Education, Labour Market Experience and Cognitive Skills: Evidence from PIAAC

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All views and opinions are our own.

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Introduction

- How does experience-on-the job shape cognitive skills?
  - Specially among individuals with primary schooling?
- Individuals with primary schooling specially exposed to economic fluctuations
  - Charles et al., 2016, Acemoglu and Restrepo (2018)
  - Non-trivial share of labor force: 6-9pp in France or Korea, above 20pp in UK, Italy or Spain
  - Have they built skills in their previous job that can be used elsewhere?
- Production of Human capital (Ben-Porath, 1967)
  - Returns to experience in the US do not vary much by skill (Gladden and Taber, 2009), they do in DK (Sorensen and Vejlin, 2014)
- That literature studies wages, we look at cognitive skills.

What do we do?

- Measure skills using data from International Assessments of Skills of Adults (IALS, PIAAC)
  - PIAAC measures skills in different domains, can explore the role of task specialization in jobs on differential skill acquisition (literature on education: Lavy, 2015, Metzer and Woessman 2015, Silva et al. 2012)
  - IALS and PIAAC contain repeated measures of skills at the cohort level, can check evolution.
- Why looking at skill assessments and not wages?
  - Skills available for everyone, regardless of labor status
  - Evidence that skills measured in international assessments priced in the labor market (Leuven et al, 2004, Hanushek, 2015).
  - BUT, must handle selection into tasks and unobserved heterogeneity

Data

1. **Program for International Assessment of Adult Competences (PIAAC)**
   - 24 participant countries 2012, use 18 (lack of data on tasks)
   - Measure three different of cognitive skills (Numeracy, Literacy and Problem Solving)
   - Respondents who have some labor market experience
2. **International Assessment of Adult Literacy, 1994**
   - Use 13 countries for which we have two observations (one in PIAAC, another one on IALS).
   - Countries: Belgium, Czech Republic, Canada, Denmark, Finland, Ireland, Italy, Neterlands, Norway, Sweden, United Kingdom, United States
   - Use ten year cohorts (1950-1959) and (1960-1969), by gender and schooling (150 obs per cell)

- Additional countries in PIAAC: Estonia, France, Germany, Korea, Slovak Republic, Spain

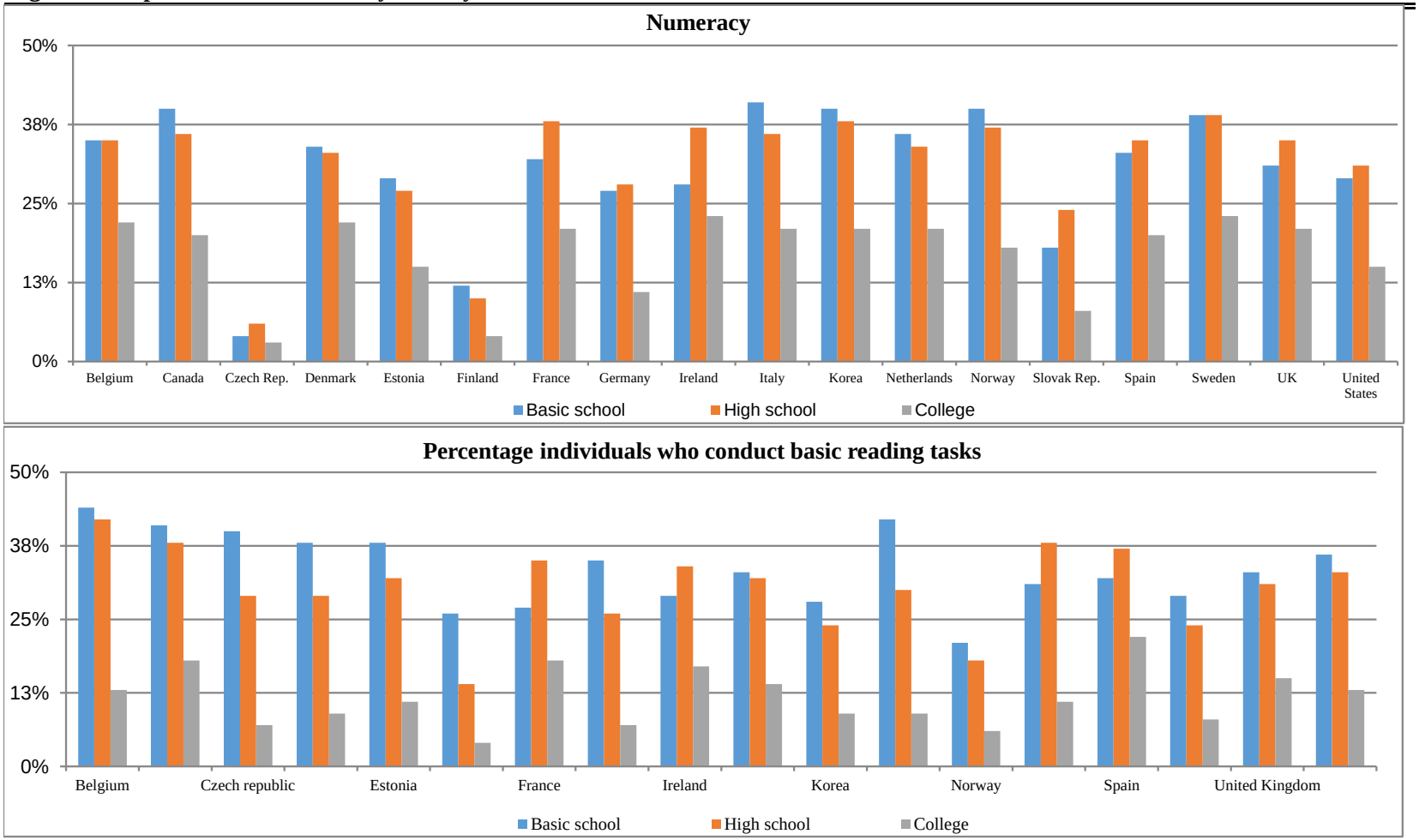
Data: PIAAC 2012

- Data on competences (mean subtracted and divided by s.d. from now on)
  1. Literacy: "understanding and using written texts".
  2. Numeracy: "using, interpreting and communicating mathematical ideas"
  3. Problem Solving "in technology-rich environments" (not available in 3 countries)
- Data on tasks performed on current or last job (**bold if basic**)
  1. Reading-related: **reading emails, guides, articles, writing reports**, reading journals, books, writing articles
  2. Math-related: **elaborating budget, using calculator or percentages**, elaborating graphs, using algebra
  3. ICT: text-processing, internet use, transactions over internet.
- Use individuals 18-35 (current tasks close to past ones). Experiment with 18-55

