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

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The socio-economic impact of technological change
INAPP Auditorium - 30 November 2018

Outline

- **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)

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- **Consolidated evidence on task-driven polarization in the US (*Autor and Dorn, 2013*) while mixed results in the European case (*Fernadenz-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 (*Fernadenz-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 manyfold: 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 changes 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**

Data and descriptive evidence (2)

Table 1. Variables – description and sources

Variables	Description	Source
Labor market variables		**RCFL**
• **Total employment (Log diff)** • **Women (%)** • **Young workers (%)** • **College degree (%)** • **Temporary employment (%)** • **Median wage (Log diff)**	• # 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**
• **RTI index and subcomponents** • **Technology and organization vars**	• Dimensions comprised in the RTI by 4-digit occupation (see table 2 for details)	
Economic variables		**AIDA-BvD**
• **Total revenues (Log diff)** • **Capital stock (Log diff)** • **R&D investments (Log diff)**	• 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)

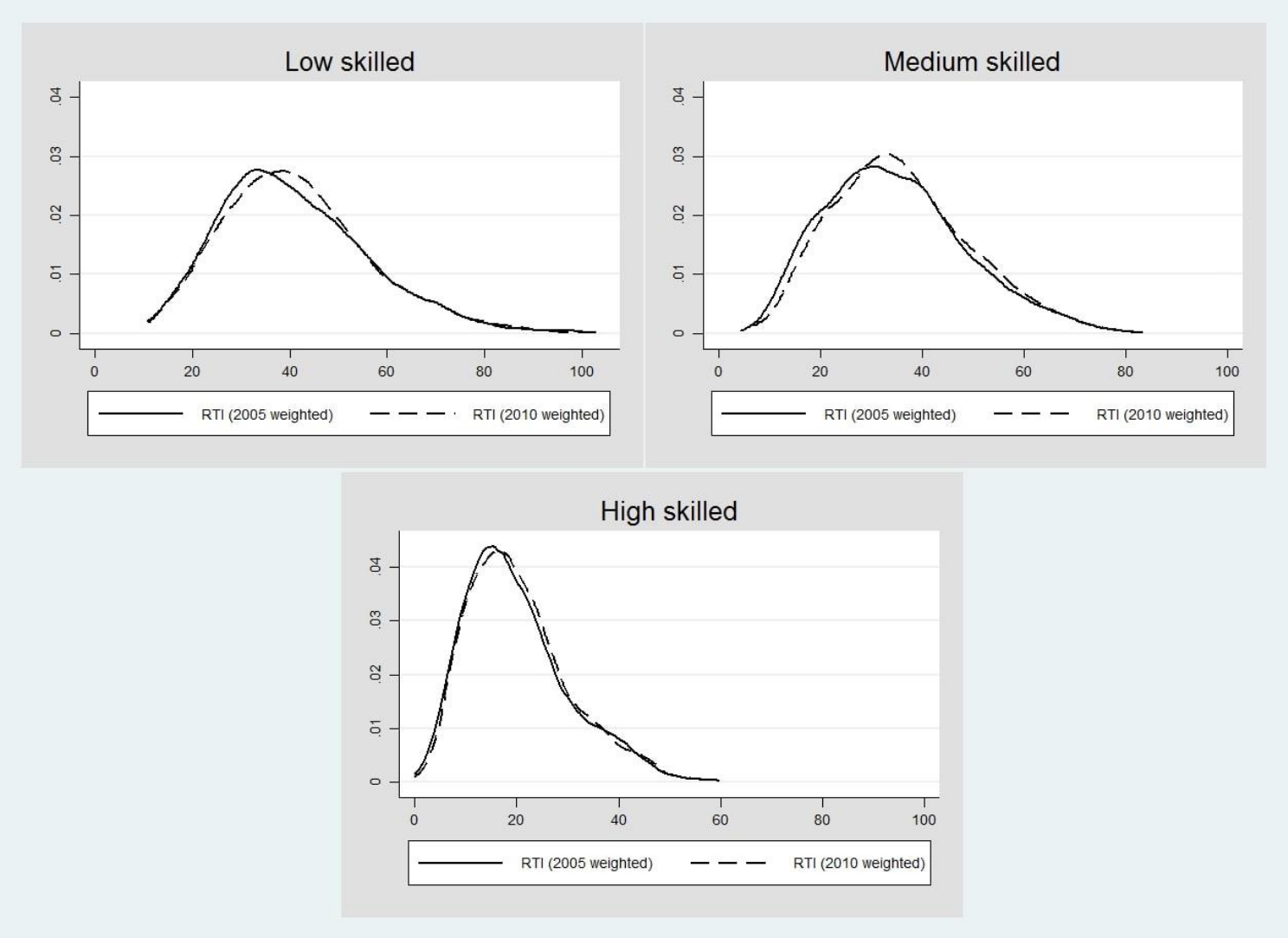
- **The Routine Task Index (RTI - Autor et al. 2003):**

