

---

# Earnings effects of digital skills

Stefan Speckesser (National Institute of  
Economic and Social Research)

Input for *European Think Tank Exchange*  
Cologne – 05 December 2018



# Outline

---

- Motivation and context
  - Categories of digital skills
  - Labour market context
  - Aims of this study
- Literature background
- Data
- Descriptive findings
  - Digital skills and online learning
  - Digital skills and earnings
- Results from empirical earnings functions
  - Headline findings
  - Subgroup heterogeneity
- Conclusion



# Categories of digital skills

---

- Recent report on digital skills in the UK economy by Ecorys (literature review/expert interviews) found three categories of digital skills
  - ‘Basic digital literacy skills’ (everyone in modern life)
  - ‘Digital skills for the general workforce’ (Processing information using applications in most occupations)
  - ‘Digital skills for ICT professions’ (possibly other professional)
- EU-28 ‘DigComp 2.1’ framework (Carretero et al. 2017):
  - 21 digital competences in five areas:
    - Information/data literacy; Communication and collaboration; Digital content creation; Safety; Problem solving
    - Eight proficiency levels (‘foundation’ to ‘highly specialised’)



# Labour market context

---

- Context of both general and vocational education
  - Inclusion of digital skills in school curriculum
  - Further and higher education (also: apprenticeships, re-skilling)
- UK Employer Skills Surveys (2017): 13% of UK businesses report skills shortage of existing staff (4% of UK workforce)
  - Employers with skill gaps report deficiencies in analytical skills (43%) and digital skills (35%), increased from 2015
  - 6% of all employers have skills shortage vacancies (226,000 vacancies), 33% attributed to a lack of 'digital skills'
    - Basic computer literacy (23%) and/or more advanced or specialist IT skills (21%)
    - In the ICT sector, 60% of all skills shortage vacancies are related to lack of digital skills



# Aims of this study

---

- Aim of this study: Description of digital skills associated with occupations and related earnings differentials
  - Description of occupational profiles/clustering
  - Exploration of available online learning (web-harvested)
  - Merged database of IT Skills (occupation level) linked to hourly earnings (individual level), controlling for observable characteristics
- Estimation of empirical earnings functions for U.S. data
  - Exploiting that occupations classified at same level – e.g. business and finance occupations 13-0000 –
    - Are associated with different clusters of digital skills use – e.g. 13-2051 ‘Financial Analysts’ and 13-1161 ‘Market Research Analysts’
    - Specialise in high/low intensity digital and ‘hot’ skills



# Literature background

---

- Relevance of IT skills in the workplace
  - ‘Digital inclusion’ (impact of technology limited on manual/routine jobs, but significant for professional and managerial groups (Clayton and Macdonald, 2013).
  - ‘Platform work’ (= providing services via online platforms, Broughton et al., 2018)
  - Data from occupational expert systems (O\*NET) and other skills demand measures (e.g. Burning Glass Technologies analysis of job adverts, Djumalieva and Sleeman, 2018)
  - Future demand: Some research findings
    - Automation, digitalisation, AI, big data, internet of things
    - Change to jobs likely effect of automation (Arntz et al., 2016)
    - Digital skills in cognitive, non-routine tasks (e.g. HR software, see Djumalieva and Sleeman, 2018)



# Literature background

---

- Despite the relevance, few evidence on the earnings returns of digital skills
- Previous studies on returns to digital skills
  - The returns to digital skills are mixed
    - Computer skills have no substantial impact on wages after controlling basic skills (Borghans and Weel, 2004).
    - ICT skills can increase the earnings and vary by demographic groups (Dolton et al., 2007)
    - Using Fixed Effect model, a year of adopting a computer earns 3.6% higher (Zoghi and Pabilonia, 2007)
    - A small return to the use of the 'office IT' (Dolton and Pelkonen, 2008)



# Literature background

---

- Background to online learning/digital skills acquisition more generally
  - Types of online courses.
    - According to Kaplan and Haenlein (2016), there are four types of distance education, Massive Open Online Courses (MOOCs), Small Private Online Courses (SPOCs), Synchronous Massive Online Courses (SMOCs), Synchronous Private Online Courses (SSOCs)
  - Positive impacts of online education.
    - E-learning can achieve an effective learning outcomes of knowledge, competence, and values (Azeiteiro et al., 2015)
    - Positive economic return to distance education (Li, 2018)





# Data

---

- Occupational Information Network (O\*NET): A database of occupational requirements and worker attributes
  - Funded by U.S. Department of Labor since the 1990's
  - Database 23.1 (July 2018) with data for 1,110 occupations
  - 8,753 'Technology Skills' (= software packages) from O\*NET 'tools and technology' (affecting 972 occupations)
  - EU-28 ESCO systematic is not of similar level of detail
- Current Population Survey
  - Microdata of 60,000 U.S. households (monthly)
  - Used by BLS to report e.g. monthly unemployment rate, employment totals and earnings, etc.)
  - Pooled CPS microdata (All months of 2017) to obtain large samples of earnings for 972 occupation cells