Data: IALS 1994

- Data on literacy (made comparable to subsequent assessments)
  1. Literacy: "understanding and using written texts".
  2. Nothing on numeracy or problem solving
- Data on tasks performed on current or last job (**bold if basic**)
  1. Reading-related: **reading letters or memos, reports articles or manuals**, writing articles or reports
  2. Math-related:reading bills, diagrams, using maths to compute costs or budgets
- Use measures that account for self-reported frequency of each task
- Use cohorts born 1950-1969 grouped in two cohorts (between 25 and 44 in IALS, between 43 and 62 in PIAAC)

Figure 1: Proportion of basic tasks by country and level of education



Source: PIAAC (2012). Basic numeric tasks include elaborating a budget, using a calculator, reading bills, using fractions or percentages, reading diagrams. Basic reading tasks include reading email, reading guides, reading manuals, writing emails, writing reports, reading articles
The list of countries coincides with that in Table 1.

Main test: Impact of Job Specialization on relative score

$$C_{mi} = \alpha_0 + \alpha_m J_{mi} + \gamma_m * X_{mi} + C_{0i} + \epsilon_{mi}$$

- C_{mi}: cognitive skill of respondent i in domain m (m=numeracy, literacy, problem solving)
- J_{mi}: skill content of job (m=numeracy, reading, computer-related)
- C_{0i}: unobserved pre-market skill endowment

- C_{0i} can be partialed out with multiple measurement of skills.
  - Assumption 1: α_m constant across tasks and skills. Evidence for this later on

$$C_{ni} - C_{li} = \alpha * (J_{ni} - J_{li}) + \gamma * X_i + \epsilon_{ni} - \epsilon_{li}$$

Main test: Selection

- An individual fixed effect model captures α as well as sorting -individuals with better pre-market math skills select into mathy jobs
- Assumption 2: basic tasks do not increase the skills of individuals with high-school or college
  - Roy (1956) model: the correlation between basic tasks (using a calculator) and skills among high-school identifies selection
- Strategy: difference out the impact of specialization in basic tasks among primary school relative to high-school or college

$$C_{n,p} - C_{l,p} = \delta_{primary}(J_{basic,n,p} - J_{basic,l,p}) + \epsilon_{n,p} - \epsilon_{l,p}$$
$$C_{n,h} - C_{l,h} = \delta_{highschool}(J_{basic,n,h} - J_{basic,l,h}) + \epsilon_{n,h} - \epsilon_{l,h}$$
$$\alpha = \delta_{primary} - \delta_{highschool}$$

