Training, Automation, and Wages: Individual-Level Evidence from PIAAC

Oliver Falck[a] Yuchen Mo Guo[a] Christina Langer[b]
Valentin Lindlacher[c] Simon Wiederhold[d]

[a] ifo Institute & LMU Munich
[b] Stanford Digital Economy Lab
[c] TU Dresden
[d] Halle Institute for Economic Research (IWH) & MLU Halle-Wittenberg

SkillShift: Future-Proofing the Workforce

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Welders with high and low automation risk

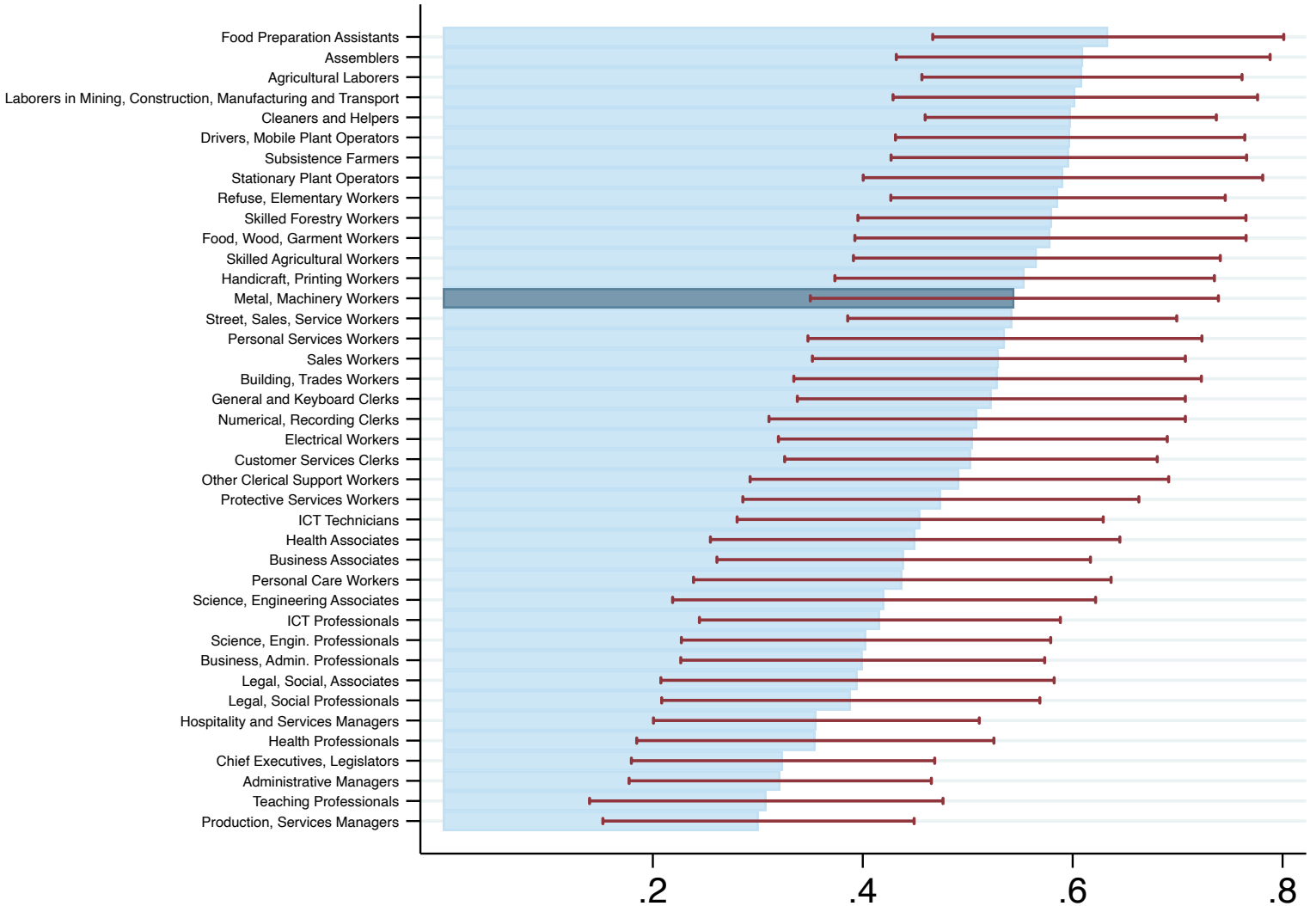
Welder performing manual-routine task

Welders performing digital and interactive tasks

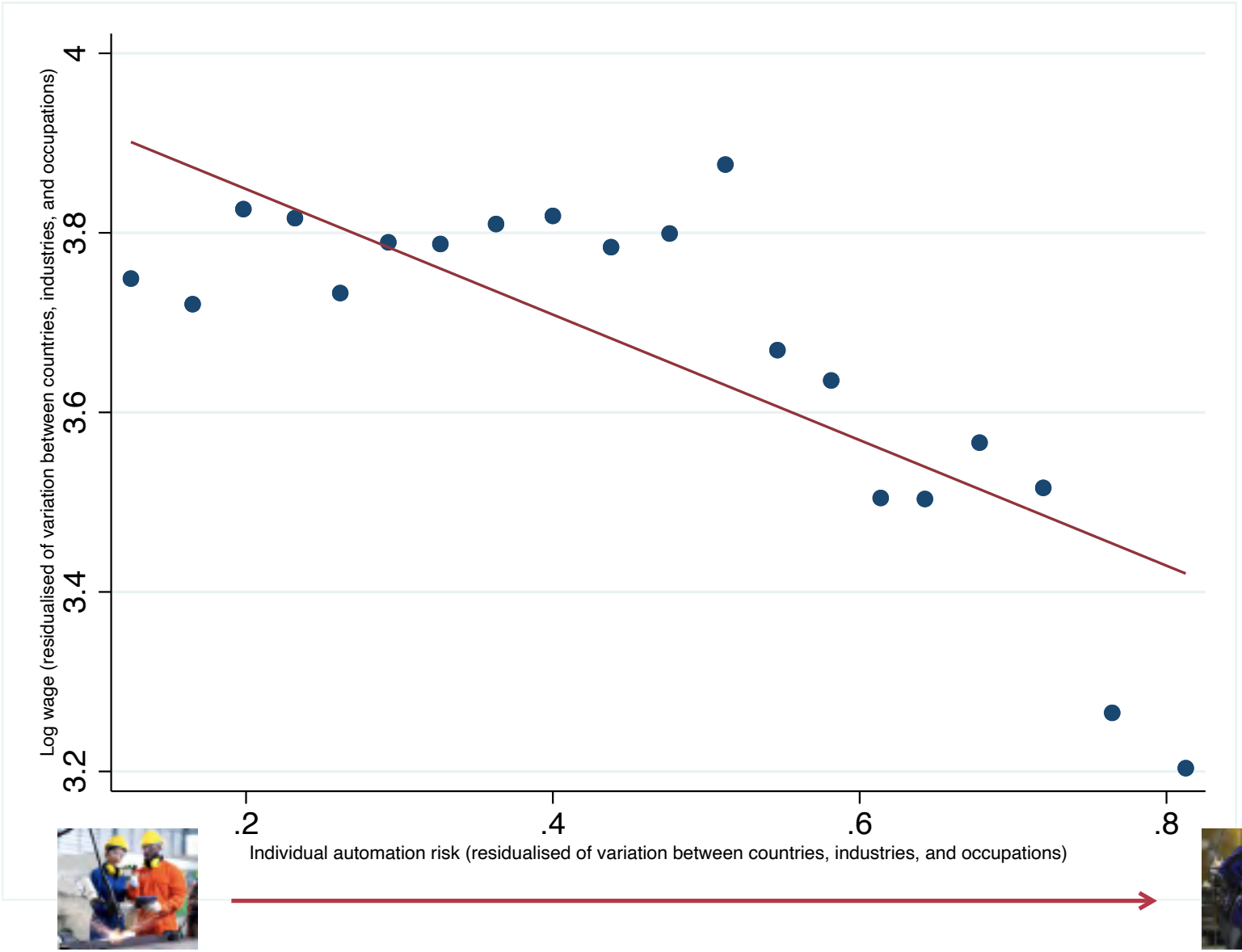
Image sources: https://blog.hirebotics.com/robotic-welder-operator
https://www.cyberweld.co.uk/robotic-welding-processes

U.S.: Change in automation risk 2012-2017

Substantial spread in automation risk within occupations



Even within occupations: Lower automation risk related to higher wages



Training and the adaptability to technological change

Does training enable workers to upgrade their tasks and perform tasks at a lower risk of automation?

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Challenges in existing work:

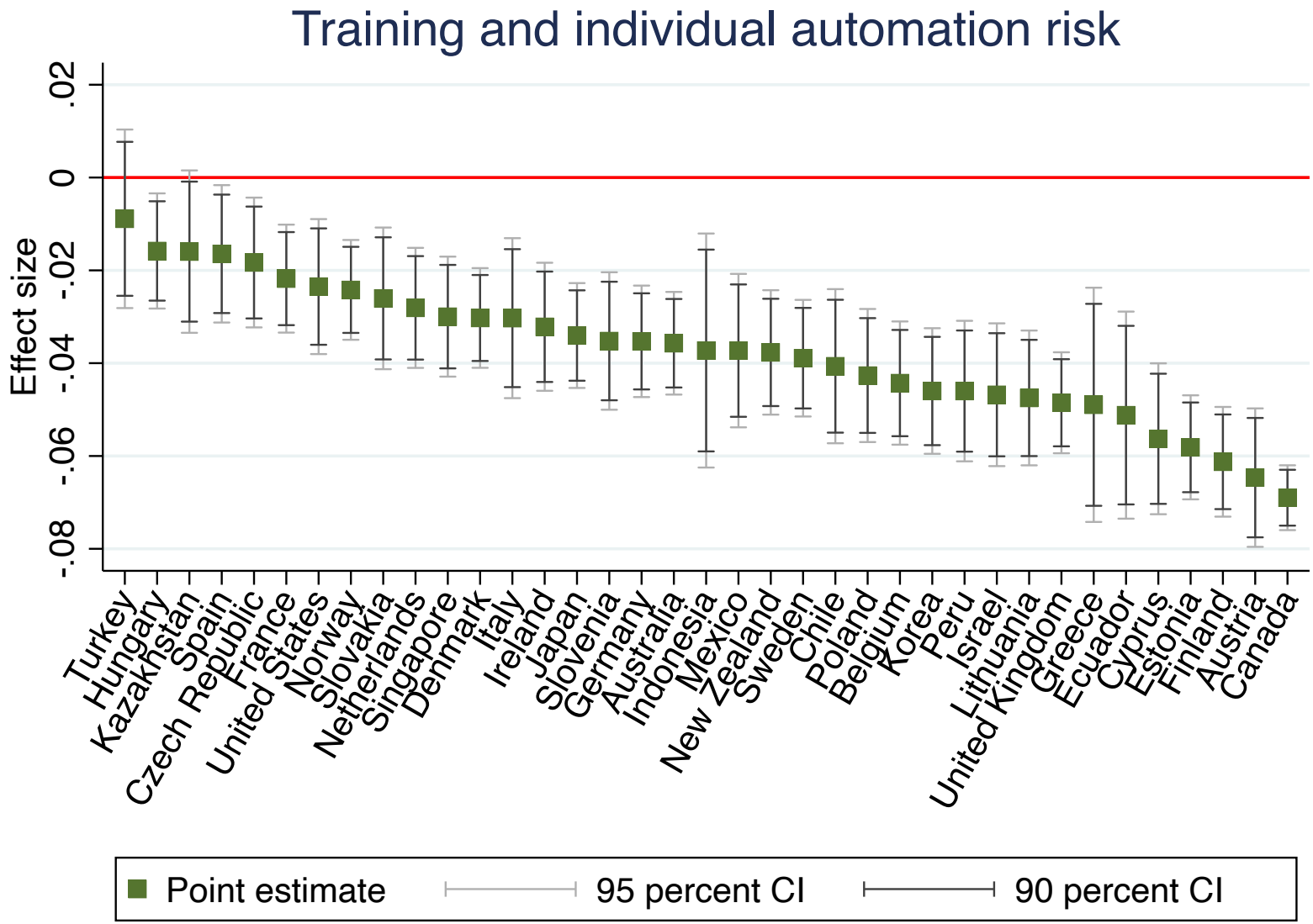
- **Occupation-level measures of automation risk**, no measure of task composition and automation risk at the individual level
- Estimates suffer from **selection bias**

Our solution:

- **1. Rich international micro-survey data (PIAAC):** Training, job tasks, and wages at the individual level
- **2. Individual-level automation risk measure**: Unique individual-level measure of automation risk based on task data
- **3. Empirical strategy**: Compare workers with and without training within occupations and rigorously account for selection into training (unique ability control, entropy balancing, impute past automation risk)

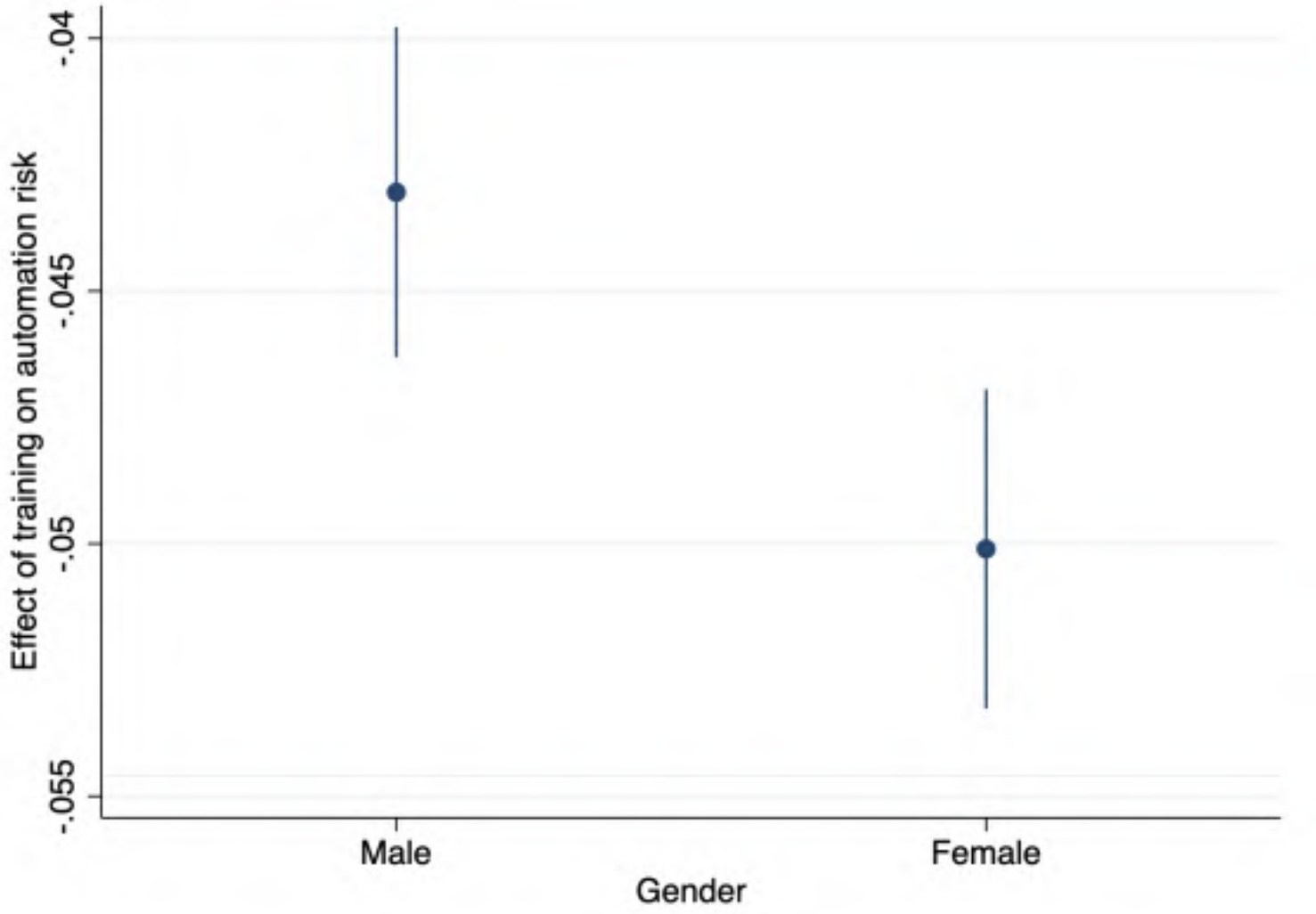
Data and measures | Empirical strategy

Training decreases workers' automation risk!



