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Technology, Skills, and Globalization: Explaining International Differences in Routine and Non-Routine Work Using Survey Data

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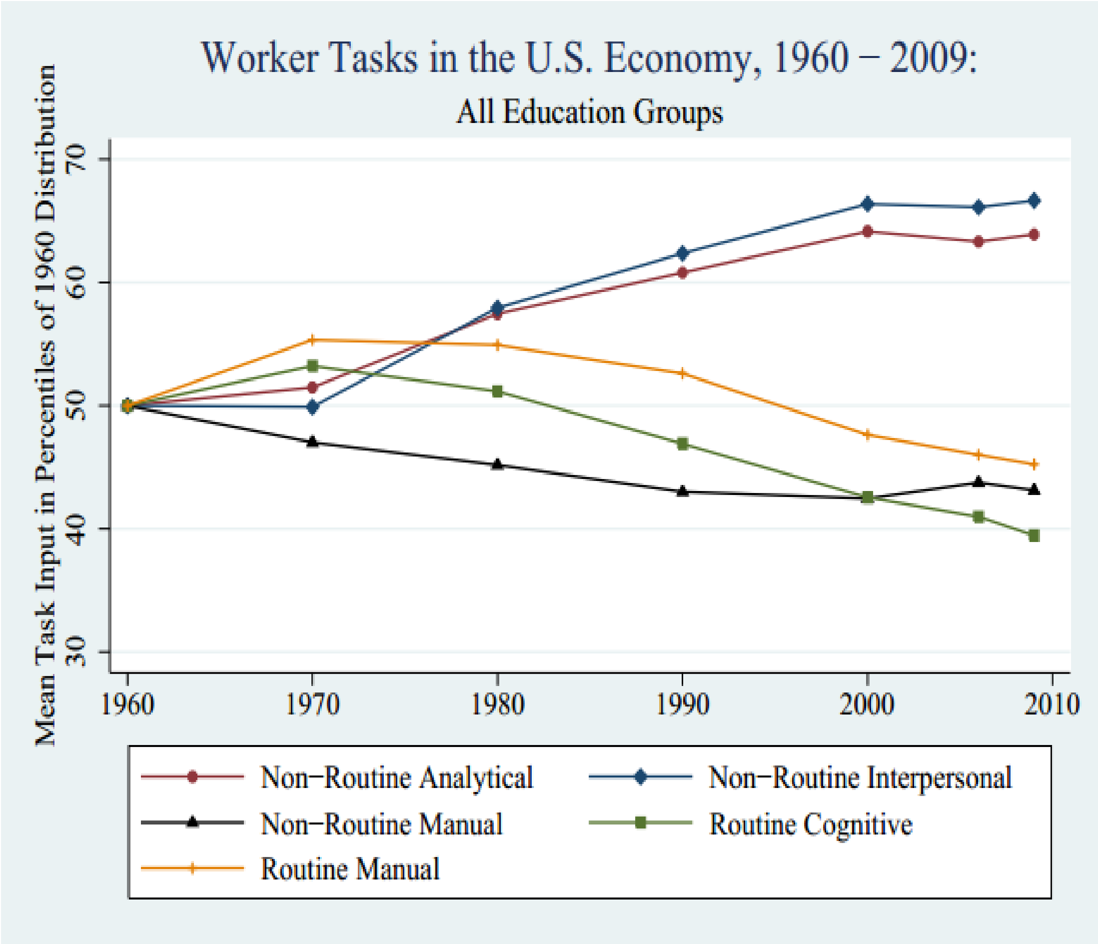
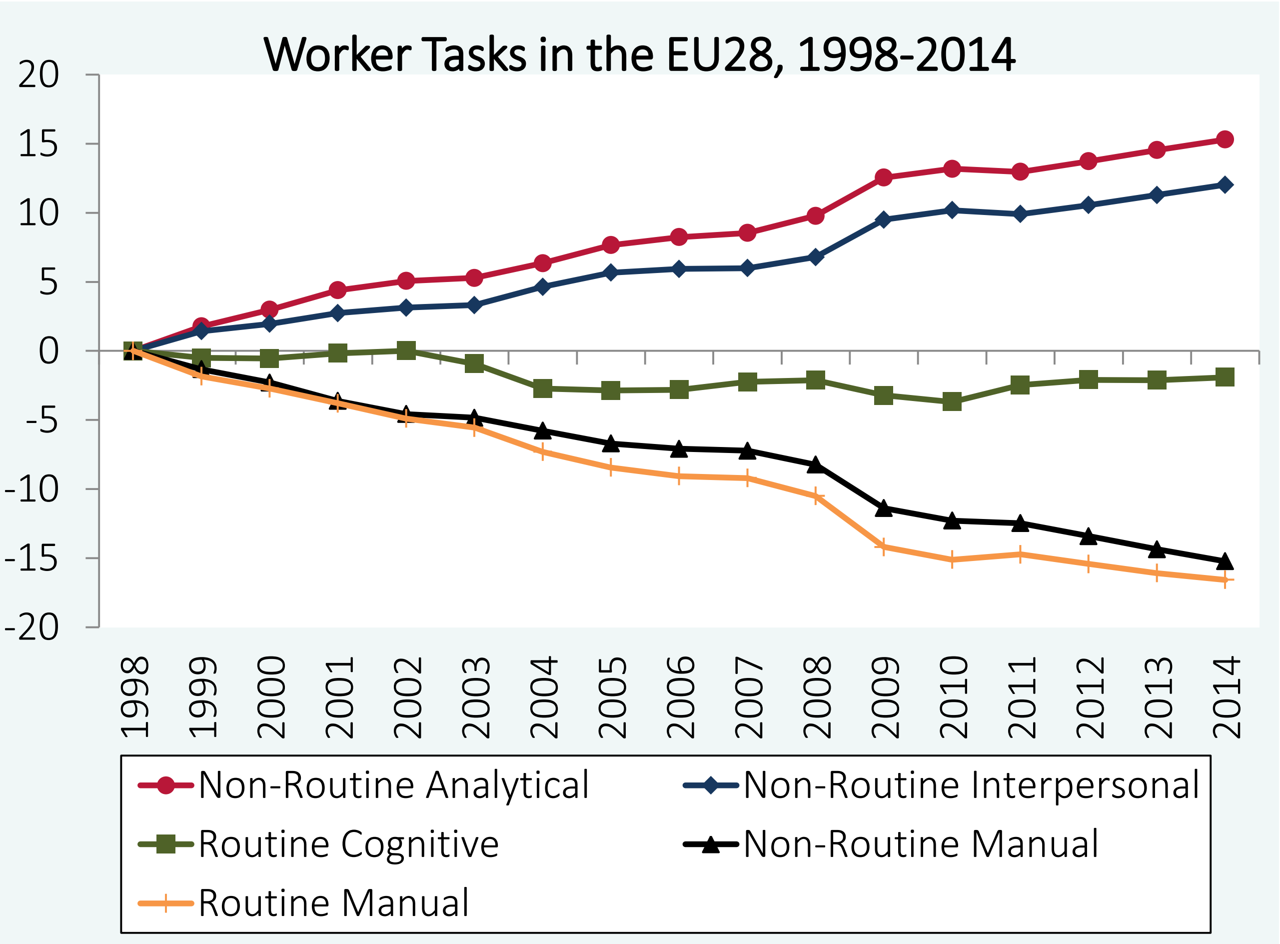
Motivation: the shift away from routine tasks and towards non-routine tasks is a secular change on developed countries' labor markets



Source: Autor, Price (2013)



Source: own calculations

Four key factors explain differences in tasks over time and across countries

- **Technological progress** (computers, ICT, robots, etc.)
  Autor, Levy, Murnane 2003, Spitz-Oener 2006, Autor & Dorn 2013, Michaels et al. 2013
- **Globalization** (FDI, trade, and global value chains)
  Oldenski, 2012, Goos et al. 2014, Reijnders & de Vries 2018
- **Structural change** (sectoral composition)
  Bárány & Siegel, 2018; Du & Park, 2017, Hardy et al. 2018
- **Supply of skills** (worker human capital, demographics)
  Salvatori, 2015; Hardy et al., 2018, Montresor, 2018

Task contents are usually measured with O*NET, the US database on occupational demands (Autor et al. 2003, Acemoglu & Autor 2011)

	Non-routine cognitive (analytical / interpersonal)	Routine cognitive	Routine manual	Non-routine manual
Task items	Abstract thinking, creativity, problem solving /Guiding, directing, motivating, communicating	Repeating the same tasks, being exact or accurate, structured work	Pace determined by equipment, controlling machines and processes, making repetitive motions	Operating vehicles, mechanized devices, manual dexterity, spatial orientation
Relationship b/w human tasks and ICT	Complementary	Easy to automate	Easy to automate	Automation tough or unprofitable
Occupations rich in these tasks	Specialists (e.g designers, engineers, IT developers), technicians, managers	Office clerks, sellers, administrative workers, cashiers	Production workers, e.g. machine operators, assemblers and locksmiths	Drivers, miners, construction workers, waiters and waitresses, porters, cooks

Limitations in the global study of tasks

- Data: most countries lack information on worker tasks
  - Focus on occupational structure assuming the US occupation-specific tasks
- Data: tasks are measured at the level of occupation with O*NET, the US database
  - Tasks in the same occupation may differ depending on workers' skills, tenure, etc.
- Coverage: most research focused on the US and Western Europe
  - Story may be different in the middle-income and developing countries

The contribution of this paper

- We construct task content measures which:
  - Are measured at the worker level and country-specific
  - Are consistent with the Acemoglu & Autor (2011) measures based on O*NET

- Data from worker surveys in 42 countries, including high, middle, and low-income
  - Previous studies using survey data examine only richer or poorer countries, and define tasks in an ad-hoc fashion
    (De la Rica & Gortazar 2016, Marcolin et al. 2016, Dicarlo 2016)

- We examine the contributions of technology, globalization, structural change, and skill supply to task differences across countries

Preview of our findings

- The task contents of occupations are different around the world

- The routine intensity of tasks is higher in less developed countries, also within particular occupations.

- Cross-country differences in tasks can be attributed to differences in:
  - Technology – in 25%, even more for high-skilled occupations;
  - Globalization – in 20%, even more for low-skilled and offshorable occupations;
  - Supply of skills – in 20%.