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

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 (NRCI)
Establishing and maintaining personal relationships
Guiding, directing and motivating subordinates
Coaching/developing others

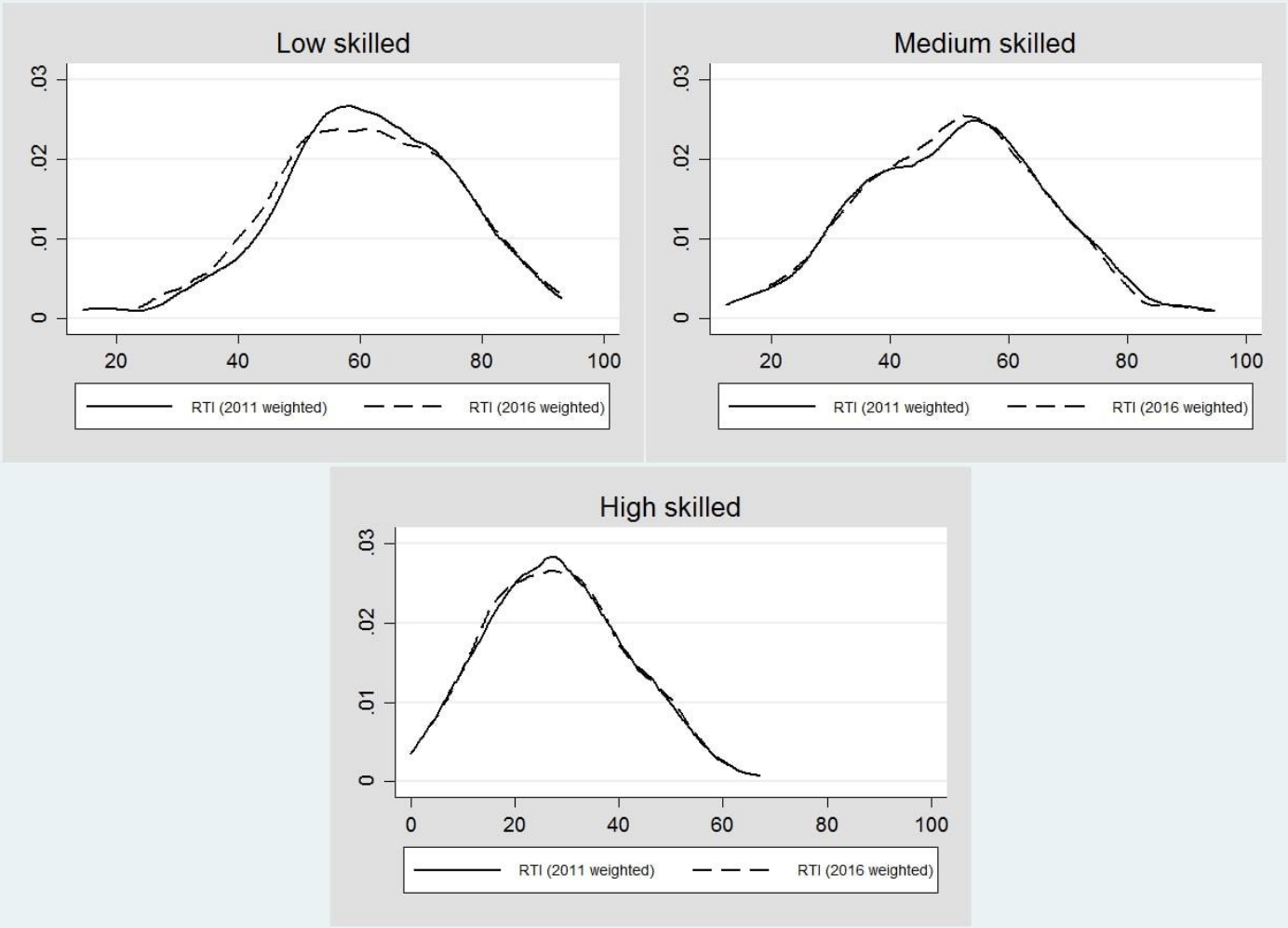
Data and descriptive evidence (4)