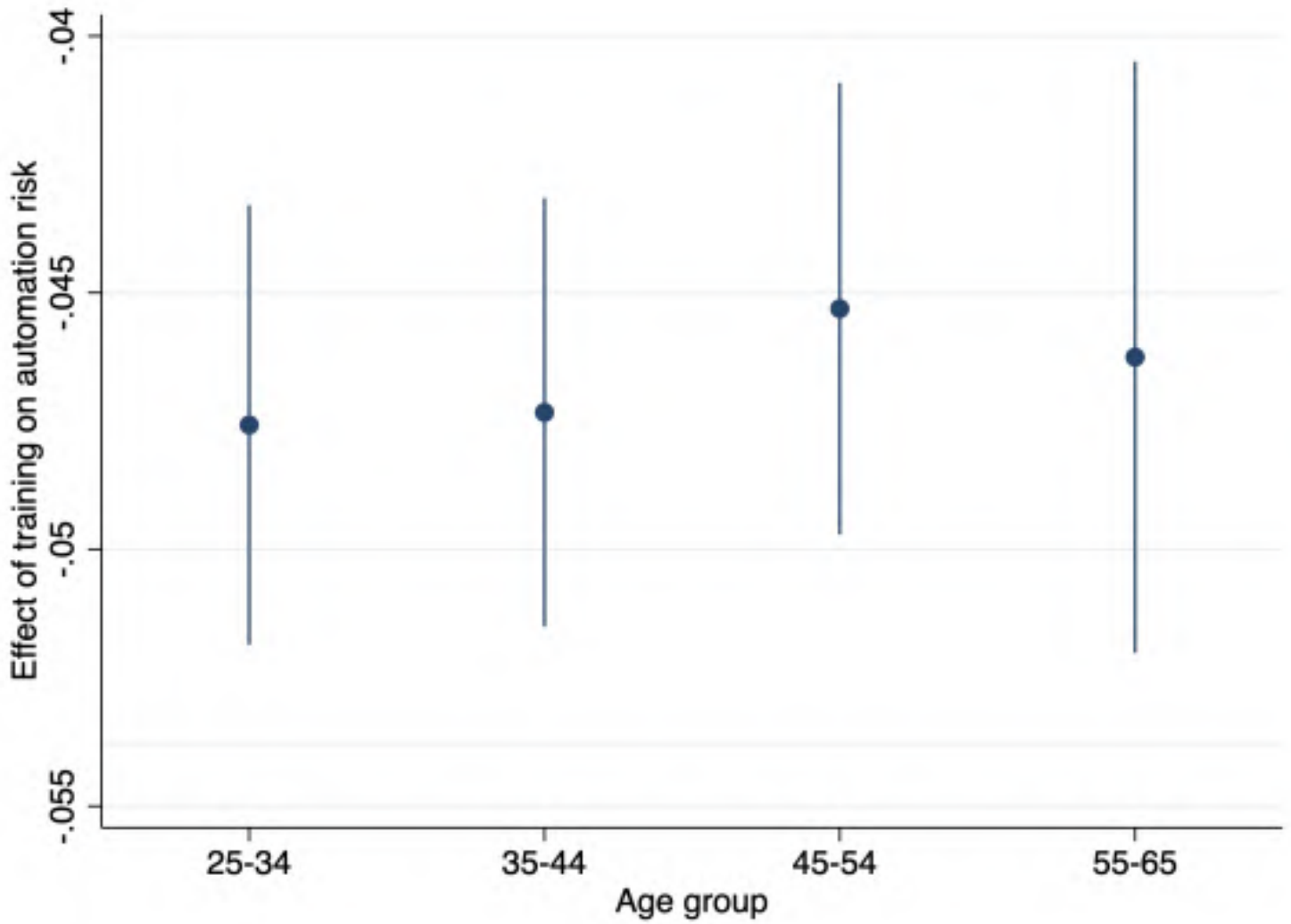
Regression table

Training more effective for women



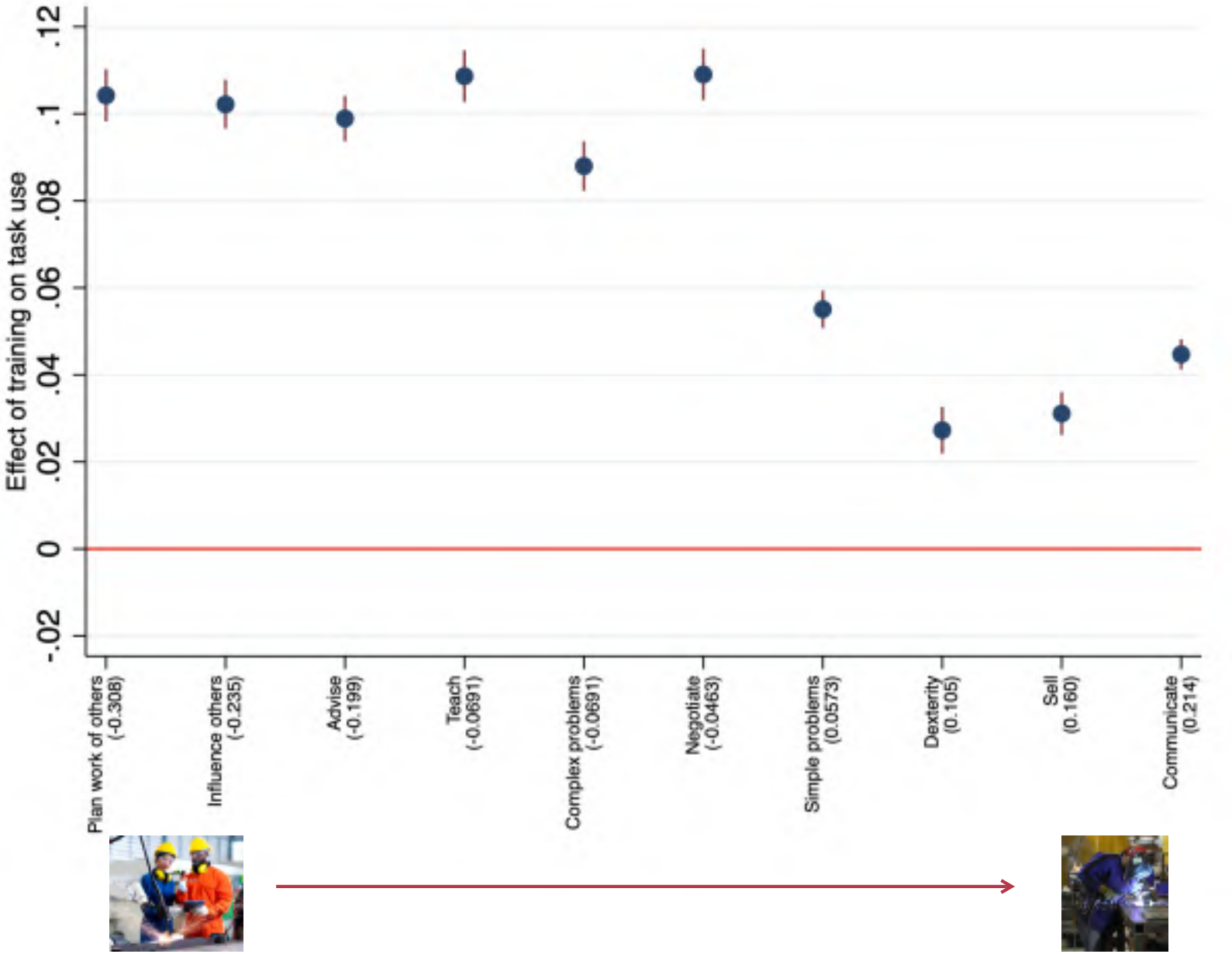
Regression table

Elderly workers benefit equally from training!

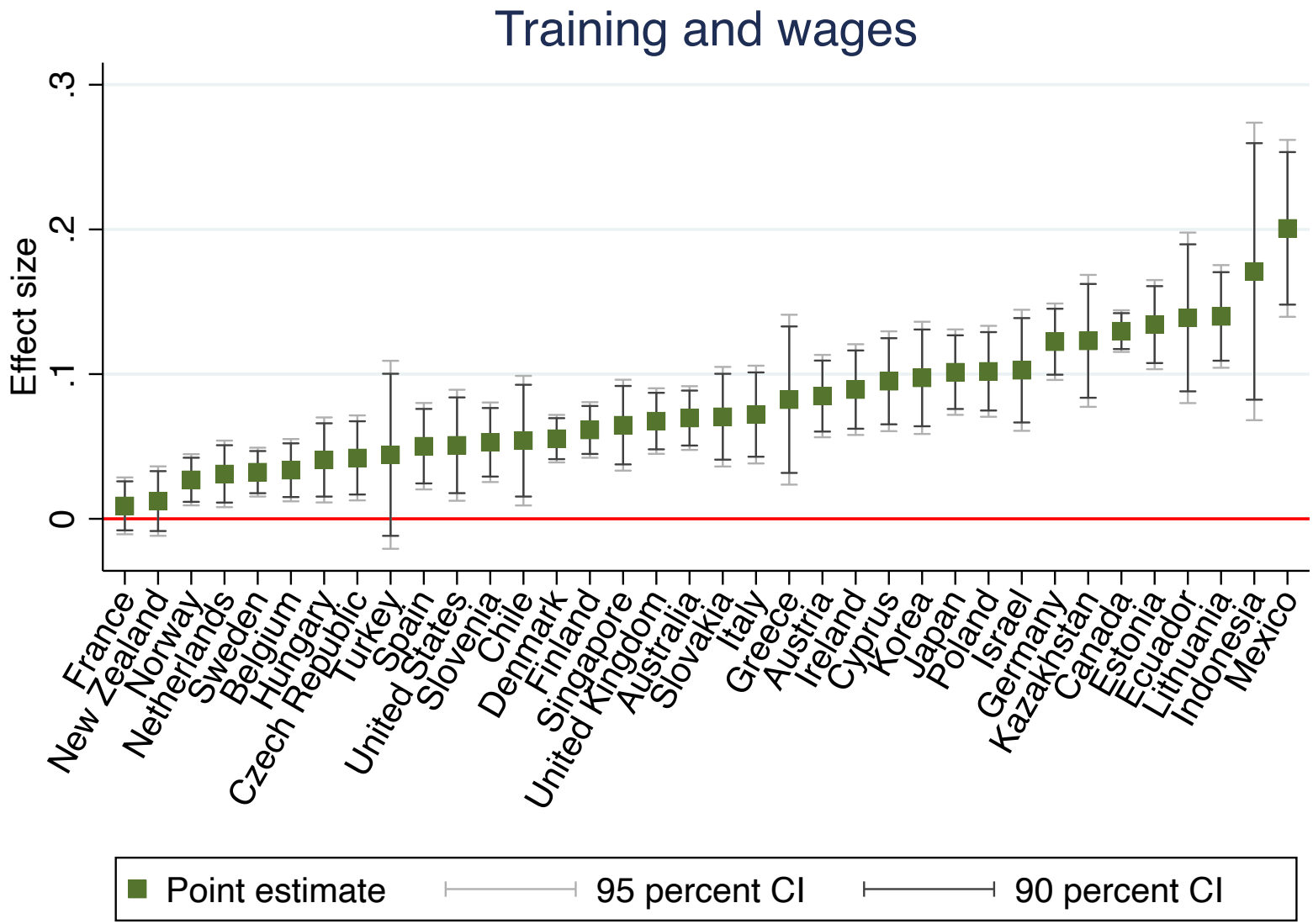


Regression table | Training effect by gender and age

Training increases tasks that are less automtable



Training pays off in terms of wages for workers!



Regression table | By gender | By age

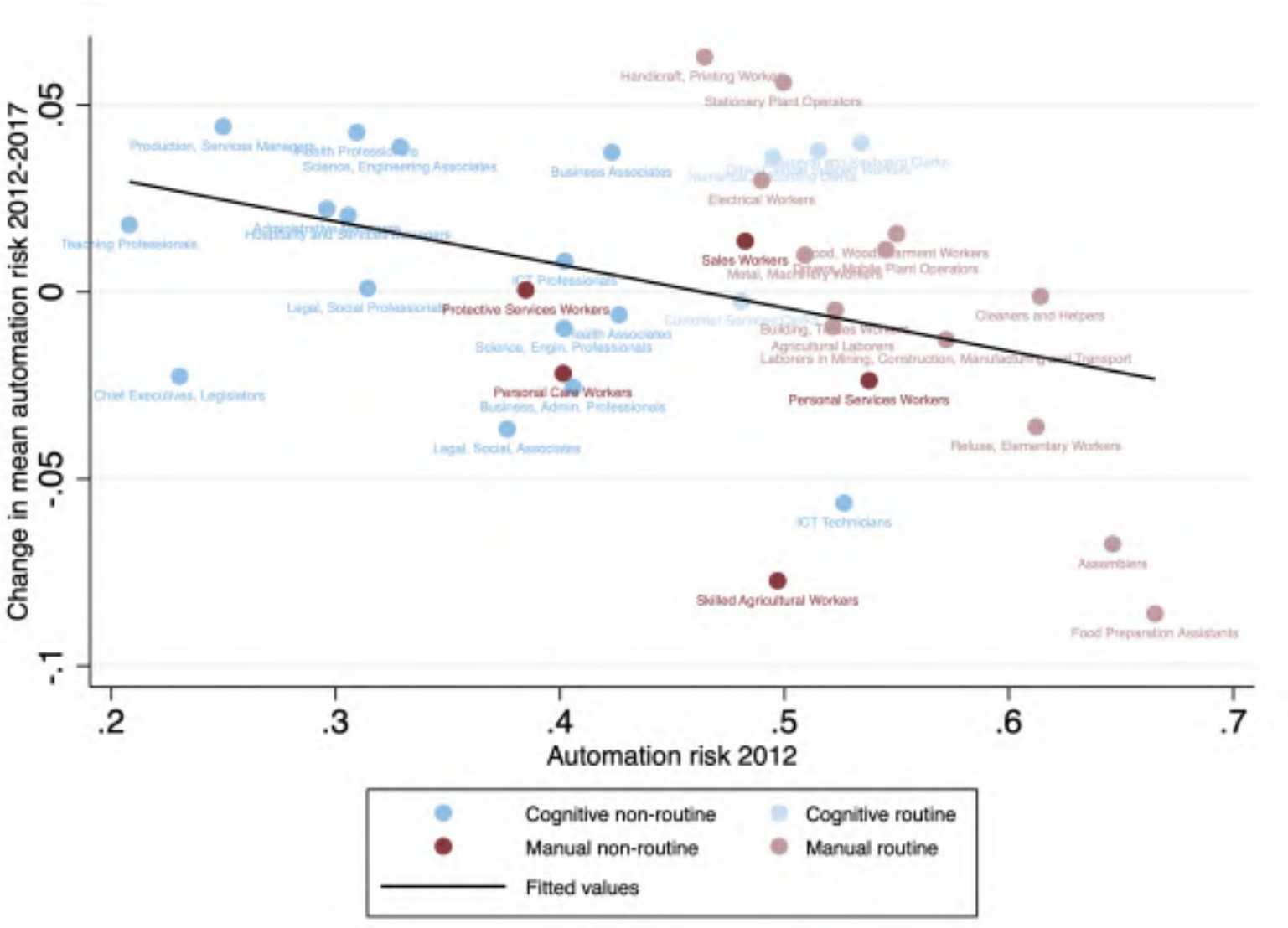
Conclusion

- Micro-level evidence on the **effect of training on individual-level automation risk and wages** using rich micro-data on training, tasks, and wages
- Data allows to **compare workers within-occupations** and apply extensive entropy balancing to **account for selection into training**
- Training as a **key factor for adapting** to technological change
- Training **decreases automation risk**
- Training **more effective for women** and **equally effective for younger and older** workers
- Training **increases wages**