# Data

---

- Web-harvested data
  - Using the O\*NET 'Technology Skills', obtain web-scraped data from Lynda (LinkedIn Learning) for available online tutorials, views and average duration of online training related to these skills)
  - Merging of 'Online training availability' to 972 occupations
  - Create measures of average availability/demand of online trainings associated with 972 occupations



# Digital skills and online learning

Table 1: 25 most widely used programmes in main groups

| IT programmes (O*NET)         |   |                                  | Online learning characteristics |               |         |
|-------------------------------|---|----------------------------------|---------------------------------|---------------|---------|
| Programme                     | Wider programme group                       | Number of occupations associated | Available online tutorials      | Mean duration | Views   |
| Microsoft Excel               | Spreadsheet software                        | 836                              | 10,450                          | 2.1           | 230,879 |
| Microsoft Word                | Word processing software                    | 750                              | 13,177                          | 3.6           | 247,718 |
| Microsoft Office              | Office suite software                       | 707                              | 1,437                           | 0.4           | 123,734 |
| Microsoft PowerPoint          | Presentation software                       | 509                              | 3,777                           | 3.6           | 287,276 |
| Web browser software          | Internet browser software                   | 441                              | 2,954                           | 1.4           | 323,976 |
| Microsoft Outlook             | Electronic mail software                    | 402                              | 3,507                           | 1.4           | 207,621 |
| Microsoft Access              | Data base user interface and query software | 309                              | 13,804                          | 0.4           | 274,983 |
| Email software                | Electronic mail software                    | 282                              | 3,740                           | 1.9           | 280,589 |
| Data entry software           | Data base user interface and query software | 248                              | 1,759                           | 1.9           | 155,914 |
| SAP                           | Enterprise resource planning ERP software   | 203                              | 154                             | 0.9           | 119,694 |
| Autodesk AutoCAD              | Computer aided design CAD software          | 165                              | 4,504                           | 3             | 49,441  |
| Spreadsheet software          | Spreadsheet software                        | 148                              | 1,211                           | 6.5           | 469,276 |
| Microsoft Project             | Project management software                 | 147                              | 7,756                           | 2.8           | 288,744 |
| Word processing software      | Word processing software                    | 143                              | 4,529                           | 7.7           | 515,150 |
| Microsoft Visio               | Graphics or photo imaging software          | 126                              | 783                             | 0.9           | 333,051 |
| Adobe Systems Adobe Acrobat   | Document management software                | 123                              | 6,991                           | 2             | 126,276 |
| Adobe Systems Adobe Photoshop | Graphics or photo imaging software          | 121                              | 25,757                          | 1.8           | 147,518 |
| Database software             | Data base user interface and query software | 119                              | 2,450                           | 1.9           | 173,225 |
| Microsoft SharePoint          | Project management software                 | 116                              | 3,887                           | 1.1           | 155,402 |
| Microsoft Windows             | Operating system software                   | 115                              | 14,557                          | 2             | 117,397 |
| Structured query language SQL | Data base user interface and query software | 108                              | 5,043                           | 3.4           | 706,762 |
| The MathWorks MATLAB          | Analytical or scientific software           | 99                               | 3                               | 1.2           | 54,378  |
| SAS                           | Analytical or scientific software           | 96                               | 110                             | 1.9           | 12,336  |
| Microsoft Publisher           | Desktop publishing software                 | 93                               | 3,135                           | 0.5           | 145,525 |

Source:  
O\*NET and  
web  
harvested  
online  
learning data  
from Lynda



# Digital skills and online learning

Table 2: 25 main groups of IT programmes and individual programmes

| Wider programme group   | Programmes |
|---|------------|
| Analytical or scientific software                                   | 1,685      |
| Data base user interface and query software                         | 893        |
| Medical software  | 676        |
| Financial analysis software   | 356        |
| Computer aided design CAD software                                  | 346        |
| Enterprise resource planning ERP software                           | 264        |
| Human resources software  | 256        |
| Graphics or photo imaging software                                  | 226        |
| Project management software   | 201        |
| Document management software  | 197        |
| Development environment software                                    | 183        |
| Materials requirements planning logistics and supply chain software | 169        |
| Accounting software   | 165        |
| Industrial control software   | 162        |
| Customer relationship management CRM software                       | 142        |
| Compliance software   | 128        |
| Map creation software   | 127        |
| Computer aided manufacturing CAM software                           | 122        |
| Information retrieval or search software                            | 120        |
| Computer based training software                                    | 119        |
| Music or sound editing software                                     | 107        |
| Point of sale POS software  | 99         |
| Word processing software  | 94         |
| Calendar and scheduling software                                    | 89         |
| Inventory management software                                       | 82         |
| Total   | 8,753      |

