How routine tasks affect labor market inequalities between vocational and tertiary graduates over the career

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Supplementary material

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A. Tables

Table A1: Analytic sample restrictions and the associated changes in case numbers

Criteria	Person-years		Persons	
	N	%	N	%
Initial sample	**761,461**	**100**	**104,643**	**100**
Not employed	447,394	58.8	74284	71.0
Outside age range (25-65)	393,396	51.7	63,237	60.4
Missing occupation	376,823	49.5	60,248	57.6
No vocational or tertiary degree	318,917	41.9	48,462	46.3
Missing income information	318,903	41.9	48,462	46.3
Analytic sample	**318,903**	**41.9**	**48,462**	**46.3**

Notes: The numbers in each row represent the new sample size (N / %) after applying the respective restriction.

Table A2: Mean RTI and N for ISCO88COM 3-digit occupational categories

ISCO88com three-digit code	Mean RTI	N
231. College, university and higher education teaching professionals	-0.718	405
242. Legal professionals	-0.662	465
111. Legislators and senior government officials	-0.600	40
246. Religious professionals	-0.545	121
312. Computer associate professionals	-0.541	837
213. Computing professionals	-0.517	1,148
114. Senior officials of special-interest organisations	-0.493	94
234. Special education teaching professionals	-0.448	231
214. Architects, engineers and related professionals	-0.444	2,510
245. Writers and creative or performing artists	-0.433	652
235. Other teaching professionals	-0.430	297
211. Physicists, chemists and related professionals	-0.427	118
244. Social science and related professionals	-0.401	1,380
232. Secondary education teaching professionals	-0.392	2,017
241. Business professionals	-0.360	1,853
233. Primary and pre-primary education teaching professionals	-0.346	481
212. Mathematicians, statisticians and related professionals	-0.336	31
123. Other specialist managers	-0.316	795
334. Other teaching associate professionals	-0.313	397
347. Artistic, entertainment and sports associate professionals	-0.296	310
247. Public service administrative professionals	-0.296	1,016
121. Directors and chief executives	-0.289	525
221. Life science professionals	-0.266	79
131. Managers of small enterprises	-0.231	1,533
332. Pre-primary education teaching associate professionals	-0.201	1,130
322. Health associate professionals (except nursing)	-0.197	781
345. Police inspectors and detectives	-0.167	267
122. Production and operations managers	-0.160	620
222. Health professionals (except nursing)	-0.141	844
311. Physical and engineering science technicians	-0.124	2,119
615. Fishery workers, hunters and trappers	-0.102	2
342. Business services agents and trade brokers	-0.077	426
733. Handicraft workers in wood, textile, leather and related materials	-0.072	5
243. Archivists, librarians and related information professionals	-0.047	99
724. Electrical and electronic equipment mechanics and fitters	-0.036	620
313. Optical and electronic equipment operators	-0.035	200
333. Special education teaching associate professionals	-0.031	139
341. Finance and sales associate professionals	-0.030	2,403
723. Machinery mechanics and fitters	0.040	1,144

811. Mining and mineral-processing-plant operators	0.040	6
742. Wood treaters, cabinet-makers and related trades workers	0.063	303
816. Power-production and related plant operators	0.082	108
412. Numerical clerks	0.090	1,467
713. Building finishers and related trades workers	0.092	1,326
346. Social work associate professionals	0.097	818
744. Pelt, leather and shoemaking trades workers	0.113	26
343. Administrative associate professionals	0.115	2,953
516. Protective services workers	0.122	529
323. Nursing and midwifery associate professionals	0.130	1,791
712. Building frame and related trades workers	0.130	483
315. Safety and quality inspectors	0.133	400
344. Customs, tax and related government associate professionals	0.155	1,413
611. Market gardeners and crop growers	0.155	644
914. Building caretakers, window and related cleaners	0.162	497
419. Other office clerks	0.174	1,951
722. Blacksmiths, tool-makers and related trades workers	0.177	552
721. Metal moulders, welders, sheet-metal workers	0.183	655
931. Mining and construction labourers	0.185	54
348. Religious associate professionals	0.208	13
411. Secretaries and keyboard-operating clerks	0.217	631
612. Animal producers and related workers	0.225	119
513. Personal care and related workers	0.227	1,438
511. Travel attendants and related workers	0.231	67
731. Precision workers in metal and related materials	0.233	214
413. Material-recording and transport clerks	0.233	929
734. Craft printing and related trades workers	0.238	221
743. Textile, garment and related trades workers	0.243	167
514. Other personal services workers	0.243	403
711. Miners, shotfirers, stone cutters and carvers	0.245	43
314. Ship and aircraft controllers and technicians	0.247	87
321. Life science technicians and related associate professional	0.256	295
614. Forestry and related workers	0.270	51
422. Client information clerks	0.284	517
825. Printing-, binding- and paper-products machine operators	0.348	29
522. Shop, stall and market salespersons and demonstrators	0.348	1,785
512. Housekeeping and restaurant services workers	0.351	1,260
814. Wood-processing- and papermaking-plant operators	0.372	46
823. Rubber- and plastic-products machine operators	0.375	136
741. Food processing and related trades workers	0.379	248
732. Potters, glass-makers and related trades workers	0.384	75

