



Does routinization affect occupation dynamics? Evidence from the 'Italian O*Net' data

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- **Context, literature and contribution**
- **Key research questions**
- **Data and descriptive evidence**
- **Econometric strategy and results**
- **Making the role of technological and organizational innovation explicit**
- **Conclusions**

Context, literature and contribution (1)

- The fast unfolding of automation and digitization is bringing (again) to the fore a generalized **fear of mass tech-unemployment**...and with it a flourishing of studies aimed at quantifying such risks in terms of # jobs (*Frey and Osborne, 2017; OECD, 2017; Acemoglu and Restrepo, 2018; Marcolin et al. 2018*)
- A long lasting literature investigating the linkage between ICTs-tasks-labor mkt dynamics...from the **SBTC** (*focus on skills - Acemoglu, 2002*) to **RBTC** (*tasks as the 'very object' of replacement by machines - Autor et al. 2003 and followers...*)
- However, recent technological developments risk to reshape lab mkts in a more **radical** and **widespread** way than before (*Brynjolfsson and McAfee, 2014*)...while the existing evidence (*on polarization*) is challenged by theoretical and methodological problems plus country-level heterogeneities...

Context, literature and contribution (2)

- Consolidated evidence on task-driven **polarization** in the US (*Autor and Dorn, 2013*) while mixed results in the European case (*Fernandez-Macias and Hurley, 2013; Goos et al. 2014; Cirillo, 2016*)
- **Theoretical** (excluding few exceptions all analysis rely on restrictive GE assumptions), **conceptual** (tasks as a highly complex object) and **measurement** issues are still in place (*Fernandez-Macias and Hurley, 2013*)
- Between and within-occupation heterogeneity matter (highly detailed and disaggregated infos are needed) and **macro, structural, institutional factors** should be explicitly accounted for...

Context, literature and contribution (3)

- Taking advantage of a rich dataset providing **O*Net-type information** on the task content of Italian occupations, this work analyses empirically whether employment patterns are affected by task characteristics in terms of ‘relative routinarity’
- **The contribution is manifold:** i) for the 1st time the relationship between routine-task and employment dynamics is explored using O*Net type information collected in a EU country ii) the role of routine task is analysed accounting for a large set of occupation, sectoral and institutional factors iii) sectoral (*manuf vs services*) and occupational (*young and college degree workers vs the rest of the workforce*) heterogeneities are highlighted iv) thanks to specific ICP questions (*if a technological or an organizational innovation occurred during the last three years*) the role of technological and organizational innovations is explicitly analysed

Research questions

- **We provide an econometric answer to the following research questions:**
 - ✓ **RQ 1** – Does ‘routinization’ (*i.e. being characterized by a relatively large share of repetitive and codifiable tasks*) penalize Italian occupations in terms of employment dynamics?
 - ✓ **RQ 2** – Does ‘routinization’ has differentiated effect in services vis-a-vis manufacturing?
 - ✓ **RQ 3** - Does ‘routinization’ affect heterogeneously young workers as compared to the rest of the workforce?
 - ✓ **RQ4** - Does ‘routinization’ affect heterogeneously workers with college degree as compared to the rest of the workforce?
 - ✓ **RQ5** – Does the RTI-employment relationship change when technological and organizational innovations are explicitly accounted for?

Data and descriptive evidence (1)

- The **adopted dataset** merges information on: a) task, skills, work attitudes, technological and organizational innovations at the 4-digit occupation-level from the ICP INAPP-ISTAT dataset b) employment, income, workers' socio-demographic characteristics, contract types at the 4-digit occupation level drawn from the Italian LFS c) balance-sheet data (AIDA BvD) on revenues, demand, investments and R&D expenditure referring to representative occupation-industry 4-digit cells

Table 1. Variables – description and sources

Variables	Description	Source
Labor market variables		RCFL
<ul style="list-style-type: none"> • Total employment (Log diff) • Women (%) • Young workers (%) • College degree (%) • Temporary employment (%) • Median wage (Log diff) 	<ul style="list-style-type: none"> • # employees by 4-digit occupation/1-digit ATECO sector • Share of women (employees) over the total by 4-digit occupation/1-digit ATECO sector • Share of 15-34 years old employees over the total by 4-digit occupation/1-digit ATECO sector • Share of employees with college degree over the total by 4-digit occupation/1-digit ATECO sector • Share of employees with temporary contract over the total by 4-digit occupation/1-digit ATECO sector • Median wage reported by the RCFL respondents by 4-digit occupation/1-digit ATECO sector (data available for the 2011-2016 period only) 	
Task-related variables		ICP INAPP
<ul style="list-style-type: none"> • RTI index and subcomponents • Technology and organization vars 	<ul style="list-style-type: none"> • Dimensions comprised in the RTI by 4-digit occupation (see table 2 for details) 	
Economic variables		AIDA-BvD
<ul style="list-style-type: none"> • Total revenues (Log diff) • Capital stock (Log diff) • R&D investments (Log diff) 	<ul style="list-style-type: none"> • Weighted average of the median revenues as reported by companies' balance sheet at the 4-digit ATECO level. The adopted weight is the log of total employment at the ATECO 4-digit. • Weighted average of companies' capital stock as reported by companies' balance sheet at the 4-digit ATECO level. The adopted weight is the log of total employment at the ATECO 4-digit. • Weighted average of the median R&D expenditure as reported by companies' balance sheet at the 4-digit ATECO level. The adopted weight is the log of total employment at the ATECO 4-digit. 	