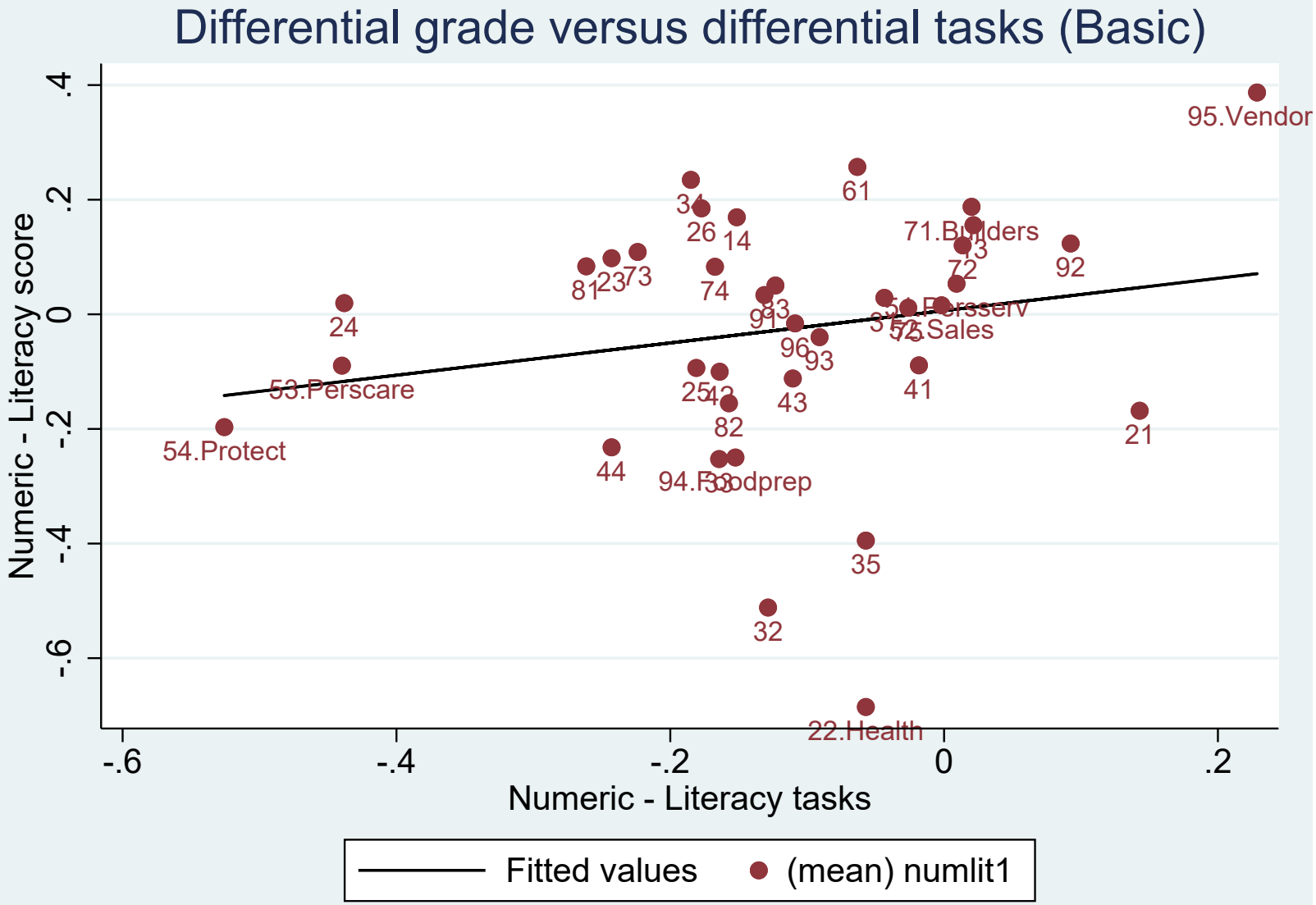
2nd test: Using synthetic cohorts

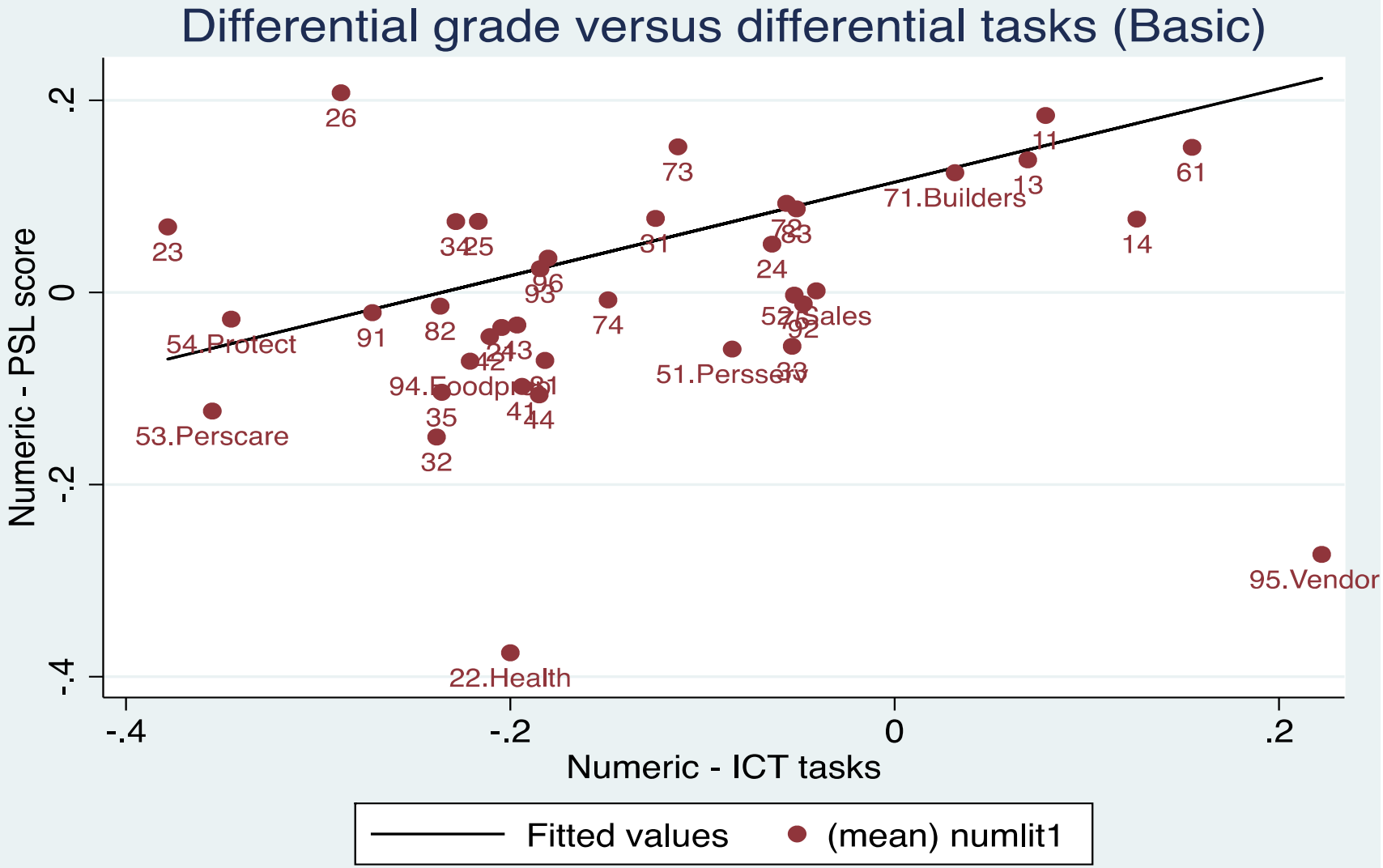
$$\bar{C}_{l,c,t} = \alpha_0 + \alpha \bar{J}_{l,c,t} + \mu_{c,l} + \bar{C}_{0,c} + \epsilon_{l,c,t}$$

- $\bar{C}_{l,c,t}$ cohort c mean of literacy score t=1994 (IALS), 2012 (PIAAC)
- $\bar{J}_{l,c,t}$ cohort c mean of reading tasks t=1994 (IALS), 2012 (PIAAC)

- Changes in the cohort-level task content of jobs between 1994 and 2012 are unlikely to reflect sorting

$$\bar{C}_{l,c,2012} - \bar{C}_{l,c,1994} = \alpha_1(\bar{J}_{l,c,2012} - \bar{J}_{l,c,1994}) + \bar{\epsilon}_{l,c,2012} - \bar{\epsilon}_{l,c,1994}$$