833. Agricultural and other mobile plant operators	0.407	337
714. Painters, building structure cleaners and related trades workers	0.411	419
829. Other machine operators not elsewhere classified	0.440	284
921. Agricultural, fishery and related labourers	0.441	78
815. Chemical-processing-plant operators	0.445	220
821. Metal- and mineral-products machine operators	0.449	287
911. Street vendors and related workers	0.458	2
832. Motor vehicle drivers	0.462	1,209
812. Metal-processing plant operators	0.473	93
831. Locomotive engine drivers and related workers	0.487	165
414. Library, mail and related clerks	0.488	397
933. Transport labourers and freight handlers	0.502	324
421. Cashiers, tellers and related clerks	0.532	426
826. Textile-, fur- and leather-products machine operators	0.538	104
813. Glass, ceramics and related plant operators	0.558	6
822. Chemical-products machine operators	0.558	83
915. Messengers, porters, doorkeepers and related workers	0.581	210
827. Food and related products machine operators	0.582	137
916. Garbage collectors and related labourers	0.631	44
828. Assemblers	0.647	81
834. Ships' deck crews and related workers	0.674	2
932. Manufacturing labourers	0.692	617
913. Domestic and related helpers, cleaners and launderers	0.729	807
824. Wood-products machine operators	0.993	4

Notes: Based on pooled observations from BiBB/BAuA Employment survey (2018, 2012, 2006).

Table A3: KOB decomposition with task complexity as an additional predictor

	Income		Unemployment risk	
	Estimate	SE	Estimate	SE
Mean outcome – Tertiary educ.	4,010.067	3.878	0.032	0.001
Mean outcome – Vocational educ.	2,506.743	1.627	0.046	0.000
Outcome difference	**1,503.324**	**4.202**	**-0.014**	**0.001**
Endowment effects				
RTI	11.463	7.084	0.013	0.002
Task complexity	203.130	5.520	-0.018	0.001
Coefficient effects				
RTI	85.710	11.265	-0.001	0.002
Task complexity	-143.499	9.015	0.004	0.001
Interaction				
RTI	-250.385	18.467	0.008	0.003
Task complexity	321.449	20.164	-0.008	0.003
Intercept difference	1,275.457	13.827	-0.011	0.003

Notes: From the perspective of vocationally trained workers with tertiary graduates as the reference category. Coefficients were obtained from person-fixed effects regression. RTI is measured categorically, and coefficients were normalized as suggested in Yun (2005). Task complexity is measured using three items "How often do these activities occur in your work: working with computers (1-3)", "How often does it occur in your work, that you have to make difficult decisions on your own? (1-3)", "How often does it occur in your work, that you have to react to problems and solve them?". Responses are averaged across respondents and occupations to build a complexity index included in the decomposition as a continuous variable.