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



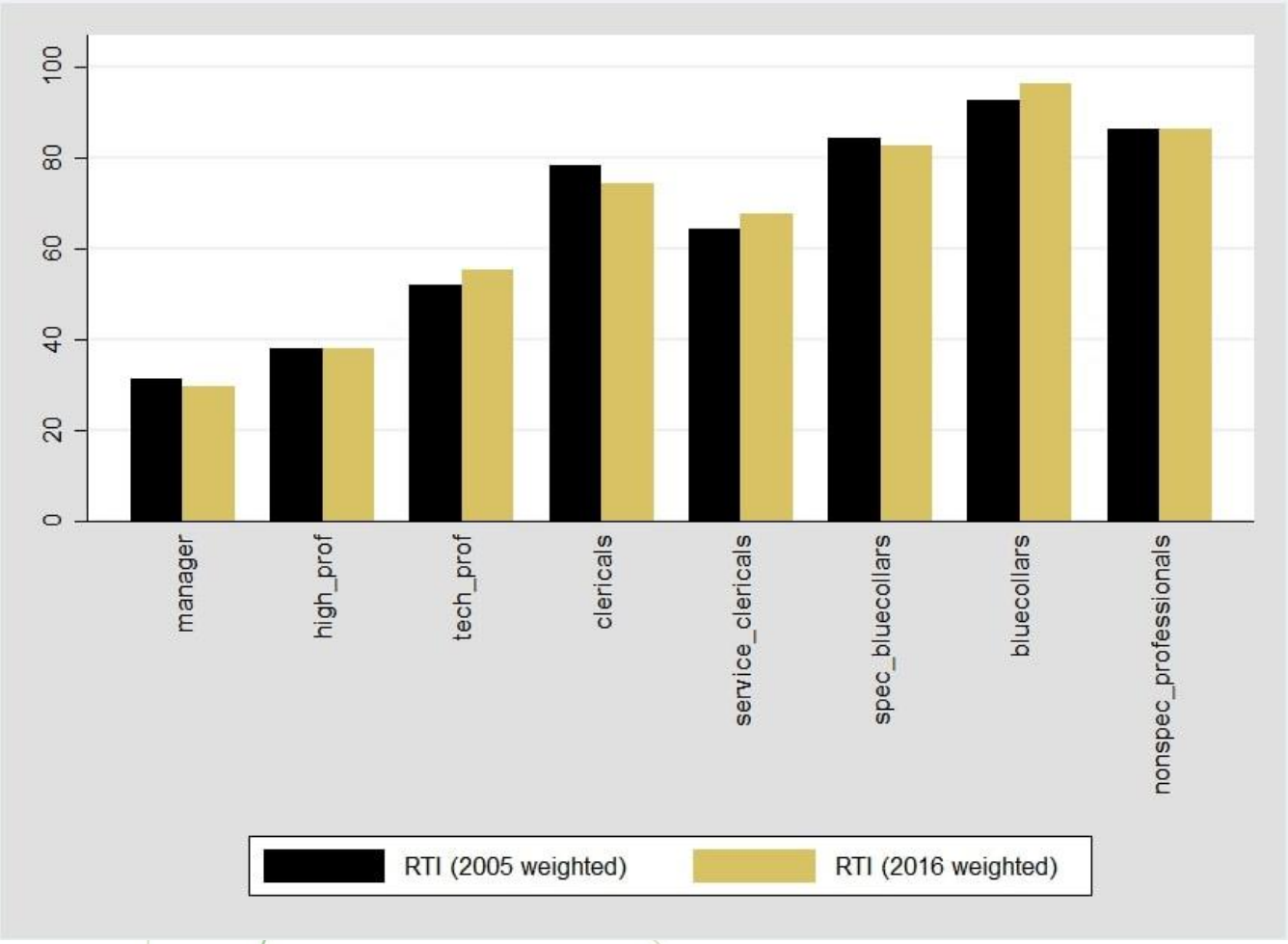
Data and descriptive evidence (5)