Data and descriptive evidence (3)

- The Routine Task Index (RTI - Autor et al. 2003):**

$$RTI_i = RM_i + RC_i - NRM_i - NRMIA_i - NRCA_i - NRCA_i \quad i \in CP2011_{4digit}$$

Routine manual (RM)

Pace determined by speed of equipment

Controlling machines and processes

Spend time making repetitive motions

Routine cognitive (RC)

Importance of repeating the same tasks

Importance of being exact or accurate

Structured v. Unstructured work (reverse)

Non-routine manual (NRM)

Operating vehicles, mechanized devices, or equipment

Spend time using hands to handle, control or feel objects, tools or controls

Manual dexterity

Spatial orientation

Non-routine manual: interpersonal adaptability (NRMIA)

Social Perceptiveness

Non-routine cognitive: Analytical (NRCA)

Analyzing data/information

Thinking creatively

Interpreting information for others

Non-routine cognitive: Interpersonal (NRCAI)

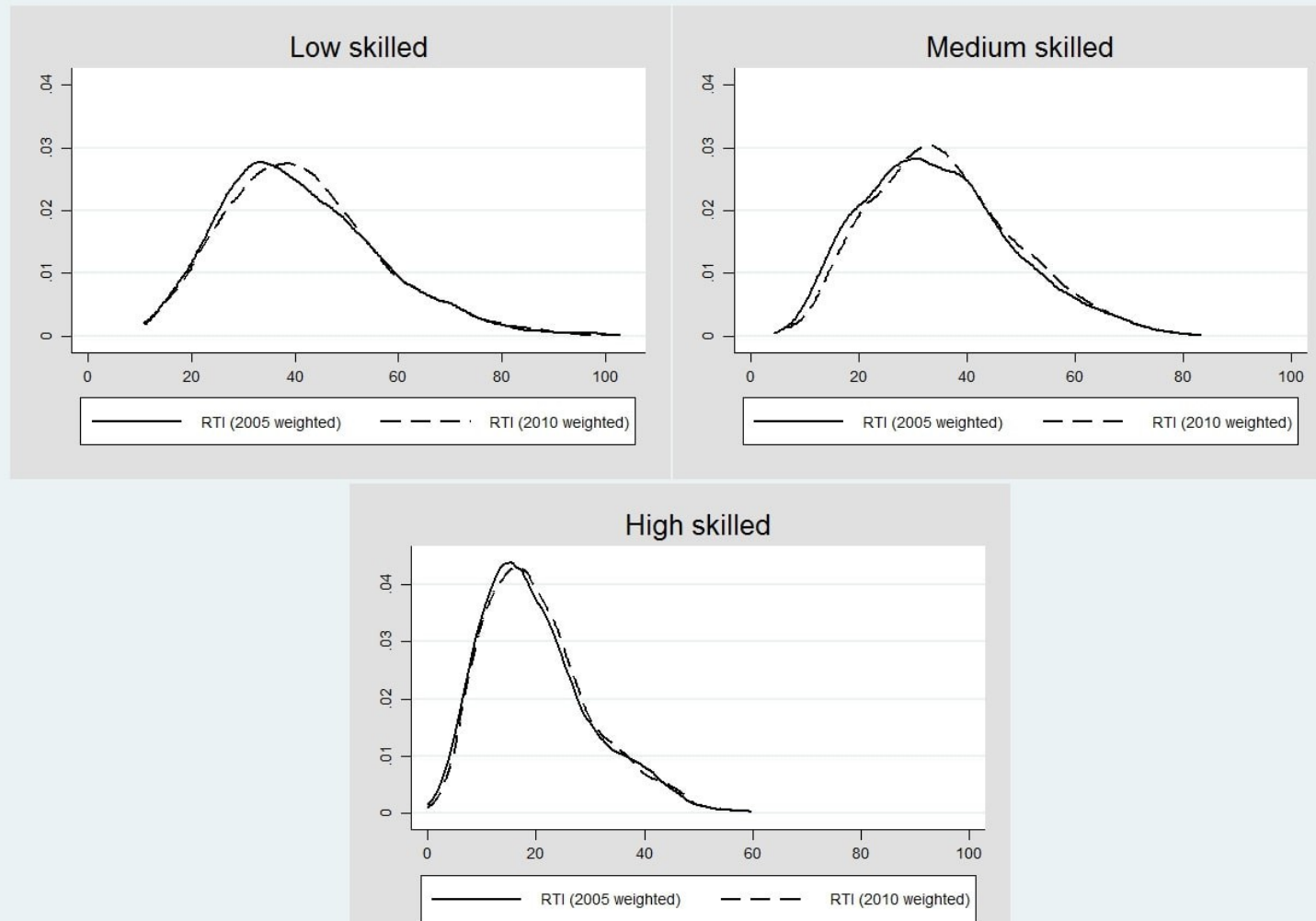
Establishing and maintaining personal relationships