Table A4: KOB decomposition when measuring education at age 30 instead of 25

	Income		Unemployment risk	
	Estimate	SE	Estimate	SE
Mean outcome – Tertiary educ.	4,116.869	3.873	0.030	0.001
Mean outcome – Vocational educ.	2,530.964	1.647	0.042	0.000
Outcome difference	**1,585.905**	**4.192**	**-0.012**	**0.001**
$\overline{RTI}$ *per category – Tertiary educ.*				
< -0.6	0.052	0.001	0.052	0.001
-0.6 to -0.4	0.309	0.002	0.309	0.002
-0.4 to -0.2	0.270	0.002	0.270	0.002
-0.2 to 0.0	0.154	0.001	0.154	0.001
0.0 to 0.2	0.126	0.001	0.126	0.001
0.2 to 0.4	0.059	0.001	0.059	0.001
0.4 to 0.6	0.021	0.000	0.021	0.000
> 0.6	0.010	0.000	0.010	0.000
$\overline{RTI}$ *per category – Vocational educ.*				
< -0.6	0.001	0.000	0.001	0.000
-0.6 to -0.4	0.037	0.000	0.037	0.000
-0.4 to -0.2	0.071	0.001	0.071	0.001
-0.2 to 0.0	0.150	0.001	0.150	0.001
0.0 to 0.2	0.342	0.001	0.342	0.001
0.2 to 0.4	0.235	0.001	0.235	0.001
0.4 to 0.6	0.116	0.001	0.116	0.001
> 0.6	0.049	0.000	0.049	0.000
Endowment effect	**149.463**	**6.136**	**0.002**	**0.002**
$\breve{\beta}$ *per category – Tertiary educ.*				
< -0.6	-110.615	37.229	0.003	0.005
-0.6 to -0.4	119.657	17.994	0.001	0.003
-0.4 to -0.2	249.256	17.511	0.001	0.002
-0.2 to 0.0	217.552	19.674	-0.009	0.003
0.0 to 0.2	77.355	19.062	-0.006	0.003
0.2 to 0.4	-97.024	24.261	-0.002	0.003
0.4 to 0.6	-163.396	41.037	0.001	0.006
> 0.6	-292.785	58.125	0.012	0.008
$\breve{\beta}$ *per category – Vocational educ.*				
< -0.6	236.571	54.659	0.030	0.013
-0.6 to -0.4	148.359	14.543	-0.002	0.004
-0.4 to -0.2	174.102	11.692	-0.004	0.003
-0.2 to 0.0	40.997	10.201	-0.004	0.003
0.0 to 0.2	-60.779	9.510	-0.004	0.002
0.2 to 0.4	-143.591	9.880	-0.003	0.002
0.4 to 0.6	-150.438	11.447	-0.007	0.003
> 0.6	-245.221	14.016	-0.005	0.003
Coefficient effect	**84.507**	**11.861**	**0.001**	**0.002**
Interaction	-44.535	12.792	-0.001	0.002
Intercept difference	1,396.470	14.406	-0.015	0.003

Notes: Analytic sample is restricted to observations aged between 30 and 65. From the perspective of vocationally trained workers with tertiary graduates as the reference category. $\overline{RTI}$ is mean routine task intensity. $\breve{\beta}$ is the normalized regression coefficient obtained from person fixed effects models.

