Online Appendix:
"Interpersonal, cognitive, and manual skills: How do they shape employment and wages?"

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Abstract

We study how interpersonal, cognitive, and manual skills affect employment and wages in a search and matching model through their impact on productivity, complementarity, job destruction, and the cost of unemployment. Combining several data sets on workers who acquired skills in vocational education and training (VET), we quantify each channel, allowing for unobserved heterogeneity in ability. All three skills increase productivity, yet they affect job destruction rates differentially. While manual skills are associated with lower job destruction, interpersonal and cognitive skills have the opposite effect. Focusing on low-ability workers, we then estimate the value of VET. Through VET, wages increase up to 10% and unemployment drops by over 50%. Low-ability workers thus have particularly large benefits from acquiring manual skills because they increase wages and shield from unemployment.

Keywords: Multidimensional skills, unemployment, wages, vocational education and training, labour market search.
JEL classification numbers: E24, J23, J24, J64.

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A   The Swiss Education System

Figure A.1 presents a simplified overview of the educational system in Switzerland. The education system is geographically diverse as the authority over education lies with the cantons rather than with the federal government. This figure shows some of these cantonal differences such as the different timing of when tracking starts (i.e. in most cantons primary school lasts six years and tracking starts in year 7, however, in some cantons tracking starts as early as year 5). Moreover, in some cantons VET is primarily available through training at host firms, while other cantons (mostly in the French-speaking parts) also offer it through vocational schools.
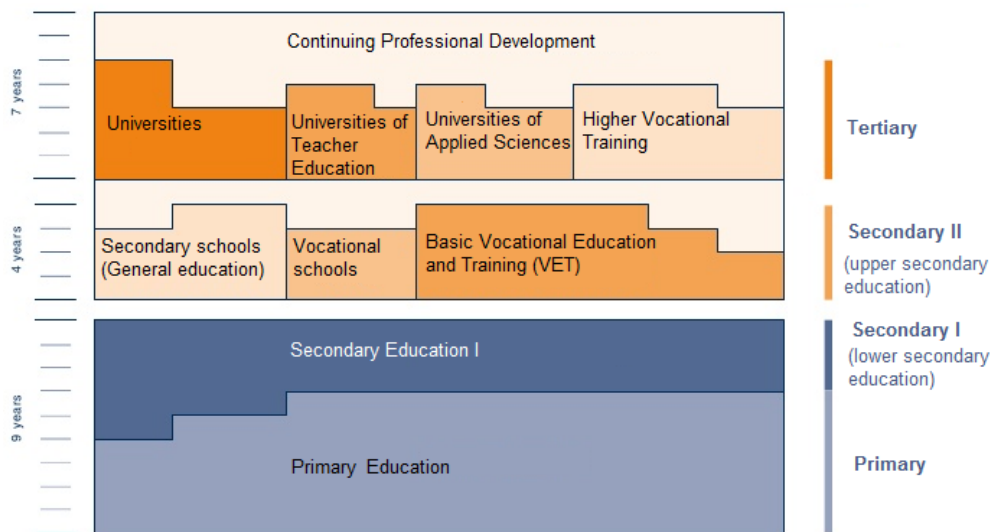

Figure A.1: Educational system in Switzerland
Source: PH Zürich. Modified by Authors.

B   Selection into vocational and general education

We present further evidence on selection into vocational and general education in Switzerland. We use the "Transitions from Education to Employment" longitudinal study (TREE). The TREE study is a panel survey which follows students through their post-compulsory education and training into employment. The data collects information about the standardised PISA test scores and self-assessed personality traits prior to completing compulsory education. It also records education, training and employment outcomes of study participants in subsequent waves. The data used in this paper covers one cohort of approximately 2,000 students in their last year of compulsory education in year 2000 (wave 1).[1]

Figure B.1 presents the distribution of standardised PISA test scores in reading and maths (as a measure of ability) and the distribution of self-assessed personality traits (persistence, locus of control and ambition) of male pupils in their last year of compulsory education. We split the pupils according to their future education pathway: compulsory education, vocational education (3- or 4-year VET) only, vocational + tertiary education, and general education.