Differential grade versus differential tasks (Basic)
Numeric - Literacy score
Numeric - Literacy tasks
-.6
-.4
-.2
0
.2
.4
95.Vendor
61
34
26
14
71.Builders
92
81
23
73
74
72
24
53.Perscare
25
43
41
54.Protect
82
44
21
35
32
22.Health
Fitted values
(mean) numlit1


Differential grade versus differential tasks (Basic)
Numeric - PSL score
.2
0
-.2
-.4
Numeric - ICT tasks
-.4
-.2
0
.2
26
73
11
61
71.Builders
13
23
34
25
31
14
24
96
93
74
54.Protect
91
82
52
Sales
92
51.Persserv
94.Foodpr
35
41
44
53.Perscare
32
95.Vendor
22.Health
Fitted values
(mean) numlit1

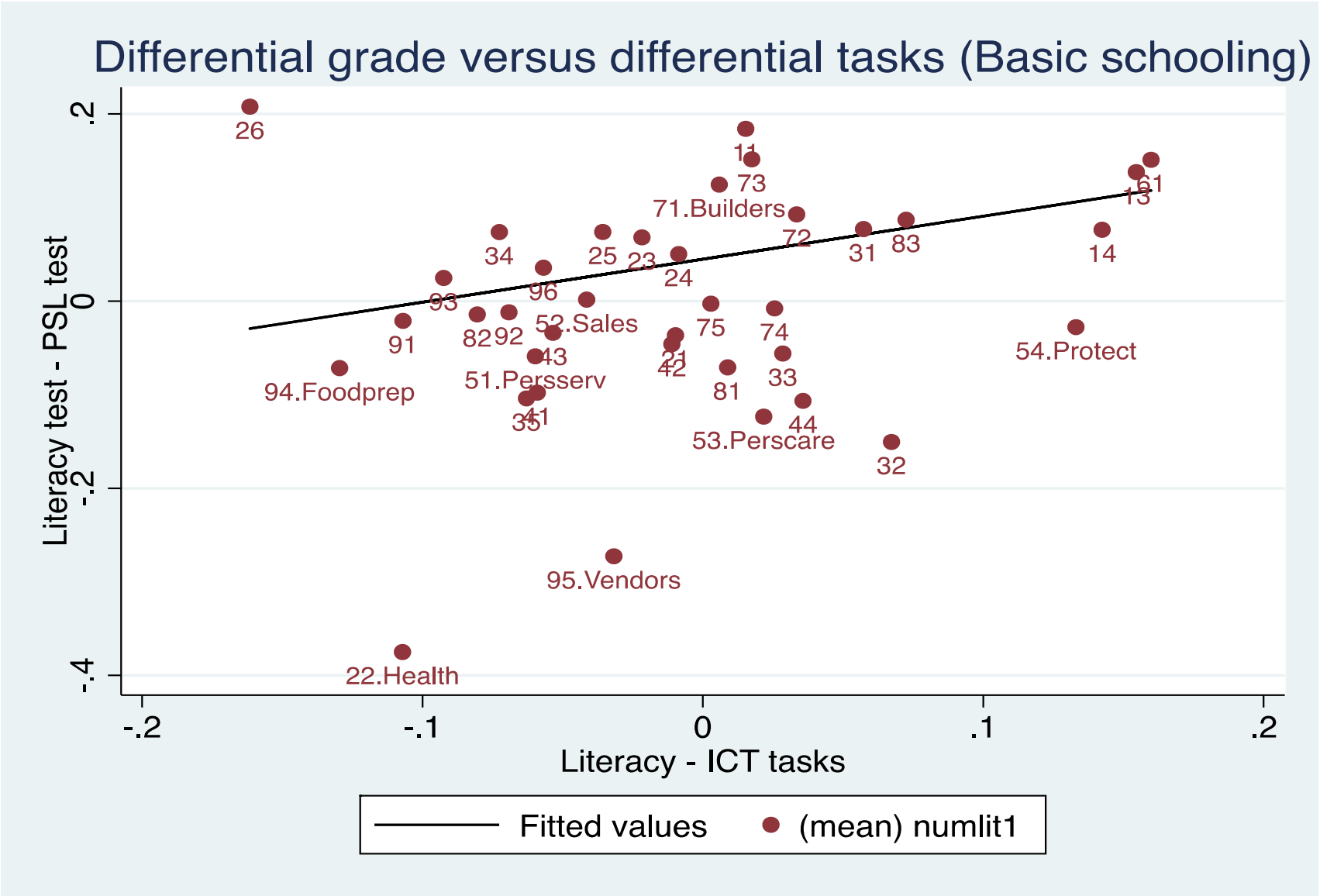

Differential grade versus differential tasks (Basic schooling)
Literacy test - PSL test
Literacy - ICT tasks
.2
0
-.2
-.4
-.2
-.1
0
.1
.2
26
11
73
71.Builders
61
13
72
31
83
14
34
25
23
24
96
93
52.Sales
75
74
91
82
92
43
21
42
54.Protect
94.Foodprep
51.Persserv
81
33
35
41
44
53.Perscare
32
95.Vendors
22.Health
Fitted values
(mean) numlit1

Table 4: The impact of tasks on numeracy and literacy scores (All countries pooled)

	Sample with respondents between 16-35 years of age	
Dependent variable:	Numeracy score	Literacy score
1. (Numeracy tasks)$_{basic}$	.129***	
	(.0338)	
2. (Literacy tasks)$_{basic}$		.123***
		(.0364)
3. (Numeracy tasks)$_{basic}$*High school	-.0147	
	(.0388)	
4. (Literacy tasks)$_{basic}$*High school		.0561
		(.0428)
5. (Numeracy tasks)$_{basic}$*College	-.0223	
	(.0440)	
6. (Literacy tasks)$_{basic}$*College		-.0183
		(.0532)
7. (Numeracy tasks)$_{advanced}$	.194***	
	(.0364)	
8. (Literacy tasks)$_{advanced}$		.0220
		(.0358)
9. (Numeracy tasks)$_{advanced}$*High school	.0213	
	(.0395)	
10. (Literacy tasks)$_{advanced}$*High school		.0111
		(.0389)
11. (Numeracy tasks)$_{advanced}$*College	.0820**	
	(.0408)	
12. (Literacy tasks)$_{advanced}$*College		0.0789*
		(0.0419)
Average number of obs.	30,125	30,125
Average R squared	0.261	0.239

a. The dependent variable is the individual-specific score in the numeracy test and the score in the literacy test , each normalized by its s.d. All models control for age, gender, country dummies and potential experience.