Table A5: KOB decomposition of income for different occupational levels

Income	High-level occup.		Medium-level occup		Low-level occup.	
	Estimate	SE	Estimate	SE	Estimate	SE
Mean outcome – Tert. educ.	4,287.15	4.23	2,350.99	8.16	2,028.60	10.02
Mean outcome – Voc. educ.	3,039.10	3.03	1,959.71	2.35	2,361.61	2.24
Outcome difference	**1,248.05**	**5.21**	**391.28**	**8.49**	**-333.01**	**10.26**
$\overline{RTI}$ *per category – Tert. educ.*						
< -0.6	0.06	0.00	.	.	.	.
-0.6 to -0.4	0.36	0.00	.	.	.	.
-0.4 to -0.2	0.31	0.00	.	.	.	.
-0.2 to 0.0	0.17	0.00	.	.	0.07	0.00
0.0 to 0.2	0.09	0.00	0.40	0.01	0.26	0.01
0.2 to 0.4	0.01	0.00	0.54	0.01	0.13	0.01
0.4 to 0.6	.	.	0.07	0.00	0.32	0.01
> 0.6	.	.	.	.	0.22	0.01
$\overline{RTI}$ *per category – Voc. educ.*						
< -0.6	0.00	0.00	.	.	.	.
-0.6 to -0.4	0.11	0.00	.	.	.	.
-0.4 to -0.2	0.19	0.00	.	.	.	.
-0.2 to 0.0	0.33	0.00	.	.	0.07	0.00
0.0 to 0.2	0.34	0.00	0.32	0.00	0.37	0.00
0.2 to 0.4	0.03	0.00	0.61	0.00	0.15	0.00
0.4 to 0.6	.	.	0.07	0.00	0.27	0.00
> 0.6	.	.	.	.	0.13	0.00
Endowment effect	**50.56**	**7.22**	**4.65**	**0.95**	**-8.18**	**1.71**
$\check{\beta}$ *per category – Tert. educ.*						
< -0.6	-302.79	35.06	.	.	.	.
-0.6 to -0.4	-17.28	18.07	.	.	.	.
-0.4 to -0.2	142.59	17.45	.	.	.	.
-0.2 to 0.0	116.68	20.85	.	.	59.86	71.33
0.0 to 0.2	76.63	23.34	-49.24	28.55	77.98	41.90
0.2 to 0.4	-15.83	55.66	-154.36	31.09	30.92	51.83
0.4 to 0.6	.	.	203.60	46.31	-97.29	42.05
> 0.6	.	.	.	.	-71.47	47.32
$\check{\beta}$ *per category – Voc. educ.*						
< -0.6	78.26	59.22	.	.	.	.
-0.6 to -0.4	35.35	18.80	.	.	.	.
-0.4 to -0.2	124.02	16.38	.	.	.	.
-0.2 to 0.0	-16.45	15.71	.	.	38.69	13.19
0.0 to 0.2	-61.52	16.10	5.50	8.33	31.04	7.77
0.2 to 0.4	-159.65	26.81	-62.04	8.30	-8.23	9.49
0.4 to 0.6	.	.	56.54	12.83	-18.99	8.17
> 0.6	.	.	.	.	-42.51	11.38
Coefficient effect	**91.77**	**17.05**	**-63.16**	**20.13**	**-0.19**	**13.36**
Interaction	-91.45	11.30	1.45	3.09	-12.84	7.79
Intercept difference	1,197.17	17.97	448.35	21.45	-311.80	16.72

Notes: From the perspective of vocationally trained workers with tertiary graduates as the reference category. Occupational categories are based on 1-digit ISCO88-COM groups (High=1-3; Medium=4-6, Low=7-9). Some estimates are missing because not all occupational categories have observations for all levels of RTI.

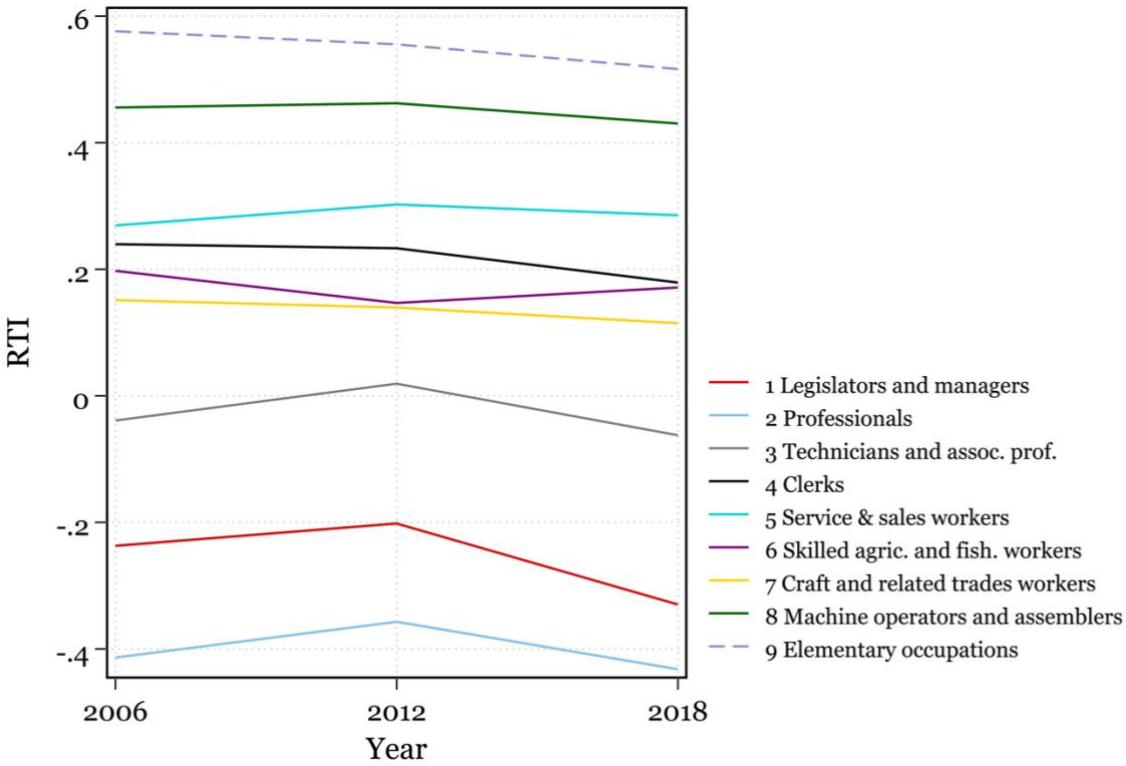
Table A6*:* KOB decomposition of unemployment risk for different occup. levels