We find a fair amount of heterogeneity in PISA test scores both within and across education groups. Pupils in the vocational education track have on average lower reading and maths test scores than those in the general education track, but higher scores than those with compulsory education only. Distinguishing vocational pupils by their future education level is crucial. The PISA test scores distributions of vocational pupils who later enrol in tertiary education dominate the ones of "only vocational" pupils, but they are similar to those of general education pupils. This suggests that "vocational + tertiary" pupils have comparable academic abilities to their peers in general education. In contrast, reading and maths scores of most pupils with only vocational education fall short of the median pupil in general education. Instead, their score distributions resemble those of pupils with only compulsory education.

In terms of personality traits, differences across education tracks are less stark. For locus of control and ambition, the respective distributions differ only marginally. For persistence, we find that pupils in the vocational and general education track are on average more persistent than those who do not go beyond compulsory education.

Table B.1 provides summary statistics for PISA test scores (reading, maths) and personality traits by education tracks (upper panel), as well as by occupation cluster (as defined in the beginning of Section **??**) for those within the vocational education track. It also gives the share of each occupation cluster who enrol in tertiary education within 10 years.

Breaking up the vocational education track into occupation clusters which differ in their skill
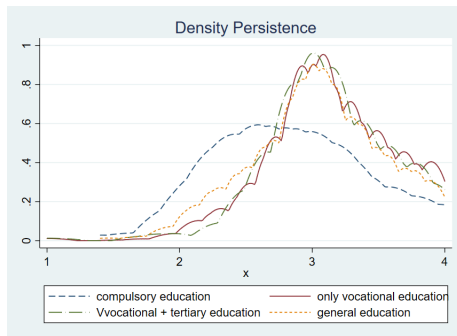
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[1]Due to sample size issues, non-negligible attrition in subsequent waves and missing information, this data cannot be used to estimate the labour market model in our paper.
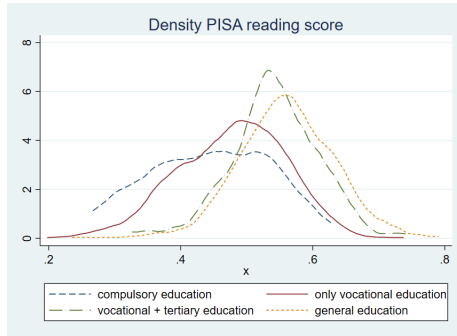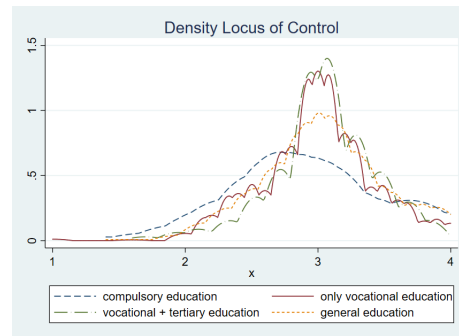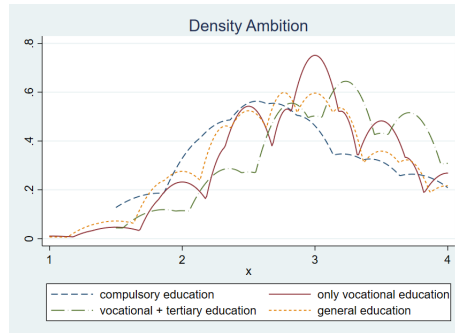
(a) PISA reading test score
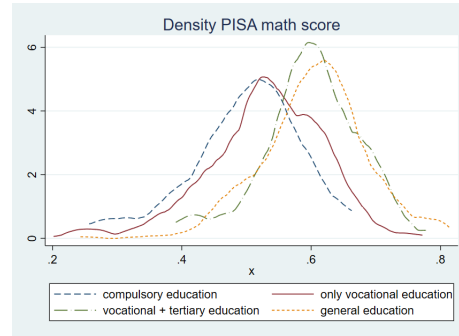
(b) PISA math test score

(c) Persistence (self-assessed)

(d) Locus of Control (self-assessed)

(e) Ambition (self-assessed)

Figure B.1: Selection into compulsory, vocational, and general education

Notes: Standardised PISA reading and maths test scores lie between 0 and 1. Personality traits "Persistence", "Locus of control" and "Ambition" are the average over a number of ordinal survey questions relative to each trait which can take on value 1 'not at all true', 2 'hardly true', 3 'moderately true', and 4 'exactly true'. We distinguish: compulsory education (those who do not enrol in any further education programme), only vocational education (those who complete vocational education, but do not enrol in tertiary education within 10 years of graduation), vocational + tertiary education (those who complete vocational education and eventually enrol into tertiary education within 10 years after graduating from VET), and general education (those who complete 12 or 13 years of general education such as Gymnasium).

