Reanalyzing Zero Returns to Education in Germany

– Online Appendix –

Daniel A. Kamhöfer[*,a,b] and Hendrik Schmitz[b,c,d]

[a] *Department of Economics, University of Duisburg-Essen, Essen, Germany*
[b] *CINCH Health Economics Research Center, Essen, Germany*
[c] *Department of Economics, University of Paderborn, Paderborn, Germany*
[d] *RWI, Essen, Germany*

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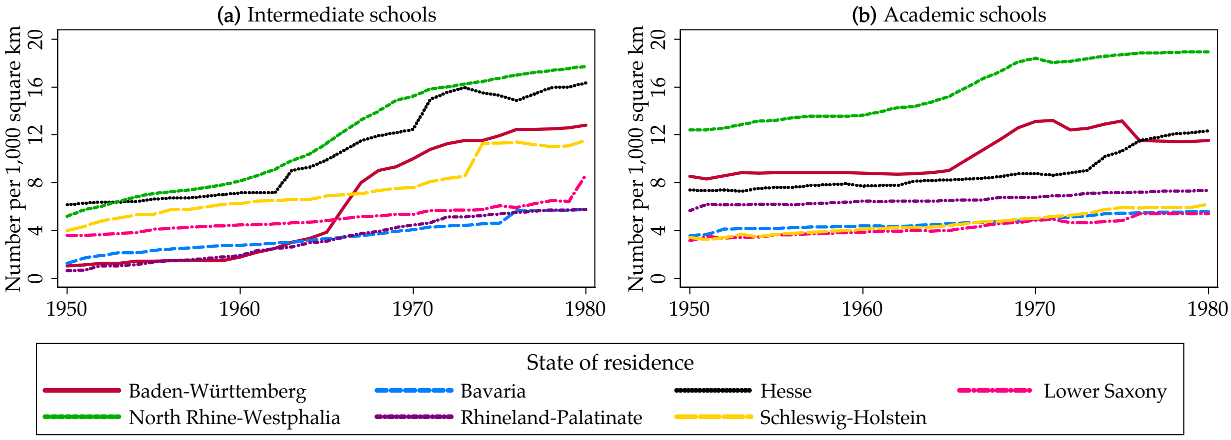
*All correspondence to Daniel A. Kamhöfer, University of Duisburg-Essen; Mail: Schützenbahn 70, 45127 Essen, Germany; Phone: +49 (0)201 183-6831; Email: daniel.kamhoefer@uni-due.de.

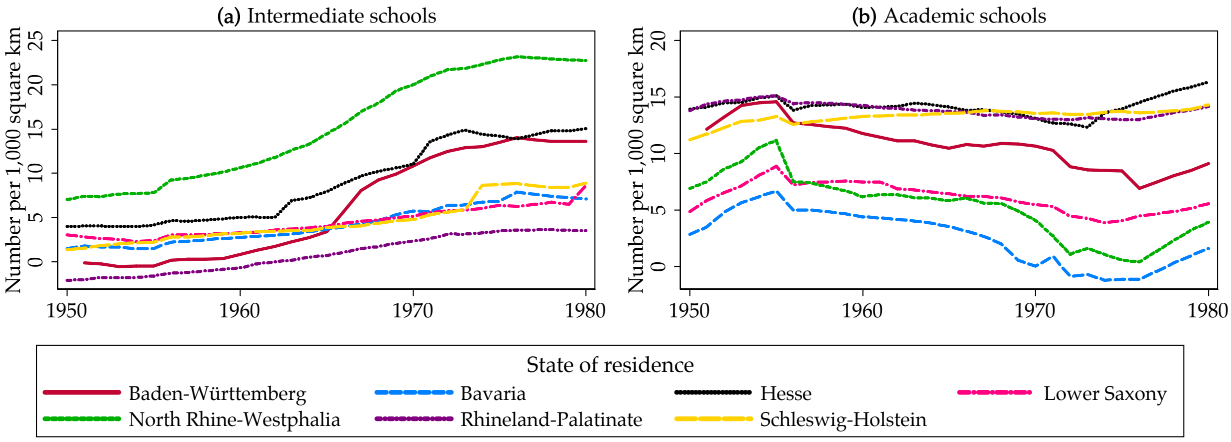
Online Appendix A: Figures and Tables

Figure A1: Number of intermediate and academic schools per 1,000 square km



Source: Own calculations, data taken from the German Statistical Yearbook (German Federal Statistical Office, 1992). Since birth cohorts 1940-1970 are used and school supply is measured at the respondent's age of 10, we use information on school supply from 1950-1980.