Source: O\*NET



# Digital skills and online learning

Table 3: Online learning characteristics of 25 main groups of IT programmes

| Data for occupations from O*NET                            |            | Lynda online learning data |               |         |
|--|------------|----------------------------|---------------|---------|
| Wider programme group                                      | Programmes | Available tutorials        | Mean duration | Views   |
| Analytical or scientific software                          | 1,685      | 859                        | 5.30          | 169,432 |
| Data base user interface and query software                | 893        | 1,049                      | 5.04          | 186,067 |
| Medical software   | 676        | 421                        | 3.94          | 142,306 |
| Financial analysis software                                | 356        | 319                        | 5.47          | 182,165 |
| Computer aided design CAD software                         | 346        | 454                        | 4.80          | 148,394 |
| Enterprise resource planning ERP software                  | 264        | 1,323                      | 4.21          | 163,484 |
| Human resources software                                   | 256        | 754                        | 2.18          | 118,843 |
| Graphics or photo imaging software                         | 226        | 1,247                      | 6.41          | 166,226 |
| Project management software                                | 201        | 1,918                      | 3.74          | 177,454 |
| Document management software                               | 197        | 866                        | 3.85          | 143,076 |
| Development environment software                           | 183        | 1,380                      | 3.67          | 212,843 |
| Materials requirements planning logistics and supply chain | 169        | 433                        | 3.72          | 172,428 |
| Accounting software  | 165        | 581                        | 5.92          | 206,214 |
| Industrial control software                                | 162        | 942                        | 6.61          | 174,611 |
| Customer relationship management CRM software              | 142        | 954                        | 2.86          | 148,961 |
| Compliance software  | 128        | 224                        | 2.12          | 125,745 |
| Map creation software                                      | 127        | 474                        | 5.95          | 186,188 |
| Computer aided manufacturing CAM software                  | 122        | 318                        | 1.14          | 70,754  |
| Information retrieval or search software                   | 120        | 574                        | 7.49          | 198,337 |
| Computer based training software                           | 119        | 1,053                      | 3.06          | 137,720 |
| Music or sound editing software                            | 107        | 398                        | 8.00          | 165,898 |
| Point of sale POS software                                 | 99         | 770                        | 4.86          | 161,823 |
| Word processing software                                   | 94         | 1,050                      | 3.16          | 182,728 |
| Calendar and scheduling software                           | 89         | 1,030                      | 3.80          | 197,035 |
| Inventory management software                              | 82         | 530                        | 6.52          | 135,871 |
| Grand Total  | 8,753      | 870                        | 4.55          | 172,238 |

Source:  
O\*NET and  
web  
harvested  
online  
learning data  
from Lynda



# Digital skills and online learning

---

- 'IT Skills' and available online learning
  - Shows widespread use of basic application software in occupations at different level of skills and specialisation
  - Online learning
    - Widespread training availability of trainings and high user demand for basic applications, especially Microsoft (Table 3, e.g. Word processing software)
    - Limited availability in specialist application software for different purposes (analytical/management like SAP) coinciding with high view numbers
    - Specialist software (e.g. SAS, MATLAB): Limited online training and lower view numbers (Table 1 and Table 3)
    - Widespread IT skills: Tutorials likely to differ by proficiency levels; web-harvested data do not offer sufficient information on proficiency levels