Thanks for your attention!


falck@ifo.de

United States: Change in mean automation risk 2012 - 2017



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Data and Measures

Data: PIAAC (Programme for the International Assessment of Adult Competencies)

- **Representative surveys** of working-age individuals in 39 countries conducted in 2011-2012, 2014-2015, and 2017, respectively
- Information on **training, tasks, wages**, and background characteristics at the **individual level**

Measures: Training

- Information on **participation in on-the-job training** in the last 12 months before the survey in PIAAC's background questionnaire

Survey item on training

Measures: Automation risk

- Self-reported intensity of **task use** in different domains: manual, cognitive, digital, and social tasks
- Measure of **individual automation risk** between 0 and 1 following Nedelkoska and Quintini (2018)

Example for task items in PIAAC Automation risk details Example for task items in PIAAC Back

Empirical strategy: The effect of job training

1. Data on training and **automation risk at the individual level** allow to **compare automation risk** of workers with and without training **within occupations**

2. Control for selection into training using numeracy skills and detailed individual-level controls

3. Further account for selection into training: **Entropy balancing** to **render both groups comparable** by aligning training and non-training group on observables

Empirical specification | Entropy balancing approach | Entropy balancing: Numeracy skills | Balancing table | Back

Measures: Job training

- Information on participation in on-the-job training in the last 12 months before the survey in PIAAC's background questionnaire

Code	B_Q12c
Question	During the last 12 months, have you attended any organized sessions for on-the-job training or training by supervisors or co-workers?
Help	1. This type of training is characterised by planned periods of training, instruction or practical experience, using normal tools of work. 2. It is usually organised by the employer to facilitate adaptation of (new) staff. 3. It may include general training about the company as well as specific job-related instructions (safety and health hazards, working practices). 4. It includes for instance organised training or instructions by management, supervisors or co-workers to help the respondent to do his/her job better or to introduce him/her to new tasks, but can also take place in the presence of a tutor.
Responses	01 Yes 02 No DK DK RF RF

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Measures: Automation risk

- Self-reported intensity of **task use** in different domains: manual, cognitive, digital, and social tasks. Construct a measure of **individual automation risk** between 0 and 1 following Nedelkoska and Quintini (2018)
- Tasks and contributions to automation risk as estimated in Nedelkoska and Quintini (2018):

	Logit Coefficients
Plan Work of Others	-0.308***
Influence Others	-0.235***
Advise	-0.199***
Teach	-0.0691***
Complex Problems	-0.0691**
Negotiate	0.0463*
Simple Problems	0.0573*
Dexterity	0.105***
Sell	0.160***
Communicate	0.214***

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

Example for task items in PIAAC | Automation risk details | Back

Measures: Task use examples

Question	making speeches or giving presentations in front of five or more people?	
Responses	01	Never
	02	Less than once a month
	03	Less than once a week but at least once a month
	04	At least once a week but not every day
	05	Every day
	DK	DK
	RF	RF

Question	using skill or accuracy with your hands or fingers?	
Responses	01	Never
	02	Less than once a month
	03	Less than once a week but at least once a month
	04	At least once a week but not every day
	05	Every day
	DK	DK
	RF	RF

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Measures: Automation risk

- **Individual-level data on task use** at work in PIAAC in various task domains
- Nedelkoska and Quintini (2018): Predict **probability of automation** based on job tasks in PIAAC
- 1. Based on Frey and Osborne (2013): **Occupations** in which all tasks can be automated receive a value of 1, all others 0
- 2. How much does **each task contribute** to the probability of automation?
- 3. Based on individual task composition: **Predict individual automation risk** ranging from 0 to 1

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Empirical strategy: The effect of job training

1. Data on automation risk, skills, and wages at the individual level allow isolating **within-country** (c)**, within-industry** (j)**, and within-occupation** (o) **variation**:

$$Y_{icjo} = \alpha + \beta_1 \text{jobtraining}_{icoj} + \delta_c + \eta_j + \zeta_o + \varepsilon_{icjo}. \tag{1}$$

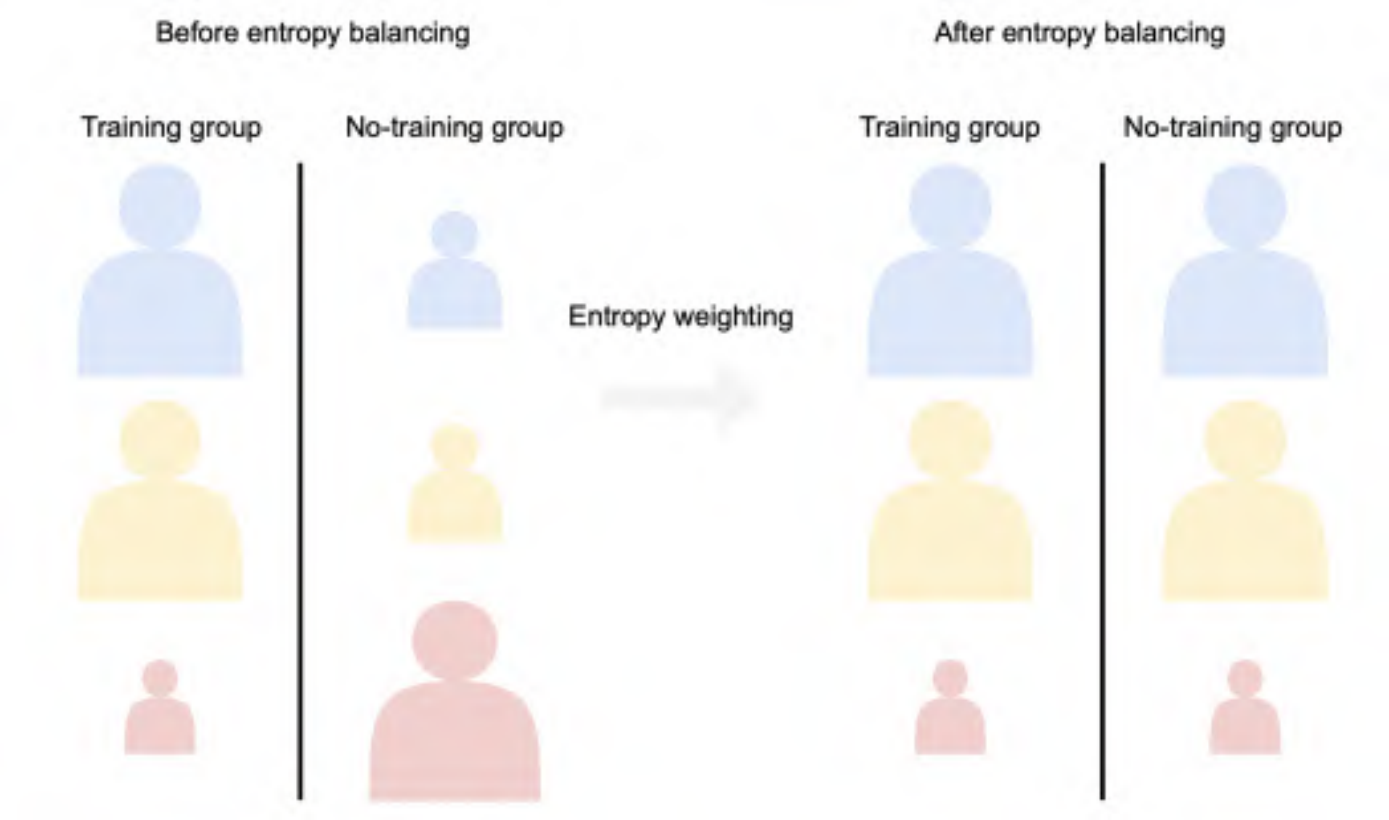
2. Control for **selection into training** using numeracy skills and detailed individual-level controls:

$$Y_{icoj} = \alpha + \beta_1 \text{jobtraining}_{icoj} + \beta_2 \text{numeracy}_{icoj} + \mathbf{X}'_{icoj}\gamma + \delta_c + \zeta_o + \eta_j + \varepsilon_{icoj}. \tag{2}$$

3. Further account for selection into training: **Entropy balancing**

Entropy balancing approach | Entropy balancing: Numeracy skills | Balancing table | Back