Figure A2: Number of intermediate and academic schools per 1,000 square km adjusted by cohort size



Source: Own calculations, data taken from the German Statistical Yearbook (German Federal Statistical Office, 1992). Since birth cohorts 1940-1970 are used and school supply is measured at the respondent's age of 10, we use information on school supply from 1950-1980. We create this figure using a two-step procedure. In the first step, we regress the number of intermediate and academic schools, respectively, on state and year indicators and the state and year-specific cohort size. In the second step, we use the coefficients of the first step to predict the cohort size-adjusted number of schools.

Table A1: Summary statistics for the instruments

Panel A: Size of the states and introduction of compulsory schooling

	Area (in 1,000 square km)	Mandatory ninth grade for basic track schools		
		Year of introduction	First cohort affected	Share of students affected
Schleswig-Holstein	15.799	1956	1941	76.0%
Lower Saxony	47.635	1962	1947	80.5%
North Rhine-Westphalia	34.088	1967	1953	74.6%
Hesse	21.115	1967	1953	71.4%
Rhineland-Palatinate	18.854	1967	1953	78.3%
Baden-Württemberg	35.751	1967	1953	72.6%
Bavaria	70.550	1969	1955	78.5%
Average				76.0%

Panel B: Number of intermediate schools per 1,000 square km by selected years

	1950	1960	1970	1980
Schleswig-Holstein	3.988	6.266	7.595	11.583
Lower Saxony	3.590	4.492	5.353	8.670
North Rhine-Westphalia	5.192	8.155	15.225	17.748
Hesse	6.157	7.151	12.456	16.339
Rhineland-Palatinate	0.636	1.909	4.455	5.781
Baden-Württemberg	1.063	1.790	9.986	12.811
Bavaria	1.247	2.764	4.068	5.755
Average	3.125	4.647	8.448	11.241

Panel C: Number of academic schools per 1,000 square km by selected years

	1950	1960	1970	1980
Schleswig-Holstein	3.418	4.114	5.000	6.203
Lower Saxony	3.149	3.863	4.891	5.416
North Rhine-Westphalia	12.409	13.641	18.394	18.922
Hesse	7.388	7.720	8.762	12.361
Rhineland-Palatinate	5.675	6.471	6.789	7.372
Baden-Württemberg	8.559	8.811	13.119	11.552
Bavaria	3.558	4.394	4.947	5.599
Average	6.308	7.002	8.843	9.632

Source: Years and birth cohorts affected by the compulsory schooling reform are taken from Pischke and von Wachter (2005), all other information are form the German Statistical Yearbook (German Federal Statistical Office, 1992). The nature of the variation in compulsory schooling and school supply is distinct. In general, the German Constitution guarantees the autonomy of the Federal States in educational policy. After the WWII, basic track schools offered 8 years of education in total. For reasons described in the text, some states decided to introduce a mandatory ninth grade at an early stage (see panel A of this table). In 1964 the prime ministers of the states agreed on the Hamburg Accord (*Hamburger Abkommen*) in order to unify some key characteristics of the educational systems in the German states. Besides the introduction of a mandatory ninth grade in all states by 1967, the Hamburg Accord mainly regulated the start of the school year, see Pischke (2007). The number of schools per track remained unaffected by the Hamburg Accord or any other agreement. In other words, while changes in compulsory schooling are the consequence of a small degree of unification, the variation in the school construction reflects the states' autonomy in educational issues.

Table A2: Means of selected variables by track

	Basic	Inter.	Acad.	Total
Income				
Gross hourly wage (in €)	14.64	17.65	23.10	17.84
Gross monthly wage (in €)	2,474	3,053	4,269	3,132
Education				
Years of education	10.26	12.17	16.73	12.57
University degree (in %)	5.00	15.84	78.15	27.42
Apprenticeship (in %)	79.00	88.97	34.23	70.99
Cognitive skills				
Raw crystallized intelligence test score	23.21	28.69	31.64	26.56
Socio-demographic characteristics				
Female (in%)	39.50	47.31	40.36	42.41
Age (in years)	48.32	46.54	47.54	47.51
Mother has intermediate school degree (in %)	6.07	15.91	42.08	19.07
Father has intermediate school degree (in %)	7.64	22.14	51.48	24.36
Number of siblings	2.35	1.67	1.47	1.89
Self-assessed health stats at least good (in %)	46.18	55.60	60.61	53.11
Obesity: Body Mass Index > 30 (in %)	22.00	14.52	11.60	16.77
Migratinal background (in %)	29.09	7.39	7.40	16.08
Measure of skills needed for job[a]	2.19	2.73	3.50	2.74
Observations[b]	2,200	1,894	1,405	5,499
Share (in %)	40.01	34.44	25.55	100

Source: Own calculations based on SOEP data. For cognitive skills the number of observations varies from the number given at the bottom of the table.