We use three surveys which include comparable data on the skill use at work, literacy and labor market status

PIAAC (OECD)

- 32 countries surveyed between 2011 and 2015
- sample sizes: from 4000 (Russia) to 26000 (Canada)

STEP (World Bank)

- 9 countries surveyed between 2011 and 2015
- sample sizes: from 2400 (Ukraine) to 4000 (Macedonia) urban residents
- representative for the survey areas

CULS (Chinese Academy of Social Science)

- 6 cities (Guangzhou, Shanghai, Fuzhou, Shenyang, Xian, Wuhan) in 2016
- sample size 15500
- representative for the survey area

Representativeness of the data is limited in some countries. Bear that in mind when looking at the results

PIAAC

- Belgium – Flanders
- Russia – without Moscow municipal area
- UK – England and Northern Ireland
- Indonesia – Jakarta
- Singapore – only permanent residents (approx. 75% of population)

STEP – urban survey with additional limitations in some countries

- Bolivia – four main cities – La Paz, El Alto, Cochabamba and Santa Cruz de la Sierra (approx. 80% of urban population)
- Colombia – 13 main metropolitan areas
- Georgia – no Abkhazia, South Ossetia
- Lao PDR – both urban and rural, but we drop rural for consistency
- China (CULS) – 6 cities

We construct our task measures on the US PIAAC and O*NET data

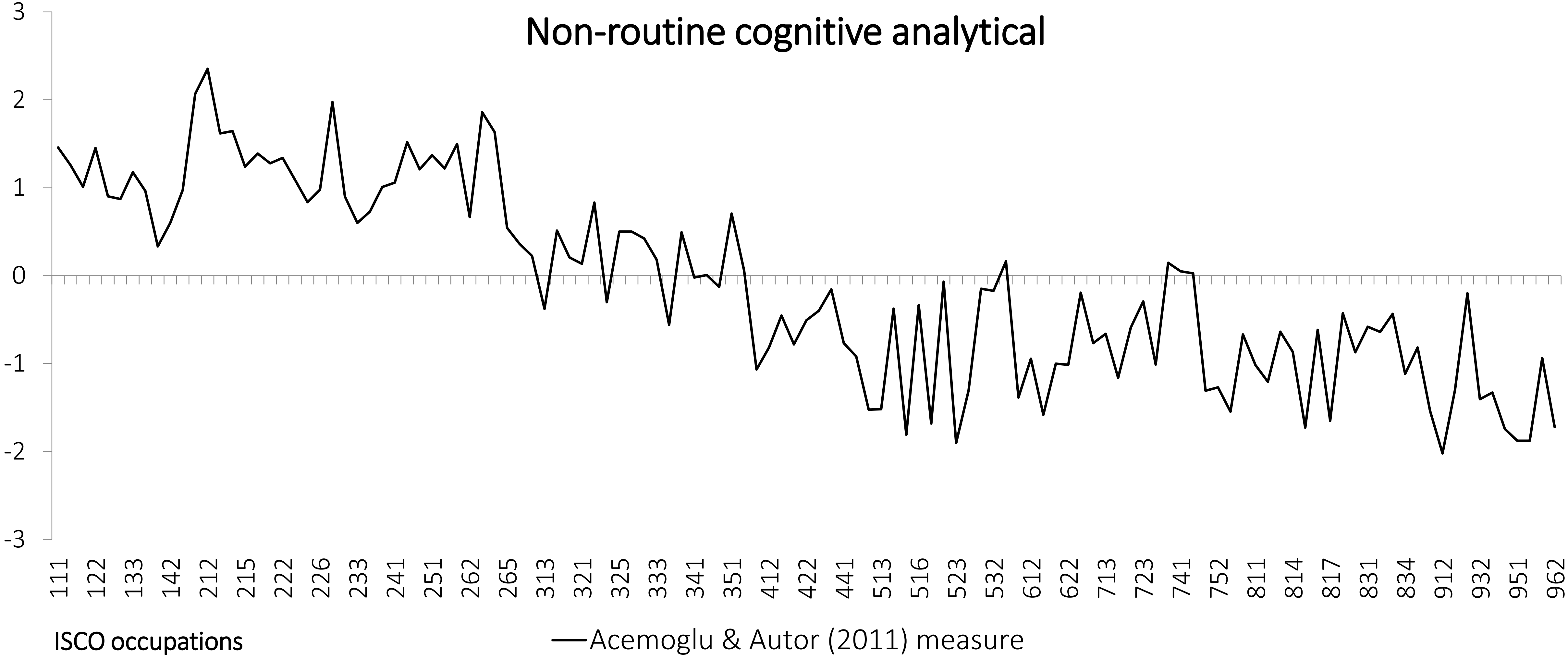
Merge O*NET with the US PIAAC and calculate the Autor & Acemoglu (2011) task measures: non-routine cognitive analytical and personal, routine cognitive, manual

Find combinations of PIAAC questions that approximate best the Autor & Acemoglu (2011) task measures across occupations in the US

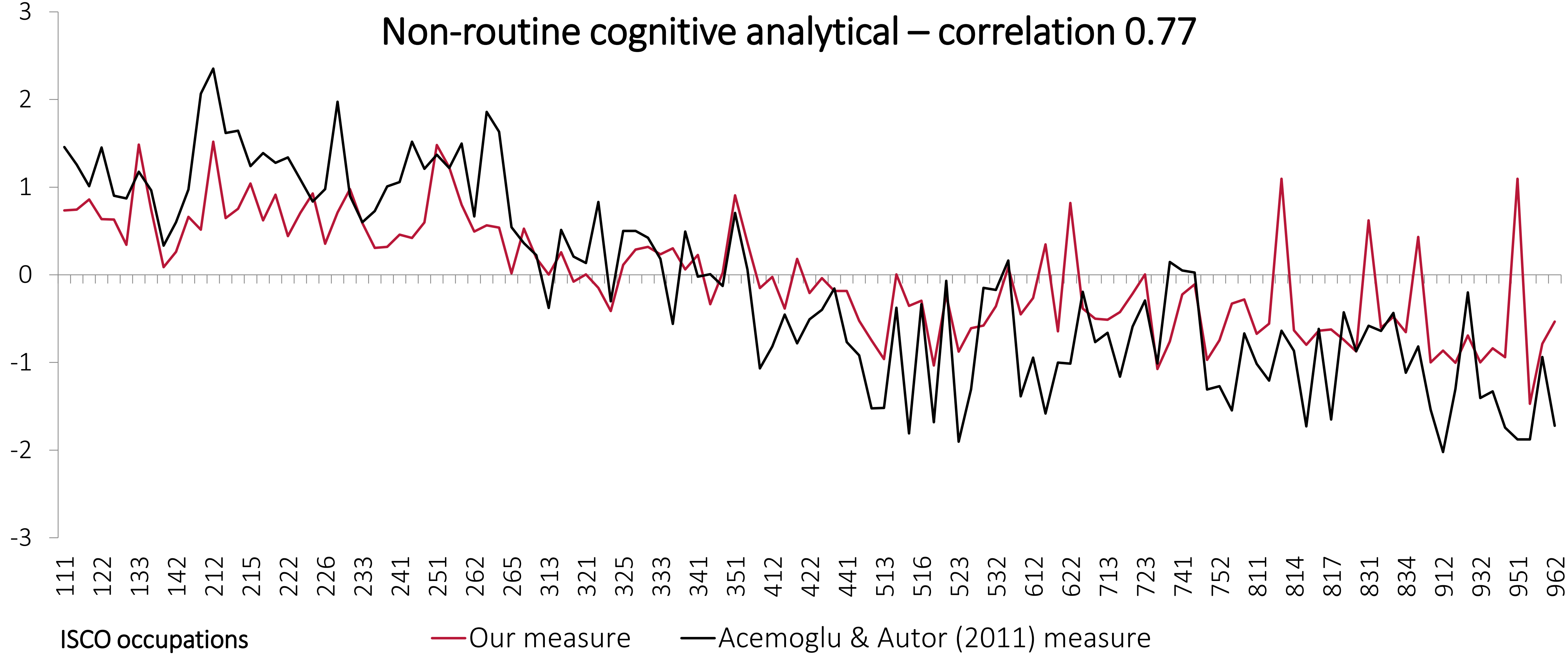
We define task contents with these PIAAC / STEP items

	Non-routine cognitive analytical	Non-routine cognitive personal	Routine cognitive	Manual
Task items	Reading news (at least once a month) Reading professional titles (at least once a month) Solving problems Programming (any frequence)	Supervising Presenting (any frequence)	Changing order of tasks – reversed (not able) Filling forms (at least once a month) Presenting – reversed (never)	Physical tasks
Correlation with O*NET tasks	0.77	0.72	0.55	0.74

Example: the established Autor & Acemoglu (2011) measure contents calculated with O*NET data for the US



At the 3-digit occupation level in the US, the correlations between our measures and O*NET measures range from 0.55 to 0.77



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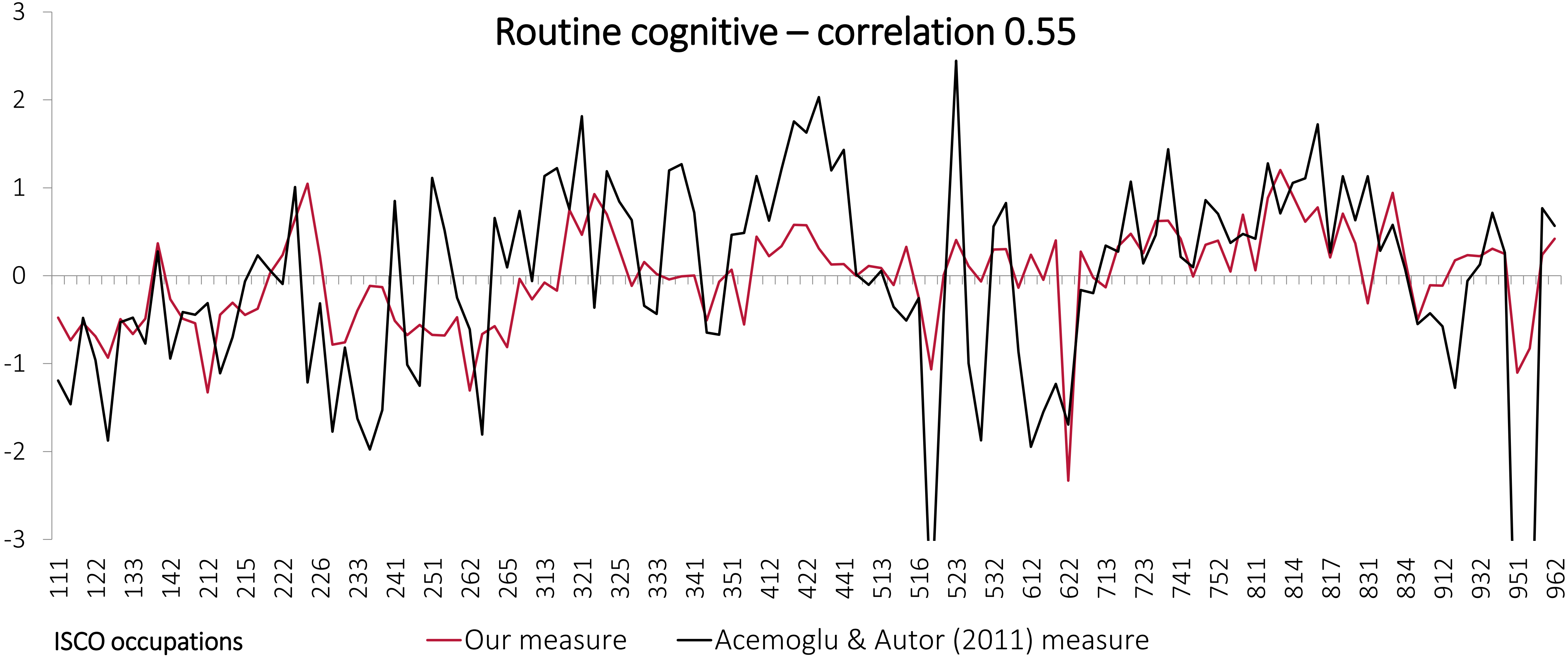


