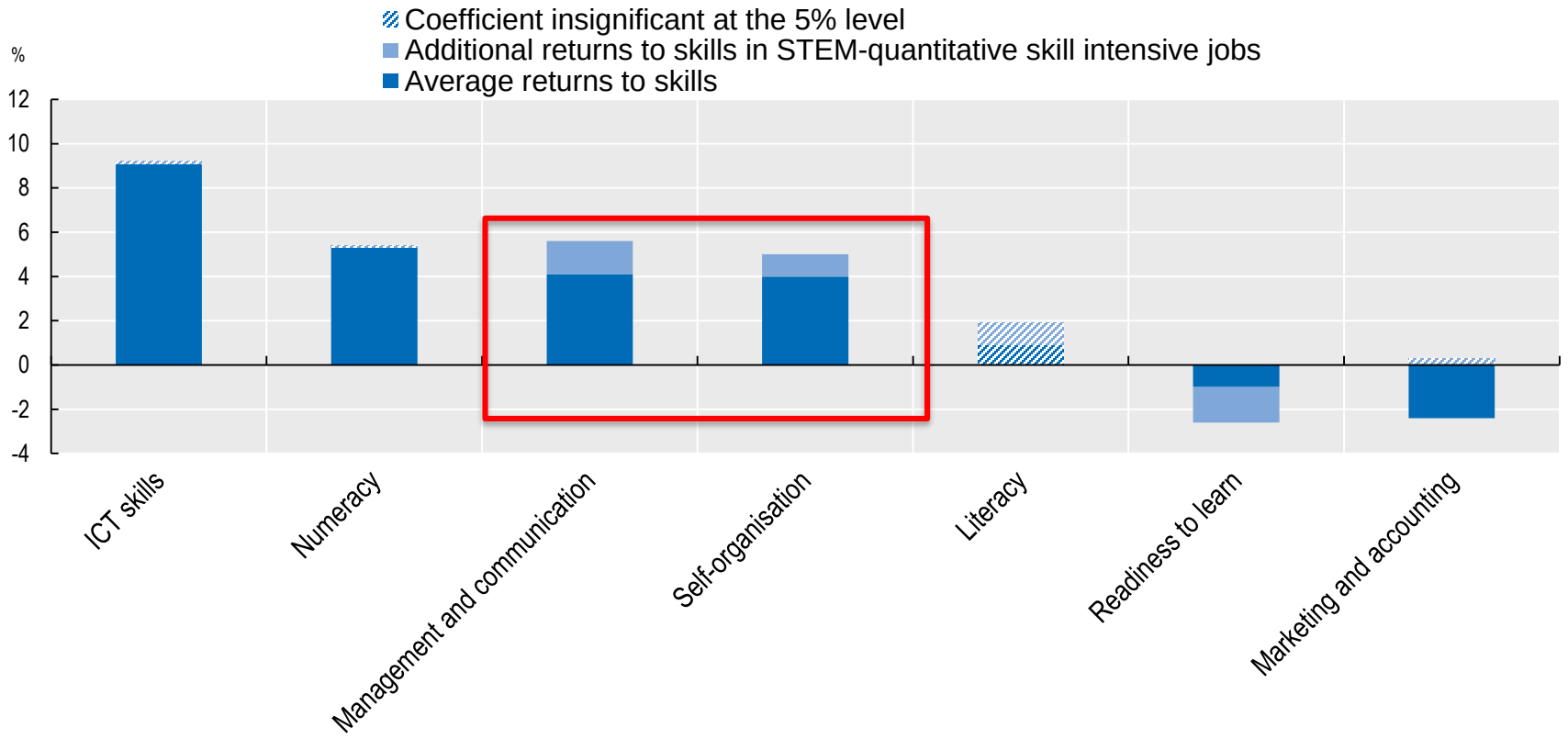
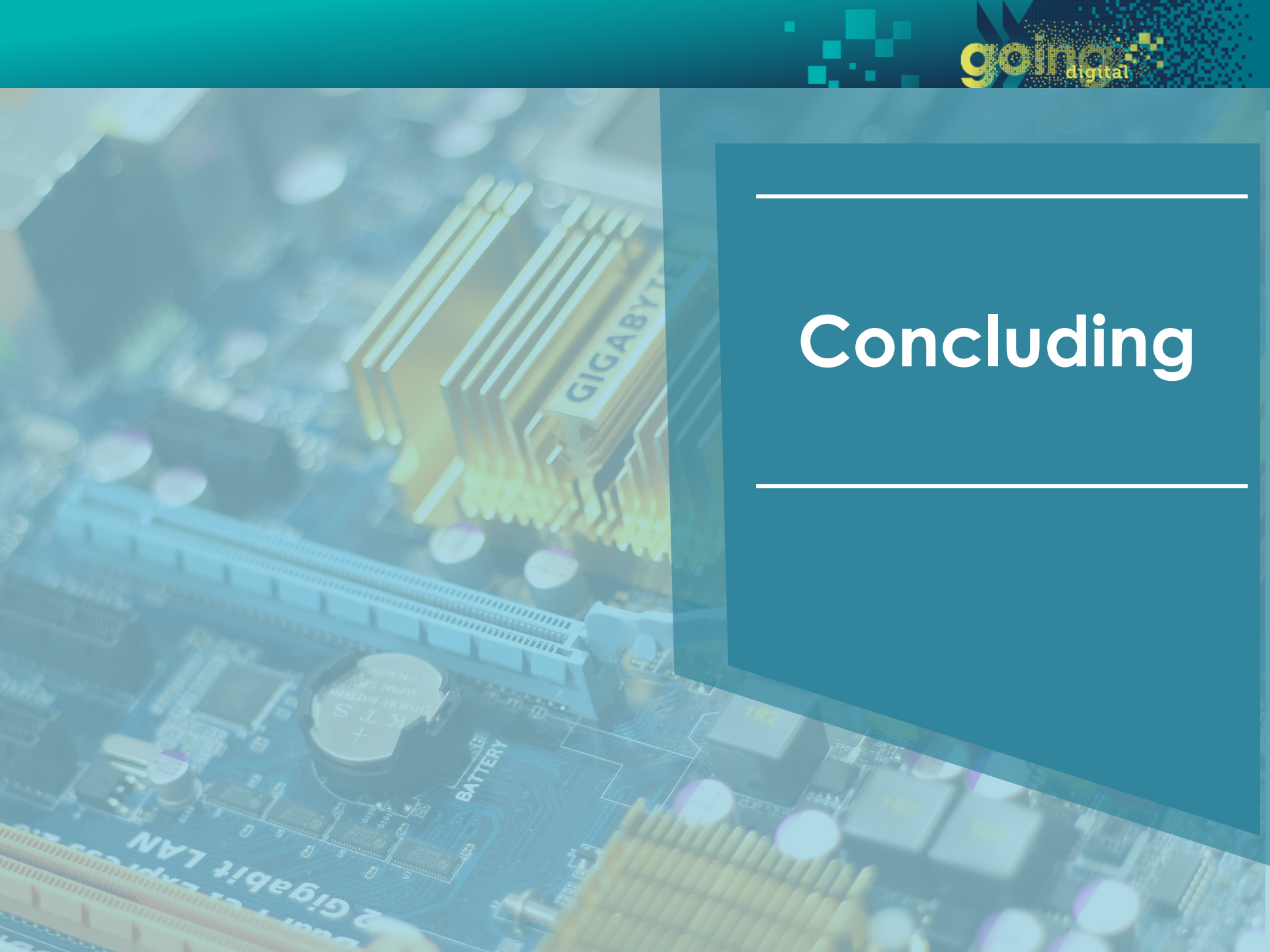