Guiding, directing and motivating subordinates

Coaching/developing others

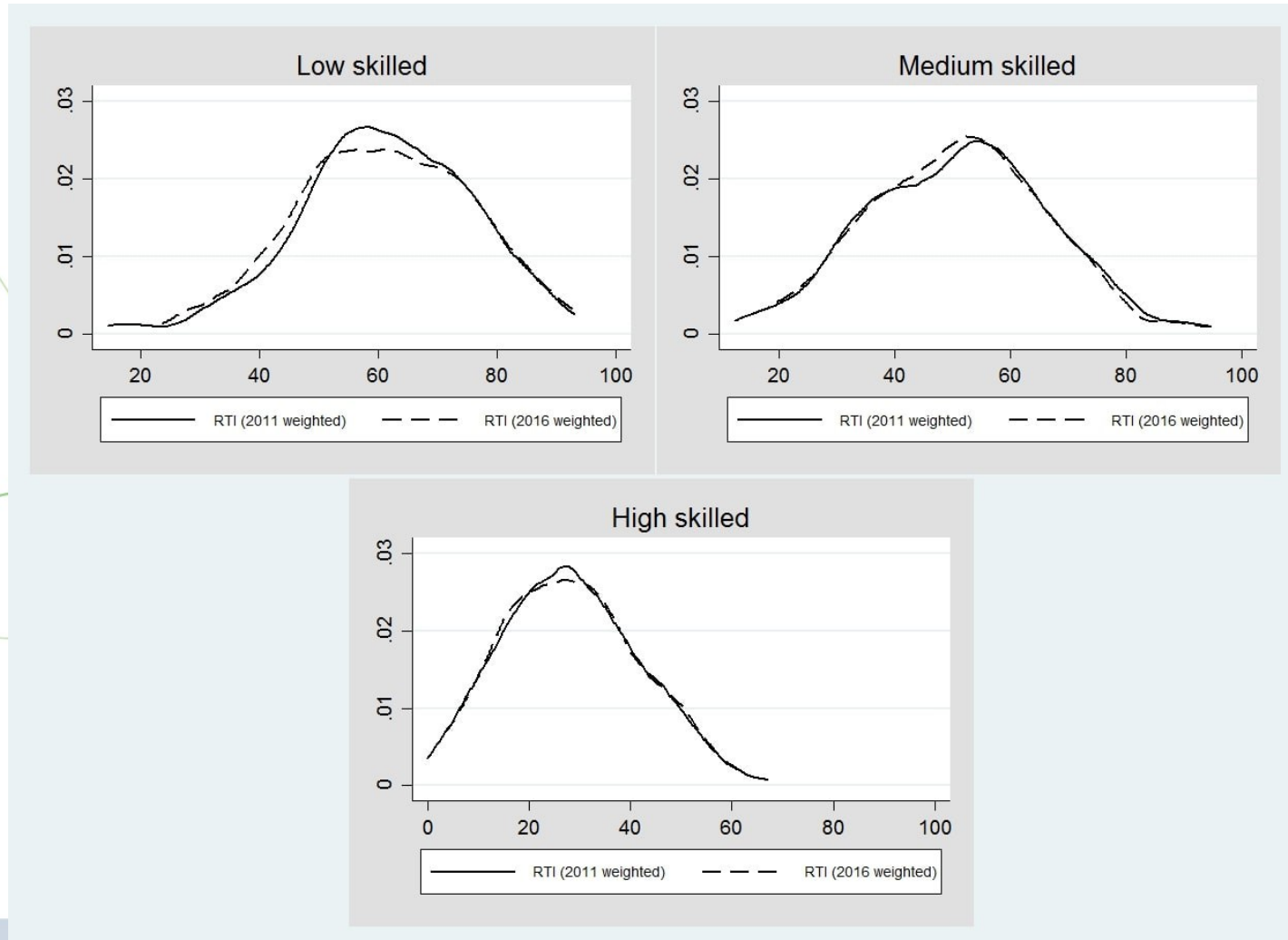
Data and descriptive evidence (4)

**Figure 1. The evolution of the Italian occupational structure by task characteristics
RTI weighted log (employees) by 4-digit occupation and skill groups – years 2005-2010**



Data and descriptive evidence (5)

**Figure 2. The evolution of the Italian occupational structure by task characteristics
RTI weighted log (employees) by 4-digit occupation and skill groups – years 2011-2016**



**Figure 3. The evolution of the Italian occupational structure by task characteristics
RTI weighted log (employees) by 1-digit occupation – years 2005-2016**

