Digitalisation, routineness and employment

Exploring Italian task-based data

Valeria Cirillo[1], Rinaldo Evangelista[2], Dario Guarascio[1], **Matteo Sostero**[3,1,4]

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[1]Italian National Institute for Public Policy Analysis (INAPP)
[2]University of Camerino
[3]Sant'Anna School of Advanced Studies
[4]European Commission - Joint Research Centre, Seville (personal opinions)

Motivation

Background

"Digital technology as technological revolution"

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

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What consequences on employment? Job creation, destruction or transformation? (Arntz et al. 2016; Frey and Osborne, 2017; OECD, 2018)

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:

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

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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);

Digitization: occupational perspective

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

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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 $\simeq$ ISCO) and sector (ATECO 1 digit $\simeq$ 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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We also calculate the Routine Technical Index (RTI, Goos et al. 2014) to measure routineness.

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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)

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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 compute programs for various purposes."

Performing digital *tasks*

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:

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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.

Routine Task Intensity

Finally, we construct a **routine task intensity** (RTI, see Goos et al. 2014) from the ICP questionnaire.

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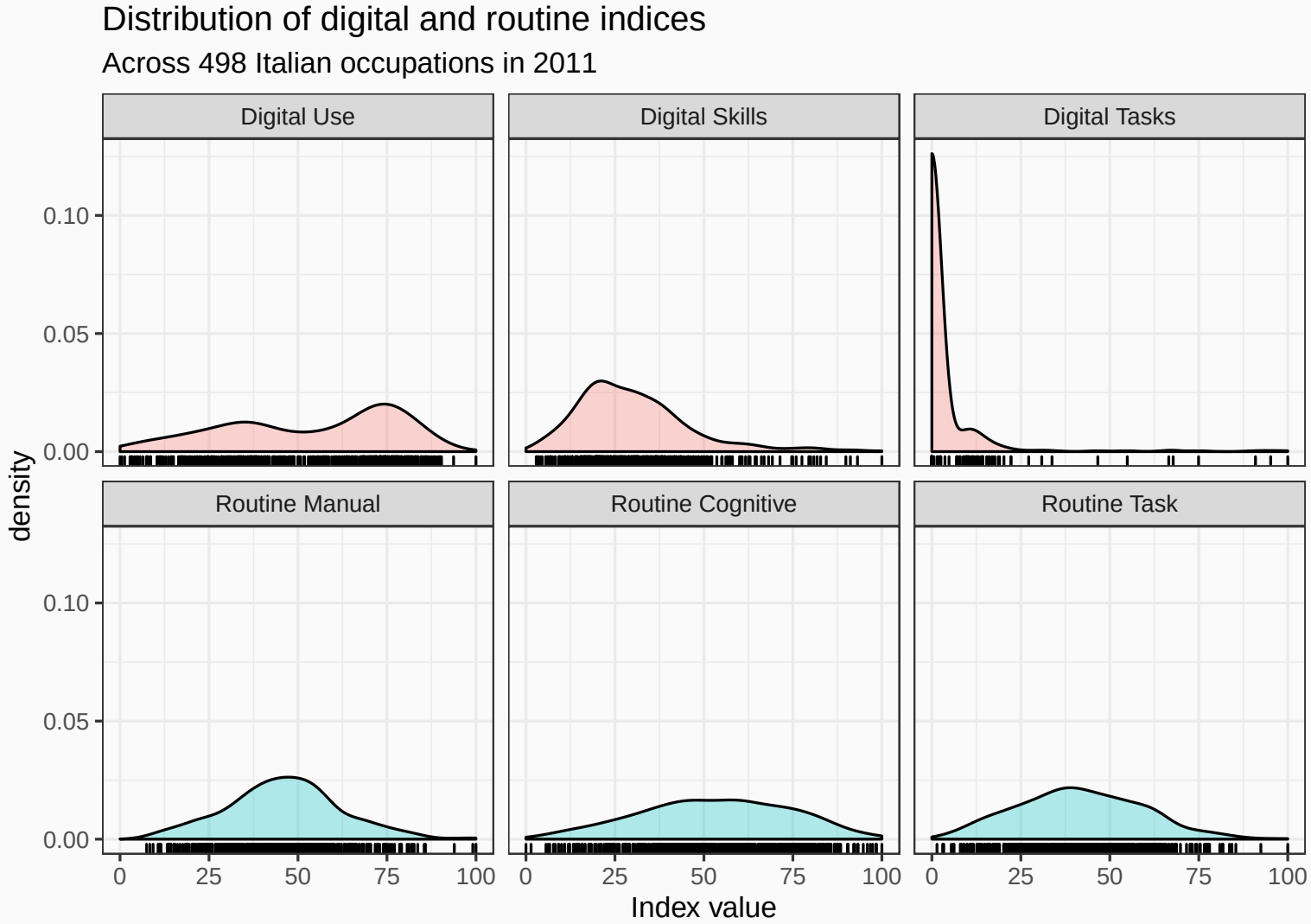
Structure of RTI:

- 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)