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



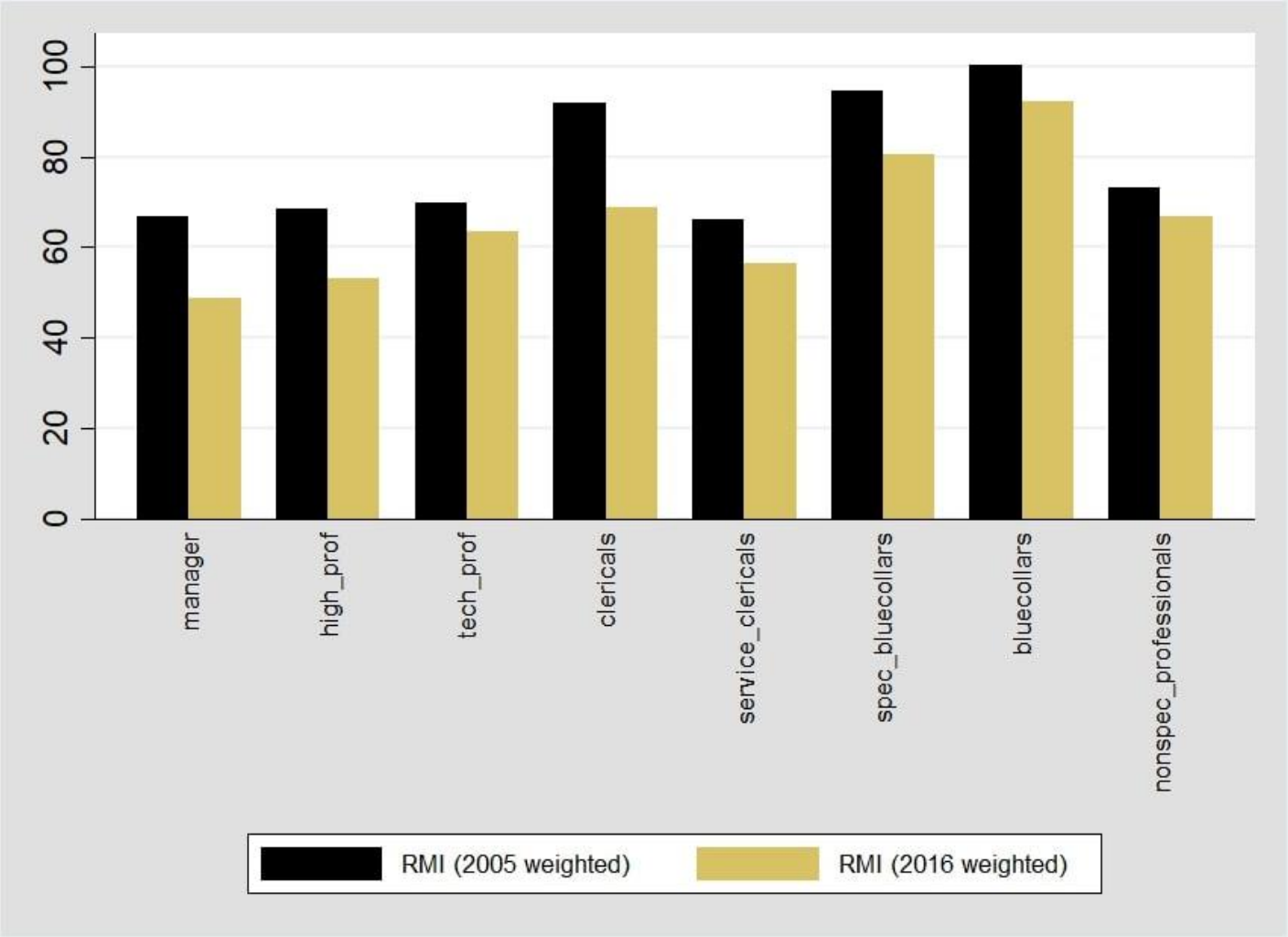
Data and descriptive evidence (6)