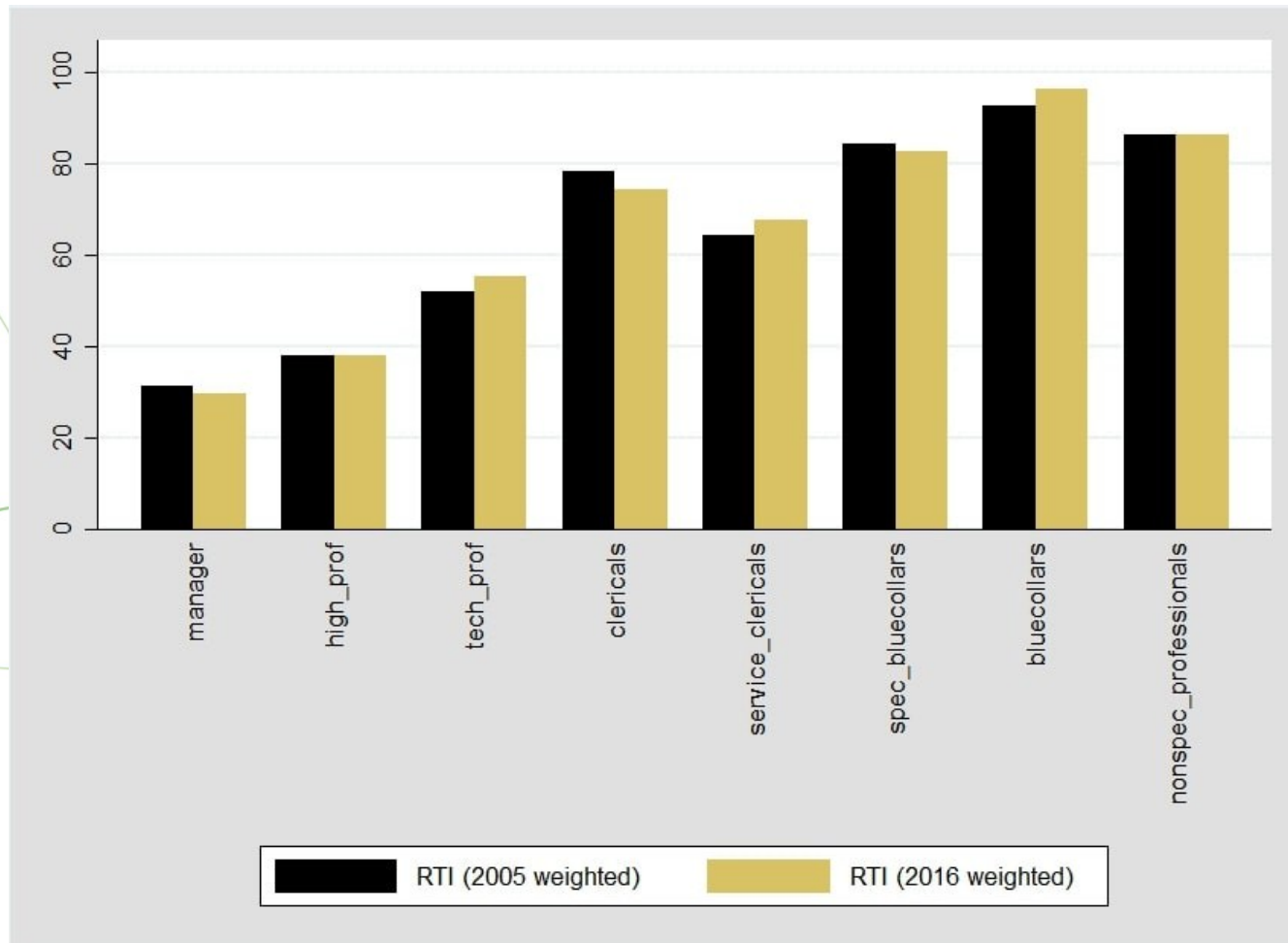
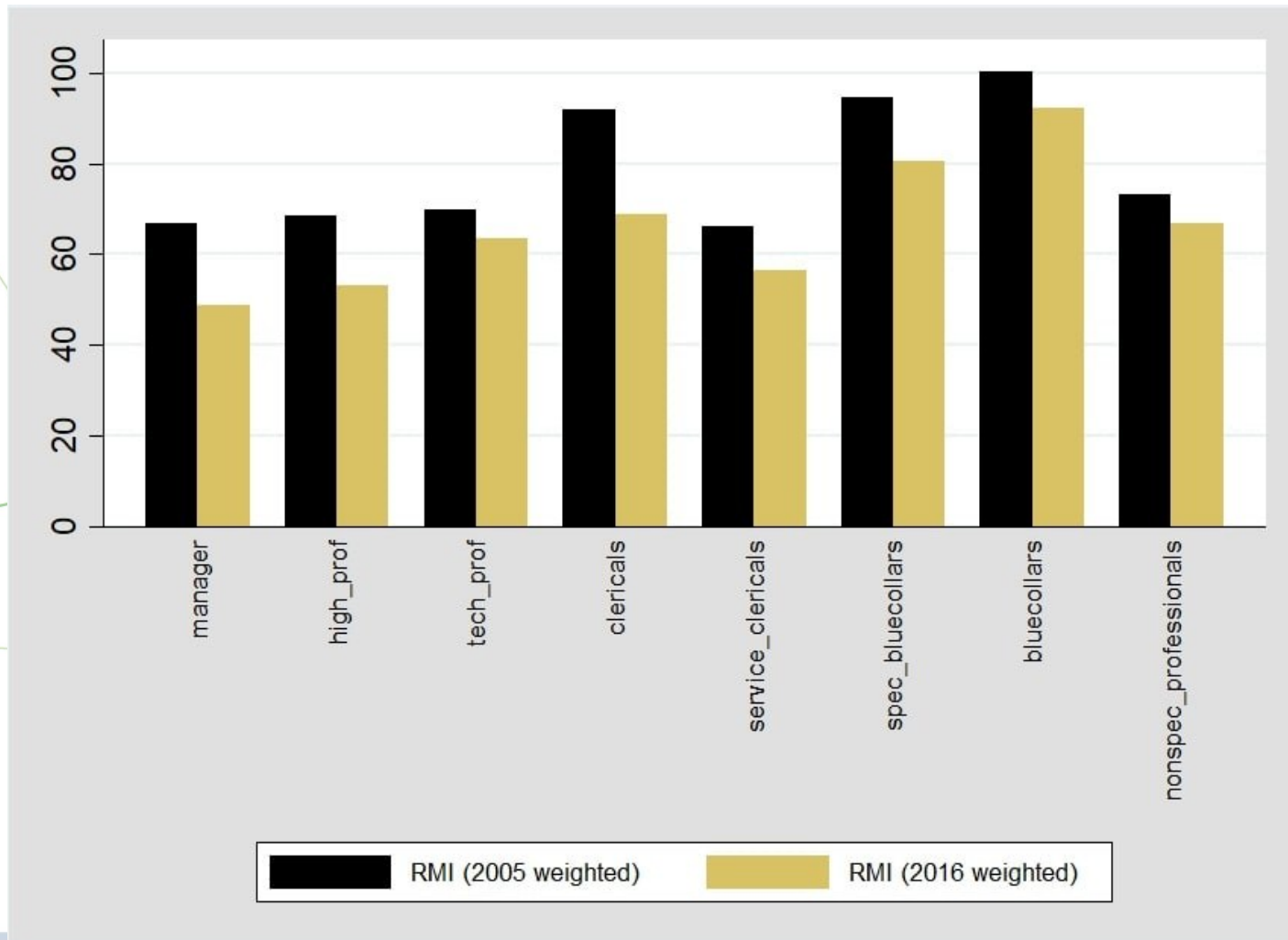