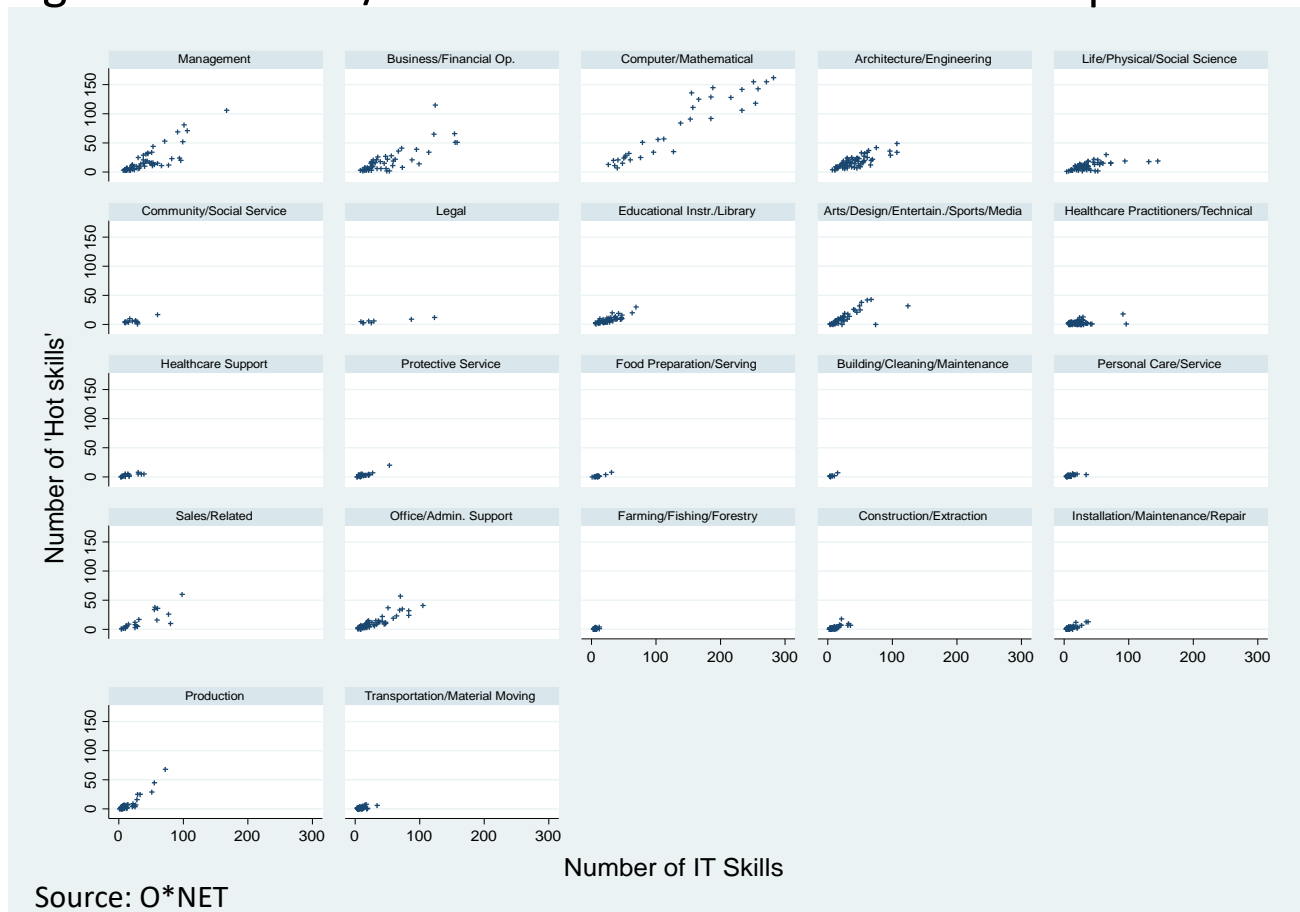
# Digital skills and online learning

Figure 1: IT Skills/"Hot Skills" associated with occupations in major groups



# Digital skills and online learning

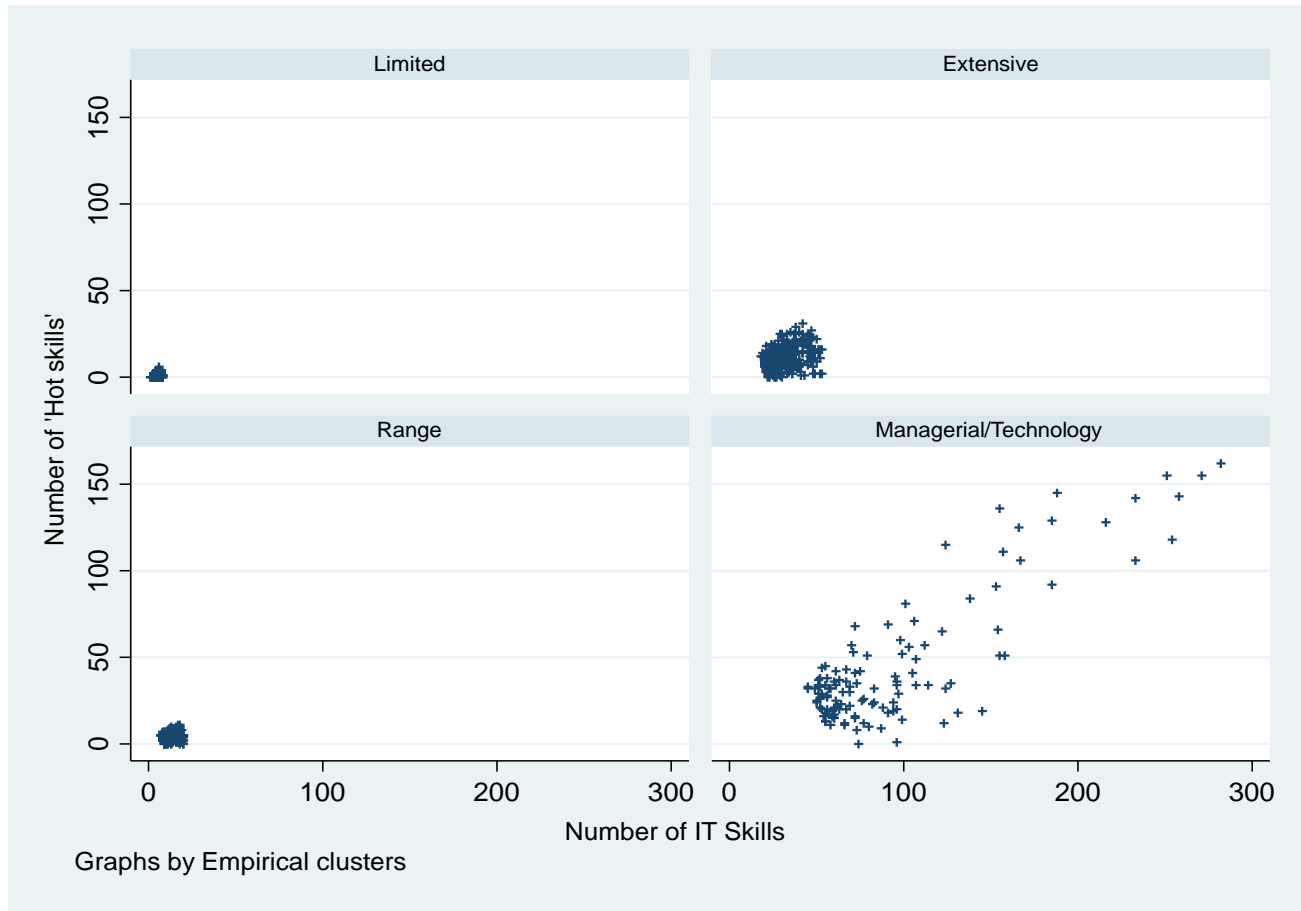
Figure 2: IT Skills/"Hot Skills" associated with occupations in major groups