We use the selected PIAAC / STEP questions to measure worker tasks in all 42 countries

There is no unit of a task – we relate all countries to the US distribution:

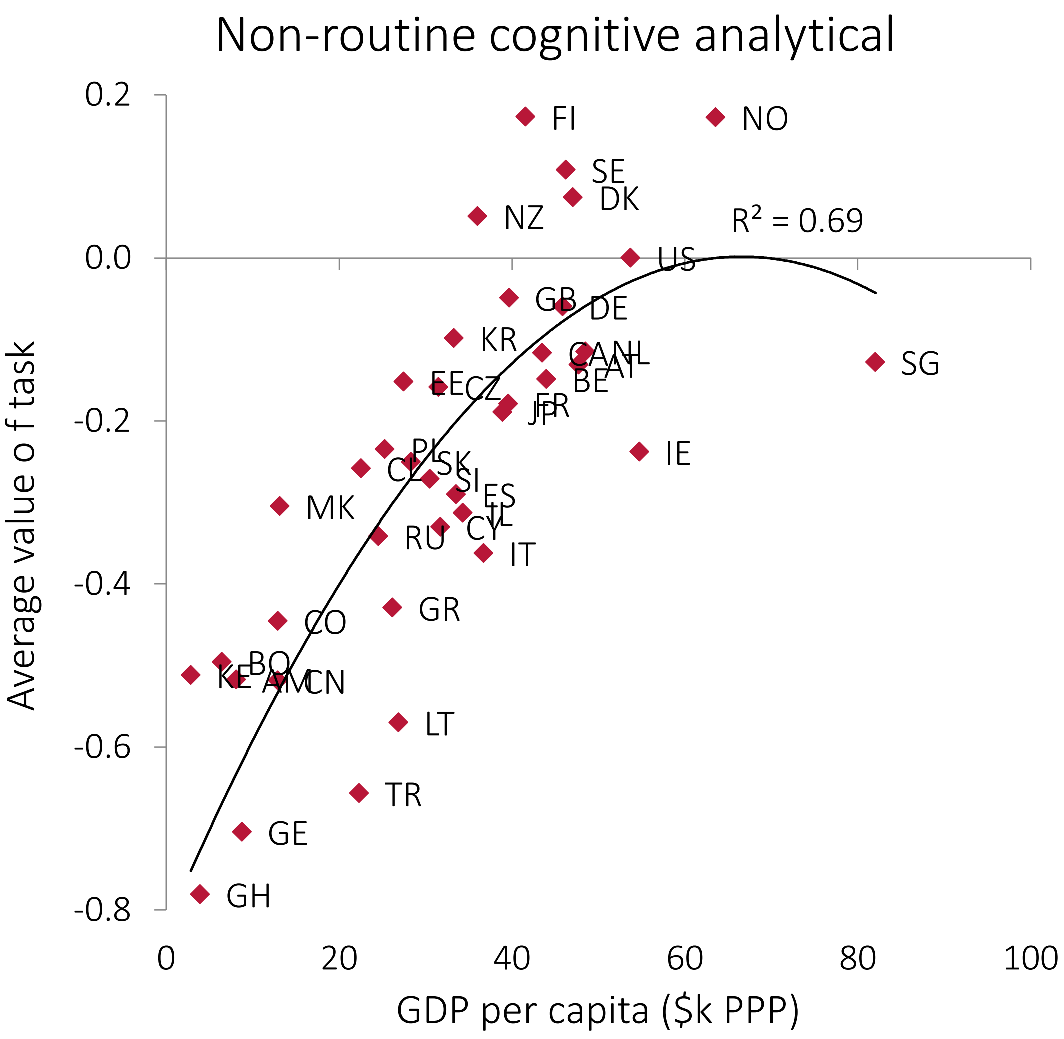
- 0 is the average level of a given task in the US
- 1 is equivalent to the standard deviation of a given task in the US

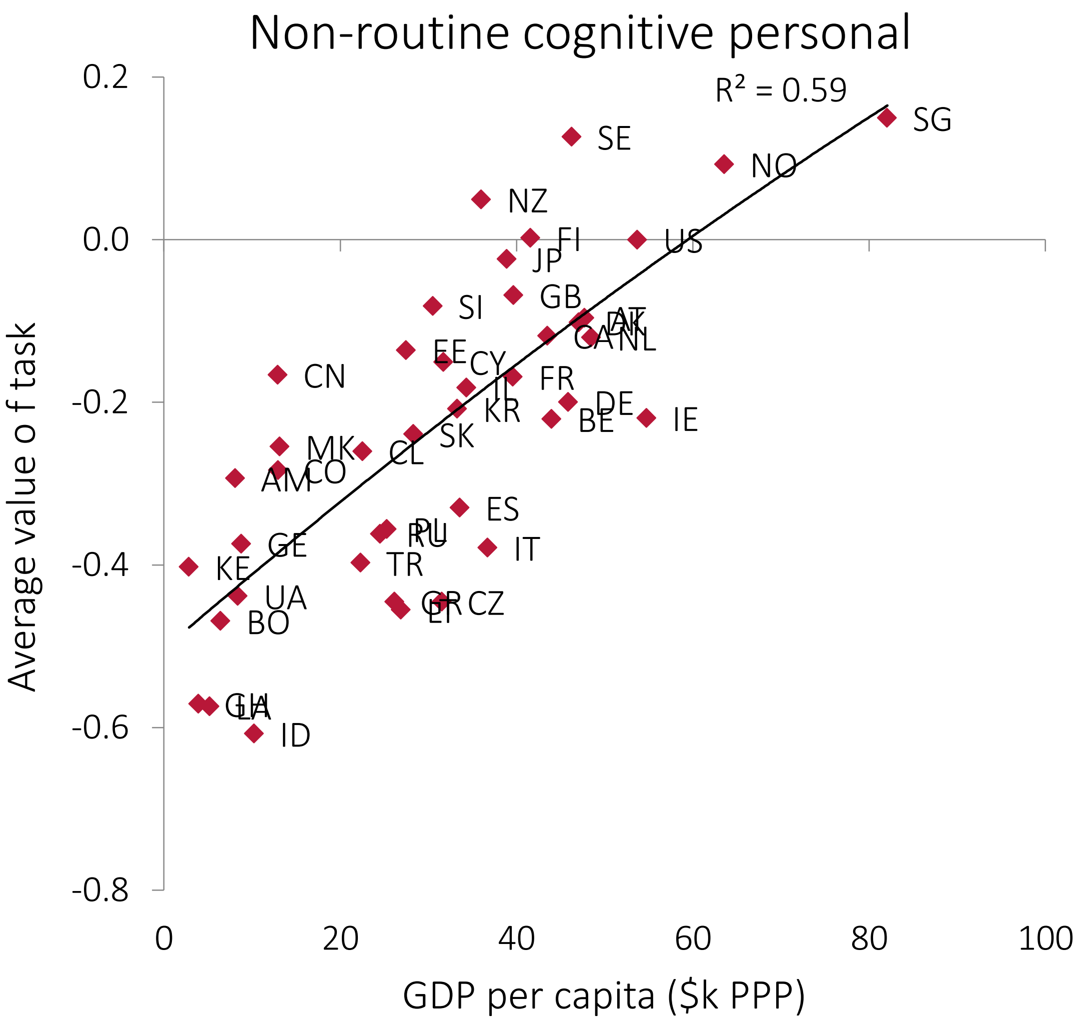
We also define routine task intensity (RTI)

$$RTI = \ln(r_{cog}) - \ln \left(\frac{nr_{analytical} + nr_{personal}}{2} \right)$$

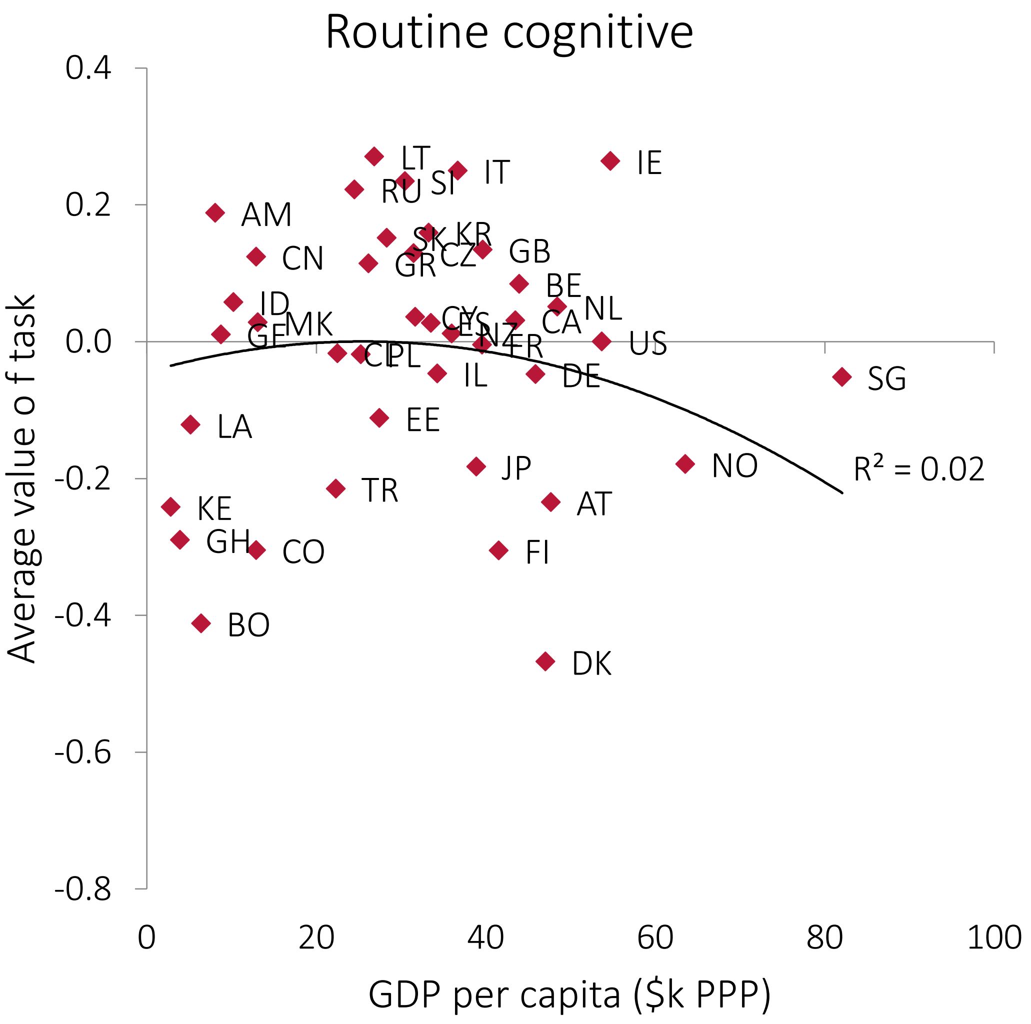
- RTI increases with the relative importance of routine tasks,
- RTI decreases with the relative importance of non-routine tasks.