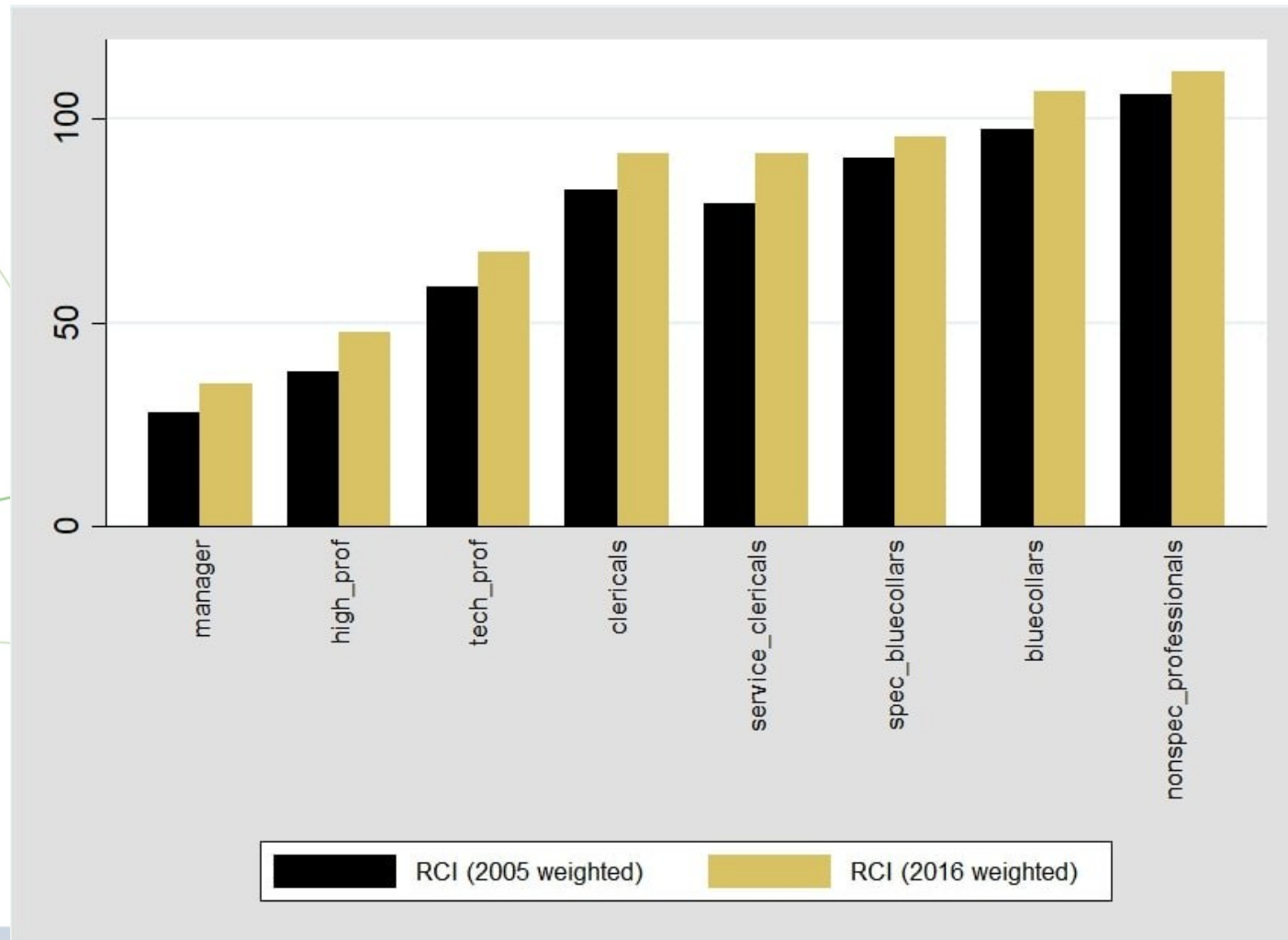