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



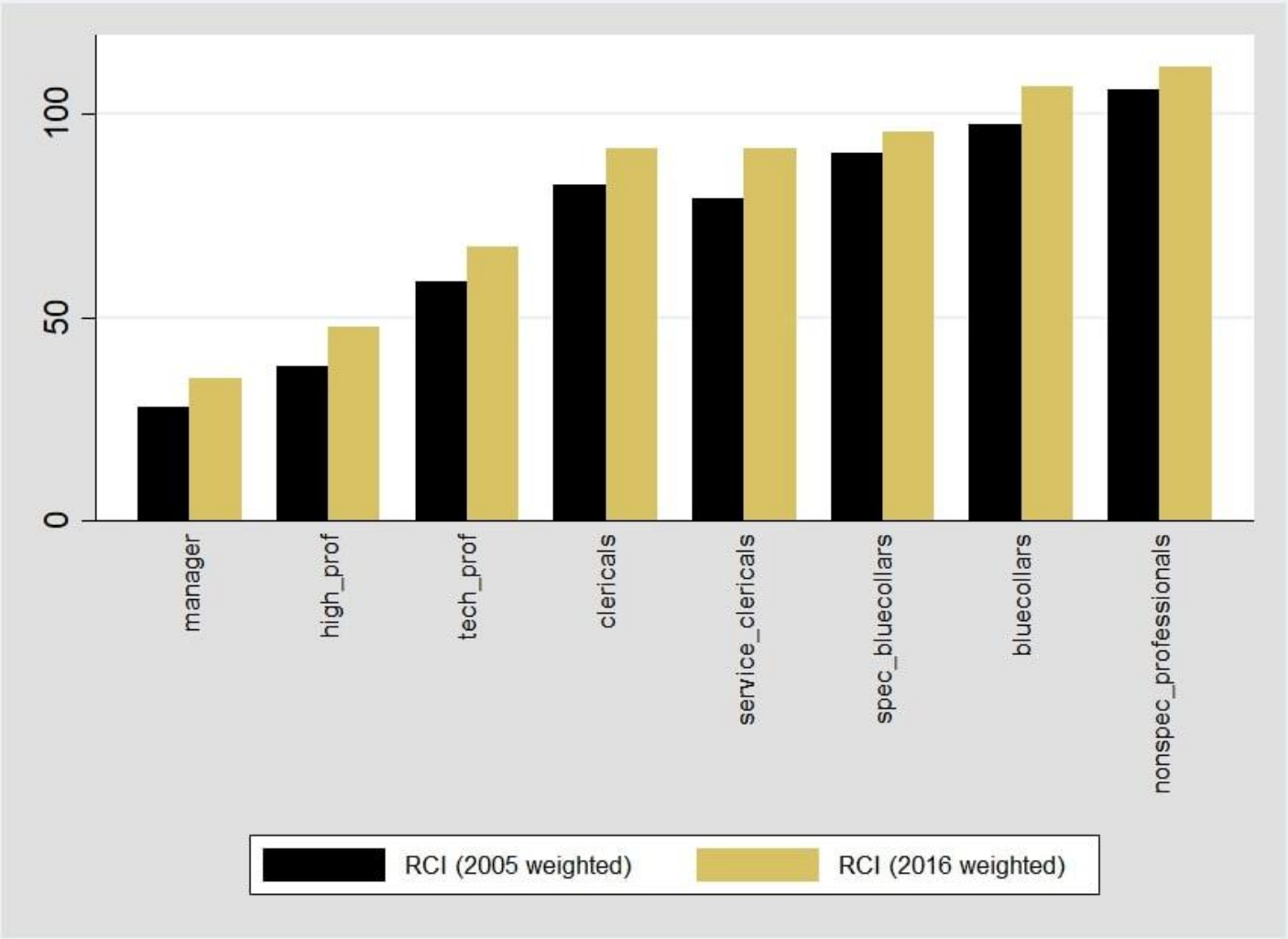
Data and descriptive evidence (7)

