Digitalisation, routineness and employment

Exploring Italian task-based data

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Motivation
Background

“Digital technology as technological revolution”

(Freeman and Louçã, 2001; Brynjolfsson and McAfee, 2014)

→ expect to change in economic structures, the organization of production, employment dynamics and skill demand.
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Challenges of measuring adoption:

• Difficult to measure digitalisation (McKinsey Global Institute, 2015; Calvino et al., 2018);

• Difficult to capture its effects on employment diverse contexts (Guerrieri and Bentivegna, 2012; Evangelista et al., 2014)
Digitization: technological perspective

Stylized technological perspective:

Routine occupations $\xrightarrow{\text{Digital technology}}$ Automation

Issues:
1. Nexus between digital technology and routine occupations
2. Concept and measurement of digital technology

Digitalisation = buy/use ICTs (computers, software, internet, robots).

- Investment in computer and IT capital: Autor et al. (2003, 2013); Michaels et al. (2014);
- Use of robots: Acemoglu and Restrepo (2017); Graetz and Michaels (2017); Dauth et al. (2017);
- Share of employees in ICT services: Marcolin et al. (2016);
- Broader set of ICT related technologies: Bockerman et al. (2018);
- Multifaceted and heterogeneous nature of digitalisation: Guerrieri and Bentivegna (2012); Calvino et al. (2018);
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Occupational perspective: focus on work organization
(inspired by Braverman, 1974; Fernandez-Macias and Hurley, 2016)

• Routineness and digitalisation are attributes of tasks in a given
  organisation of work – rather than of occupation or worker;
• Digitalisation can occur when specific conditions are both verified:
  • technical – availability of digital technologies
  • work-content related — tasks that are apt to be standardized, encoded
• Interaction between digitalisation and routineness;
• When both conditions are verified, we expect to observe employment
  contraction.
Research questions and methods

Research questions

1. In what way are different occupations actually digitised today?
2. Are routine occupations also digitized?
3. How does this affect employment?
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Our approach

Using Italian task-based occupational survey data, we:

1. Measure three distinct aspects of occupation digitalisation;
2. Measure occupational routineness independently, in context;
3. Estimate the distinct and joint relation of routineness and digitalisation on employment.
Data and indicators
Data sources

Data on **skills, tasks, and work contents** from *Indagine Campionaria sulle Professioni* (2012 ICP, Italian Occupational Survey) by INAPP-ISTAT:

- covers about 800 occupations defined at 5-digit ISCO level
- about 400 qualitative and quantitative variables on each occupation (O*Net-type survey): skills, work contents, attitudes, tasks, organization, technology, standardization, control;
- representative sample of 16,000 Italian workers interviewed; ~20 sampled per 5-digit occupation with expert panel validation;
- Two-step sampling (company–employee); questionnaires administered CAPI to workers.
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Combine occupation-level data (at CP 4 digit ≃ ISCO) and sector (ATECO 1 digit ≃ NACE) with **employment and labor market variables** (2011–2016) stem from the quarterly *Italian Labor Force Survey* (ILFS) by ISTAT on employment, workers socio-demographic characteristics, contract types.
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Constructing indicators from ICP questionnaire

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3. **Digital tasks**: how central are specific digital technologies to one’s occupation.

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G19  Working with computers: “Using computers and information systems (software and hardware) to program, write software, manage functions, input data, or process information”. Response on 1–7 complexity scale, with suggested benchmarks:

   2  Input employee data on a digital database
   4  Develop an inventory management software
   6  Develop an IT system for a large multinational

G24  Documenting and recording: “To input, transcribe, record, archive or store information in on a written, magnetic or electronic medium.” (1–7 complexity scale)

H2  Using e-mail as part of one’s occupation (1–7 frequency scale)
Second, the digital skills index measures technology-related knowledge, to assess the worker’s ability to understand it and possibly harness it.
Being equipped with digital skills

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Based on questions from the ICP survey on knowledge complexity (1–7 scale with industry-specific benchmarks), normalized [0-100]

- **B9  Informatics and electronics**: “Knowledge of electronic circuits, processors and chips in electronic devices, including knowledge of software package and applications”.
- **B31  Telecommunication**: “Knowledge of radio transmission, broadcast, and connection and management of telecommunication systems”.
- **C6  Sciences**: “Applying scientific rules and methods to solve problems”.
- **C18  Operation analysis**: “Analysing characteristics and requirement of the necessary tools, services or products for project development”
- **C19  Technological design**: “Developing or adapting tools and technologies responding to user demands.”
- **C22  Programming**: “Writing computer programs for various purposes.”
Third, the **digital tasks** index based on the defining tasks of occupations.