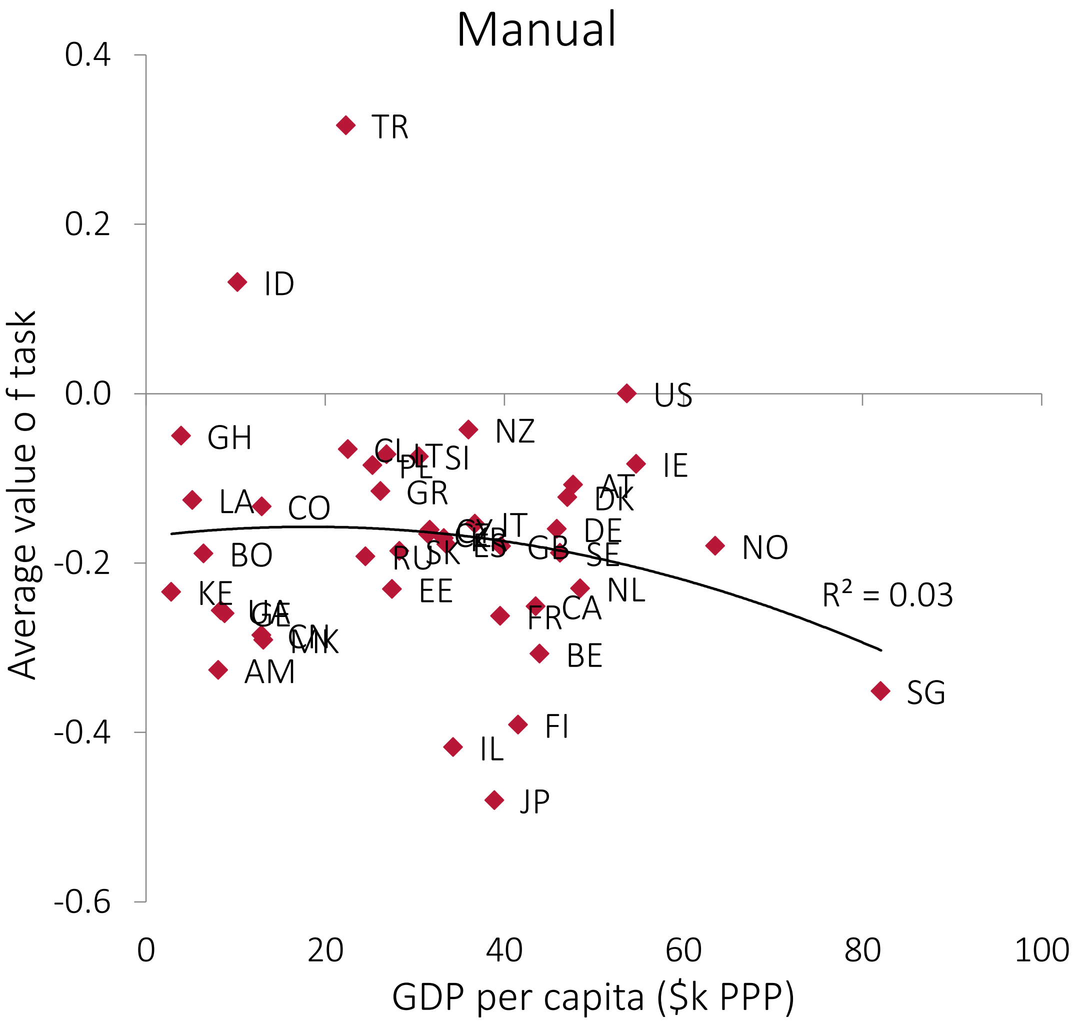
The more developed countries exhibit higher average values of non-routine tasks than the less developed countries



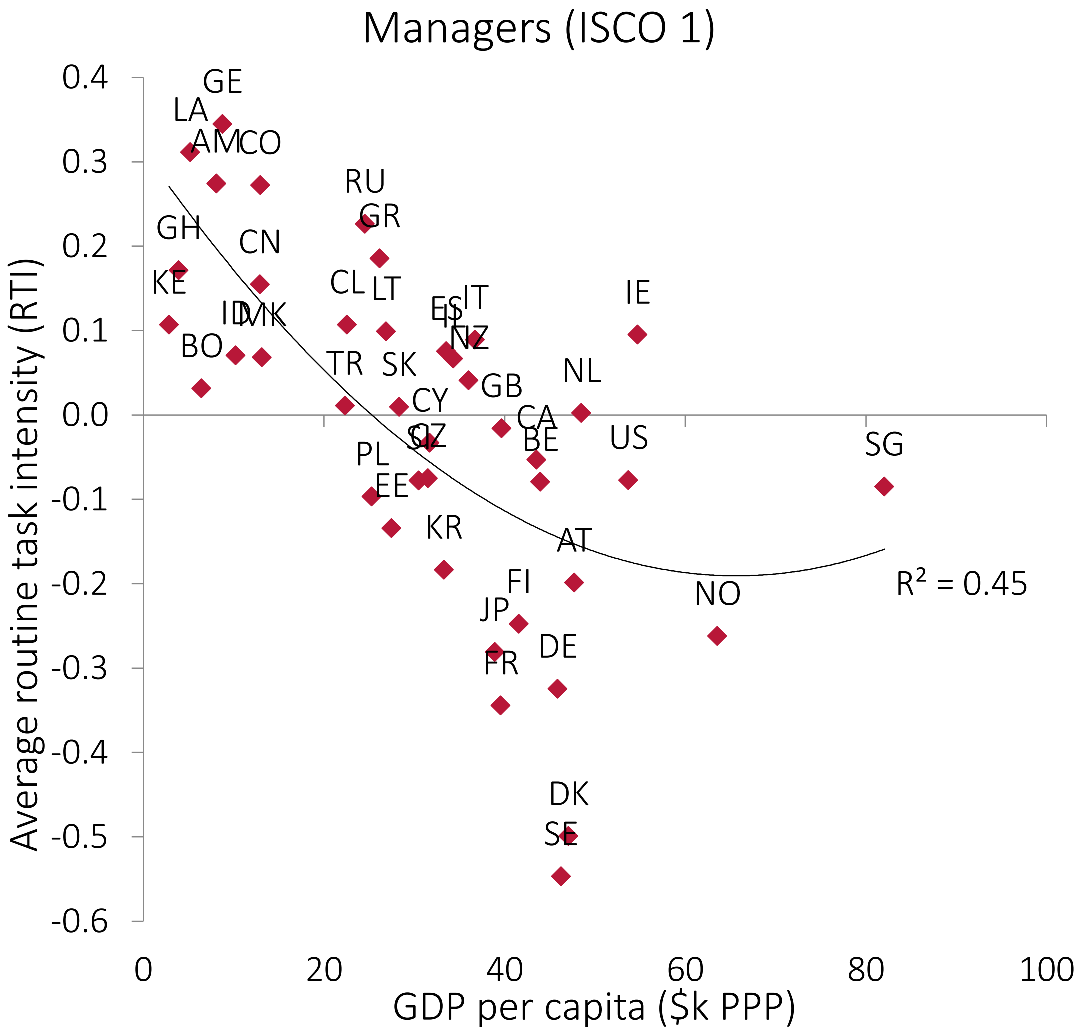


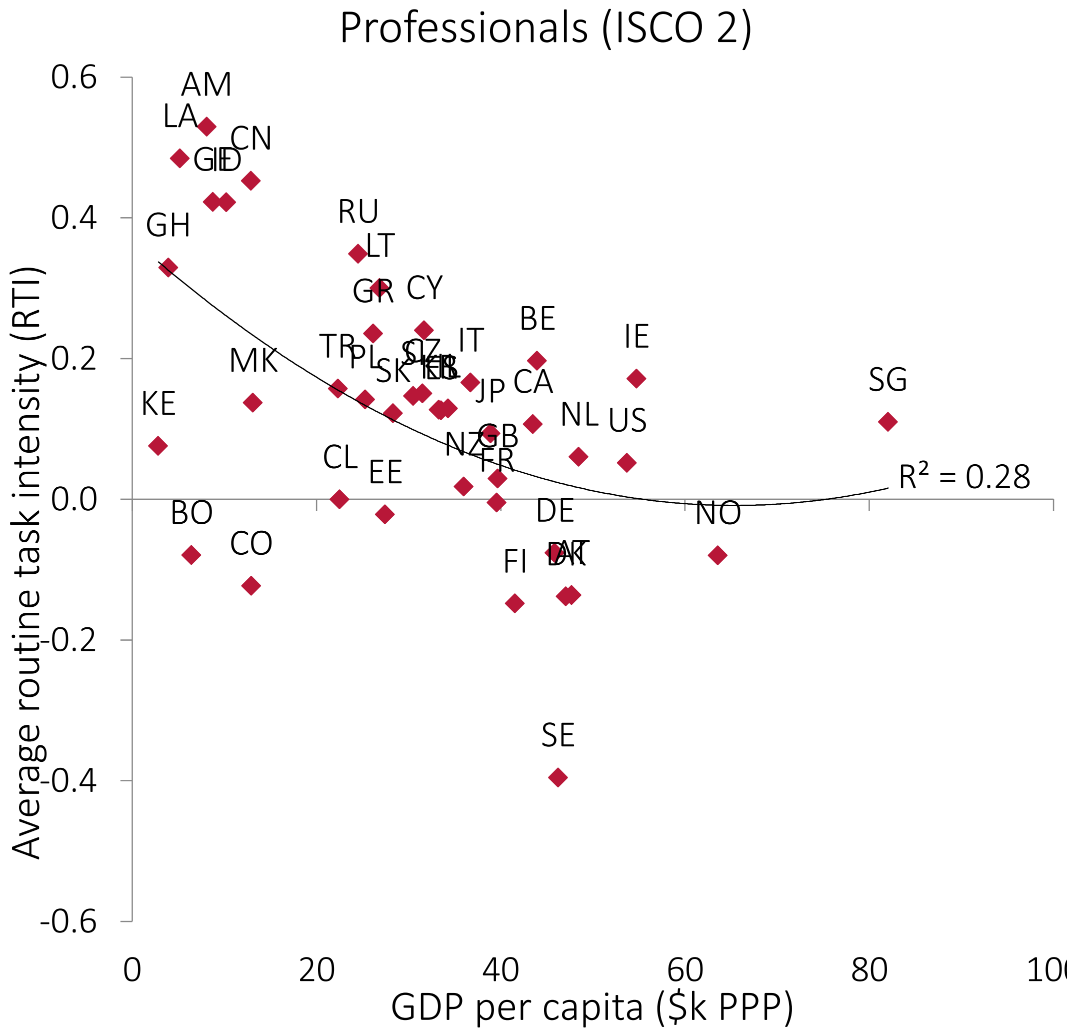
The relationship of routine cognitive and manual tasks with GDP per capita is inverse U-shaped but not significant