Entropy balancing



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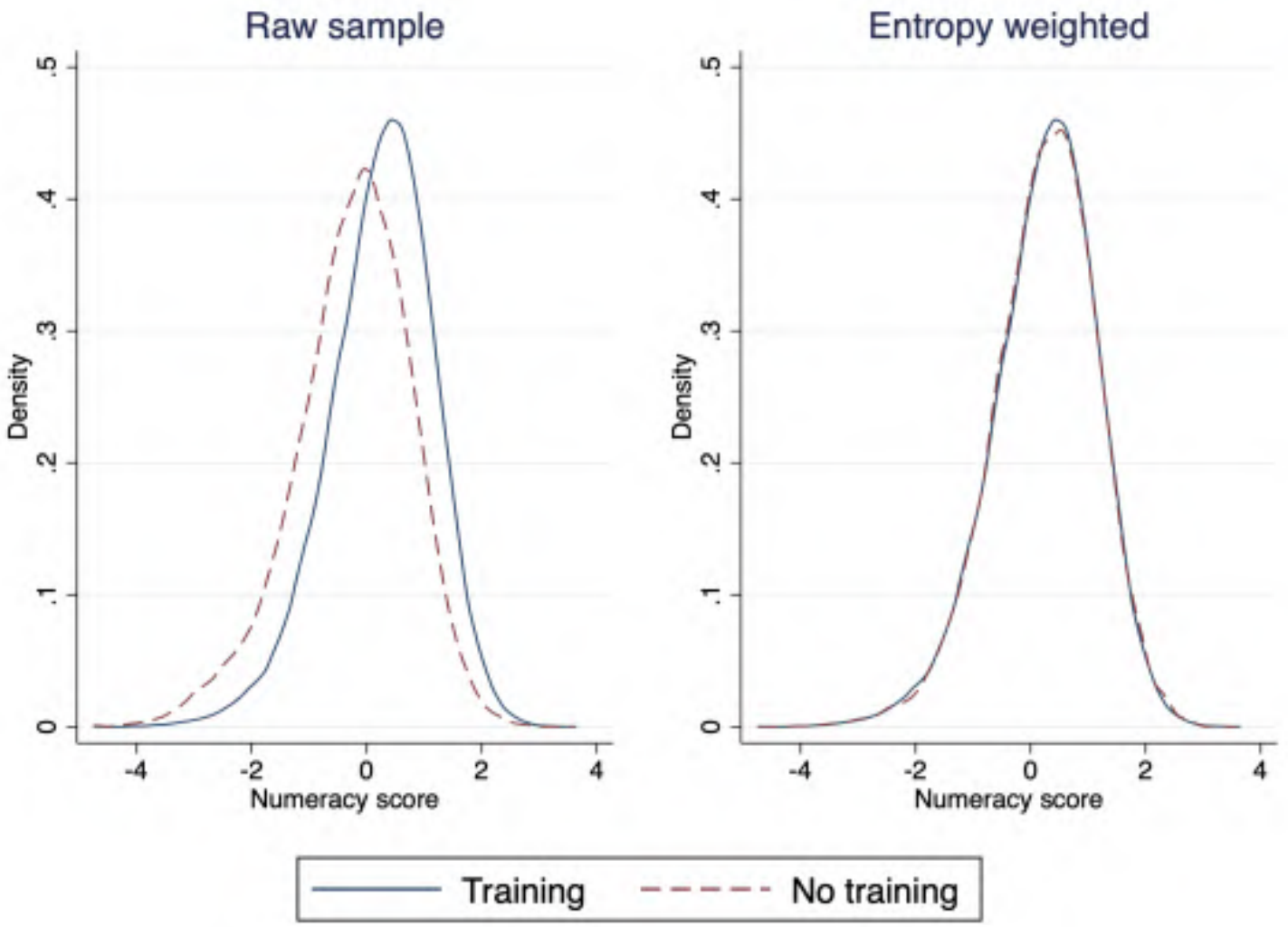
Entropy balancing: Numeracy skills



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Entropy balancing

Balancing table

	(1) Training	(2) No Training	(3) No Training (Entropy Weighted)	Difference (1)-(2)	Difference (1)-(3)
Variable	Mean/(SE)	Mean/(SE)	Mean/(SE)	P-value	P-value
Numeracy Skills	0.249	-0.228	0.249	0.000***	1.000
	(0.004)	(0.005)	(0.004)		
Share Age Group 25-34	0.281	0.263	0.281	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Age Group 35-44	0.295	0.270	0.295	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Age Group 45-54	0.266	0.263	0.266	0.298	1.000
	(0.002)	(0.002)	(0.002)		
Share Age Group 55-65	0.157	0.203	0.157	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Female	0.515	0.507	0.515	0.019**	1.000
	(0.002)	(0.002)	(0.002)		
Share Immigrant	0.154	0.156	0.154	0.450	1.000
	(0.002)	(0.002)	(0.002)		
Share Neither Parent Has Attained Upper Secondary Education	0.296	0.418	0.296	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share At Least One Parent Has Attained Secondary and Post-Secondary Education	0.371	0.342	0.371	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share At Least One Parent Has Attained Tertiary Education	0.293	0.182	0.293	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Has Chidlren	0.170	0.186	0.170	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Training (Other)	0.043	0.078	0.043	0.000***	1.000
	(0.001)	(0.001)	(0.001)		
Share Firm Size 1 to 10 People	0.184	0.359	0.184	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Firm Size 11 to 50 People	0.299	0.298	0.299	0.720	1.000
	(0.002)	(0.002)	(0.002)		
Share Firm Size 51 to 250 People	0.264	0.194	0.264	0.000***	1.000
	(0.002)	(0.002)	(0.002)		
Share Firm Size 251 to 1000 People	0.142	0.086	0.142	0.000***	1.000
	(0.001)	(0.001)	(0.001)		
Share Firm Size More than 1000 People	0.105	0.050	0.105	0.000***	1.000
	(0.001)	(0.001)	(0.001)		

Back

Training reduces individual automation risk

Training and automation risk

	(1) Automation Risk	(2) Automation Risk	(3) Automation Risk	(4) Automation Risk	(5) Automation Risk
Job Training	-0.0839***	-0.0559***	-0.0511***	-0.0464***	-0.0467***
	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0012)
Numeracy Skills			-0.0229***	-0.0175***	-0.0129***
			(0.0009)	(0.0010)	(0.0008)
Observations	91470	91470	91470	91470	91470
R^2	0.11	0.20	0.22	0.24	0.20
Country FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	Yes	Yes	Yes
Controls	No	No	No	Yes	Yes
Entropy Balancing	No	No	No	No	Yes

Robust standard errors in parentheses

$^{*}\ p < 0.10,\ ^{**}\ p < 0.05,\ ^{***}\ p < 0.01$

Decomposition by tasks Back

Robustness, imputed automation risk 2012

	(1) Automation Risk	(2) Automation Risk
Job Training	-0.0444***	-0.0383***
	(0.0117)	(0.0099)
Numeracy Skills	0.0054	-0.0000
	(0.0064)	(0.0065)
Imputed Automation Risk 2012		0.3157*
		(0.1915)
Observations	1238	1238
R^2	0.34	0.36
Country FE	Yes	Yes
Industry FE	Yes	Yes
Occupation FE	Yes	Yes
Controls	Yes	Yes
Entropy balancing	Yes	Yes

Robust standard errors in parentheses
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Back

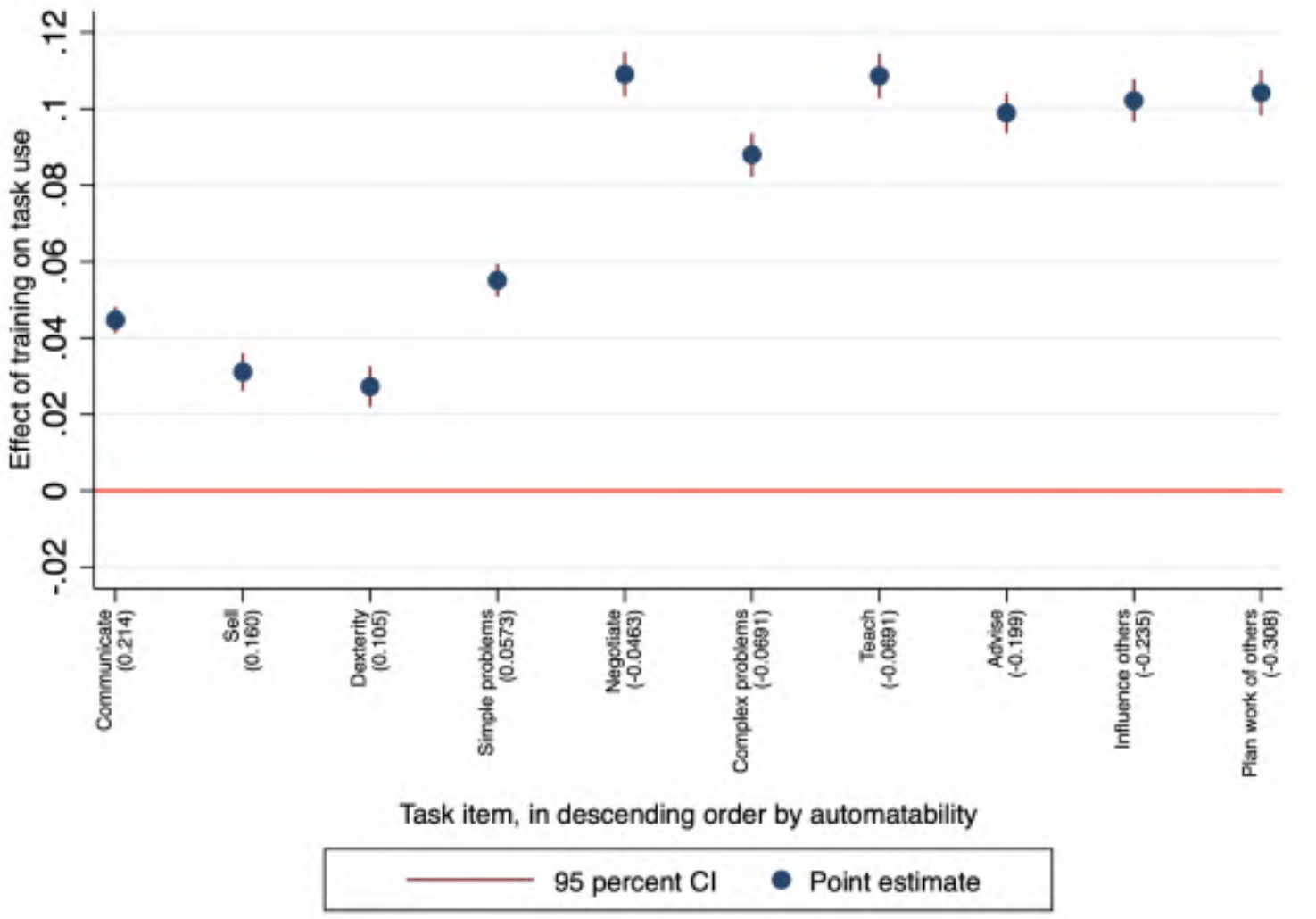
Robustness, residuals from predicted automation risk