Unemployment risk	High-level occup.		Medium-level occup		Low-level occup.	
	Estimate	SE	Estimate	SE	Estimate	SE
Mean outcome – Tert. educ.	0.028	0.001	0.052	0.002	0.067	0.003
Mean outcome – Voc. educ.	0.035	0.001	0.053	0.001	0.051	0.001
Outcome difference	**-0.007**	**0.001**	**-0.002**	**0.002**	**0.016**	**0.003**
$\overline{RTI}$ *per category – Tert. educ.*						
< -0.6	0.062	0.001	.	.	.	.
-0.6 to -0.4	0.356	0.002	.	.	.	.
-0.4 to -0.2	0.311	0.002	.	.	.	.
-0.2 to 0.0	0.172	0.001	.	.	0.067	0.004
0.0 to 0.2	0.091	0.001	0.396	0.006	0.257	0.007
0.2 to 0.4	0.009	0.000	0.538	0.006	0.131	0.005
0.4 to 0.6	.	.	0.066	0.003	0.323	0.007
> 0.6	.	.	.	.	0.221	0.006
$\overline{RTI}$ *per category – Voc. educ.*						
< -0.6	0.004	0.000	.	.	.	.
-0.6 to -0.4	0.106	0.001	.	.	.	.
-0.4 to -0.2	0.187	0.001	.	.	.	.
-0.2 to 0.0	0.330	0.002	.	.	0.072	0.001
0.0 to 0.2	0.338	0.002	0.316	0.002	0.371	0.002
0.2 to 0.4	0.034	0.001	0.612	0.002	0.153	0.001
0.4 to 0.6	.	.	0.072	0.001	0.270	0.002
> 0.6	.	.	.	.	0.135	0.001
Endowment effect	**0.002**	**0.001**	**-0.000**	**0.000**	**-0.001**	**0.001**
$\check{\beta}$ *per category – Tert. educ.*						
< -0.6	0.007	0.005	.	.	.	.
-0.6 to -0.4	0.001	0.002	.	.	.	.
-0.4 to -0.2	-0.000	0.002	.	.	.	.
-0.2 to 0.0	-0.009	0.003	.	.	0.048	0.023
0.0 to 0.2	-0.006	0.003	0.003	0.007	0.019	0.013
0.2 to 0.4	0.007	0.007	0.004	0.008	-0.034	0.017
0.4 to 0.6	.	.	-0.007	0.012	-0.023	0.013
> 0.6	.	.	.	.	-0.010	0.015
$\check{\beta}$ *per category – Voc. educ.*						
< -0.6	0.008	0.011	.	.	.	.
-0.6 to -0.4	0.003	0.003	.	.	.	.
-0.4 to -0.2	-0.001	0.003	.	.	.	.
-0.2 to 0.0	-0.003	0.003	.	.	0.003	0.004
0.0 to 0.2	-0.001	0.003	0.000	0.003	0.004	0.002
0.2 to 0.4	-0.006	0.005	0.002	0.003	0.004	0.003
0.4 to 0.6	.	.	-0.003	0.004	-0.007	0.002
> 0.6	.	.	.	.	-0.004	0.003
Coefficient effect	**-0.003**	**0.003**	**0.002**	**0.005**	**-0.002**	**0.004**
Interaction	0.001	0.002	0.000	0.001	-0.002	0.002
Intercept difference	-0.007	0.003	-0.003	0.006	0.022	0.005