Figure 4. The evolution of the Italian occupational structure by task characteristics
RMI (manual tasks only) weighted log (employees) by 1-digit occupation - years 2005-2016



Data and descriptive evidence (8)

Figure 5. The evolution of the Italian occupational structure by task characteristics RMI (cognitive tasks only) weighted log (employees) by 1-digit occupation - years 2005-2016



**Fig. 6 - Change in employment by RTI's quintiles
2005-2010 (LHS) and 2011-2016 (RHS)**

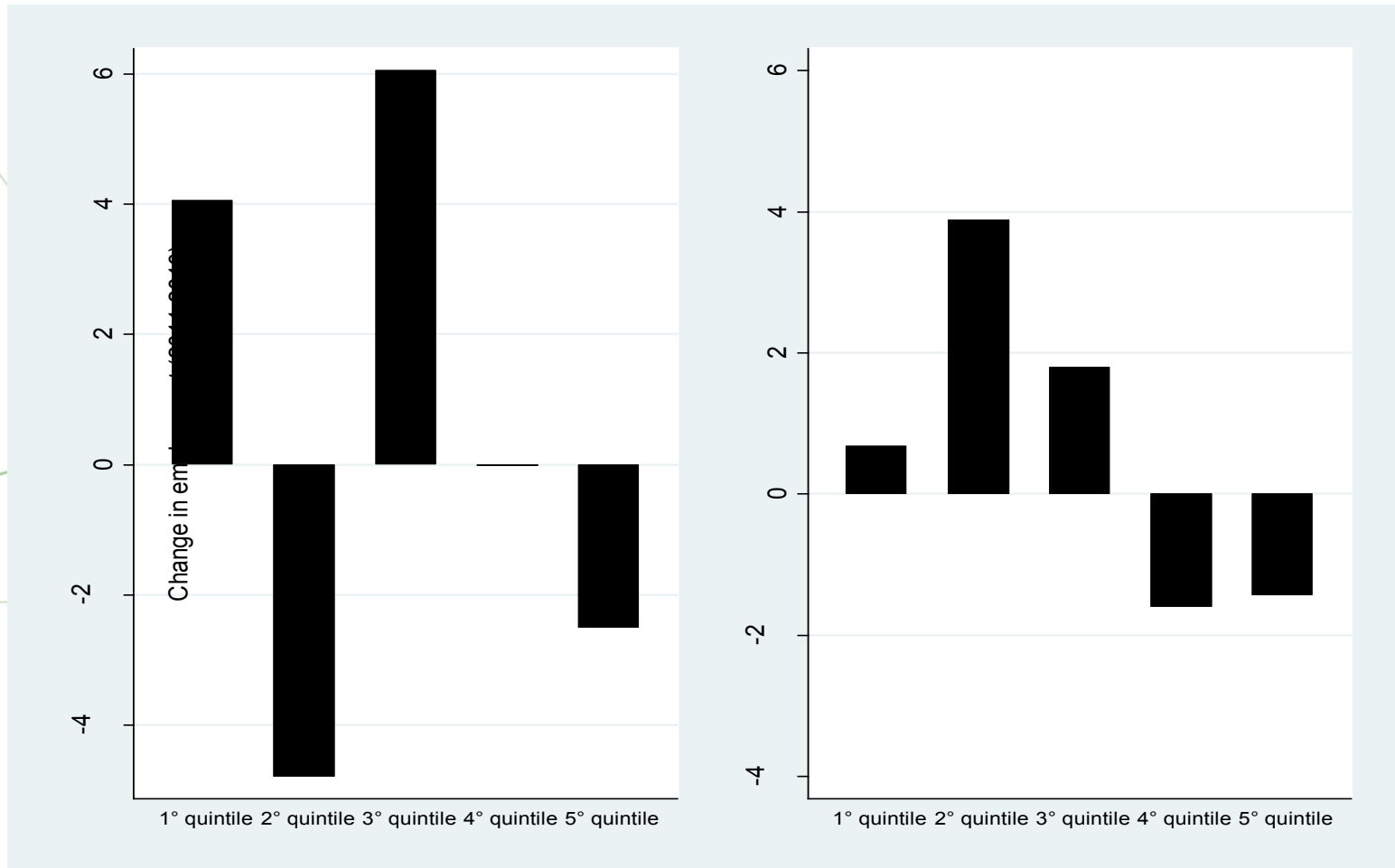


Table 3 – Italian occupations (4-digit) ranked by RTI

Top ten 'routinary' occupations (RTI ranking - 2005-2010)

Navy machineries operators

Electrical and ICT equipment assemblers

Spinning and winding machinery operators

Petroleum-related machineries operators

Unqualified personnel in manufacturing

Bank tellers

Manufacturing assembly line operators

Mining and quarrying plant operators

Mass wood production operators

Mass production of chemical products operators

Top ten 'routinary' occupations (RTI ranking - 2011-2016)

Textile industry operators

Operators for the production and refining of non-ferrous metals

Navy machineries operators

Operators for the production of other rubber products

Machinists for the production of other rubber products

Paper and printing industry operators

Operators for the production of bricks and tiles

Drivers of bookbinding and related machinery

Offset printers operators

Data and descriptive evidence (11)

Table 4 – Example: key factors not captured by the RTI...
 Source: *Cetrulo, Guarascio and Virgillito (2019, forthcoming)*

4 Digit	Occupation	Main activities	Mediam wage	Women (%)	Tert. education (%)	Indet. Contracts (%)	RTI
5442	Children surveillance personnel and similar occupations	supervise and inform parents about children's behavior, organize play activities, take care of children's hygiene	598.67 Euro	.94	.13	.61	21.34
1111	Members of government bodies and national assemblies with legislative and regulatory power	participate to conferences, and congresses, appoint administrators of institutions, institutions, public companies, plan and make new law proposals	3.764.833 Euro	.34	.80	.33	22.5

Econometric strategy and results (1)

- ✓ The RQs spelled out previously are tested by means of **Pooled OLS** (std. errors clustered by occupation-sector cells) over two distinct time span (2005-2010 and 2011-2016) due to a breakdown in the 4-digit Italian occupation classification:

$$\Delta N_{i,k,t} = RTI_i + X_{i,k,t-1} + Y_{i,k,t-1} + \varepsilon_{i,k,t}$$

- $\Delta N_{i,k,t}$ is the annual change in employment (log diff) by occupation i , sector k and year t
 - RTI is a dummy assuming value 1 if the occupation-sector falls in the 4th or 5th quintile of the RTI distribution and 0 otherwise
 - $X_{i,k,t}$ includes occupation level controls: change in employment; change in (log) median wages; share of women, young workers (15-34 years), workers with college degree and with temporary contract.
 - $Y_{i,k,t}$ includes sectoral level controls: change in revenues; change in capital stock; R&D expenditure
- ✓ **Stepwise procedure:** 1) ΔN vs RTI 2) ΔN vs $RTI + X$
 3) ΔN vs $RTI + X + Y + time, sect$ and occupation-level dummies