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



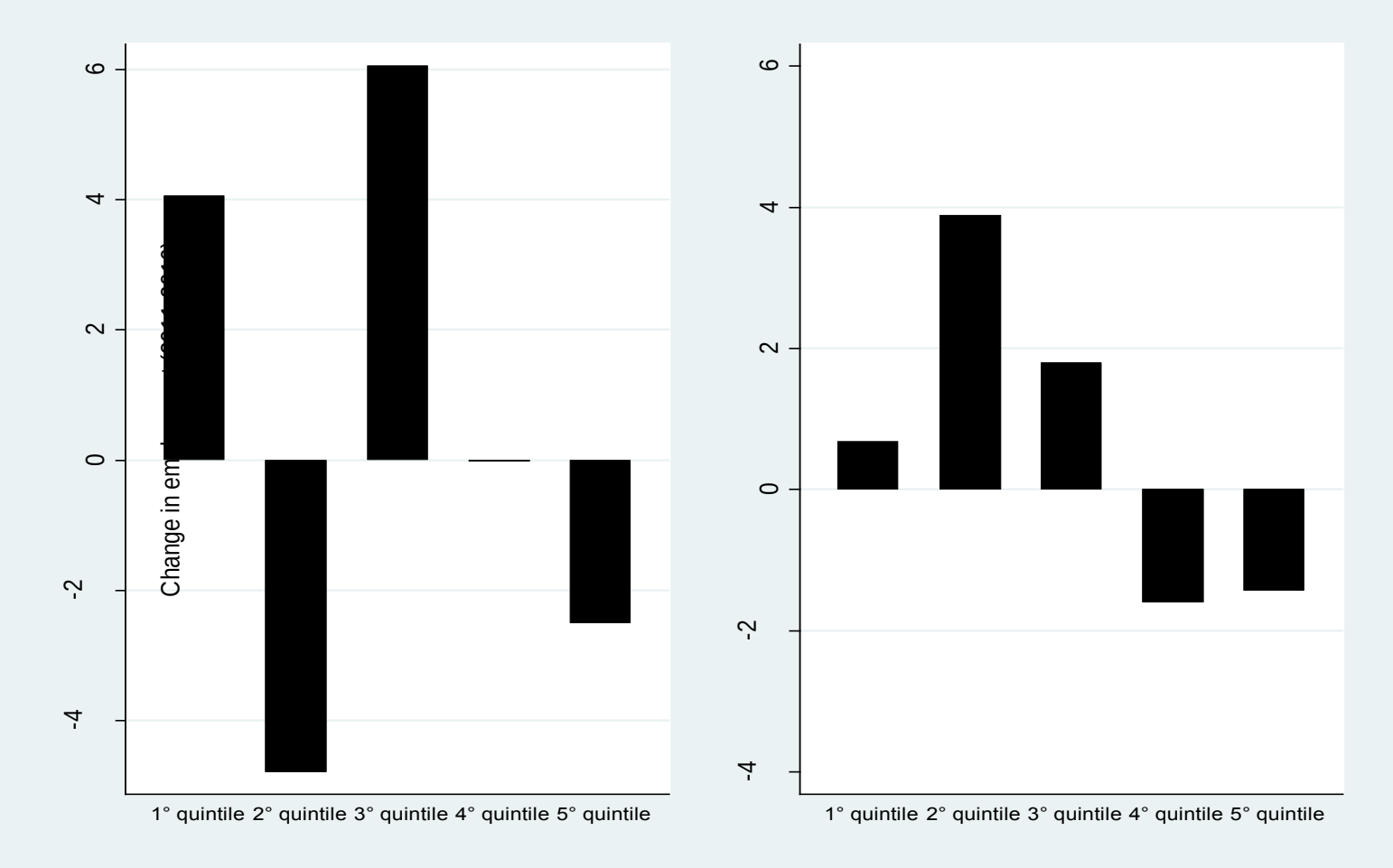
Data and descriptive evidence (8)