Notes: From the perspective of vocationally trained workers with tertiary graduates as the reference category. Occupational categories are based on 1-digit ISCO88-COM groups (High=1-3; Medium=4-6, Low=7-9). Some estimates are missing because not all occupational categories have observations for all levels of RTI.

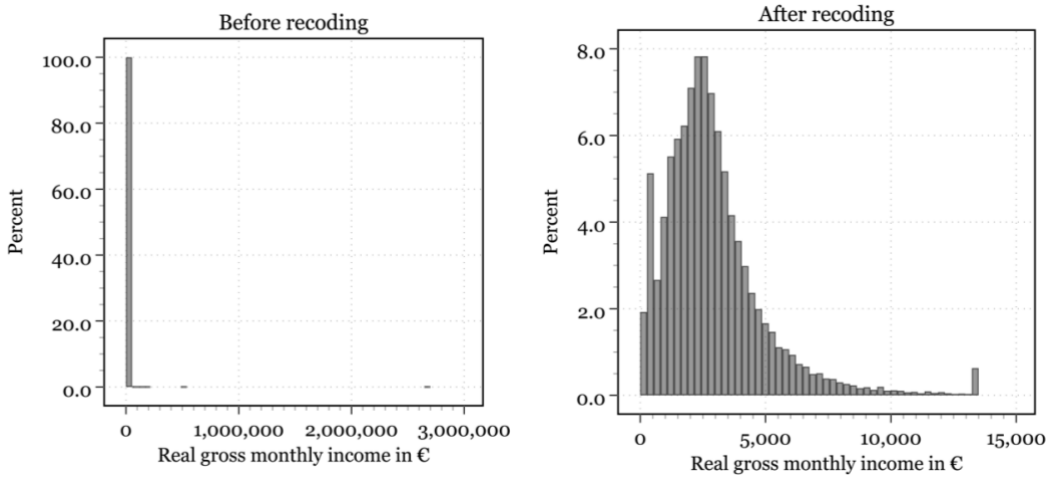
B. Figures

Figure B1: Change in task routineness over time for all major ISCO88 categories



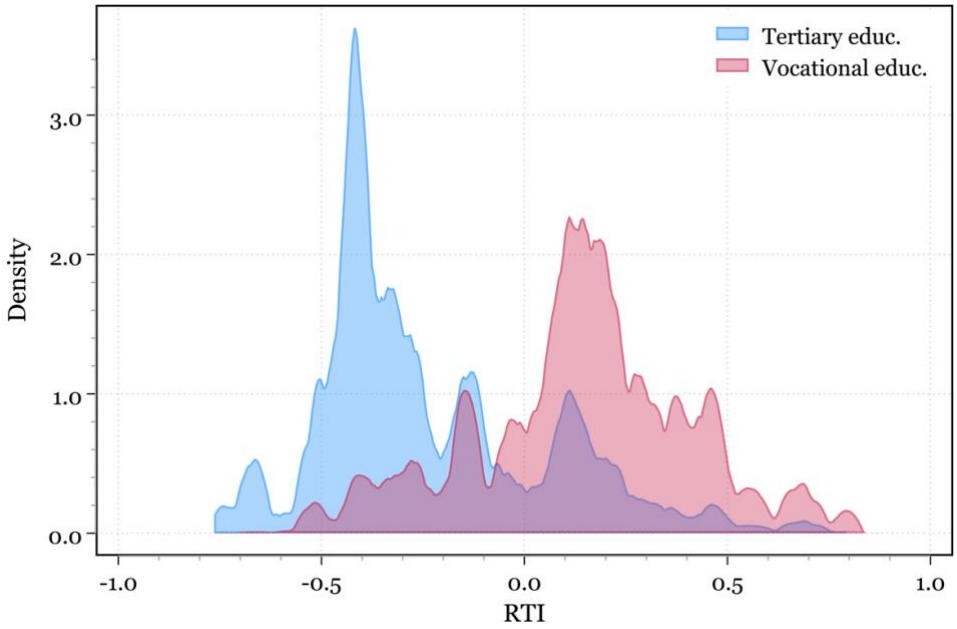
Notes: Occupation-level averages calculated from aggregated individual-level data from the BIBB/BAuA Employment survey waves in 2006, 2012, and 2018.