# Digital skills and online learning

Figure 3: Digital and "Hot" skills associated with occupations (clusters)



# Digital skills and online learning

Table 4: “Occupation clusters” and online learning

| Cluster characteristics                | Limited |           | Extensive |           | Range  |           | Managing/Techn. |           |
|--|---------|-----------|-----------|-----------|--------|-----------|-----------------|-----------|
|  | Mean    | Std. Dev. | Mean      | Std. Dev. | Mean   | Std. Dev. | Mean            | Std. Dev. |
| <b>O*NET occupations</b>               |         |           |           |           |        |           |                 |           |
| Number of IT Skills                    | 5.18    | 1.53      | 30.92     | 8.79      | 12.21  | 3.43      | 95.43           | 53.68     |
| Number of Hot Skills                   | 1.62    | 1.17      | 10.35     | 6.41      | 3.68   | 2.24      | 44.60           | 37.77     |
| Occupations                            | 242     |           | 299       |           | 310    |           | 121             |           |
| <b>Online learning characteristics</b> |         |           |           |           |        |           |                 |           |
| Mean available online tutorials        | 4490    | 3050      | 2649      | 1150      | 3599   | 1488      | 1963            | 898       |
| Mean duration                          | 3.49    | 6.31      | 3.80      | 2.43      | 3.42   | 2.96      | 3.76            | 1.51      |
| Views                                  | 223684  | 78541     | 203082    | 55378     | 218643 | 57162     | 204695          | 42811     |