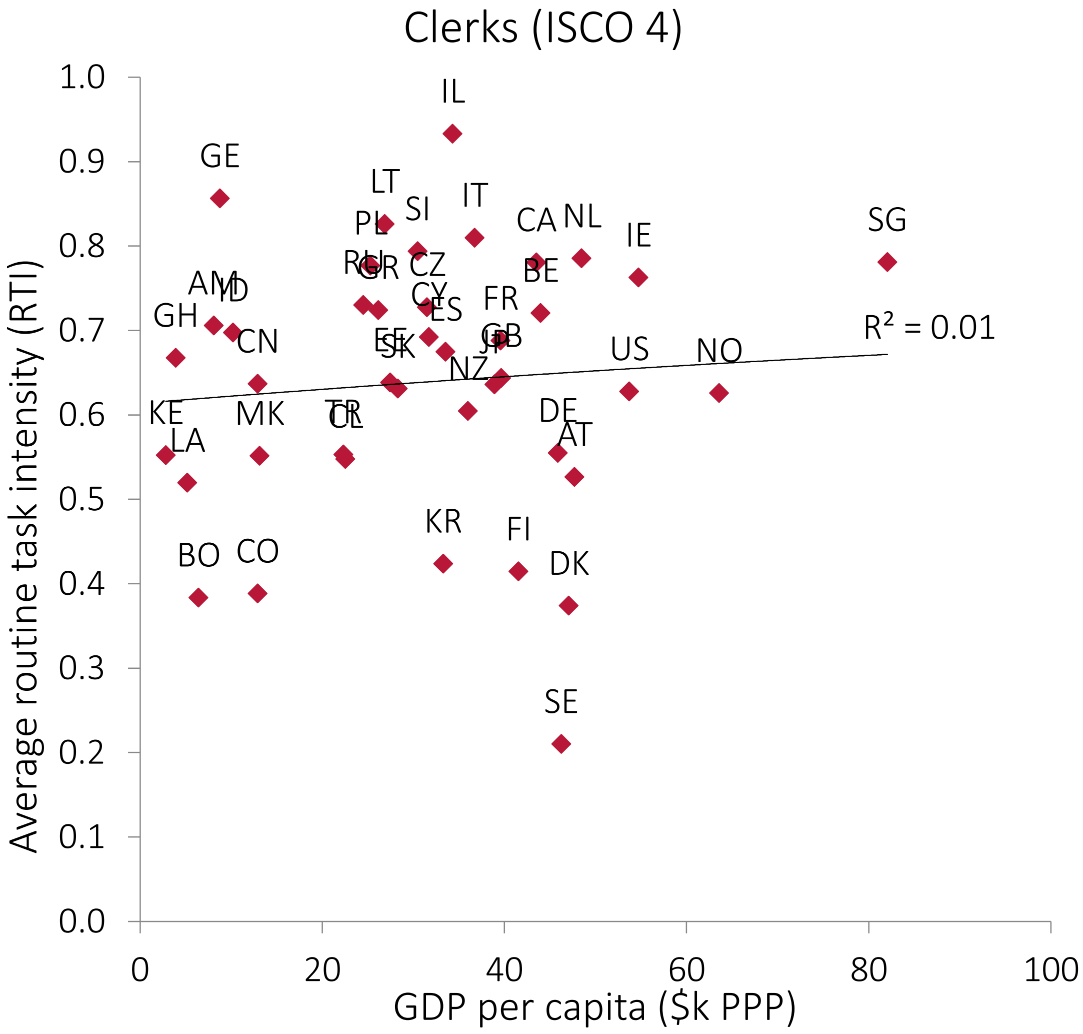


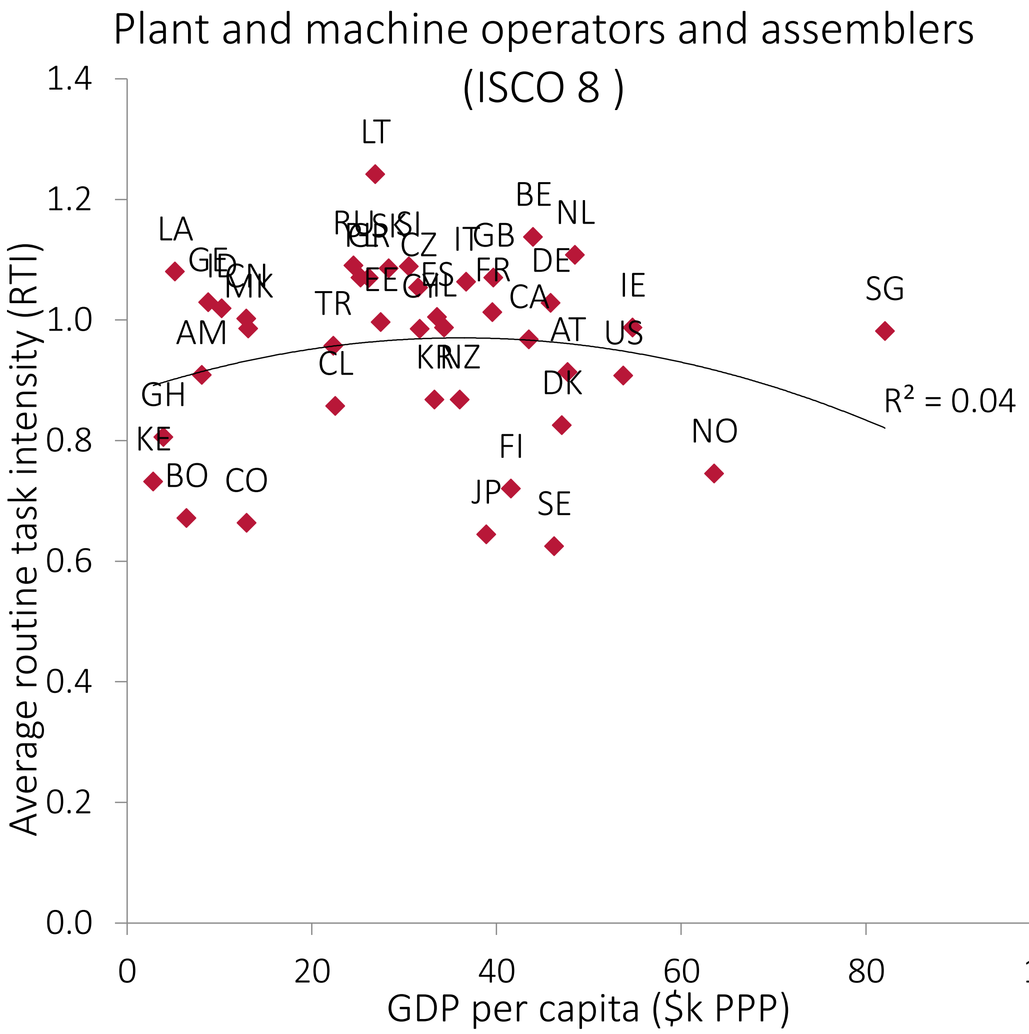
The differences in the routine task intensity are most strongly related to development level among workers in the high-skilled occupations



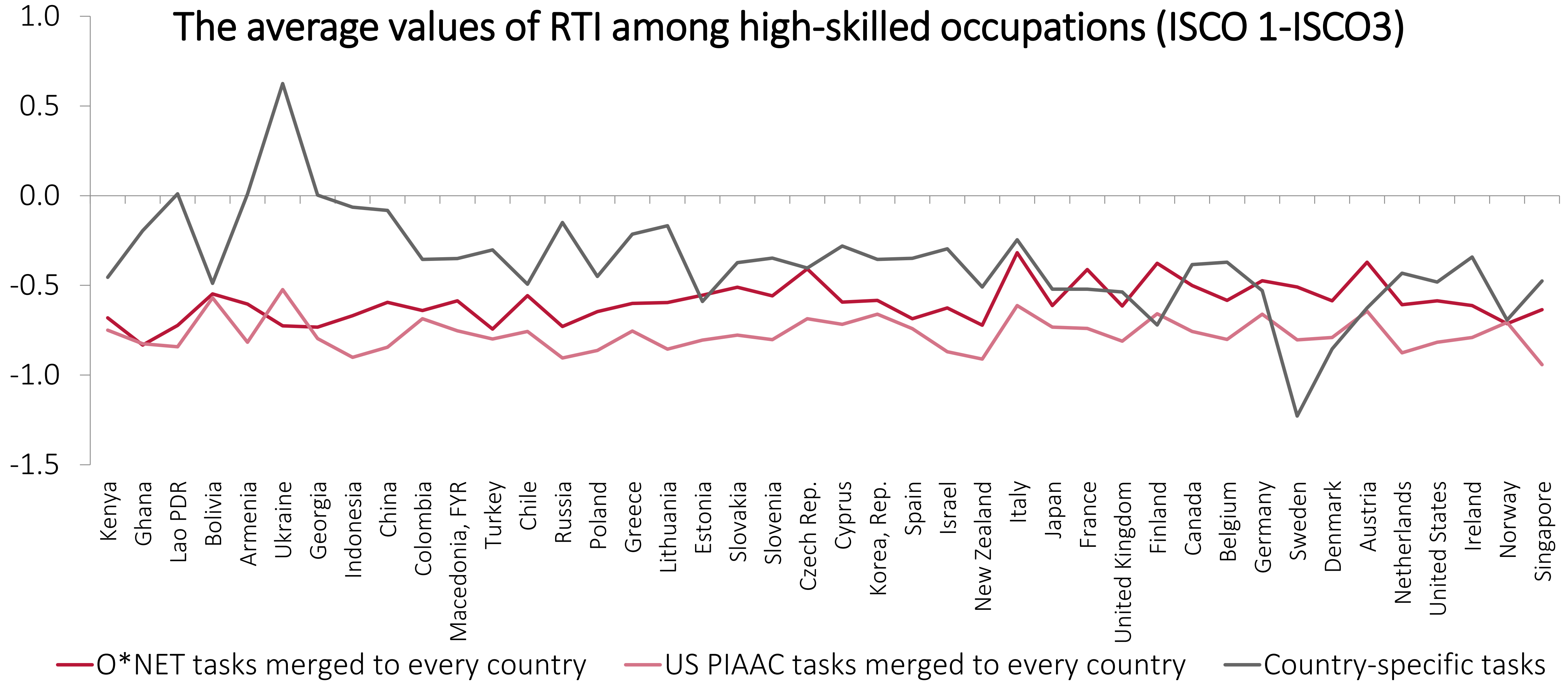


Cross-country differences in RTI of middle- and low-skilled occupations are not systematicaly related to the development level





Cross-country differences in particular occupations are visible only with the country-specific measurement



Theory behind allocation of tasks

- Tasks are endogenously assigned by employers

- Simple Roy model shows that:
  - higher demand for non-routine work
  - lower supply of educated workers

will lead to the most educated workers specialising in non-routine tasks.