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2. (Literacy tasks)$_{basic}$		.123***
		(.0364)
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	(.0388)	
4. (Literacy tasks)$_{basic}$*High school		.0561
		(.0428)
5. (Numeracy tasks)$_{basic}$*College	-.0223	
	(.0440)	
6. (Literacy tasks)$_{basic}$*College		-.0183
		(.0532)
7. (Numeracy tasks)$_{advanced}$	.194***	
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a. The dependent variable is the individual-specific score in the numeracy test and the score in the literacy test, each normalized by its s.d.

Table 5: The impact of task specialization on relative performance in numeracy and literacy score

Dependent variable:	Numeracy -Literacy score (both normalized by s.d.)	
	16-35 years of age	16-55 years of age
1. $(\text{Numeracy-Literacy tasks})_{basic}$	.119***	.086***
	(.0266)	(.0177)
2. $(\text{Numeracy-Literacy tasks})_{basic}$*High school	-.079***	-.038*
	(.0302)	(.0202)
3. $(\text{Numeracy-Literacy tasks})_{basic}$*College	-.053*	-.0293
	(.0317)	(0.0210)
4. $(\text{Numeracy-Literacy tasks})_{advanced}$	-.0022	.0178
	(.0253)	(.0173)
5. $(\text{Numeracy-Literacy tasks})_{advanced}$*High school	.0466*	.0204
	(.0280)	(.0190)
6. $(\text{Numeracy-Literacy tasks})_{advanced}$*College	.0940***	.0634***
	(.0280)	(.0189)
Obs.	30,125	71,986
R squared	0.059	0.074

Table A.2.: The impact of tasks on numeracy and literacy scores by industries.

	Sample 16-55 years, industries sorted by presence of numeric tasks			
	Manufacturing (C)	Retail (G)	Teaching (P)	Social services and health (Q)
Dependent variable: Normalized numeracy score - normalized literacy score				
1. (Numeracy-Literacy tasks)$_{basic}$	.188***	.143***	-.140	.115*
	(.052)	(.047)	(.117)	(.0625)
2. (Numeracy-Literacy tasks)$_{basic}$*High school	-.150***	-.072	.243*	-.113
	(.058)	(.055)	(.129)	(.069)
3. Impact on relative numeracy score of specialization among high school respondents =row 1 + row 2	*.038*	*.071*	*.103*	*.002*
4. (Numeracy-Literacy tasks)$_{basic}$*College	-.192***	-.092	.192	-.054
	(.066)	(.066)	(.120)	(.068)
5. Impact on relative numeracy score of specialization among college respondents =row 1 + row 4	*-.004*	*.051*	*.052*	*.061*
Average number of obs.	9,651	9,446	5,531	8,585

Discussing results -specialization

- Comparing a job with equal presence of basic math and reading tasks to another with full specialization in basic numeric tasks increases
  1. Relative numeracy scores by 11.9pp of one standard deviation among respondents with primary school
  2. by 4.0 pp of one s.d. (11.9-7.9) among high school
  3. by 6.6 pp of one s.d. (11.9-5.3) among college
- If the impact of basic tasks on relative numeric scores captures selection within high school or college graduates, the impact on primary school is 5.3 - 7.9pp of one standard deviation
- The sample 16-35 has about 24 years of age and reports 6 years of experience on average
  - 5.3 -7.9 divided by 6 yields around 1 - 1.2pp of one s.d. deviation per year of experience

Rural areas and small firms

Table 7: The impact in subsamples where sorting is unlikely

	Rural areas	Small firms <=50
	16-35 years	16-35 years
1. (Numeracy-Literacy tasks)$_{basic}$	0.182***	0.0741**
	(.0463)	(0.0322)
2. (Numeracy-Literacy tasks)$_{basic}$*High school	-0.102*	-0.0426
	(.0526)	(0.0377)
3. (Numeracy-Literacy tasks)$_{basic}$*College	-0.130**	0.0319
	(.0549)	(0.0404)
4. (Numeracy-Literacy tasks)$_{advanced}$	-0.0449	0.0179
	(.0454)	(0.0327)
5. (Numeracy-Literacy tasks)$_{advanced}$*High school	0.117**	0.0534
	(.0499)	(0.0364)
6. (Numeracy-Literacy tasks)$_{advanced}$*College	0.145***	0.0673*
	(.0499)	(0.0374)
Constant	0.151***	0.152***
	(0.031)	(0.0226)
Observations	11,659	18,826
R-squared	0.051	0.034

Model (1) estimated on a subsample of observations that the PIAAC classifies as predominantly rural regions. Models (2) are estimated on a subset of respondents whose current or last job was on a firm with less than 50 employees.
All models control for two schooling dummies (high school and college), a second-order polynomial in potential experience , interacted with schooling a dummy for female, another for paper exam and indicators of age in five-year brackets.