Econometric strategy and results (2)

Table 5. Change in employment vs RTI and controls – whole sample

	2005-2010			2011-2016		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
RTI dummy	-0.0116	-0.0334**	-0.00170	-0.0451**	-0.0530**	-0.0522**
	(0.00654)	(0.0133)	(0.0224)	(0.0143)	(0.0164)	(0.0160)
Observations	14467	10518	4233	11997	8680	6933
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.010						

Controls:

- **Positive** correlation with college degree (complementarity hp), temporary employment (confirming previous evidence on Italy - Cirillo et al.2017) and change in wages
- **Negative** correlation with young workers share

Note: time and sectoral dummies included in models 2 and 3

Econometric strategy and results (3)

Table 6. Change in employment vs RTI and controls – *manuf. vs services*

Manufacturing						
	2005-2010			2011-2016		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
RTI dummy	-0.0208** (0.00766)	-0.0195 (0.0201)	0.0295 (0.0407)	-0.0444** (0.0136)	-0.0333 (0.0203)	-0.0333 (0.0207)
Observations	14467	10518	4233	11997	8680	6933
Services						
	-0.00770 (0.0104)	-0.0345* (0.0167)	-0.0116 (0.0276)	-0.0454** (0.0161)	-0.0582** (0.0193)	-0.0587** (0.0211)
Observations	10819	7833	2717	8880	6387	4760
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.010						

Controls:

- **Positive** correlation with college degree (complementarity hp), R&D (manufacturing only), temporary empl (services only) and wages
- **Negative** correlation with young workers share

Note: time and sectoral dummies included in models 2 and 3

Econometric strategy and results (4)

Table 7. Change in employment vs RTI and controls – young workers vs rest of the workforce

Young workers (15-34 years)						
	2005-2010			2011-2016		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
RTI dummy	0.00793	0.0993***	0.104***	-0.0353	0.0464*	0.0488
	(0.00603)	(0.0235)	(0.0282)	(0.0195)	(0.0248)	(0.0268)
Observations	8697	6628	2951	7440	5593	4895
Rest of the workforce						
	0.00384	-0.135***	-0.0835*	-0.0326*	-0.131***	-0.137***
	(0.00867)	(0.0227)	(0.0371)	(0.0154)	(0.0212)	(0.0246)
Observations	13117	9737	4060	11219	8259	7153
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.010						

Controls:

- **Positive** correlation with college degree (complementarity hp), temporary empl (services only) and wages
- **Negative** correlation with women share

Note: time and sectoral dummies included in models 2 and 3

Econometric strategy and results (5)

Table 8. Change in employment vs RTI and controls – workers with college degree

	2005-2010			2011-2016		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
RTI dummy	0.0246	-0.0370	-0.0504*	0.0193	-0.0353*	-0.0366*
	(0.0350)	(0.0233)	(0.0222)	(0.0178)	(0.0177)	(0.0156)
Observations	6329	4946	2369	6153	4676	4019
Standard errors in parentheses						
* p<0.10, ** p<0.05, *** p<0.010						

Controls:

- **Positive** correlation with women and young workers share (2005-2010 only)
- **Negative** correlation with young workers share

Note: time and sectoral dummies included in models 2 and 3

- **Technology-related job destruction is expected to occur when new machineries are capable of substituting human beings in carrying out automatable and replicable tasks...**
- ✓ **Such an apparently straightforward chain of relationships might however be broken (or reshaped) due to economic and institutional constraints, power relationships and conflict, heterogeneity in terms of absorptive capacity, organizations' adaptability and propensity to change**
- ✓ **In addition, organizational innovation and capabilities (Winter, 1997; Dosi and Marengo, 2015) might emerge as the pivotal element in determining the final outcome of technological change given work (and organizations) deep characteristics ...**

Fig. 7 – Process and organizational innovation by RTI quintiles
Relative intensity by 4-digit occupation (information referring to the 2009-2011 period) – ICP INAPP