- Routine tasks are easier to offshore
  - workers in the countries which receive the offshored jobs may perform more routine tasks

We estimate worker-level models to find correlates of routine intensity

$$RTI_{ijsc} = \beta_0 + \beta_1 Z_{ijsc} + \beta_2 G_{sc} + \lambda_s + \beta_3 E_{ijsc} + \varepsilon_{ijsc}$$

RTI_{ijsc} - routine task intensity of individual i in occupation j in sector s in country $\mathbf{c}$.

Z_{ijsc} - technology used by individual i in occupation j in sector s in country $\mathbf{c}$,
G_{sc} - globalization in sector s in country $\mathbf{c}$,
λ_s - sector fixed effects,
E_{ijsc} - skills and demographic characteristics of workers.

Regressions for all workers and for workers in high (ISCO 1-3), middle (ISCO 4-5) and low-skilled (ISCO 7-9) occupations

We measure the four fundamental factors with worker, sector-country and country variables

- Technology: sector-country share of computer use at work, *sector-country robot stock (per worker), *ICT capital stock per worker

- Globalization: foreign value added share in domestic output (FVA share, Wang et al. 2017) also interacted with GDP, FDI stock/GDP

- Structural change: 19 sectors, GDP per capita (log), interactions between them

- Skill supply: education, literacy skills, sex, age group

* available for 31 countries only

Decomposition:
What explains cross-country differences in routine task intensity?

We use

- the estimated regression coefficients
- country means of explanatory factors

To decompose:

- the variance of RTI using the covariance-based decomposition (Morduch & Sicular, 2002)

$$\sigma_k = \frac{cov\left(\beta_k \bar{X}_c^k, \overline{RTI_c}\right)}{var\left(\overline{RTI_c}\right)}$$

- the difference in average RTI between each country and the US

$$\overline{RTI_j} - \overline{RTI_{US}} == \beta_1\left(\overline{Z_{ijsc}} - \overline{Z_{ijsUS}}\right) + \beta_2\left(\overline{G_{sc}} - \overline{G_{sU}}\right) + \lambda\left(\bar{S_c} - \overline{S_{US}}\right) + \beta_4\left(\overline{E_{ijsc}} - \overline{E_{ijsUS}}\right)$$

Higher probablity of computer use is related to less routine tasks. Robots & ICT are insignificant if we control for computer use probability

	All workers	High-skilled occ. (ISCO 1-3)	Middle-skilled occ. (ISCO 4-5)	Low-skilled occ. (ISCO 7-9)
Computer use	-0.501**	-0.690***	-0.353	-0.240
No. of obs. / R^2	148,569 / 0.22	62,907 / 0.13	47,373 / 0.09	38,289 / 0.08

**** p<0.01, ** p<0.05, * p<0.1.*

Globalization – specialization in global value chains – has the strongest effect among workers in low-skilled occupations

	All workers	High-skilled occ. (ISCO 1-3)	Middle-skilled occ. (ISCO 4-5)	Low-skilled occ. (ISCO 7-9)
Computer use	-0.501**	-0.690***	-0.353	-0.240
FVA share	0.266*	-0.057	0.189	0.796***
FVA* GDP pc (log, demeaned)	-0.424**	-0.216	-0.239	-0.347
FDI / GDP	0.009*	0.023***	0.010	-0.016***
GDP per capita (log, demeaned)	0.057	-0.038	0.013	0.052
No. of obs. / R^2	148,569 / 0.22	62,907 / 0.13	47,373 / 0.09	38,289 / 0.08

**** p<0.01, ** p<0.05, * p<0.1.*

Higher skills are associated with less routine tasks, especially among workers in high-skilled occupations.

		All workers	High-skilled occ. (ISCO 1-3)	Middle-skilled occ. (ISCO 4-5)	Low-skilled occ. (ISCO 7-9)
Ref. Secondary	Primary education	0.246***	0.135***	0.223***	0.135***
	Tertiary education	-0.486***	-0.267***	-0.198***	-0.142***
Ref. Lower medium	Low literacy skills	0.077***	0.032	0.051**	0.057**
	Upper Medium Literacy skills	-0.138***	-0.086***	-0.062***	-0.048**
	High literacy skills	-0.293***	-0.190***	-0.064**	-0.174***
	No. of obs. / R^2	148,569 / 0.22	62,907 / 0.13	47,373 / 0.09	38,289 / 0.08

**** p<0.01, ** p<0.05, * p<0.1.*

Female and younger workers perform more routine intensive tasks

		All workers	High-skilled occ. (ISCO 1-3)	Middle-skilled occ. (ISCO 4-5)	Low-skilled occ. (ISCO 7-9)
	Female	0.249***	0.239***	0.203***	0.346***
Ref. 25-44	Age 16-24	0.227***	0.220***	0.207***	0.147***
	Age 35-44	-0.054***	-0.062***	-0.020	-0.038*
	Age 45-54	-0.012	-0.062***	0.017	0.043*
	Age 55-64	0.020	-0.052***	0.110***	0.078***
	No. of obs. / R^2	148,569 / 0.22	62,907 / 0.13	47,373 / 0.09	38,289 / 0.08

**** p<0.01, ** p<0.05, * p<0.1.*

Overall, most of the cross-country differences in routine task intensity can be attributed to technology, globalization and skills

Decomposition of cross-country variance of RTI by fundamental factors, (% of total variance)

	Technology	Globalization	Structural Change	Supply of skills	Total
All workers	23.4	20.5	-5.4	18.2	56.7

Technology contributes the most for high- and middle-skilled occupations, globalization for the low-skilled occupations

Decomposition of cross-country variance of RTI by fundamental factors, (% of total variance)

	Technology	Globalization	Structural Change	Supply of skills	Total
All workers	23.4	20.5	-5.4	18.2	56.7
High-skilled occupations (ISCO 1-3)	25.6	9.9	10.4	6.9	52.8
Middle-skilled occupations (ISCO 4-5)	13.5	8.2	0.9	2.5	25.1
Low-skilled occupations (ISCO 7-9)	6.2	21.2	-5.3	1.1	23.3

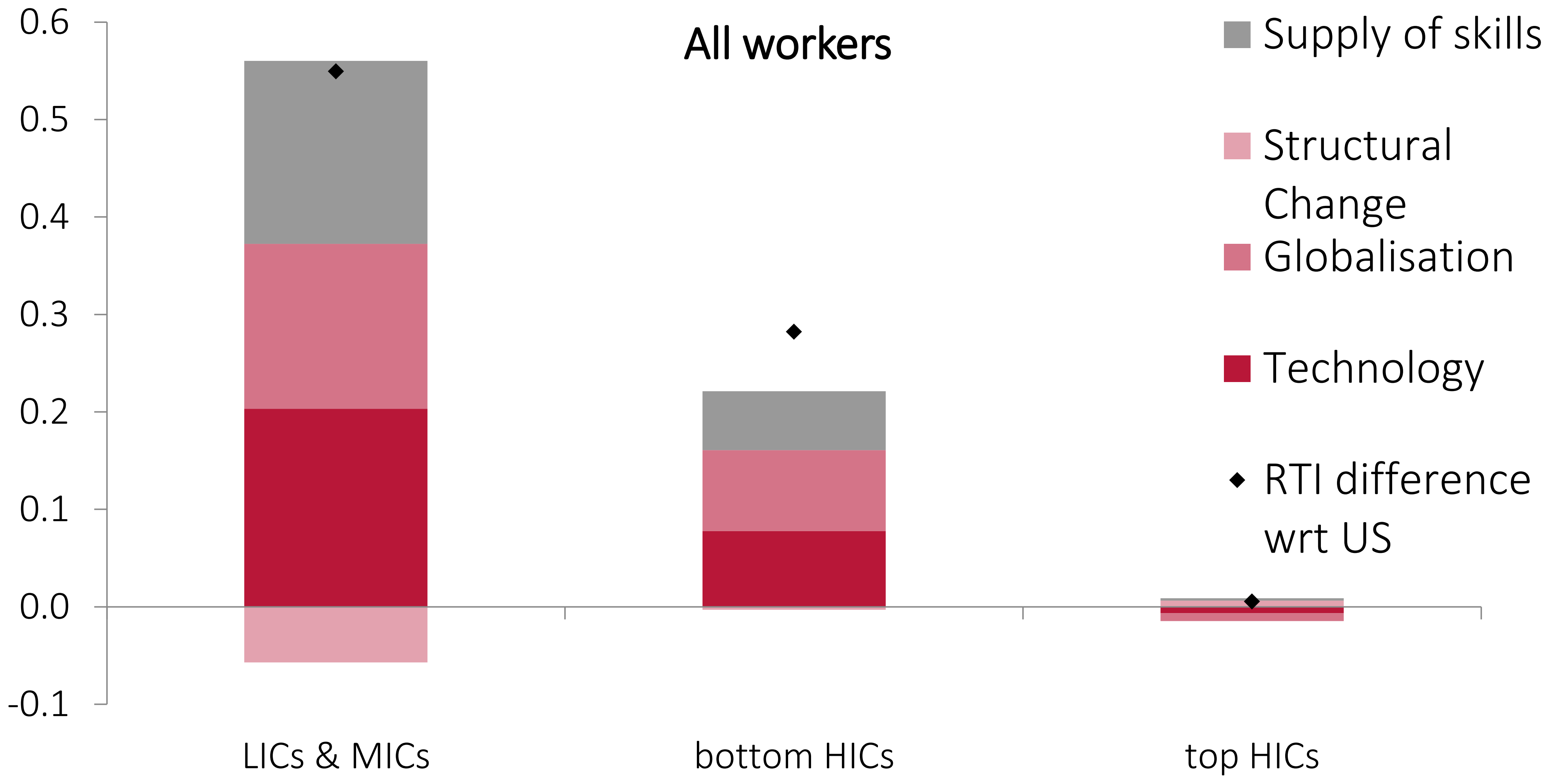
We group countries to three classes and take averages of decomposition results for each class

Low and Middle Income Countries	Bottom High Income Countries	Top High Income Countries
		France
		Israel
Kenya	Chile	Japan
Ghana	Poland	New Zealand
Lao, PDR	Lithuania	United Kingdom
Ukraine	Slovakia	Belgium
Bolivia	Cyprus	Germany
Indonesia	Estonia	Canada
China	Greece	Finland
Armenia	Czech Rep.	Austria
Georgia	Slovenia	Netherlands
Colombia	Spain	Sweden
Russia	Korea, Rep.	Denmark
Turkey	Italy	Singapore
		Ireland
		Norway