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



Data and descriptive evidence (9)

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



Data and descriptive evidence (10)

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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
Petroleoum-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

Econometric strategy and results (1)

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- ✓ **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 4. 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

Table 5. 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**	-0.0195	0.0295	-0.0444**	-0.0333	-0.0333
	(0.00766)	(0.0201)	(0.0407)	(0.0136)	(0.0203)	(0.0207)
Observations	14467	10518	4233	11997	8680	6933
	Services					
	-0.00770	-0.0345*	-0.0116	-0.0454**	-0.0582**	-0.0587**
	(0.0104)	(0.0167)	(0.0276)	(0.0161)	(0.0193)	(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)

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Table 6. Change in employment vs RTI and controls – young workers vs rest of the wforce

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 7. 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 absortative 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 – Technological and organizational innovation by RTI quintile

Relative intensity by 4-digit occupation (information referring to the 2009-2011 period) – ICP INAPP

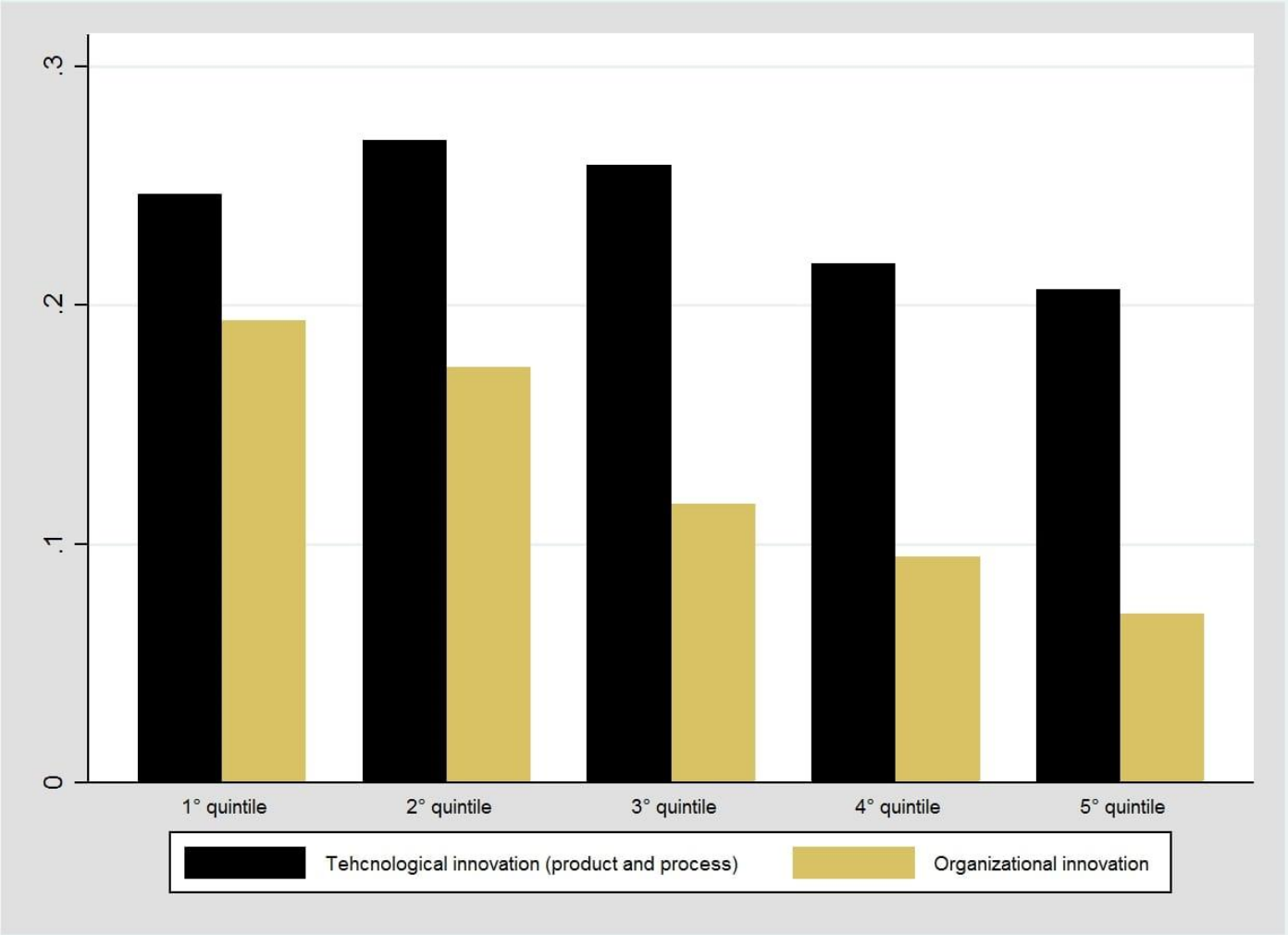

Table 8. Change in employment vs RTI, introduction of new tech and interaction term (2011-2016 sample)

	Model 1	Model 2	Model 3
RTI dummy	-0.0355	-0.0350	-0.0495*