Impact of tasks on skills, by gender

Table 5B: Task specialization on relative performance in numeracy and literacy score, by gender

Dependent variable:	Numeracy -Literacy score (both normalized by s.d.)	
	Females	Males
1. (Numeracy-Literacy tasks)$_{basic}$	.077*	.190***
	(.048)	(.039)
2. (Numeracy-Literacy tasks)$_{basic}$*High school	-.021	-.108**
	(.053)	(.0455)
3. (Numeracy-Literacy tasks)$_{basic}$*College	-.007	-.142***
	(.053)	(.050)
4. (Numeracy-Literacy tasks)$_{advanced}$	-.053	.005
	(.047)	(.038)
5. (Numeracy-Literacy tasks)$_{advanced}$*High school	-.030	.046
	(.050)	(.040)
6. (Numeracy-Literacy tasks)$_{advanced}$*College	.007	.126***
	(.049)	(.041)
Obs.	15,616	14,509
R squared	0.059	0.0487

Table 2: The impact of task specialization on relative numeracy, literacy and problem solving (respondents 16-35)

Difference in normalized scores:	Numeracy -Literacy	Numeracy-Prob solving	Literacy-Prob solving
1. (Numeracy-Literacy tasks)$_{basic}$	.125***	--	--
	(.035)		
2. (Numeracy-Computer tasks)$_{basic}$	--	.068**	--
		(.033)	
3. (Reading-Computer tasks)$_{basic}$	--	--	.071***
			(.033)
4. (Numeracy-Literacy tasks)$_{basic}$*High school	-.069*	--	--
	(.039)		
5. (Numeracy-Computer tasks)$_{basic}$*High school	--	-.025	--
		(.038)	
6. (Literacy-Computer tasks)$_{basic}$*High school	--	--	-.082***
			(.038)
7. (Numeracy-Reading tasks)$_{basic}$*College	-.049	--	--
	(.040)	-.016	
8. (Numeracy-Computer tasks)$_{basic}$*College		(.041)	
			-.119***
9. (Literacy-Computer tasks)$_{basic}$*College	--	--	(.044)
Average number of obs.	30,125	25,859	25,859
Average R squared	0.059	0.0485	0.0418

a. The dependent variable is the individual-specific pairwise difference between the score in the numeracy, literacy and problem solving test, each normalized by its s.d.

b. "Numeracy tasks" task is the fraction of all numeracy tasks that the respondents reports having performed in his or her job (current or last). Literacy task is the fraction of literacy tasks reported. The difference between "numeric" and "literacy task" is the degree of specialization in one type of tasks. It takes value 1 if the individual performs all numeric tasks in his or her job and none of the literacy ones.

c. All models condition on 2-digit occupation and industry dummies.

Table 6: The impact of task specialization on relative performance in numeracy and literacy score

	16-35 years of age	16-55 years of age
1. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{basic}$	0.192***	0.133***
	(0.0318)	(0.0214)
2. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{basic}$*High school	-0.130***	-0.0569**
	(0.0356)	(0.0239)
3. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{basic}$*College	-0.0938**	-0.0333
	(0.0365)	(0.0244)
4. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{advanced}$	0.00809	0.0596*
	(0.0505)	(0.0341)
5. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{advanced}$*High school	0.0934*	0.0254
	(0.0555)	(0.0373)
6. (Fraction of time in numeracy-Fraction of time in Literacy tasks)$_{advanced}$*College	0.155***	0.0920**
	(0.0541)	(0.0363)
Obs.		
R squared	0.062	0.076

a. The dependent variable is the individual-specific difference between the score in the numeracy test and the score in the literacy test, each normalized by its standard deviation. Basic numeric (literacy) task is the fraction of time that the respondents reports having performed basic

Figure 2. Fraction of time using reading tasks over the life cycle, evidence from IALS and PIAAC