	(1) Automation Risk	(2) Automation Risk Residuals
Job Training	-0.0464***	-0.0421***
	(0.0017)	(0.0015)
Numeracy Skills	-0.0175***	
	(0.0010)	
Observations	91470	91470
R^2	0.24	
Country FE	Yes	
Industry FE	Yes	
Controls	Yes	
Occupation FE	Yes	

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Back

Training increases use of tasks with a lower risk of automation



Back

Training increases wages

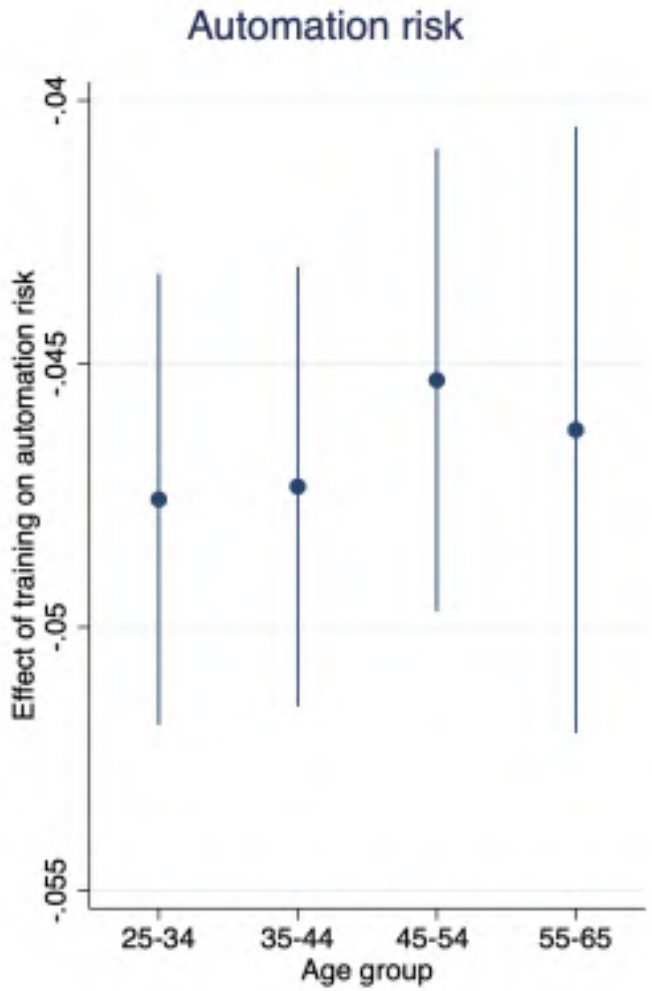
Training and wages

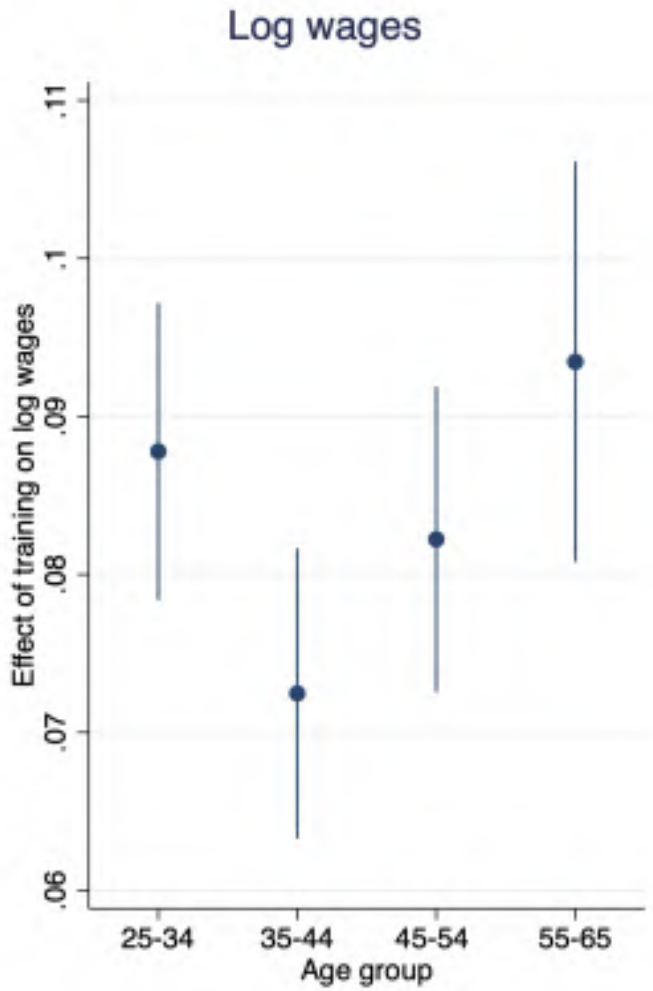
	(1) Log Wages	(2) Log Wages	(3) Log Wages	(4) Log Wages	(5) Log Wages
Job Training	0.2082***	0.1336***	0.1131***	0.1035***	0.0824***
	(0.0044)	(0.0042)	(0.0042)	(0.0041)	(0.0025)
Numeracy Skills			0.0972***	0.0878***	0.0716***
			(0.0025)	(0.0025)	(0.0018)
Observations	91470	91470	91470	91470	91470
R^2	0.16	0.27	0.29	0.34	0.35
Country FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	Yes	Yes	Yes
Controls	No	No	No	Yes	Yes
Entropy Balancing	No	No	No	No	Yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Back

Training equally effective for elderly workers





Regression table

Training equally effective for elderly workers

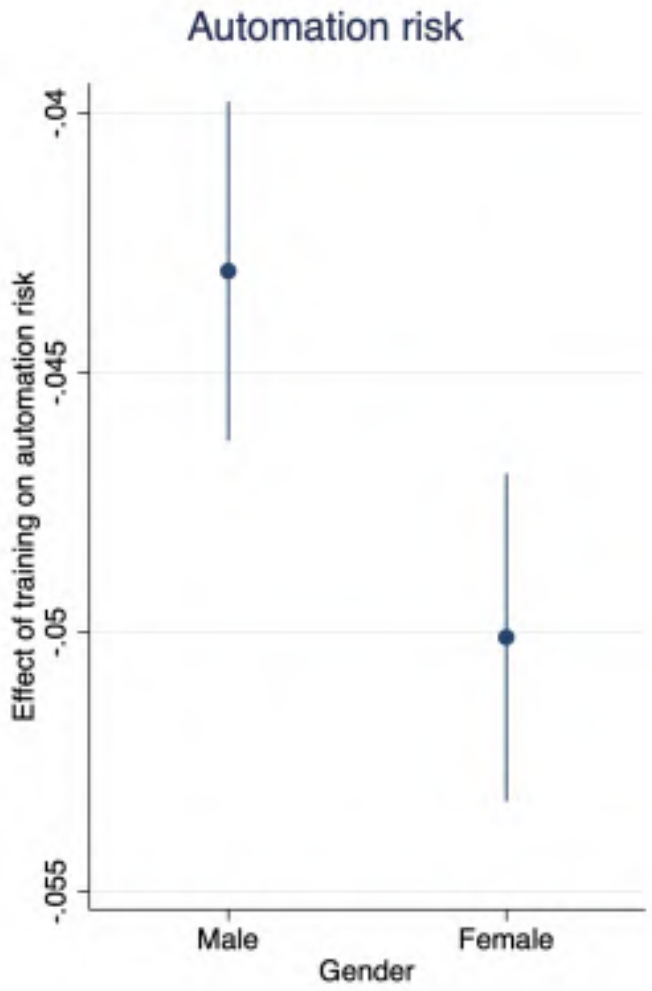
Effectiveness of training by age

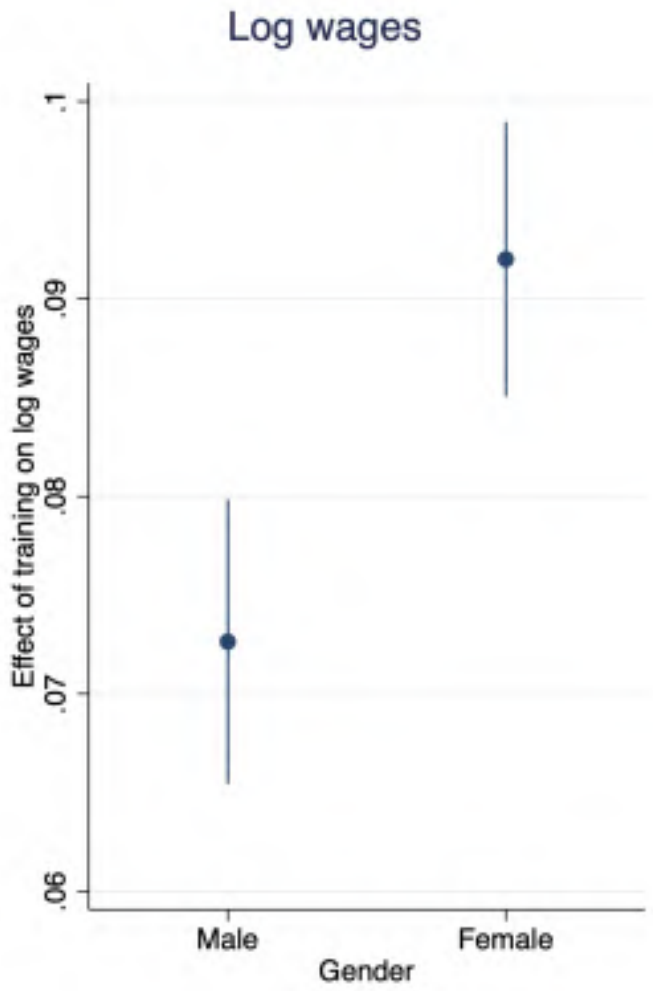
	(1) Automation Risk	(2) Log Wages
Job Training	-0.0476***	0.0878***
	(0.0022)	(0.0048)
× Age 35-44	0.0002	-0.0153
	(0.0030)	(0.0087)
× Age 45-54	0.0023	-0.0056
	(0.0031)	(0.0069)
× Age 55-65	0.0013	0.0057
	(0.0037)	(0.0081)
Age 35-44	-0.0213***	0.1509***
	(0.0022)	(0.0048)
Age 45-54	-0.0202***	0.1925***
	(0.0023)	(0.0051)
Age 55-65	-0.0127***	0.1807***
	(0.0027)	(0.0060)
Numeracy Skills	-0.0130***	0.0722***
	(0.0008)	(0.0018)
Observations	91470	91470
R^2	0.20	0.35
Country FE	Yes	Yes
Industry FE	Yes	Yes
Occupation FE	Yes	Yes
Controls	Yes	Yes
Entropy Balancing	Yes	Yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Back