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Table B.1: PISA SCORES AND PERSONALITY TRAITS

				PISA read			PISA maths			Persistence			LoC		Ambition		Enrol in tertiary
				Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Mean	SD	Mean	SD	
Compulsory education				77	0.44	0.09	39	0.50	0.09	48	2.88	0.62	2.94	0.59	2.81	0.69	n.a.
Vocational education (all)				1,311	0.49	0.08	697	0.54	0.09	1,080	3.15	0.48	3.01	0.42	2.99	0.63	16.6%
of which: only vocational				1,093	0.48	0.08	580	0.53	0.09	890	3.15	0.49	3.00	0.43	2.96	0.62	
of which: enrol in tertiary				218	0.54	0.07	117	0.60	0.07	190	3.14	0.48	3.04	0.39	3.12	0.64	
General education				689	0.56	0.07	373	0.61	0.08	585	3.05	0.51	3.05	0.46	2.87	0.65	
Vocational education by occupation cluster																	
	Interpers.	Manual	Cognitive														
	High	High	Low	3	0.50	0.07	1	0.53	0	3	3.53	0.31	3.33	0.58	3.17	0.29	n.a.
	High	Low	High	39	0.50	0.09	20	0.55	0.06	29	2.99	0.57	2.88	0.43	2.87	0.67	12.8%
	High	Low	Medium	50	0.48	0.08	28	0.52	0.08	44	3.10	0.59	2.96	0.56	2.95	0.66	4.0%
	High	Low	Low	0			0			0							
	Medium	High	High	1	0.55	n.a.	0			1	3.20	n.a.	2.40	n.a.	2.50	n.a.	n.a.
	Medium	High	Medium	21	0.45	0.06	14	0.55	0.05	18	3.00	0.38	3.11	0.33	3.06	0.66	0%
	Medium	High	Low	26	0.48	0.08	13	0.49	0.09	20	3.13	0.52	2.94	0.46	3.13	0.67	11.5%
	Medium	Low	High	144	0.54	0.07	76	0.59	0.09	115	3.05	0.51	2.99	0.49	2.93	0.65	31.3%
	Medium	Low	Medium	38	0.44	0.07	23	0.50	0.08	31	3.27	0.49	3.01	0.44	2.97	0.60	5.3%
	Medium	Low	Low	99	0.49	0.08	47	0.56	0.09	83	3.14	0.53	3.07	0.40	2.94	0.68	23.2%
	Low	High	High	57	0.47	0.09	35	0.51	0.11	45	3.21	0.44	3.06	0.38	3.06	0.65	7.0%
	Low	High	Medium	50	0.42	0.10	20	0.48	0.09	38	3.25	0.57	3.01	0.55	2.93	0.72	4.0%
	Low	High	Low	38	0.47	0.08	22	0.50	0.09	31	3.19	0.45	3.08	0.49	2.95	0.61	10.5%
	Low	Low	High	5	0.52	0.07	1	0.57	0	3	3.33	0.31	3.07	0.31	3.33	0.76	20.0%
	Low	Low	Medium	32	0.45	0.08	21	0.54	0.08	23	3.30	0.42	3.07	0.31	3.23	0.61	6.3%
	Low	Low	Low	18	0.49	0.07	10	0.54	0.07	18	3.29	0.41	3.06	0.43	3.06	0.66	11.1%
Vocational education (only matched)				619	0.49	0.09	329	0.54	0.09	501	3.15	0.51	3.02	0.45	2.98	0.65	

Notes: Standardised PISA reading and maths test scores lie between 0 and 1. Personality traits "Persistence", "LoC" (Locus of control) and "Ambition" are the average over a number of ordinal survey questions relative to each trait. They can take on value 1 "not at all true", 2 "hardly true", 3 "moderately true", and 4 "exactly true". "Enrol in tertiary" denotes the share who enrol in tertiary education within 10 years of graduating from compulsory education.