Source: O\*NET and web harvested online learning data from Lynda



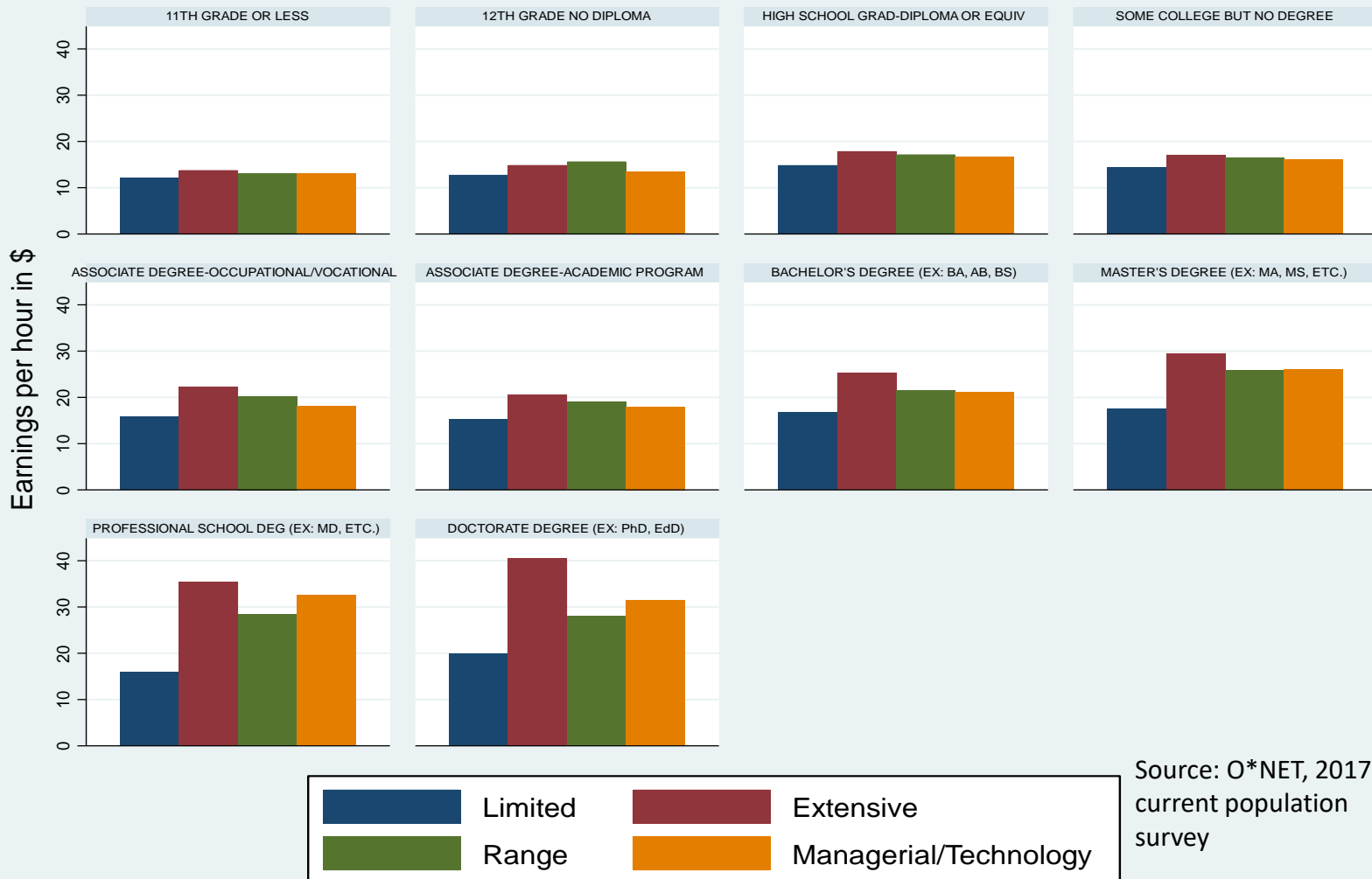
# Digital skills and earnings

Figure 4: Earnings per hour in major occupation groups by cluster



# Digital skills and earnings

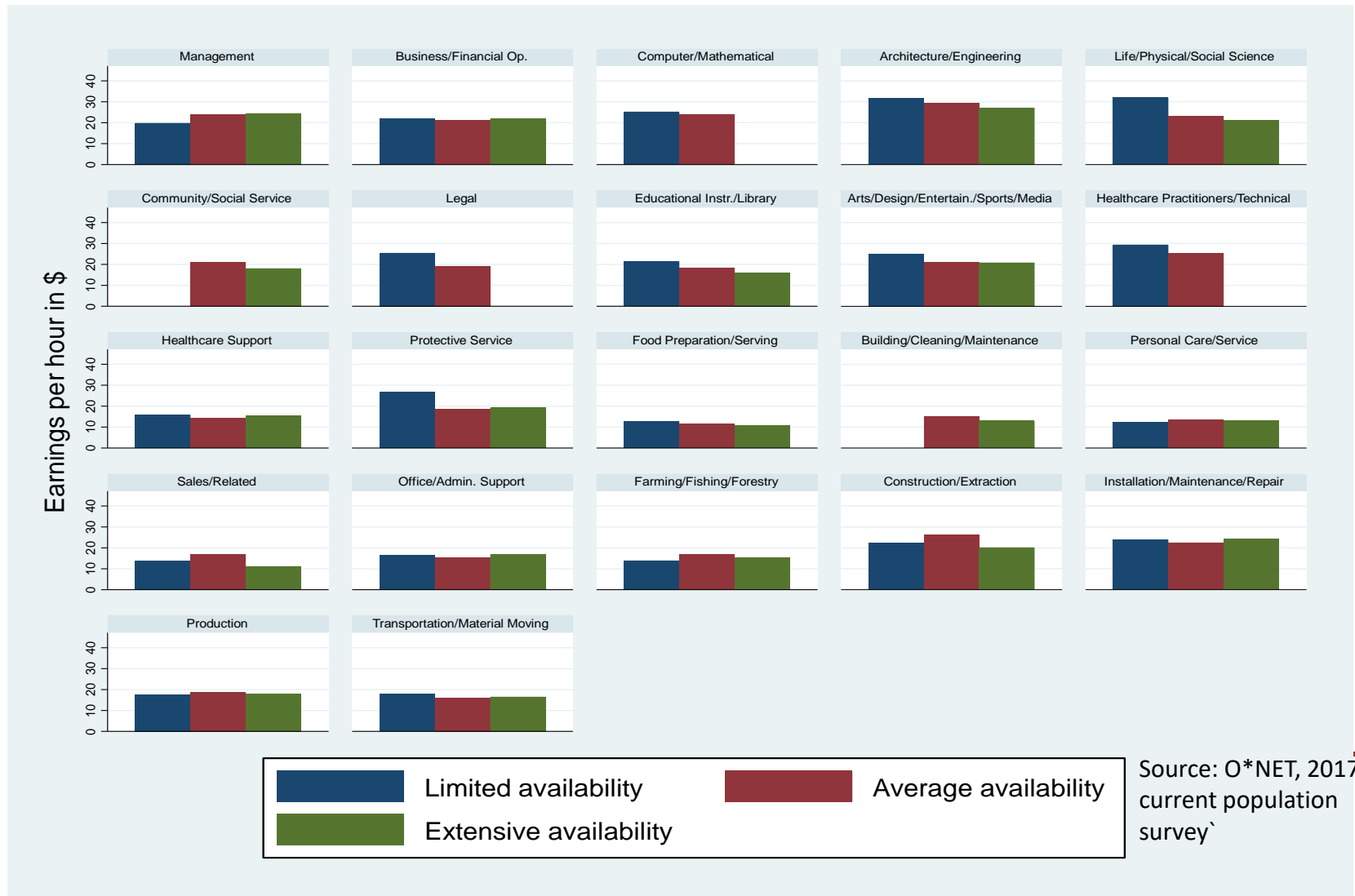
Figure 5: Earnings per hour by highest educational attainment and cluster