Training more effective for women





Regression table

Training more effective for women

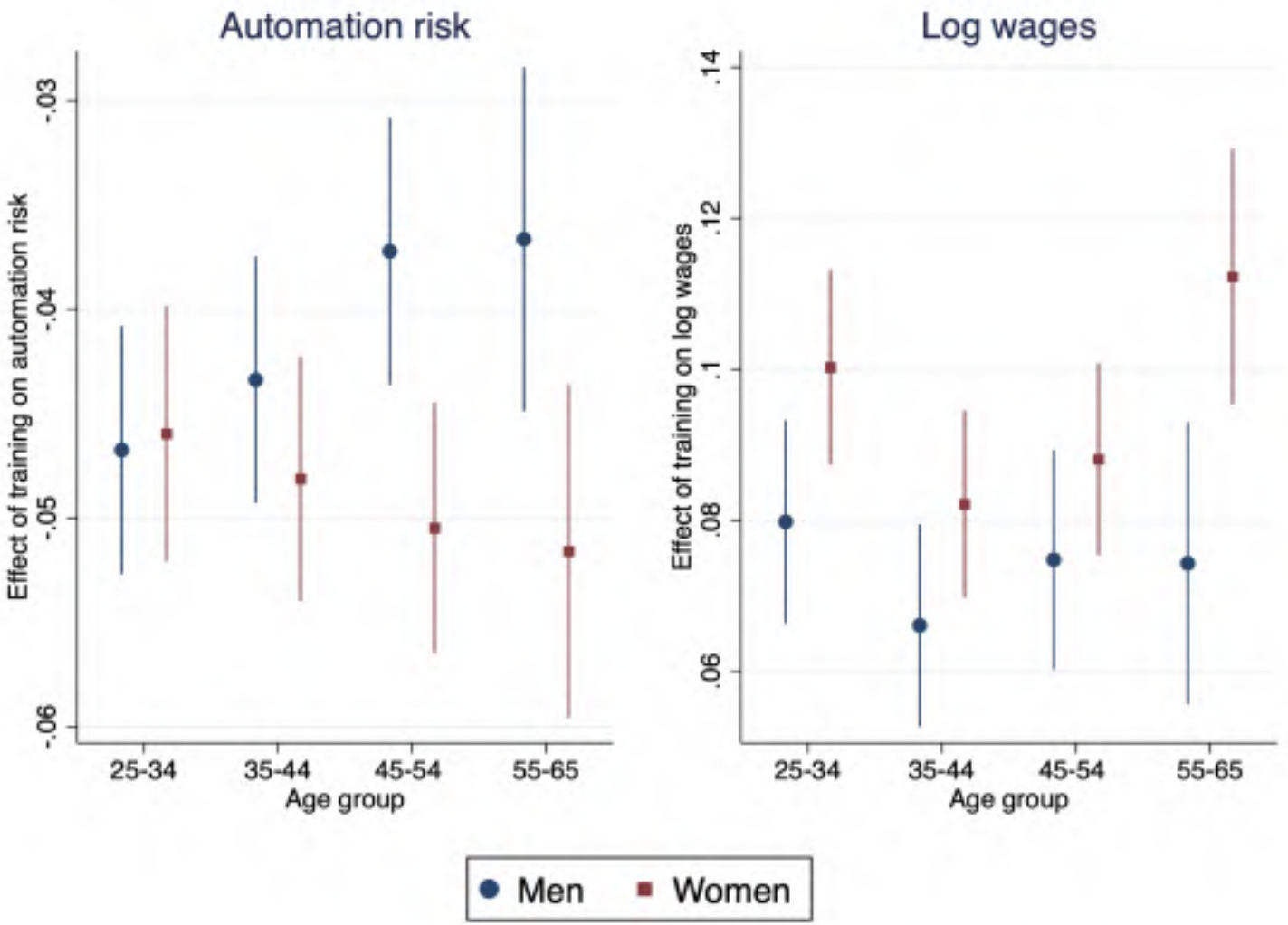
Effectiveness of training by gender

	(1) Automation Risk	(2) Log Wages
Job Training	-0.0430***	0.0726***
	(0.0017)	(0.0037)
× Female	-0.0071***	0.0194***
	(0.0023)	(0.0051)
Female	0.0213***	-0.1453***
	(0.0018)	(0.0039)
Numeracy Skills	-0.0131***	0.0723***
	(0.0008)	(0.0018)
Observations	91470	91470
R^2	0.20	0.35
Country FE	Yes	Yes
Industry FE	Yes	Yes
Occupation FE	Yes	Yes
Controls	Yes	Yes
Entropy Balancing	Yes	Yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