mix reveals a large heterogeneity across clusters. Pupils in some VET occupations (like occupation cluster 11 with intermediate interpersonal, low manual and intermediate cognitive skills, or cluster 14 with low interpersonal, high manual and intermediate cognitive skills) have on average the same abilities as those with only compulsory education. In contrast, pupils in other VET occupations (like cluster 10 with intermediate interpersonal, low manual, and high cognitive skills) resemble quite closely pupils in general education in terms of their cognitive abilities and personality traits. Their rate of enrolling in tertiary education within 10 years is also much higher than the one of the former groups.

Overall, we find that the distributions of personality traits and abilities of pupils in different education tracks overlap to a large extent. Pupils in the vocational education track at the lower ability end resemble those who only get compulsory education, while pupils at the higher end resemble those who pursue a general education track. By focussing our analysis on workers who complete vocational education, but do not eventually enrol in tertiary education, we limit the heterogeneity in unobserved ability to a considerable degree.

C BIZ skill measures and their robustness

All BIZ skills are classified either as interpersonal, cognitive or manual according to Zihlmann et al. (2012). We use 24 out of 26 skills. Interpersonal skills include high sense of responsibility, high ability to work in a team, high sociability, communication talent, service orientation, hygiene awareness, high reliability, high mental stability, patience, and high empathy. Cognitive skills include mental flexibility, abstract-logical thinking skills, practical understanding, spatial visualisation ability, technical understanding, talent for languages (oral and written), creativity, sense of aesthetics, and organisational talent. The manual skills include physical agility, manual dexterity, good fine motor skills, good sense of taste and smell, and head for heights. The two excluded "skills" are robust health and strong physique because they describe physical attributes rather than skills that can be acquired.

We add up the number of acquired skills within each of the three skills. Each worker has acquired 0 to 5 interpersonal skills, 0 to 5 cognitive skills, and 0 to 3 manual skills. Figure C.1 visualises the different skill bundles supplied by the workers in our sample. It displays the joint distribution of cognitive and interpersonal skills for each of the four different values of manual skills.
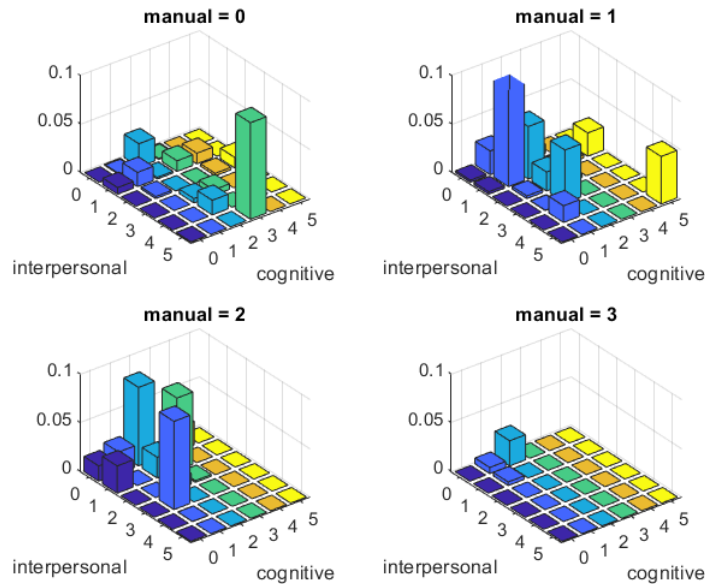
Figure C.1: Skill bundles supplied by workers

Given the range of each skill, there are $6 \times 6 \times 4 = 144$ possible skill bundles. Effectively, we observe only 45 of them in our sample. Not all skill bundles are equally frequent. Some skill bundles make up 5% or more of the sample, for other skill bundles we do not have a single observation. Generally, skill bundles close to the horizontal 00-55 line (0 interpersonal-0 cognitive to 5 interpersonal-5 cognitive) are somewhat more frequent than those off this line, reflecting the

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positive correlation of these skills. The two most common skill bundles are the 5 interpersonal - 3 cognitive - 0 manual skills bundle (which includes administrative assistants), and the 1 interpersonal - 1 cognitive - 1 manual skills bundle (which includes car mechanics). Each of these two skill bundles makes up almost 10% of the sample.