Digital sectors : better organisational structure or matching of workers and capital; better monitoring ability; implementation of profit sharing or efficiency wages …

Similar results for numeracy

4. Robustness checks

- Use top quartile of sectors in the taxonomy to define digital intensive industries
- Include combined country – industry dummies.
- Include further individual level control variables (parental education; problem solving)
- Use old classification. (Digital*numeracy) and (Digital*readiness to learn) now significant.
- Exclude bonuses (misreporting?).
- Exclude occupation dummies



Concluding

5. Next steps: ENDOGENEITY

- Of sectoral dummies: better-paying sectors attract minds and can innovate more.
  - BUT innovation take times VS contemporaneous specification
  - Different aggregation level (reverse causality)
  - Robust to lagged digital taxonomy.

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- Of sectoral dummies: better-paying sectors attract minds and can innovate more.
  - BUT innovation take times VS contemporaneous specification
  - Different aggregation level (reverse causality)
  - Robust to lagged digital taxonomy.
- Individual-level unobservables correlated to wages and skills:
  - Likely NOT individual's ability or productivity on the job: assessed skills.
  - Firm-specific wages. Reverse causality. Selection of workers.
  - But 8(skills)*2(dummy for digital) endogenous variables…

6. **Preliminary** 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
  - Complementarity of human capital and technology, by tasks.
- In digital intensive industries the bundling of workers skills seems to be especially important (self-organisation, managing & comm).
- Focusing only on STEM/Numeracy skills to face the challenges of the digital transformation is short sided (non-cognitive skills matter)

Thank you !

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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

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Digital Intensive Industries					
Literacy	59,063	55.70	9.30	6.01	89.38
Numeracy	59,063	55.37	10.26	0.00	94.05
ICT skills	58,929	55.30	21.52	21.25	84.24
Management and communication	58,898	51.36	19.24	21.03	82.48
Readiness to learn	58,749	51.10	19.13	3.43	83.68
Marketing and accounting	59,004	53.16	19.68	25.77	82.38
STEM-quantitative	59,026	50.74	17.11	35.04	94.11
Self-organisation	58,897	51.43	19.27	13.18	81.33
Less Digital Intensive Industries					
Literacy	62,177	53.89	9.58	7.87	89.03
Numeracy	62,177	53.28	10.53	3.77	87.80
ICT skills	62,052	46.52	21.74	21.25	84.24
Management and communication	61,962	49.17	20.34	21.03	82.48
Readiness to learn	61,743	49.65	19.63	3.43	83.68
Marketing and accounting	62,123	45.29	18.40	25.77	82.38
STEM-quantitative	62,144	47.87	16.16	35.04	94.11
Self-organisation	61,998	48.17	19.40	13.18	81.33