	(0.0251)	(0.0265)	(0.0222)
Introduction of new technologies (last 3 years)	-0.0131	-0.0318**	-0.0436***
	(0.00980)	(0.0123)	(0.0120)
Interaction	-0.0383	-0.0234	-0.0118
	(0.0282)	(0.0266)	(0.0267)
Time and sectoral dummies	No	Yes	Yes
Observations	8680	6933	6933
Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.010			

Controls:

- Positive correlation with the share of temporary workers and lagged wages (2005-2010 only)

Table 9. Change in employment vs RTI, introduction of org innov. and interaction term (2011-2016 sample)

	Model 1	Model 2	Model 3
RTI dummy	-0.0440	-0.0437	-0.0562**
	(0.0256)	(0.0254)	(0.0201)
Introduction of org. innovation (last 3 years)	-0.0111	-0.0357	-0.0447*
	(0.0247)	(0.0224)	(0.0222)
Interaction	-0.0278	-0.00842	0.00127
	(0.0338)	(0.0248)	(0.0260)
Time and sectoral dummies	No	Yes	Yes
Observations	8680	6933	6933
Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.010			

Controls:

- Positive correlation with the share of temporary workers and lagged wages (2005-2010 only)

Conclusions (1)

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- ✓ **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**

- ✓ **Both technological and organizational innovation seems to impact negatively on employment dynamics…but further exploration is needed…**

Conclusions (2)

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- **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**

✓ **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…(*crucial discussion in Fernandez-Macias and Hurley, 2013 plus the ongoing work with A. Cetrulo and M. Virgillito*)**

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