We validate our skill measures by comparing them to two alternative measures such as 1) a *relative* skill measure where interpersonal, cognitive and manual skills in each occupation are measured as a percentage of total skills and 2) a PCA-based measure where we perform Principal Component Analysis on the 24 skills of our 200 VET occupations and retain the three principal components. We then combine these three principal components and impose three exclusion restrictions to interpret the measures as interpersonal, cognitive, and manual skills.

We replicate the empirical analysis of Table **??** using these two alternative measures. The results are available upon request. Our main empirical results from the paper still stand when using the relative skill measures: Interpersonal and manual skills have significantly higher returns to wages than cognitive skills once we control for the academic requirement index (ARI) of an occupation, the effects of intermediate and high ARI on wages and unemployment are quantitatively very similar, and having acquired more interpersonal skills is associated with a significantly higher likelihoood of being unemployed. The results for the PCA-based skill measures align only partially with our main results in the paper. Higher interpersonal PCA-measured skills are still associated with significantly higher unemployment. However, the relative ranking of wage returns to PCA-measured skills now places cognitive skills before manual and interpersonal skills, while the wage premia of intermediate ARI becomes 0 and the wage premia of high ARI shrinks by one half compared to the main results. The cognitive PCA-skill measure confounds cognitive skills acquired in VET and higher ability, while interpersonal and manual PCA-based skills are highly negatively correlated (-.80 correlation coefficient). Given that the three principal components in the PCA only explain 33% of the variation in the 24 underlying binary variables, the PCA-based skill measures are not appropriate for our setting where we are interested in understanding the effect of *learned skills* on various labour market outcomes.

D Academic requirement index and skills of occupations

This appendix presents the skills and the respective shares of the low, intermediate and high academic requirement index (ARI) for each occupation cluster. The ARI is an index ranging from 1 to 6 based on Stalder (2011). We regroup Stalder's index into a baseline level (ARI of 1 or 2 or unknown), an intermediate level (ARI of 3 or 4) and a high level (ARI of 5 or 6). This information is used to ensure that our simulated model sample has approximately the same observed and unobserved characteristics as the data sample.

Table D.1: ACADEMIC REQUIREMENT INDEX AND SKILLS OF VET OCCUPATIONS

| Skills			Share in	ARI		
Interpersonal	Manual	Cognitive	sample	Baseline	Intermediate	High
High	High	Low	9.1%	5.0%	95.0%	0%
		High	14.9%	1.8%	44.9%	53.4%
	Low	Medium	7.7%	74.1%	19.8%	6.1%
		Low	1.9%	96.7%	3.3%	0%
Medium	High	High	7.9%	5.4%	79.4%	15.2%
		Medium	3.3%	66.5%	0%	33.5%
		Low	3.2%	88.3%	11.7%	0%
	Low	High	6.8%	17.3%	10.0%	72.7%
		Medium	7.5%	79.0%	18.7%	2.3%
		Low	13.2%	21.3%	67.0%	11.7%
Low	High	High	2.1%	0%	100%	0%
		Medium	10.8%	97.8%	2.2%	0%
		Low	4.4%	99.1%	0.9%	0%
	Low	High	1.1%	1.9%	64.2%	34.0%
		Medium	3.5%	42.9%	57.1%	0%
		Low	2.7%	70.2%	29.8%	0%

E   Identification: Parameters and moments

This appendix presents a table summarising which moments are used to identify all parameters in the model.