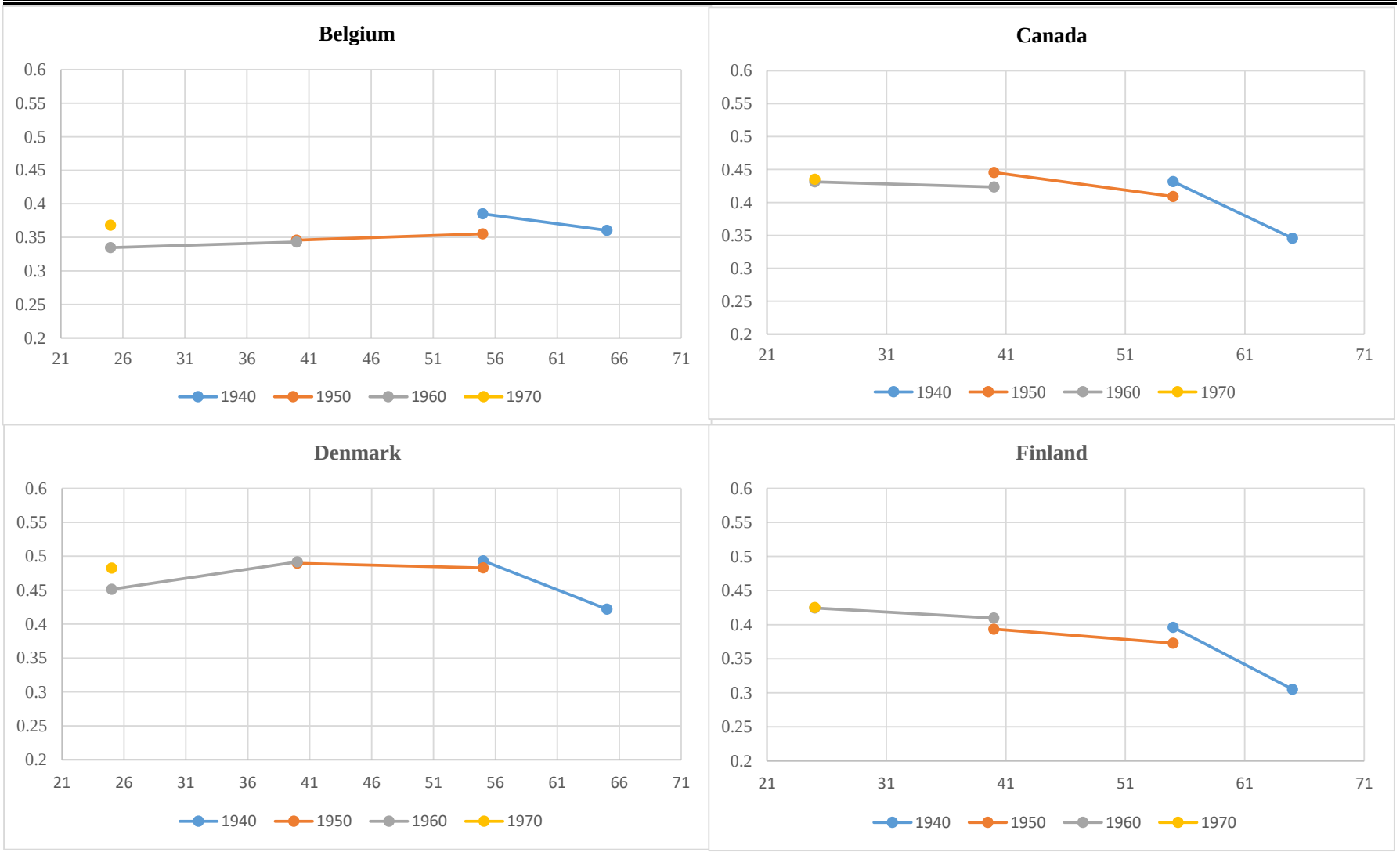


Figure 2. Fraction of time using reading tasks over the life cycle, evidence from IALS and PIAAC (continued)

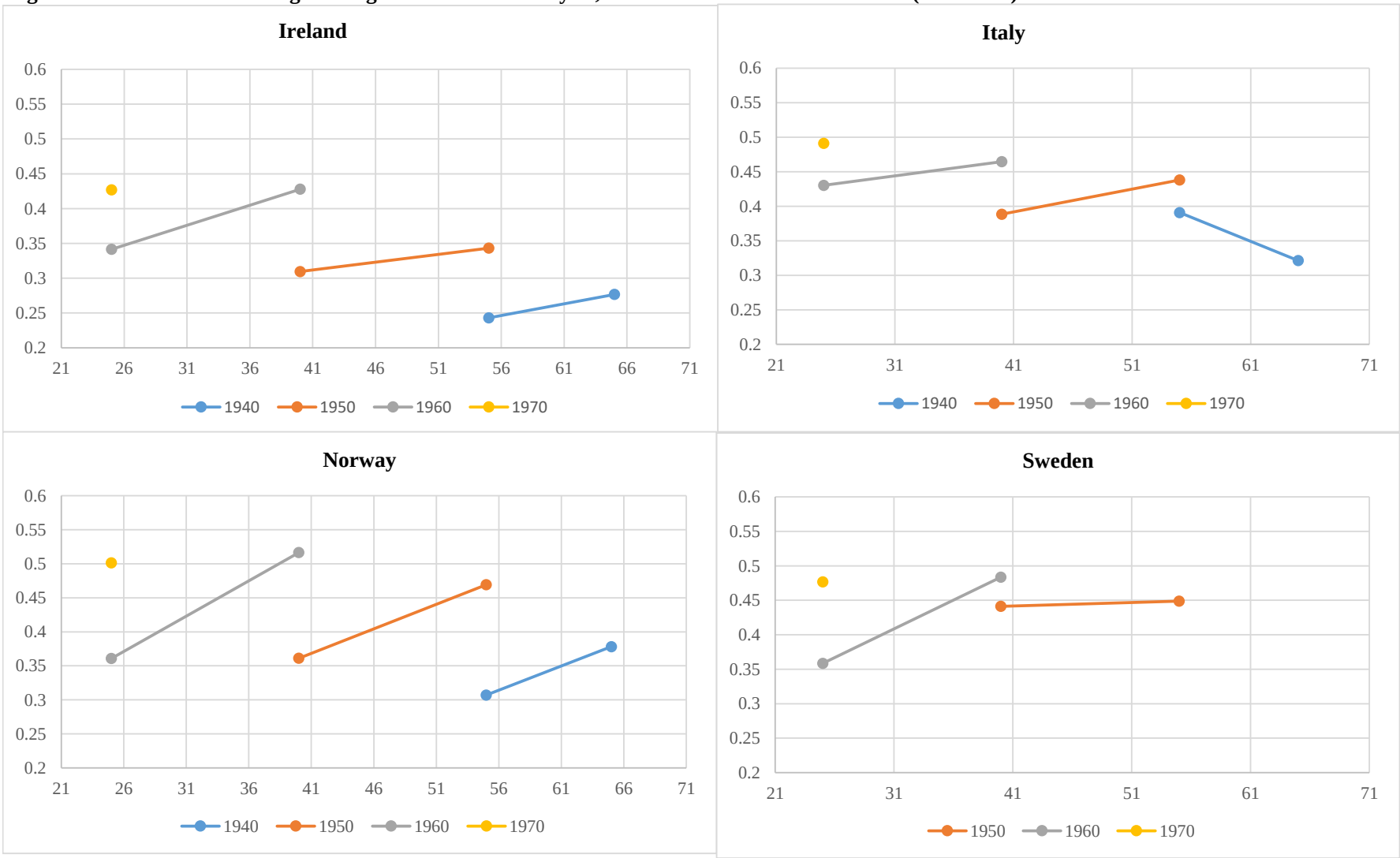
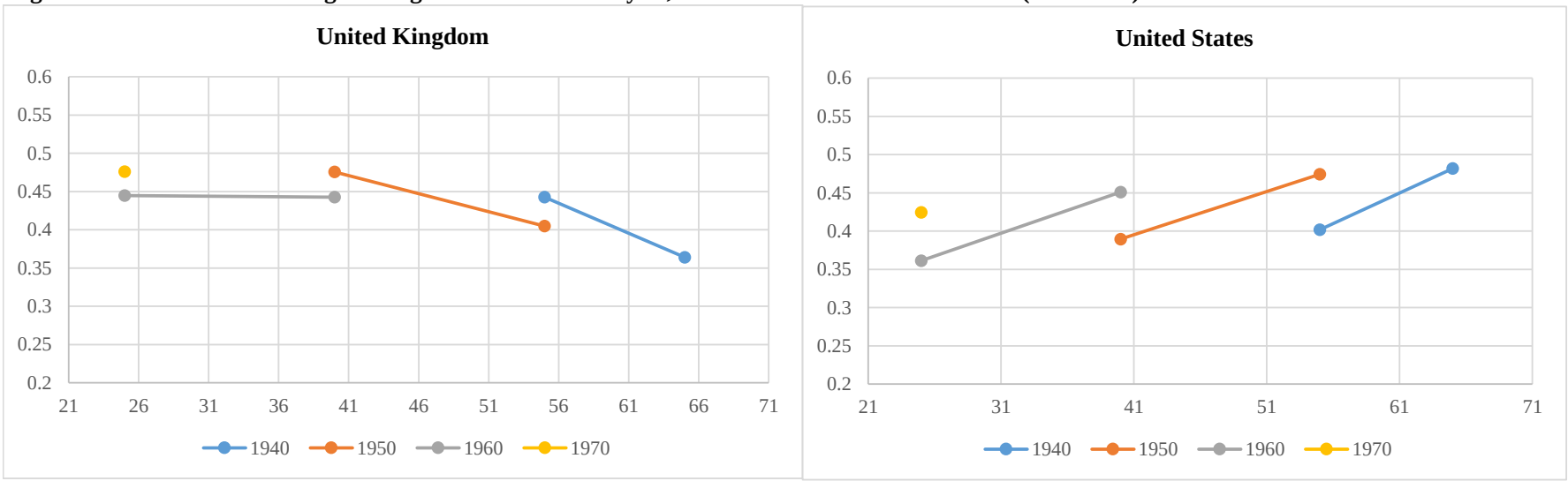