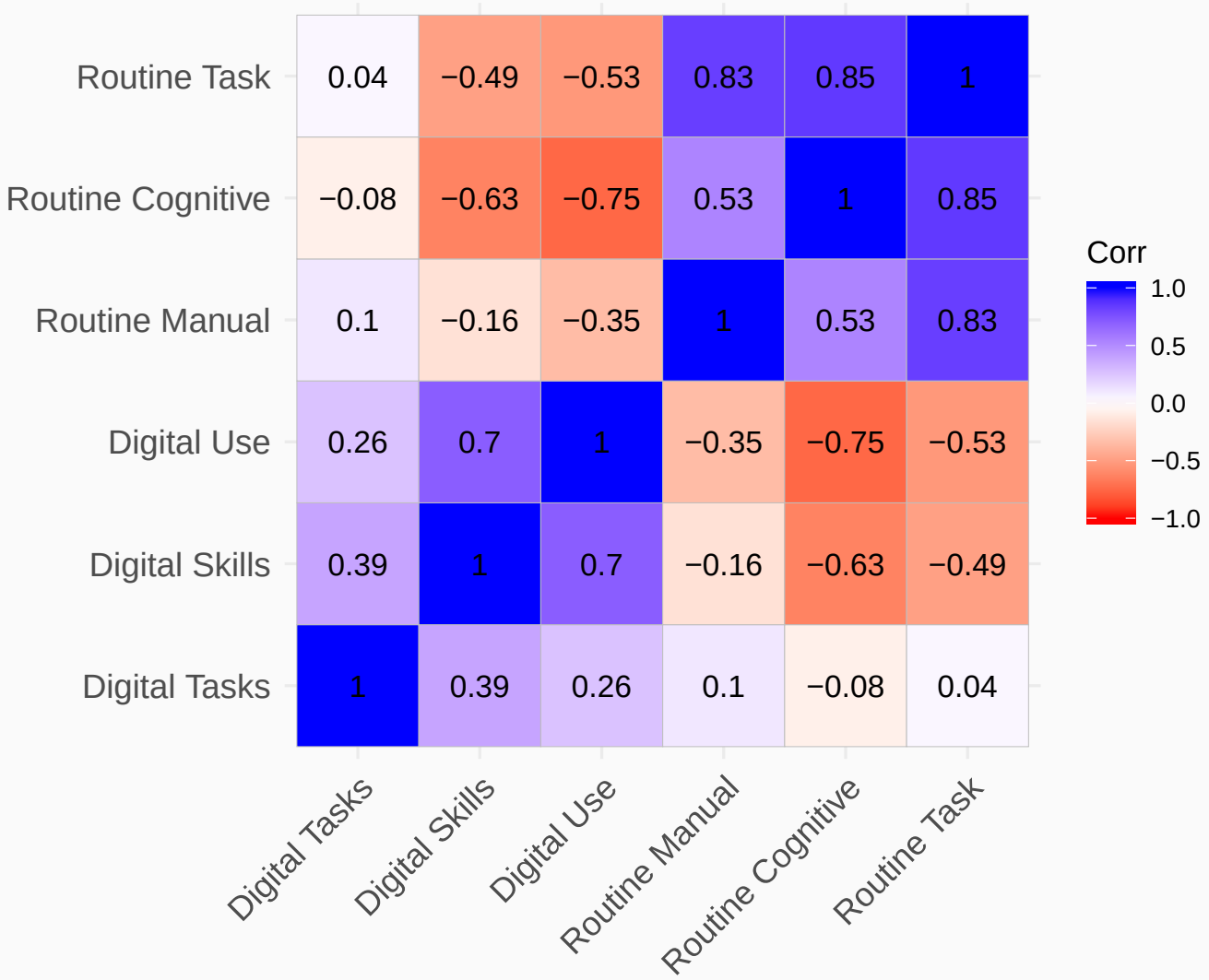
$$RTI_k = RC_k + RM_k - (NRCA_k + NRCI_k + NRM_k + NRMIA_k)$$

Descriptive evidence

Distribution of indices across occupations



Correlation across occupations of routine and digital indices



Employment change by routineness and digitalisation

Changes in employment (2016–2011, in %) for occupations by different levels of routineness (RTI) and digital intensity:

	Digital Use			Digital Skills			Digital Tasks		
	Low	Mid	High	Low	Mid	High	Low	High	Overall
Low RTI	2.19	-4.70	5.97	-8.02	-5.70	7.46	0.67	-7.30	-0.81
Mid RTI	4.98	7.29	3.49	8.48	3.64	1.95	5.71	3.74	5.32
High RTI	1.92	-2.37	-16.15	1.65	-10.56	5.88	0.87	-12.05	-0.90
Overall	2.87	-0.17	-0.56	2.66	-3.46	5.36	2.43	-4.67	1.24

Empirical strategy

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

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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:
  - 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.

Results

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	Employment rate of change (2011-2016)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Digital Use	−0.000187	−0.000371	0.00449*						
	(−0.22)	(−0.40)	(2.08)						
Digital Tasks				0.00249	0.00255	0.0206*			
				(1.65)	(1.69)	(2.23)			
Digital Skills							0.00260**	0.00287**	0.00713*
							(2.60)	(2.60)	(2.31)
RTI index		−0.000662	0.00450		−0.000564	−0.00000603		0.000654	0.00314
		(−0.52)	(1.91)		(−0.49)	(−0.01)		(0.53)	(1.53)
RTI×Dgt. Use			−0.000103*						
			(−2.50)						
RTI×Dgt. Tasks						−0.000398			
						(−1.95)			
RTI×Dgt. Skills									−0.000105
									(−1.38)
Process innovation	−0.384**	−0.380**	−0.385**	−0.435***	−0.444***	−0.446***	−0.487***	−0.487***	−0.473***
	(−2.84)	(−2.78)	(−2.87)	(−3.57)	(−3.67)	(−3.68)	(−3.90)	(−3.90)	(−3.81)
Occ−sec controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.236	−0.188	−0.505	−0.303	−0.268	−0.303	−0.313	−0.364	−0.491*
	(−1.11)	(−0.78)	(−1.87)	(−1.53)	(−1.26)	(−1.43)	(−1.54)	(−1.67)	(−2.07)
N	2281	2281	2281	2281	2281	2281	2281	2281	2281

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.