Table E.1: MODEL PARAMETERS AND CORRESPONDING MOMENTS

Parameter	Moment	#
Productivity and skill-specific demands (log-normal marginals)		
General productivity: μ_0, σ_0		
Interpersonal skills: μ_I, σ_I		
Cognitive skills: μ_C, σ_C	Mean & standard deviation of age-adjusted hourly wages by occupation cluster	32
Manual skills: μ_M, σ_M		
Correlations: $\rho_{IC}, \rho_{IM}, \rho_{CM}$		
Type-specific productivity gain: $\alpha_{\tau_m}, \alpha_{\tau_h}$	same as above, it relies on the distribution of τ being known for each occupation cluster	
Flow cost of unemployment		
Common flow cost: b_0		
Interpersonal skills cost: b_I	First percentile of age-adjusted hourly wages by occupation cluster	16
Cognitive skills cost: b_C		
Manual skills cost: b_M		
Offer arrival and destruction rates		
Offer arrival rate: λ	Yearly UE-transition rates by occupation cluster	16
General destruction rate: η_0		
Interpersonal skills marginal destruction: η_I	Yearly EU-transition rates by occupation cluster	16
Cognitive skills marginal destruction: η_C	Age-adjusted unemployment rates by occupation cluster	16
Manual skills marginal destruction: η_M		
Calibrated parameters		
Bargaining power worker: $\beta = 0.67$	Siegenthaler and Stucki (2015)	
Interest rate: $r = 0.05$		
Total moments		96

F   Goodness of fit

This appendix shows how well our model fits the observed moments. Tables F.1 and F.2 present the goodness of fit of the targeted moments. Figure F.1 displays the complete observed and simulated wage distributions (i.e. histograms) of all 16 occupation clusters. This figure goes beyond the directly targeted moments on hourly wages which only include the mean, standard deviation and lowest 1% of hourly wages for each occupation cluster.
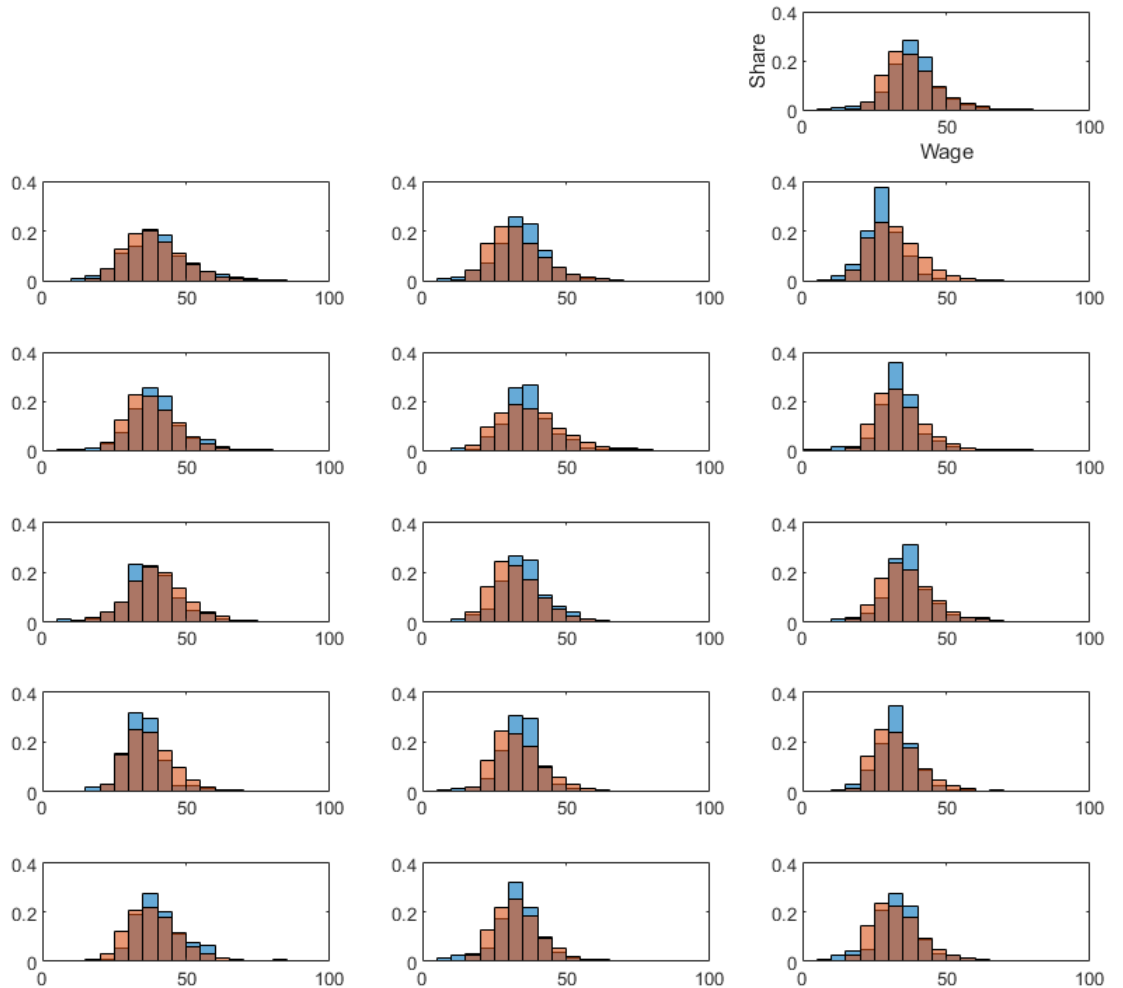
Notes: The first two lines of figures relate to the occupation clusters with high interpersonal skills (the first for high manual, the second for low manual), the two middle lines are intermediate interpersonal skills (high, low manual) and the last two lines for low interpersonal skills (high, low manual). Cognitive skills vary from high (first column), to intermediate (second column) and low (third column).