Figure 2. Fraction of time using reading tasks over the life cycle, evidence from IALS and PIAAC (continued)



Each figure contains the cohort-level averages of the use of reading tasks in IALS (1994) and PIAAC (2012) assessments. Reading tasks include reading letters or memos, reading reports, articles or manuals, writing letters and writing reports or articles. Each task is weighted by how frequently it is used on the job (daily, a few times a week, once a week, less than once a week, rarely or never)

Table 8: The impact of cohort-level changes in reading tasks on cohort-level changes in literacy scores.

Dependent variable:	(Literacy score PIAAC 2012 -Literacy score IALS 1994)			
Basic school sample			Adding country dummies	
1. (Fraction of time in basic reading tasks 2012)-(Fraction of time basic reading tasks 1994)	1.203**	1.120**	.84**	.72*
	(.47)	(.58)	(.356)	(.38)
2. (Fraction of time basic numeric tasks 2012)-(Fraction of time basic numeric tasks 1994)	--	-26.62	--	.20
		(33.59)		(.49)
Constant	-.36	-.38	.36	.36
	(.08)	(.14)	(.08)	(.08)
R-squared	.12	.149	.88	.889
High school sample				
3. (Fraction of time basic reading tasks 2012)-(Fraction of time basic reading tasks 1994)	.614*	.62*	.04	.02
	(.361)	(.361)	(.44)	(.46)
4. (Fraction of time in basic numeric tasks 2012 -Fraction of time in basic numeric tasks 1994)	--	-.04	--	-.08
		(.50)		(.26)
Constant	-.38	-.48	-.04	.02
	(.05)	(.08)	(.44)	(.12)

Observations in each panel: 50 cells =(2 cohorts x 2 genders x 13 countries) minus 2 cells with less than 10 cases.
Each score is normalized by subtracting its mean and dividing by the standard deviation. The omitted country dummy is the US
Source. Pooled IALS(1994) and PIAAC (2012) samples, cohorts born between 1960 and 1969 and 1950 and 1959

Table 8B: The impact of cohort-level changes in reading tasks on cohort-level changes in literacy scores.

Dependent variable:	(Literacy score PIAAC 2012 -Literacy score IALS 1994)			
Basic school sample			Adding country dummies	
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		(33.59)		(.49)
Constant	-.36	-.38	.36	.36
	(.08)	(.14)	(.08)	(.08)
R-squared	.12	.149	.88	.889
College sample				
1. (Fraction of time in basic reading tasks 2012)-(Fraction of time basic reading tasks 1994)	2.42**	2.52**	-.018	0.12
	(.47)	(.501)	(.37)	(.507)
2. (Fraction of time basic numeric tasks 2012)-(Fraction of time basic numeric tasks 1994)	--	-28.8	--	.149
		(.42)		(.506)
Constant	-.54	-.48	-.092	-.11
	(.049)	(.092)	(.054)	(.086)

Observations in each panel: 50 cells =(2 cohorts x 2 genders x 13 countries) minus 2 cells with less than 10 cases.

Source. Pooled IALS(1994) and PIAAC (2012) samples, cohorts born between 1960 and 1969 and 1950 and 1959. The omitted country dummy is the US

Discussing results -synthetic cohorts

- Cohorts increasing time devoted to basic reading tasks from 0 to 100
  1. Relative literacy scores by 84 pp of one standard deviation among respondents with primary school
  2. by 2-4 pp of one s.d. among high school
  3. by 0-12 pp of one s.d. among college
- Assuming that the estimated impact reflects a 18 year change, the estimate implies 72/18=4 pp of one standard deviation per year
- The estimates using specialization range between 1.6 (.016=.10/6) and 2 pp(=.13/6) of one standard deviation per year

Conclusions

- Basic numeric and reading tasks conducted on the job asssociated to an increase in cognitive skills
  - Specially among workers with primary schooling (high school drop-outs)
  - One year of experience increases cognitive skills by .8 - 1.2 standard deviation (up to 4pp)
  - Selection into jobs important
- One year of compulsory schooling increases cognitive skills by 2.7 - 2.9 pp of one standard deviation (Hanushek et al, 2015)
  - Increasing skills among prime age workers with primary education may be costlier
- Point at some degree of substitution between formal schooling and on-the-job learning.