The ICP survey contains a free-form section where a panel of respondents from each 5-digit ISCO describes up to 15 tasks that characterize their occupation. ~6200 distinct activities in total.

We identify 131 activities that explicitly involve digital technologies and are indicative of a digital occupation:
Performing digital tasks

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- “Design, develop and test database management systems”;
- “Send documents electronically to the relevant department”;
- “Inspect and check online services”…
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- “Design, develop and test database management systems”;
- “Send documents electronically to the relevant department”;
- “Inspect and check online services”,…

For each occupation, we sum the reported importance of these tasks in the respective occupations.

This index measures precisely digitization of core tasks, but cannot measure digitalisation of ancillary activities.
Finally, we construct a **routine task intensity** (RTI, see Goos et al. 2014) from the ICP questionnaire.

We include the task-related dimensions considered by Autor et al. (2003) and followers in their empirical analysis, but unlike Goos et al. (2014) our task and skill variables refer to the Italian economy.
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**Structure of RTI:**

- Routine cognitive (RC)
- Routine manual (RM)
- Non-routine cognitive: Analytical (NRCA)
- Non-routine cognitive: Interpersonal (NRCI)
- Non-routine manual (NRM)
- Non-routine manual: interpersonal adaptability (NRMIA)

\[
RTI_k = RC_k + RM_k - (NRCA_k + NRCI_k + NRM_k + NRMIA_k)
\]
Descriptive evidence
Distribution of digital and routine indices across 498 Italian occupations in 2011
### Correlation across occupations of routine and digital indices

<table>
<thead>
<tr>
<th></th>
<th>Digital Tasks</th>
<th>Digital Skills</th>
<th>Digital Use</th>
<th>Routine Manual</th>
<th>Routine Cognitive</th>
<th>Routine Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Tasks</td>
<td>1</td>
<td>0.39</td>
<td>0.26</td>
<td>0.1</td>
<td>-0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>Digital Skills</td>
<td>0.39</td>
<td>1</td>
<td>0.7</td>
<td>-0.16</td>
<td>-0.63</td>
<td>-0.49</td>
</tr>
<tr>
<td>Digital Use</td>
<td>0.26</td>
<td>0.7</td>
<td>1</td>
<td>-0.35</td>
<td>-0.75</td>
<td>-0.53</td>
</tr>
<tr>
<td>Routine Manual</td>
<td>0.1</td>
<td>-0.16</td>
<td>-0.35</td>
<td>1</td>
<td>0.53</td>
<td>0.83</td>
</tr>
<tr>
<td>Routine Cognitive</td>
<td>-0.08</td>
<td>-0.63</td>
<td>-0.75</td>
<td>0.53</td>
<td>1</td>
<td>0.85</td>
</tr>
<tr>
<td>Routine Task</td>
<td>0.04</td>
<td>-0.49</td>
<td>-0.53</td>
<td>0.83</td>
<td>0.85</td>
<td>1</td>
</tr>
</tbody>
</table>

The correlation heatmap visualizes the correlation coefficients between different occupational indices. The colors range from blue (low correlation) to red (high correlation) with a scale from -1 to 1.
Changes in employment (2016–2011, in %) for occupations by different levels of routineness (RTI) and digital intensity:

<table>
<thead>
<tr>
<th></th>
<th>Digital Use</th>
<th>Digital Skills</th>
<th>Digital Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
</tr>
<tr>
<td>Low RTI</td>
<td>2.19</td>
<td>-4.70</td>
<td>5.97</td>
</tr>
<tr>
<td>Mid RTI</td>
<td>4.98</td>
<td>7.29</td>
<td>3.49</td>
</tr>
<tr>
<td>High RTI</td>
<td>1.92</td>
<td>-2.37</td>
<td>-16.15</td>
</tr>
<tr>
<td>Overall</td>
<td>2.87</td>
<td>-0.17</td>
<td>-0.56</td>
</tr>
</tbody>
</table>
Empirical strategy
Empirical strategy

Combining the data from ILFS and ICP, we explore the relation (weighted OLS) between $\Delta N_{ij}$ changes in employment between 2011 and 2016 in occupation ($i$)–sector($j$) cells (ISCO 4-digit $\times$ NACE 1-digit) and:

- Digital occupational digital indices (use/skill/task);
- RTI routine technical index;
- Occupation-sector controls:
  - share of young employees (15-34 years old);
  - share of women;
  - share of employees with temporary contracts;
  - share of part-time employees.
- $Y_i$: share in occupation $i$ who saw process innovation;
- $Z_j$: sector fixed effects;
- Robust Standard Errors.
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$$\Delta N_{ij} = \alpha + \beta Digital_i + \delta RTI_i + \theta X_{ij} + \psi Y_i + Z_j + \varepsilon_{ij}$$

$$\Delta N_{ij} = \alpha + \beta Digital_i + \delta RTI_i + \gamma Digital_i \times RTI_i + \theta X_{ij} + \psi Y_i + Z_j + \varepsilon_{ij}$$

- $Digital_i$: occupational digital indices (use/skill/task);
- $RTI_i$: routine technical index;
- $X_{ij}$: occupation-sector controls:
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Results
## Results

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<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digital Use</strong></td>
<td>$-0.000187$</td>
<td>$-0.000371$</td>
<td>$0.00449^*$</td>
<td>$0.00249$</td>
<td>$0.00255$</td>
<td>$0.0206^*$</td>
<td>$0.00260^{**}$</td>
<td>$0.00287^{**}$</td>
<td>$0.00713^*$</td>
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<tr>
<td></td>
<td>($-0.22$)</td>
<td>($-0.40$)</td>
<td>($2.08$)</td>
<td>($1.65$)</td>
<td>($1.69$)</td>
<td>($2.23$)</td>
<td>($2.60$)</td>
<td>($2.60$)</td>
<td>($2.31$)</td>
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<tr>
<td><strong>Digital Tasks</strong></td>
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<td><strong>Digital Skills</strong></td>
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<td></td>
<td>$-0.000662$</td>
<td>$0.00450$</td>
<td>$-0.000564$</td>
<td>$-0.00000603$</td>
<td>$0.000654$</td>
<td>$0.00314$</td>
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<td></td>
<td>($-0.52$)</td>
<td>($1.91$)</td>
<td>($-0.49$)</td>
<td>($-0.01$)</td>
<td>($0.53$)</td>
<td>($1.53$)</td>
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<tr>
<td><strong>RTI index</strong></td>
<td>$-0.000103^*$</td>
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<td>($-2.50$)</td>
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<tr>
<td><strong>RTI × Digital Use</strong></td>
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<td><strong>RTI × Digital Skills</strong></td>
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<td><strong>Process innovation</strong></td>
<td>$-0.384^{**}$</td>
<td>$-0.380^{**}$</td>
<td>$-0.385^{**}$</td>
<td>$-0.435^{***}$</td>
<td>$-0.444^{***}$</td>
<td>$-0.446^{***}$</td>
<td>$-0.487^{***}$</td>
<td>$-0.487^{***}$</td>
<td>$-0.473^{***}$</td>
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<td><strong>Occ–sec controls</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Sector dummies</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Constant</strong></td>
<td>$-0.236$</td>
<td>$-0.188$</td>
<td>$-0.505$</td>
<td>$-0.303$</td>
<td>$-0.268$</td>
<td>$-0.303$</td>
<td>$-0.313$</td>
<td>$-0.364$</td>
<td>$-0.491^*$</td>
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<td></td>
<td>($-1.11$)</td>
<td>($-0.78$)</td>
<td>($-1.87$)</td>
<td>($-1.53$)</td>
<td>($-1.26$)</td>
<td>($-1.43$)</td>
<td>($-1.54$)</td>
<td>($-1.67$)</td>
<td>($-2.07$)</td>
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<td><strong>N</strong></td>
<td>2281</td>
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</table>

* t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001
Conclusions
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We develop three distinct digital indicators of occupations (digital tasks, digital competences, digital use), and we calculate routineness (RTI) independently, using data provided by the INAPP-ISTAT survey on Italian occupations.
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Digitalisation and routineness vs employment:

- Complex relation between digitalisation, routineness and skill levels: positive relation between digitalisation and skills, negative between routineness and skill (descriptive evidence);
- Distinct effects between routineness and digitalisation: highly digital professions see greater increase in employment (in manufacturing).
- Occupations using more digital tools - or with a high share of digital tasks - that are also highly routine tend to be penalized in employment terms.