Figure B2: Distributions of real income before and after recoding the top 0.5 percent.



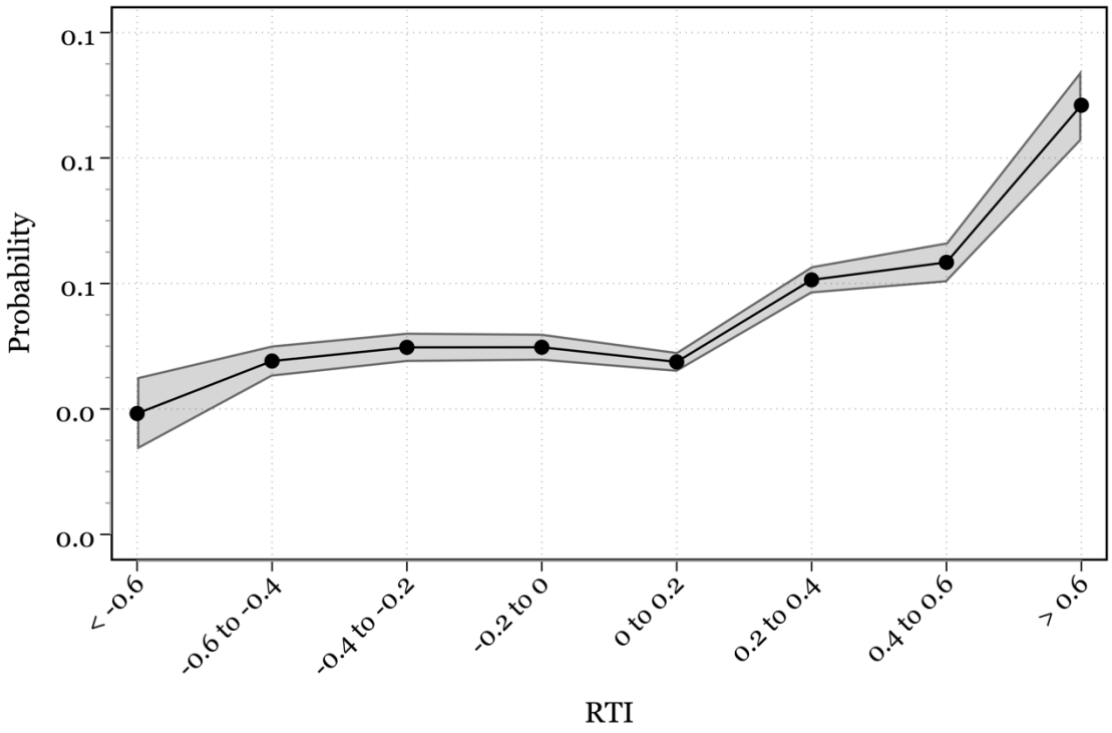
Notes: Bins are set to 50. The increase on the left side of the distribution in the right graph is due to "Minijobbers" – workers in Germany with marginal employment contracts that are exempt from taxes and social security contributions. Minijobbers typically earn around €450 per month.

Figure B3: Distributions of RTI for vocational and tertiary education



Notes: Kernal density estimates are obtained using the Epanechnikov kernel function. We specify the half-width of the kernel to be 0.02.

Figure B4: Marginal probabilities to change occupation for levels of RTI



Notes: Obtained from unadjusted linear probability regression. Occupational mobility is measured as a change in three-digit ISCO codes with individuals reporting job change in the respective year as an additional criterion. See Decker et al. (2023) for more information on measurement. Shaded areas represent 95% confidence intervals.