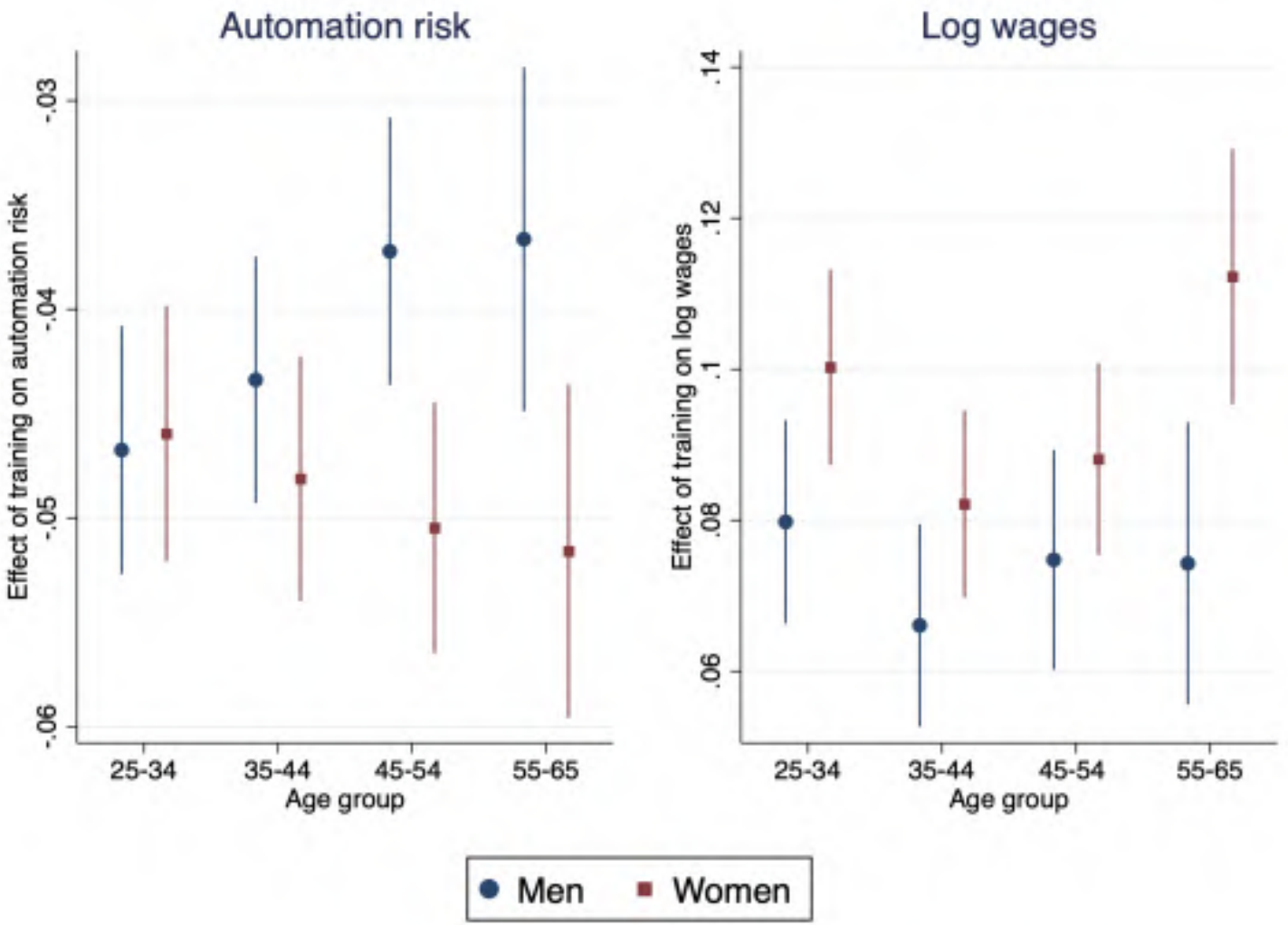
Back

Training effects for elderly and female workers



Back

Training effects for elderly and female workers



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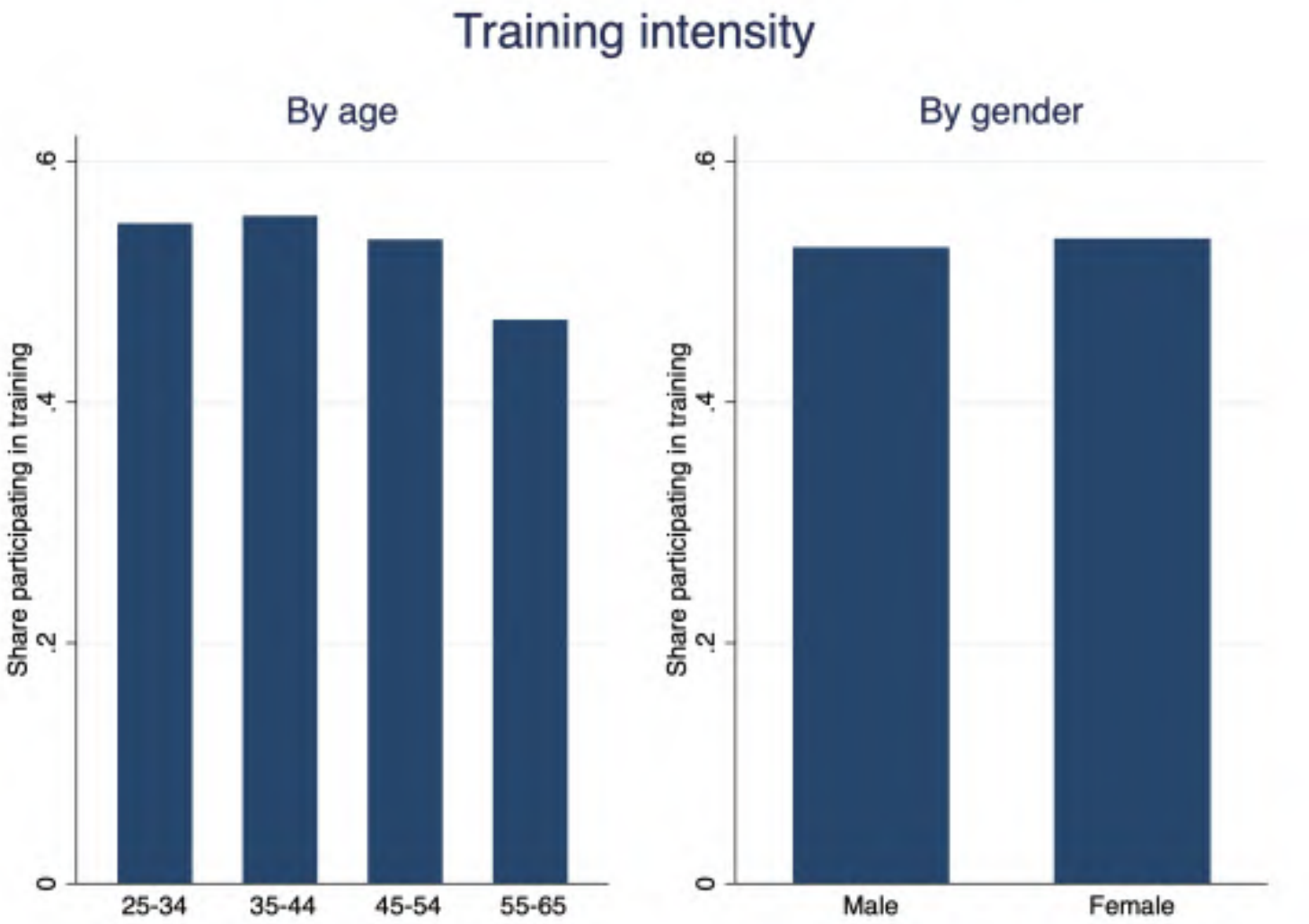
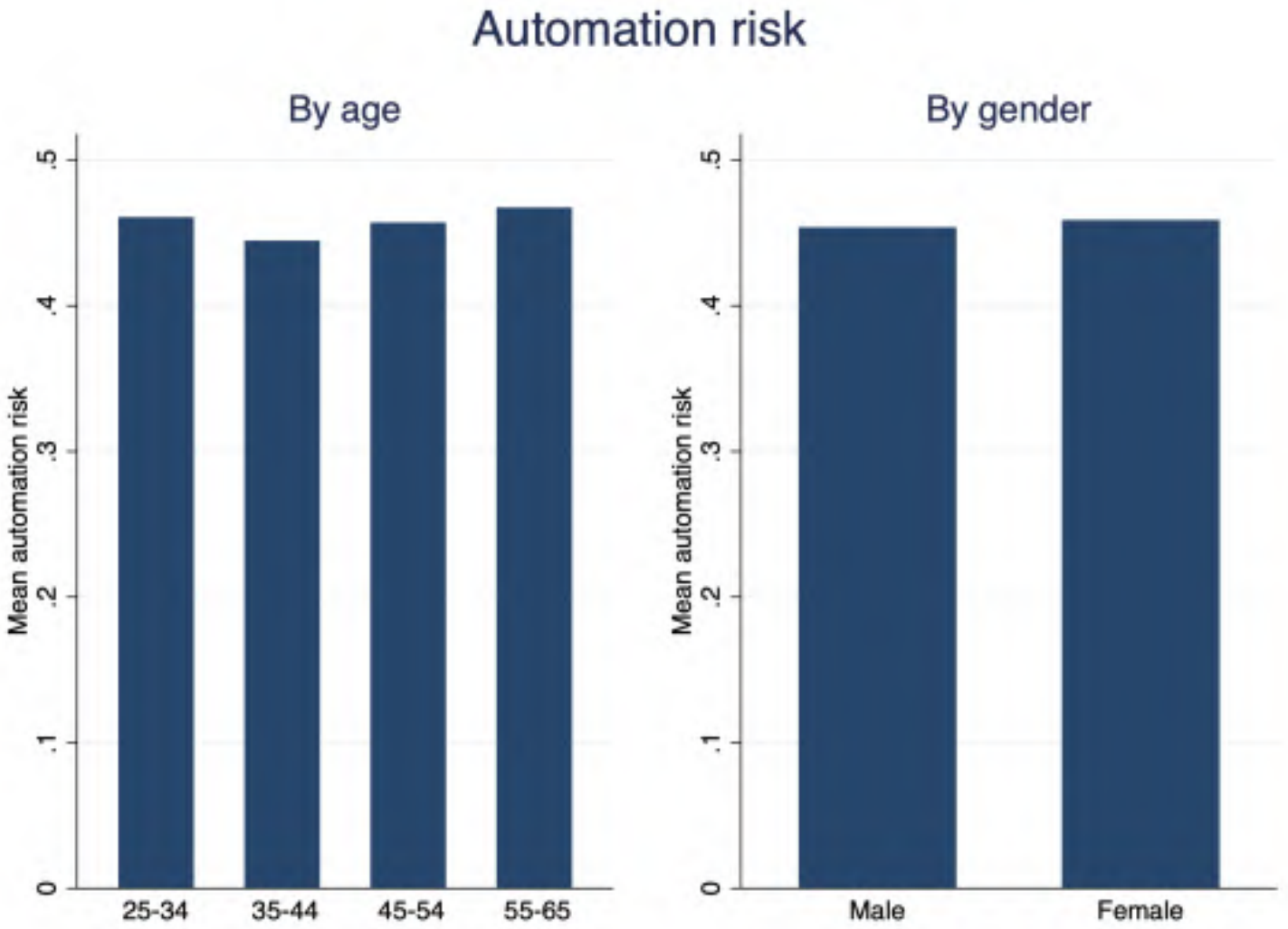
Training intensity by age and gender



Automation risk by age and gender



Training improves digital skills

Training and digital skills

	(1) Digital Skills	(2) Digital Skills	(3) Digital Skills	(4) Digital Skills	(5) Digital Skills
Job Training	0.2999***	0.2116***	0.0879***	0.0770***	0.0509***
	(0.0100)	(0.0098)	(0.0076)	(0.0074)	(0.0045)
Numeracy Skills			0.8213***	0.7778***	0.7762***
			(0.0048)	(0.0048)	(0.0032)
Observations	72180	72180	72180	72180	72180
R^2	0.08	0.14	0.54	0.58	0.59
Country FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	Yes	Yes	Yes
Controls	No	No	No	Yes	Yes
Entropy Balancing	No	No	No	No	Yes

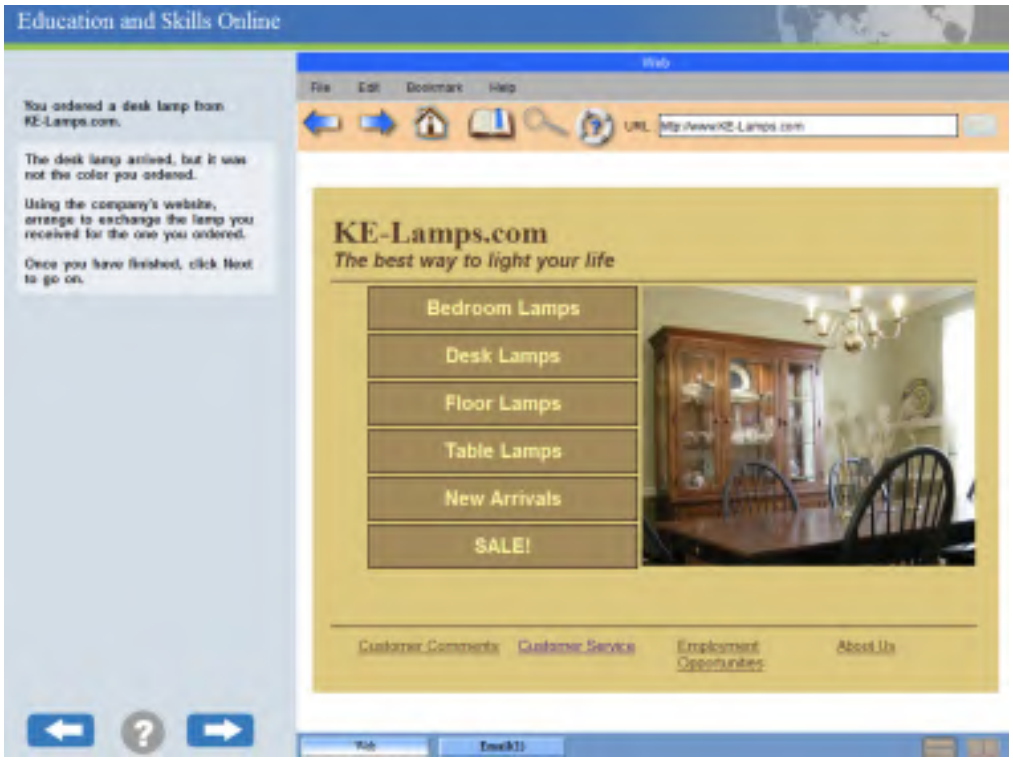
Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Example: Digital skill item in PIAAC Back

Digital skills

- Skills in problem-solving in technology-rich environments
- "Use digital technology, communication tools, and networks to acquire and evaluate information, communicate with others, and perform practical tasks"
- Test scores measured on a 500-point scale



U.S. sample: Training and automation risk in 2012 and 2017

Training and automation risk

	(1) Automation Risk (2012 and 2017)	(2) Automation Risk (2012)	(3) Automation Risk (2017)
Job training	-0.0388***	-0.0323***	-0.0504***
	(0.0053)	(0.0067)	(0.0086)
Numeracy Skills	0.0034	0.0010	0.0056
	(0.0035)	(0.0045)	(0.0056)
Observations	4073	2430	1643
R^2	0.27	0.31	0.26
Country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Entropy Balancing	Yes	Yes	Yes

Robust standard errors in parentheses
$^{*}\ p < 0.10,\ ^{**}\ p < 0.05,\ ^{***}\ p < 0.01$

Back