[a]ISCO scale-based measured of the skill level demanded by the respondents job, scale ranges from 1 (low skills needed) to 4 (high skills needed), see International Labour Organization (2012).

[b]Based on wage information.

Table A3: Robustness for wage as outcome variable

Specification	OLS	IV		
		Instruments referring to		
		Basic	Inter.	Acad.
First stage results				
Log net hourly wage	– –	0.908***	0.092***	0.167***
		(0.189)	(0.025)	(0.043)
Only school years	– –	0.373***	0.047***	0.098***
		(0.115)	(0.015)	(0.026)
Socio-economic controls	– –	0.902***	0.083***	0.119***
		(0.101)	(0.014)	(0.024)
Institutional controls	– –	0.864***	0.097***	0.208***
		(0.207)	(0.033)	(0.055)
Female specification	– –	0.924***	0.097***	0.172***
		(0.191)	(0.024)	(0.041)
Second stage results				
Log net hourly wage	0.067***	0.008	0.019	0.000
	(0.002)	(0.028)	(0.035)	(0.038)
Only school years	0.102***	−0.031	−0.020	−0.012
	(0.004)	(0.068)	(0.075)	(0.063)
Socio-economic controls	0.029***	0.017	−0.018	−0.043
	(0.004)	(0.026)	(0.039)	(0.053)
Institutional controls	0.069***	0.015	0.039	0.033
	(0.002)	(0.030)	(0.042)	(0.035)
Female specification	0.068***	0.000	0.008	0.005
	(0.002)	(0.027)	(0.035)	(0.035)
Reduced form	– –	0.000	−0.000	0.001
		(0.025)	(0.017)	(0.030)

Source: Own calculations based on SOEP data. Control variables: female, as well as state and birth cohort fixed effects. State of schooling $\times$ year aged 10-clustered standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Explanations: Log net hourly wage: dependent variable is the net instead of the gross hourly wage in logs. Observations: 5,499. Only school years: endogenous explanatory variable is limited to primary and secondary education. Observations: 5,268. Socio-economic controls: additional control variables: dummy variables for mother's/father's education (at least intermediate school degree), number of siblings, dummy variables for at least good self-assessed health status, obesity (Body Mass Index > 30), migrational background, university degree, completed apprenticeship training, and an ISCO scale-based measure of the skill level demanded by the respondent's job. Leaving the potentially endogenous variables university degree and completed apprenticeship training out, does not change the pattern. Observations: 4,666. Institutional controls: additional control variables (starting with the baseline model) for the average size of the schools per track by year and federal state. Observations: 5,499. Female interaction terms: additional interaction terms between female and the state and birth cohort fixed effects are included. Observations: 5,499. Reduced form: instrument directly plugged into the the wage equation instead of instrumented years of education. Observations: 5,499.

Table A4: Robustness for crystallized intelligence as outcome variable

Specification	OLS	IV		
		Instruments referring to		
		Basic	Inter.	Acad.
First stage results				
Only school years	– –	0.600***	0.062***	0.137***
		(0.182)	(0.022)	(0.039)
Socio-economic controls	– –	1.129***	0.125***	0.169***
		(0.174)	(0.025)	(0.043)
Institutional controls	– –	1.118***	0.103**	0.234***
		(0.276)	(0.046)	(0.072)
Female specification	– –	0.991***	0.062*	0.157***
		(0.255)	(0.034)	(0.060)
Second stage results				
Only school years	0.067***	−0.072	−0.023	−0.033
	(0.007)	(0.096)	(0.099)	(0.082)
Socio-economic controls	0.023*	−0.018	0.038	−0.044
	(0.012)	(0.051)	(0.073)	(0.103)
Institutional controls	0.046***	−0.024	−0.024	0.009
	(0.004)	(0.054)	(0.079)	(0.054)
Female specification	0.045***	−0.035	0.007	−0.014
	(0.004)	(0.054)	(0.095)	(0.069)
Reduced form	– –	−0.030	0.002	−0.016
		(0.051)	(0.031)	(0.053)