Figure F.1: Goodness of fit: Wage distributions of observed (blue) and simulated (orange) wages by occupation cluster

Table F.1: GOODNESS OF FIT I: WAGES

Skills			Mean hourly wage			Std. dev. hourly wage			Lowest 1% hourly wage		
Interpersonal	Manual	Cognitive	Observed	Std. Err.	Simulated	Observed	Std. Err.	Simulated	Observed	Std. Err.	Simulated
High	High	Low	38.49	0.28	38.10	9.27	0.29	9.06	12.58	1.46	22.34
	High	High	39.86	0.29	39.32	11.92	0.25	11.14	14.89	0.82	19.84
	Low	Medium	34.34	0.31	33.15	9.42	0.29	9.70	12.48	1.38	17.07
	Low	Low	28.03	0.43	32.42	6.37	0.34	9.11	12.70	1.77	16.96
	High	High	39.66	0.31	38.75	9.59	0.29	9.28	16.78	2.09	22.71
	High	Medium	37.29	0.49	37.33	9.96	0.52	10.71	14.81	2.50	19.07
	Low	Low	33.57	0.43	34.12	8.47	0.58	8.69	10.59	2.73	19.52
	Low	High	38.25	0.36	40.18	10.13	0.33	10.01	9.74	2.20	18.71
Medium	High	Medium	35.12	0.29	32.83	8.81	0.28	8.79	12.92	1.28	17.59
	High	Low	37.15	0.23	36.39	9.15	0.27	9.18	13.74	1.24	19.83
	Low	High	34.94	0.44	37.70	7.07	0.49	8.48	15.78	1.76	22.85
	Low	Medium	34.04	0.20	33.62	7.38	0.27	8.63	11.63	1.64	18.97
Low	High	Low	33.02	0.38	33.12	8.79	0.53	8.36	12.63	1.98	19.75
	High	High	40.83	0.80	38.94	9.06	0.87	9.41	23.15	3.95	22.09
	Low	Medium	33.03	0.42	33.38	8.47	0.40	8.64	9.65	1.68	17.89
	Low	Low	33.33	0.52	33.04	9.51	0.59	8.56	10.23	1.53	18.17
All (not directly targeted)			36.52		36.23	9.81		11.95	12.93		18.94
Contribution to loss function					286.0			112.0			273.3
Correlation obs. & sim. moments					0.86			0.72			0.61
Correlation obs. & sim. moments in model without skills					0.83			0.50			0.61

Notes: The table displays the observed moments, their standard errors and simulated counterparts from the model for the mean hourly wage, the standard deviation in hourly wages and the 1% of hourly wages. The first 16 rows relate to the targeted moments for each occupation cluster in the sample. Row 17 relates to the overall moments which are not directly targeted. Line 18 shows the correlation between the observed and simulated moments (as a measure of fit for between occupation cluster variation), while row 19 shows the same correlation between the observed and simulated moments for a model without skills (but allowing for different ARI across occupation clusters).