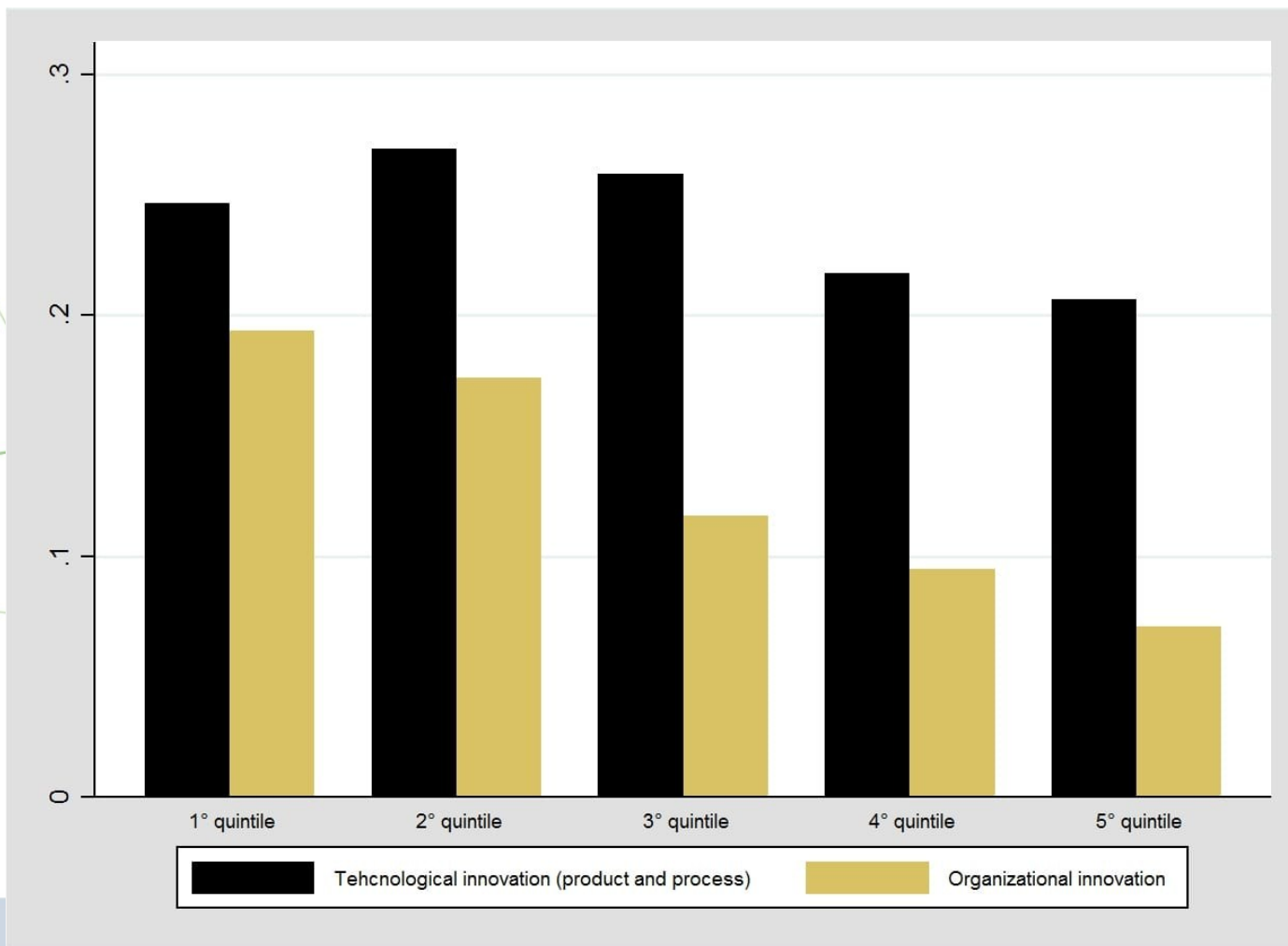


Table 9. Change in employment vs new processes, products and organizational innov.
Pooled OLS with clustered std. errors by RTI's quintiles - (2011-2016 sample)

	RTI - Q1	RTI - Q2	RTI - Q3	RTI - Q4	RTI - Q5
New processes (last 3 years)	-0.0593*	-0.0249	0.0407	-0.112*	-0.0734**
	(0.0268)	(0.0141)	(0.0219)	(0.0522)	(0.0266)
Controls, sectoral and time dummies	Yes	Yes	Yes	Yes	Yes
Observations	1221	1389	1474	1359	1476
New products (last 3 years)	-0.0321	0.00609	0.00912	-0.0279	-0.0263
	(0.0509)	(0.0318)	(0.0252)	(0.0444)	(0.0348)
Controls, sectoral and time dummies	Yes	Yes	Yes	Yes	Yes
Observations	1221	1389	1474	1359	1476
Organizational innovation (last 3 years)	-0.0786	0.000898	-0.0122	-0.0477	-0.0761**
	(0.0693)	(0.0161)	(0.0221)	(0.0526)	(0.0219)
Controls, sectoral and time dummies	Yes	Yes	Yes	Yes	Yes
Observations	1221	1389	1474	1359	1476
Standard errors in parentheses					
* p<0.10, ** p<0.05, *** p<0.010					

Conclusions (1)

- ✓ Occupations characterized by relatively large shares of routinary tasks are penalized in terms of employment dynamics (stronger evidence for the 2011-2016 period)
- ✓ As shown in previous contributions (Autor and Dorn, 2013), services emerge as the sector where the risk of replacement for routinary occupations is more substantial and widespread – **sectoral heterogeneity matters...**
- ✓ Italian occupations with high level of routinary tasks seems to get 'younger' rather than 'older' as in Autor and Dorn (2009)...while a weaker (negative) correlation with the RTI is found wrt workers with college degree
- ✓ Process innovation seems to play a role in explaining employment dynamics (particularly at the top of the RTI distribution)...while a much weaker statistical association is found concerning product and organizational innovations...

Conclusions (2)

- **Take home message and way ahead:**
 - ✓ **Within-occupation heterogeneity in terms of tasks seems to be one of the relevant dimensions explaining employment dynamics even in the Italian case...**
 - ✓ **However, this evidence might be significantly driven by structural factors (i.e. weakening of the industrial base, precarious work) requiring additional research to be adequately unravelled...need to further investigate the role of process innovation...**
 - ✓ **Offshoring needs to be more explicitly considered while indicators capturing the role of organizational routines and capabilities as well as that of hierarchies and power need to be considered to better understand the complexity of work...(*ongoing work with A. Cetrulo and M. Virgillito within the INAPP-SSSUP research agreement*)**

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