Source: O\*NET, 2017 current population survey

# Digital skills and earnings

Figure 6: Earnings by occupational groups and availability of online learning



# Digital skills and earnings

Table 6: Results of regression analyses for clusters (men)

| <b>Empirical clusters (Base Limited)</b> | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
| Extensive                                | 0.1393 | 0.0081 | 0.1169 | 0.0077 | 0.1197 | 0.0076 | 0.1188 | 0.0076 |
| Range                                    | 0.0943 | 0.0070 | 0.0874 | 0.0067 | 0.0881 | 0.0066 | 0.0892 | 0.0066 |
| Managerial/Technology                    | 0.2054 | 0.0108 | 0.1619 | 0.0103 | 0.1618 | 0.0102 | 0.1629 | 0.0101 |
| Controlling for                          |        |        |        |        |        |        |        |        |
| Occupation group                         | ✓      |        | ✓      |        | ✓      |        | ✓      |        |
| Work experience                          |        |        | ✓      |        | ✓      |        | ✓      |        |
| Industry                                 |        |        |        |        | ✓      |        | ✓      |        |
| Geography                                |        |        |        |        |        |        | ✓      |        |

Table 7: Results of regression analyses for clusters (women)

| <b>Empirical clusters (Base Limited)</b> | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
| Extensive                                | 0.1176 | 0.0075 | 0.1199 | 0.0073 | 0.1256 | 0.0073 | 0.1218 | 0.0072 |
| Range                                    | 0.0480 | 0.0066 | 0.0593 | 0.0064 | 0.0721 | 0.0064 | 0.0687 | 0.0064 |
| Managerial/Technology                    | 0.1783 | 0.0076 | 0.1582 | 0.0074 | 0.1617 | 0.0075 | 0.1583 | 0.0074 |
| Controlling for                          |        |        |        |        |        |        |        |        |
| Occupation group                         | ✓      |        | ✓      |        | ✓      |        | ✓      |        |
| Work experience                          |        |        | ✓      |        | ✓      |        | ✓      |        |
| Industry                                 |        |        |        |        | ✓      |        | ✓      |        |
| Geography                                |        |        |        |        |        |        | ✓      |        |

Source: O\*NET, 2017 current population survey



# Digital skills and earnings

Table 8: Results of regression analyses for digital skills/hot skills (men)

| Skills/Hot skills | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Skill             | 0.0024 | 0.0002 | 0.0019 | 0.0002 | 0.0019 | 0.0002 | 0.0019 | 0.0002 |
| Hot skill         | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0002 | 0.0004 | 0.0002 | 0.0004 |
| Controlling for   |        |        |        |        |        |        |        |        |
| Occupation group  | ✓      |        | ✓      |        | ✓      |        | ✓      |        |
| Work experience   |        |        | ✓      |        | ✓      |        | ✓      |        |
| Industry          |        |        |        |        | ✓      |        | ✓      |        |
| Geography         |        |        |        |        |        |        | ✓      |        |

Table 9: Results of regression analyses for digital skills/hot skills (women)

| Skills/Hot skills | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     | Coef.  | SE     |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Skill             | 0.0014 | 0.0002 | 0.0012 | 0.0002 | 0.0014 | 0.0002 | 0.0013 | 0.0002 |
| Hot skill         | 0.0011 | 0.0003 | 0.0009 | 0.0003 | 0.0005 | 0.0003 | 0.0005 | 0.0003 |
| Controlling for   |        |        |        |        |        |        |        |        |
| Occupation group  | ✓      |        | ✓      |        | ✓      |        | ✓      |        |
| Work experience   |        |        | ✓      |        | ✓      |        | ✓      |        |
| Industry          |        |        |        |        | ✓      |        | ✓      |        |
| Geography         |        |        |        |        |        |        | ✓      |        |