Table F.2: Goodness of Fit II: Unemployment and Labour Market Transitions

Skills			Unemployment rate			EU rate			UE rate		
Interpersonal	Manual	Cognitive	Observed	Std. Err.	Simulated	Observed	Std. Err.	Simulated	Observed	Std. Err.	Simulated
High	High	Low	0.038	0.006	0.038	0.023	0.006	0.027	0.500	0.104	0.658
		High	0.046	0.005	0.052	0.026	0.005	0.036	0.519	0.069	0.657
	Low	Medium	0.029	0.005	0.039	0.026	0.006	0.025	0.875	0.085	0.570
		Low	0.080	0.017	0.052	0.059	0.019	0.026	0.556	0.176	0.606
	High	High	0.017	0.004	0.031	0.006	0.003	0.018	0.500	0.224	0.649
		Medium	0.023	0.007	0.029	0.018	0.008	0.021	0.750	0.250	0.677
Medium		Low	0.024	0.007	0.028	0.019	0.008	0.017	0.800	0.200	0.625
		High	0.040	0.007	0.030	0.029	0.007	0.025	0.765	0.106	0.625
	Low	Medium	0.038	0.006	0.030	0.030	0.007	0.020	0.706	0.114	0.682
		Low	0.044	0.005	0.029	0.021	0.004	0.019	0.587	0.073	0.595
	High	High	0.027	0.010	0.025	0.037	0.015	0.018	1.000	0.250	0.639
		Medium	0.033	0.005	0.023	0.017	0.004	0.014	0.650	0.109	0.639
Low		Low	0.036	0.008	0.023	0.014	0.006	0.012	0.500	0.151	0.621
		High	0.020	0.012	0.033	0.011	0.011	0.014	0.000	0.250	0.657
	Low	Medium	0.021	0.007	0.032	0.007	0.005	0.019	0.750	0.250	0.579
		Low	0.026	0.008	0.022	0.023	0.010	0.014	0.750	0.250	0.574
All (not directly targeted)			3.49%		3.38%	2.18%		2.21%	61.0%		63.4%
Contribution to loss function					46.4			36.2			32.9
Correlation obs. & sim. moments					0.64			0.44			-0.31
Correlation obs. & sim. moments in model without skills					-0.01			0.08			0.21

Notes: The table displays the observed moments, their standard errors and simulated counterparts from the model for the unemployment rate, the employment-unemployment (EU) and the unemployment-employment (UE) yearly transition rate, respectively. The first 16 rows relate to the targeted moments for each occupation cluster in the sample. Row 17 relates to the overall moments which are not directly targeted. Row 18 shows the correlation between the observed and simulated moments (as a measure of fit for between occupation cluster variation), while line 19 shows the same correlation between the observed and simulated moments for a model without skills (but allowing for different ARIs across occupation clusters).

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G Estimation results: Compulsory education

This appendix presents the estimation results of a simple search model for a sample of workers who only have completed compulsory education. In this simplified model all parameters related to skills (i.e. skill-specific productivity, destruction rates, unemployment costs) are dropped. We use the same estimation algorithm as for the full model. Table G.1 presents the estimated parameters and standard errors, table G.2 reports the fit of the targeted moments.

Table G.1: ESTIMATED PARAMETERS: COMPULSORY EDUCATION

	Estimate	Std. Err.	Mean	Std. Dev
μ_{00}: General productivity (location)	3.78	0.07	45.72	13.47
σ_{00}: General productivity (scale)	0.29	0.02		
λ_{00}: Offer arrival rate	0.87	0.05		
$\eta_{00} * 100$: Destruction rate	5.77	0.33		
b_{00}: General unemployment cost	-246.35	55.05		

Notes: The general productivity follows a log-normal distribution. The mean is given by $\exp(\mu + \sigma^2/2)$ and the variance by $\left[exp(\sigma^2) - 1 \right] exp(2\mu + \sigma^2)$. Asymptotic standard errors are computed following French and Jones (2011).

Table G.2: GOODNESS OF FIT: COMPULSORY EDUCATION

	Observed	Std. Err.	Simulated
Mean hourly wage	30.76	0.10	30.44
Std. dev. hourly wage	8.49	0.10	8.97
Lowest 1% hourly wage	7.13	0.45	14.90
Unemployment rate	0.066	0.003	0.063
EU rate	0.032	0.002	0.037
UE rate	0.619	0.027	0.570

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