Source: Own calculations based on SOEP data. Control variables: female, as well as state and birth cohort fixed effects. State of schooling × year aged 10-clustered standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Explanations: Only school years: endogenous explanatory variable is limited to primary and secondary education. Observations: 2,355. Socio-economic controls: additional control variables: dummy variables for mother's/father's education (at least intermediate school degree), number of siblings, dummy variables for at least good self-assessed health status, obesity (Body Mass Index > 30), migrational background, university degree, completed apprenticeship training, and an ISCO scale-based measure of the skill level demanded by the respondent's job. Leaving the potentially endogenous variables university degree and completed apprenticeship training out, does not change the pattern. Observations: 1,259. Institutional controls: additional control variables (starting with the baseline model) for the average size of the schools per track by year and federal state. Observations: 2,464. Female interaction terms: additional interaction terms between female and the state and birth cohort fixed effects are included. Observations: 2,464. Reduced form: instrument directly plugged into the the wage equation instead of instrumented years of education. Observations: 2,464.

Online Appendix B: Formal Description of the Model

The conventional OLS estimation of the relationship between education and the log of hourly gross wages is the following:

$$y_i = \beta_0 + \beta_1 educ_i + \boldsymbol{\beta}_2 \mathbf{X}_i + u_i. \qquad (1)$$

y_i is the log hourly gross wage of person i (with $i = 1, 2, ..., N$ observations). *educ* denotes the years of education measured as years in school determined by chosen track plus years of further education due to an apprenticeship or university studies. $\mathbf{X}_i$ is a matrix of control variables. In the baseline specification these variables are gender as well as state of schooling and year of birth fixed effects.[1] Further variables – which might depend on education and are therefore left out in the preferred specification – are added later on to check the robustness. u_i is the error term. If there is a selection of individuals with higher skills into more education and better paid jobs, β_1 would be biasedly estimated by OLS.

To overcome this problem we instrument years of education using different instruments. The first-stage equation is

$$educ_i = \delta \text{ Instrument}_i + \gamma \mathbf{X}_i + \varepsilon_i \qquad (2)$$

where ε_i denotes the error term. The instrument is one of the following three variables: a dummy variable which is 1 if person i was affect by the compulsory schooling reform, and 0 otherwise; and the number of either intermediate or academic schools per 1,000 square km in the state of residence at the respondent's age of 10. Thus, we run three regressions with one instrument at a time.

[1] As Jürges et al. (2011) we do not include state-specific trends. Regarding our IV estimations, this would discard variation and reduce the explanatory power of the school supply instruments considerably. The second-stage results would, however, not change qualitatively. I.e., the second-stage coefficients are not large and significant after including state-specific trends, thus not leading to different conclusions.

The formal model depicted here is the same when the outcome variable is the log value of the cognitive skills test score as in Section 3 of the text. In this case, however, y in Eq. (1) states the log crystallized intelligence test score of the SOEP.

Online Appendix C: Cognitive Skill Measures and Previous Findings

In the psychological literature the commonly used test procedure to measure intelligence is the Wechsler Adult Intelligence Scale (WAIS). It covers seven distinct skill components. For two of those components the SOEP includes a short test especially designed for the conduction in the survey. According to psychological insights (see e.g. Anderson, 2007), the measure we use, crystallized intelligence, is determined by environmental factors, e.g., education. The other intelligence measure in the SOEP refers to fluid intelligence – a component of the overall intelligence that is attributed to inherited genes.

We are only aware of four studies on cognitive skill returns to secondary education. These studies based on samples for which a positive earning returns to education were established. The findings of the studies are ambiguous but indicate positive skill returns if any. Moreover, the choice of the intelligence component seems to matter.

Glymour et al. (2008) and Banks and Mazzonna (2012) instrument education using changes in compulsory schooling in the US and the UK, respectively. Using similar law changes in Continental European countries, Schneeweis et al. (2014) provide pooled evidence on the schooling-skills relationship in the Survey of Health, Ageing and Retirement in Europe (SHARE). Mazzonna (2012) uses compulsory schooling and the birth order to instrument years of education in the SHARE data. While the sets of countries analysed by Schneeweis et al. (2014) and Mazzonna (2012) include Germany, they pool the observations affected by the German compulsory schooling reform with observations from other countries (for which there is evidence on positive wage returns to education). Therefore, our study provides the first separate analysis of the effect of years of secondary education on cognitive skills.

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