Source: O\*NET, 2017 current population survey



# Digital skills and earnings

|                                     | Limited        |        | Range          |        | Managerial/Tech. |        |
|-------------------------------------|----------------|--------|----------------|--------|------------------|--------|
|                                     | Coef.          | SE     | Coef.          | SE     | Coef.            | SE     |
| Management                          |                |        | <b>0.1225</b>  | 0.0270 | <b>0.1545</b>    | 0.0260 |
| Business/Financial Op.              |                |        | 0.0310         | 0.0308 | <b>0.0709</b>    | 0.0243 |
| Computer/Mathematical               |                |        |                |        | <b>-0.1700</b>   | 0.0485 |
| Architecture/Engineering            |                |        | <b>-0.1844</b> | 0.0386 | -0.0171          | 0.0435 |
| Life/Physical/Social Science        |                |        | <b>-0.1606</b> | 0.0707 | 0.1896           | 0.0996 |
| Community/Social Service            |                |        | <b>-0.0886</b> | 0.0381 |                  |        |
| Legal                               |                |        |                |        | <b>0.2753</b>    | 0.0686 |
| Educational Instr./Library          | <b>-0.2035</b> | 0.0381 | <b>-0.1298</b> | 0.0321 | -0.0421          | 0.0824 |
| Arts/Design/Entertain./Sports/Media | <b>-0.1498</b> | 0.0662 | -0.0130        | 0.0473 | 0.0252           | 0.0601 |
| Healthcare Practitioners/Technical  | -0.1412        | 0.3625 | <b>-0.1216</b> | 0.0165 | <b>-0.3333</b>   | 0.0462 |
| Healthcare Support                  | <b>-0.1514</b> | 0.0195 | 0.0307         | 0.0237 |                  |        |
| Protective Service                  | <b>-0.3986</b> | 0.0823 | <b>-0.3118</b> | 0.0706 | -0.0874          | 0.1029 |
| Food Preparation/Serving            | <b>-0.1654</b> | 0.0176 | <b>-0.0986</b> | 0.0174 |                  |        |
| Building/Cleaning/Maintenance       |                |        | <b>0.1102</b>  | 0.0259 |                  |        |
| Personal Care/Service               | -0.0649        | 0.0650 | -0.0274        | 0.0663 |                  |        |
| Sales/Related                       | <b>-0.2822</b> | 0.0201 | <b>-0.1691</b> | 0.0279 | <b>-0.1491</b>   | 0.0198 |
| Office/Admin. Support               | <b>0.0634</b>  | 0.0173 | <b>-0.0393</b> | 0.0087 | <b>0.0960</b>    | 0.0077 |
| Farming/Fishing/Forestry            |                |        | 0.0647         | 0.0935 |                  |        |
| Construction/Extraction             | <b>-0.1650</b> | 0.0165 | <b>0.0838</b>  | 0.0237 |                  |        |
| Installation/Maintenance/Repair     | 0.0276         | 0.0356 | <b>0.0591</b>  | 0.0222 |                  |        |
| Production                          | <b>-0.0775</b> | 0.0138 | <b>-0.0560</b> | 0.0152 | <b>0.0735</b>    | 0.0207 |
| Transportation/Material Moving      | <b>-0.2606</b> | 0.0412 | <b>-0.1977</b> | 0.0402 |                  |        |

Table 10:  
Results for  
occupational  
groups  
(Base  
'Extensive')

Source: O\*NET, 2017  
current population  
survey





# Digital skills and earnings

---

- Descriptive findings
  - Higher earnings in 'Extensive' and 'IT/Management' clusters except for office support and healthcare professions
  - All education levels show higher earnings when associated with IT skills, differential increases with level of attainment
- Regression analysis
  - Men: Significant returns (12% for extensive range and 16% for managerial/technology), lower when including further characteristics
  - Women: Lower returns when controlling for occupation major groups, more similar (slightly lower) when including industry dummies
  - Higher returns with similar tendency when controlling for education (not preferred specification)



# Digital skills and earnings

---

- Subgroup heterogeneity (Base category 'Extensive')
  - No groups with 'limited digital skills' in managerial and scientific professional groups
  - Significantly lower earnings in 'limited' skills cluster for people in professional/associate professional and most skilled and basic occupations (lower for construction and production work)
  - Mostly lower earnings of those with range (as opposed to extensive) apart from management and skilled/basic
  - High digital skills ('Managerial/tech.' cluster): heterogeneity in earnings returns to digital skills
    - Positive relative to extensive for occupations in management, finance, legal and production
    - Negative in care, computer/maths and sales occupations;



# Conclusions and next steps

---

- Even detailed systematic knowledge of IT skills from O\*NET offer very little detail about the proficiency of digital skills
  - Heterogeneity in returns, but almost all occupations paid less when associated with limited Digital Skills
  - In professional and managerial occupations:
    - Variation in subgroups need to be better understood
    - Influence of wider programme groups/specific programmes need to be better understood
    - Relevance of available online resources to be explored
  - Very little systematic evidence to shape school curriculum/devise on skills investment; possibly more relevant to promote analytical skills more generally
- 



# Conclusions and next steps

---

- Next steps: Write the paper
  - Rerun clustering to obtain alternative patterns
  - Levels of proficiency vary – restriction to specific software or wider groups (e.g. ‘Computer aided design CAD software’)
  - Analysis for specific occupations
  - Acquisition of alternative data on IT skills
    - Job adverts
    - Apprenticeship vacancy data