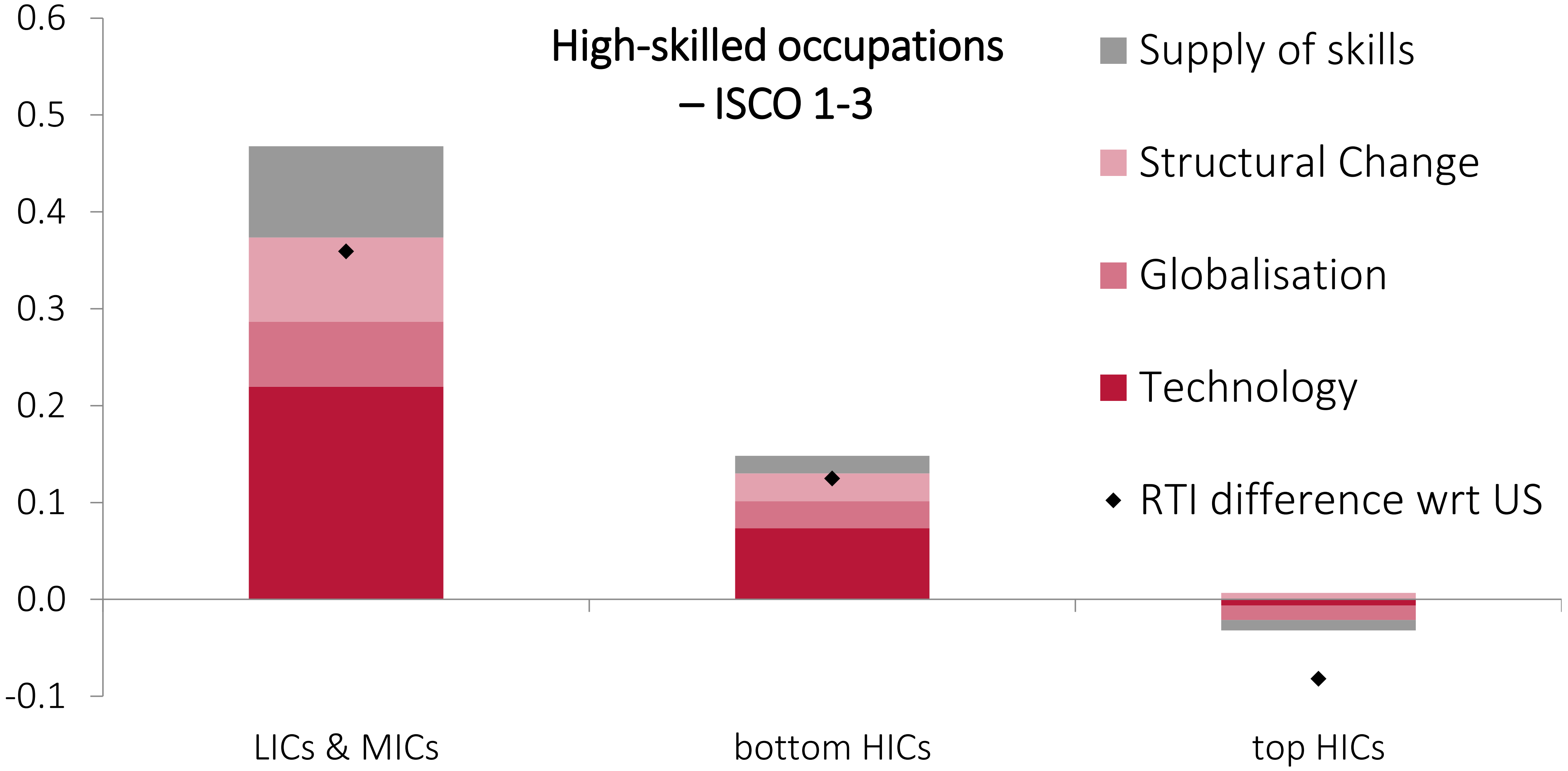
Average levels of RTI and explanatory variables by country groups

	LIHCs and MIHCs	Bottom HICs	Top HICs	US
RTI	0.54	0.28	0.01	0.00
Computer use	0.35	0.60	0.76	0.75
GDP per capita (log, demeaned)	-1.48	0.12	1.02	1.23
FDI stock/GDP	0.42	1.24	0.79	0.35
FVA Share	0.15	0.24	0.19	0.08
Education: primary	0.32	0.17	0.15	0.10
Education: tertiary	0.34	0.34	0.42	0.42
Literacy skills level: 1 or lower	0.45	0.18	0.13	0.14
Literacy skills level: 3	0.17	0.36	0.41	0.40
Literacy skills level: 4 and 5	0.02	0.08	0.15	0.15

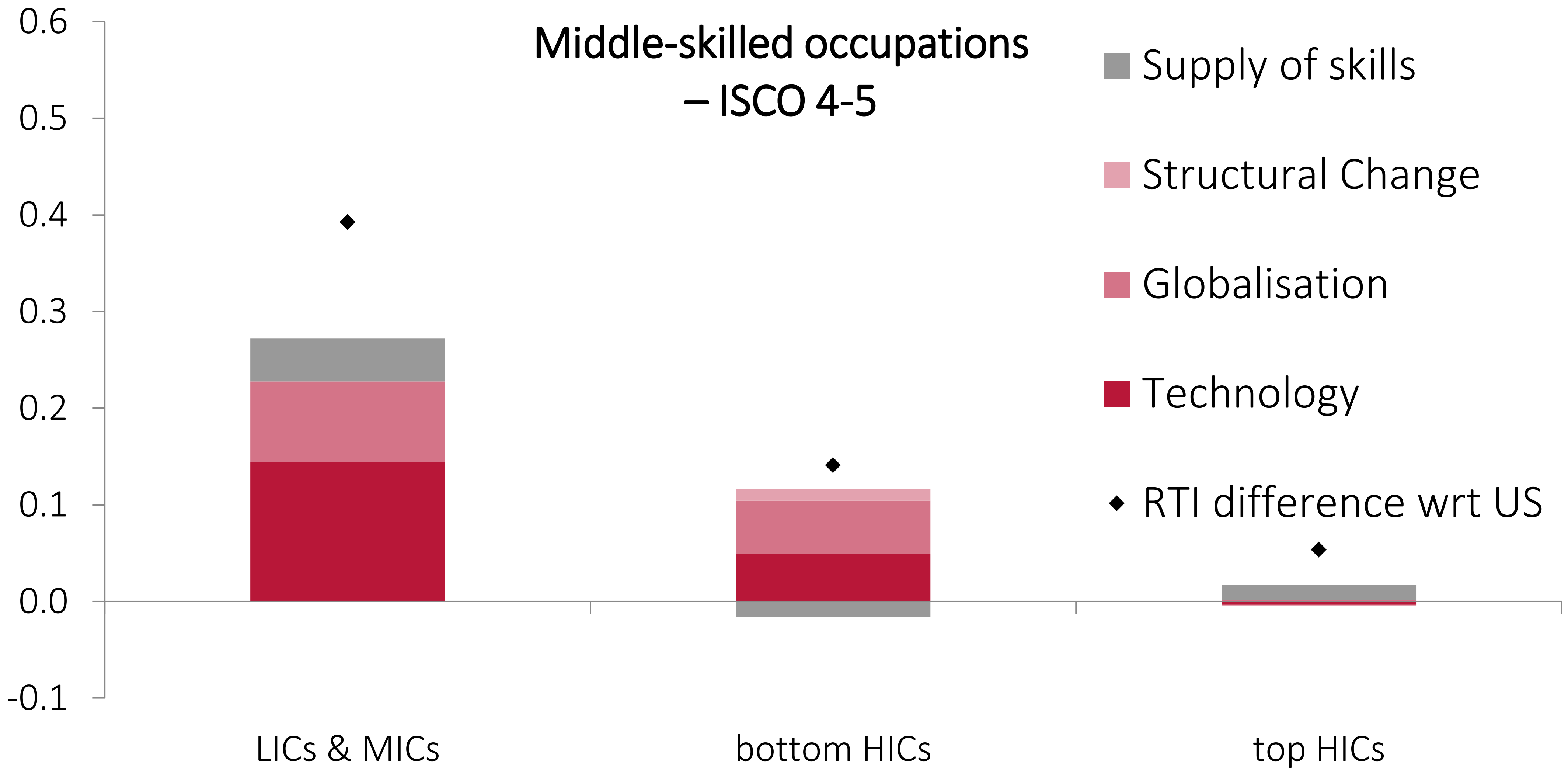
Overall, lower supply of skills matters the most in LIHc and MIHc. In bottom HICs globalization and technology are dominant



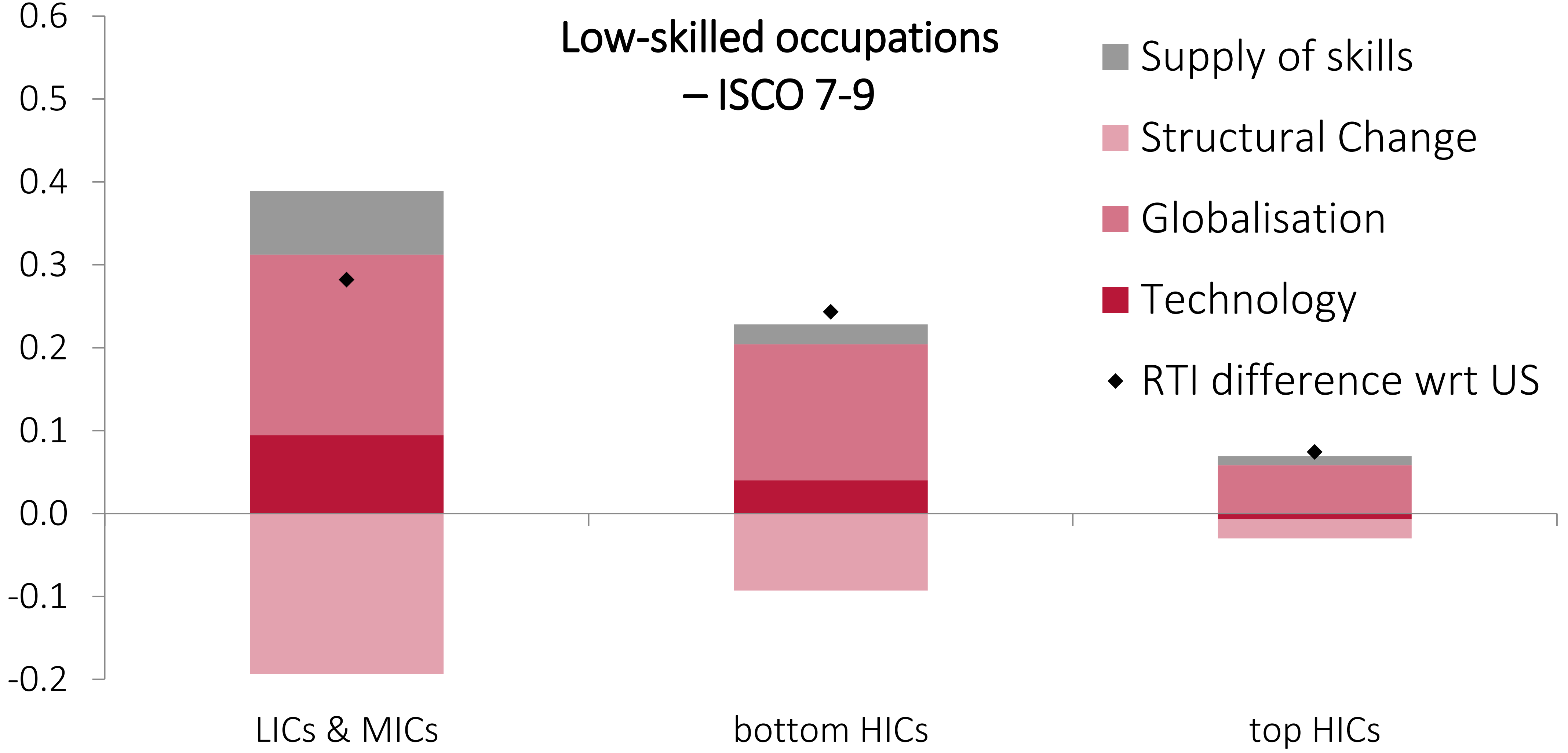
For the high-skilled occupations, technology matters the most, while skills contribute only in LICs & MICs



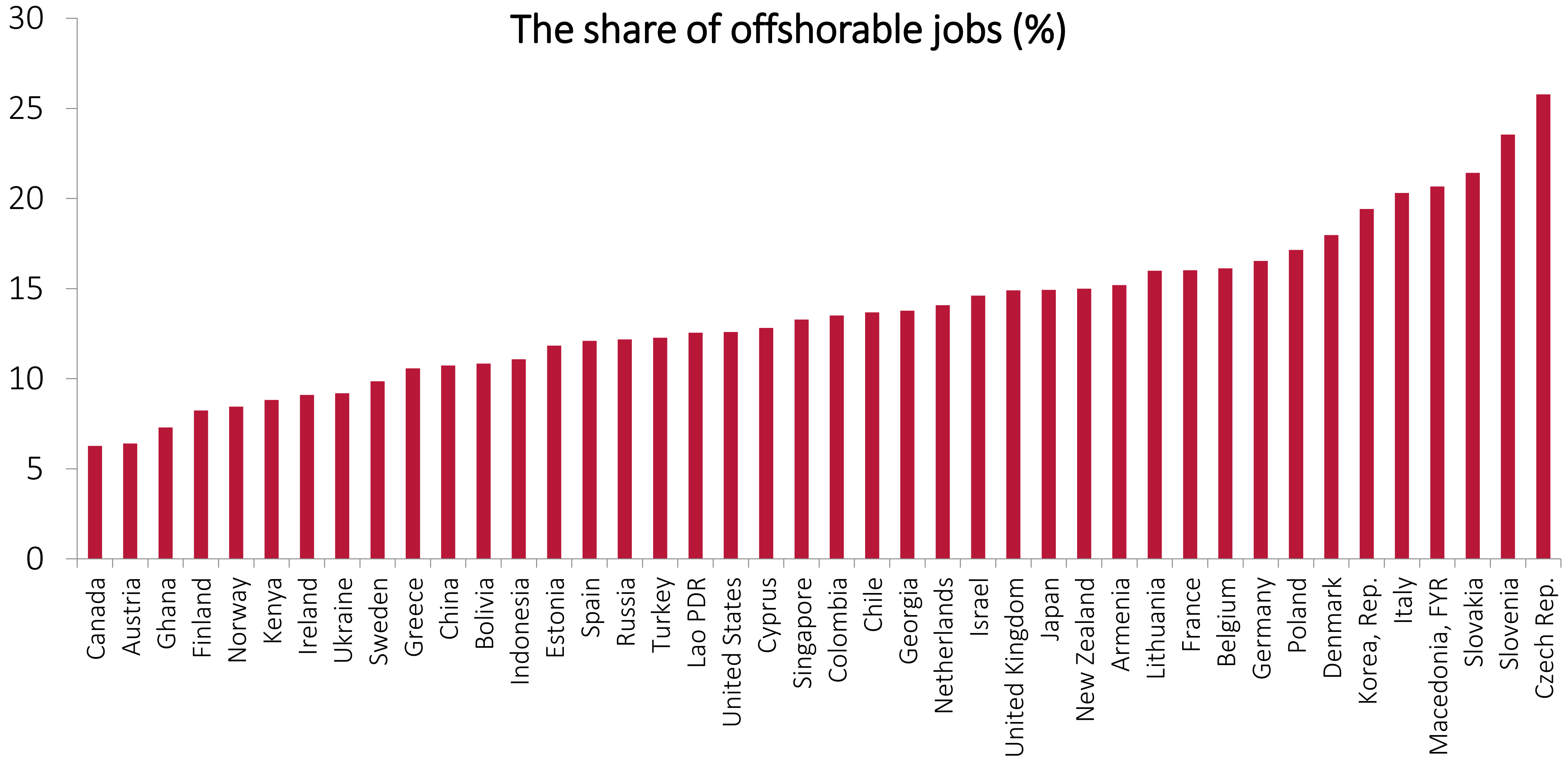
In middle-skill occupations, technology and globalization contribute the most



The contribution of globalization is the most pronounced for low-skilled occupations in all groups of countries



Next we study if the determinants of task differences are different for offshorable and non-offshorable occupations (Blinder & Krueger, 2013)

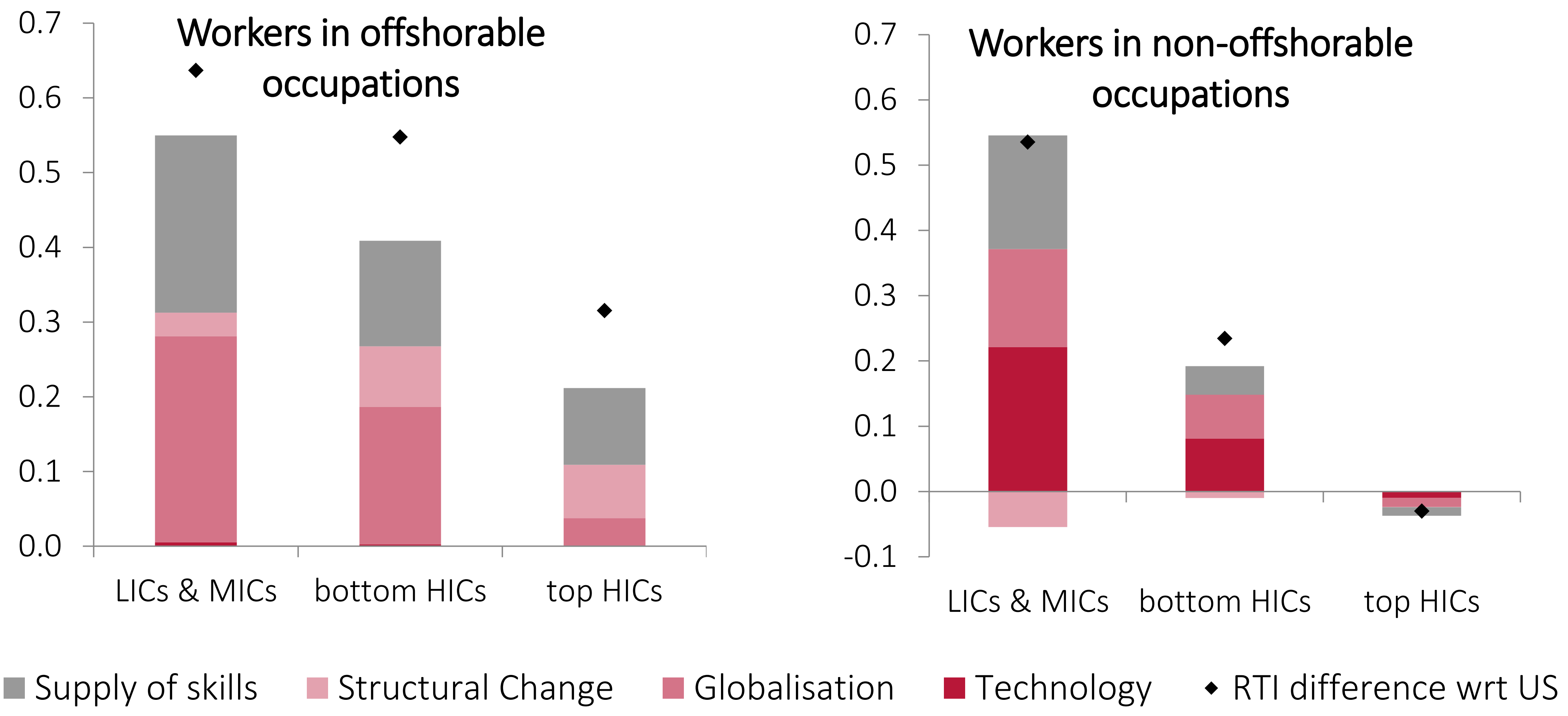


Technology matters for non-offshorable jobs. Globalization matters for offshorable jobs.

The effects of technology and globalization on RTI in offshorable and non-offshorable occupations

	All workers	Workers in non-offshorable occupations	Workers in offshorable occupations
Computer use	-0.508**	-0.555***	-0.012
FVA share	0.269*	0.171	0.762***
GDP per capita (log, demeaned)	0.060	0.062	0.015
FVA share * GDP per capita (log, demeaned)	-0.424**	-0.396**	-0.530*
FDI / GDP	0.009*	0.012**	-0.006
Skills and demographic characteristics	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes
No. of observations	148,120	129,965	18,155
R-Squared	0.220	0.222	0.245

Technology explains most of task differences among workers in non-offshorable occupations, but doesn't matter for offshorable occupations – globalization does



Finally, we assess the role of occupations

We re-estimate our model controlling for occupations

$$RTI_{ijsc} = \beta_0 + \beta_1 Z_{ijsc} + \beta_2 G_{sc} + \lambda_s + \beta_3 E_{ijsc} + \boldsymbol{\tau_o} + \varepsilon_{ijsc}$$

τ_o - occupational dummies (1-digit ISCO groups).

Occupations capture some of the differences otherwise attributed to fundamental factors, but technology still explains the most

Decomposition of cross-country variance of RTI, controlling for occupations (% of total variance)

	Technology	Globalization	Structural Change	Supply of skills	Occupations	Total
Model w/ no occupations	23	21	-5	18	-	57
Model w/ occupations	19	16	-3	8	17	57

- Task differences across countries cannot be explained by differences in occupational structures

What survey data tell us about the global differences in the nature of work

- Occupations are indeed different around the world.
  - In high-skilled occupations differences in RTI are strongly related to the development level, but in other occupations – not so much

- Technology contributes the most to the cross-country differences in tasks, especially among workers in high- and middle-skilled occupations.

- Globalization contributes the most among workers in low-skilled occupations and offshorable occupations.

- Skill supply matters more for the overall differences than for differences within occupational groups – skills determine structure of broad occupation groups.

Thanks for listening

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