THE EFFECT OF INCREASING YEARS OF COMPULSORY EDUCATION ON COGNITIVE ABILITIES IN OLD AGE

Evidence from European Countries

By

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Budapest, 3 June 2013

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Abstract

The following paper uses the Survey of Health, Ageing and Retirement (SHARE)[1] data for identifying the effects of increasing years of compulsory education on cognitive abilities for the elderly population over 50 years old in Europe. The analysis estimates the effect on compulsory schooling reforms on educational attainment and memory scores. The evaluation method is based on a regression discontinuity design. In the analysis I compare reform affected birth cohorts, with reform not affected birth cohorts in the environment of the first potentially affected birth cohort. The main results are the following: the country pooled regression estimates show that the compulsory schooling reforms have a statistically significant effect on education, and have a positive but statistically not significant effect on memory.

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1. Introduction

Calculating the returns to education is a popular and well-researched topic. For a long time return to education on earning was in the focus of economists. Further on other relationship were analyzed. We know that education is a human capital investment with positive and large returns on wages (Angrist and Krueger, 1991; Card, 1995, 1999 and 2001), health (Lleras-Muney, 2005; Cutler and Lleras-Muney, 2010) and mortality (Gathmann et al. 2012). It is clear that the private monetary returns to education are high, and it is also clear that the non-monetary benefits are also significant.

In the 20th century the educational attainment expanded. The number of students and the average year of education increased. Compulsory schooling reforms were widespread in this century, because there was a large demand for educated workers in the labour market.

Education is about teaching knowledge, cognitive and noncognitive skills and abilities. Parts of this useful knowledge are cognitive skills and abilities, more precisely verbal and numerical skills. Cognitive and noncognitive skills and abilities are very important, since they have significant effect on individuals` social, labour market and economic outcomes (Heckman et al. 2006).

Banks and Mazzonna (2012) paper looks at the effect of education on cognitive functioning in older age. They used the 1947 compulsory schooling reform in England to show the causal effect of education on cognitive abilities. Their results proved that education had a significant effect on cognitive performance for the

reform affected birth cohorts. My thesis topic is inspired by Banks and Mazzonna (2012) research.

In my thesis I am interested in the effect of compulsory schooling reforms on education and on cognitive performance, more precisely on memory scores. In the analysis I compare reform affected birth cohorts, with reform not affected birth cohorts in the environment of the first potentially affected birth cohort. I use a graphical and a regression discontinuity design; my main findings are the following. Raising the compulsory school leaving age/the compulsory years of education, have a significant increase in educational attainment in Europe. For the pooled sample of the European countries, I calculated a 0.5-year increase in education for reform affected cohorts. This equals about 14-16 % of the standard deviation. With respect to the effect of compulsory schooling reform on cognitive abilities my results are not fully conclusive. My results show that the compulsory schooling reforms likely to have a positive but statistically not significant effect on memory performance. The magnitude of the effect of compulsory schooling reform on memory score is about 6 % of a standard deviation for females who have less than 13 years of educations. My findings suggest that the compulsory schooling reforms mostly affected females' education and cognitive abilities.

The structure of the thesis is the following. Chapter 2 describes the data I use in my analysis; Chapter 3 presents the empirical model, the strategy and the results. Chapter 4 lists the main conclusions. The Appendix at the end of the thesis includes all the Tables, which I use in the analysis.

2. Data and Descriptive Statistics

Data Sources

This paper uses the Survey of Health, Ageing and Retirement in Europe (SHARE) database. The database is a cross-national panel database from 19 European countries and Israel; the panel contains individual and household level data on health, demographic and socio-economic status for over 85000 individuals. In 2013 four waves of the SHARE surveys are available for research. The SHARE survey waves are nationally representative surveys of the elderly population age 50 and above.

The SHARE data is similar and comparable with the U.S Health and Retirement Study and the English Longitudinal Study of Ageing. The 1st, 2nd and the 4th waves form a regular panel data. The 1st wave has data on 11 countries: Austria, Germany, Sweden, The Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland and Belgium in 2004/2005. Later on the 2nd wave extended the participated countries with Czech Republic and Poland in 2006/2007. Currently the 4th wave also included Estonia, Hungary, Portugal, and Slovenia. In these waves (1st, 2nd and 4th) the data collection is based on a computer assisted personal interview (CAPI), which starts with a cover screen interview and then focuses on demographics, mental, physical, psychological health, behavioural risk, employment and pensions, income and financial assets, housing, social participation and activities, household and family characteristics. Beside the baseline CAPI, there is also a regular paper and pencil questionnaire, which covers more sensitive topics as religious and political perspectives.

The 3rd wave: SHARELIFE is different, it was made to supplement the other waves, with information on people`s retrospective life histories.

My analysis uses the data from the 1st, 2nd and 4th wave. **Table 1** presents the scope of the analysis. I restrict my analysis for the countries participated at least in two waves of the above-mentioned three waves.

Table 1 Countries participated in multiple waves of SHARE

SHARE Country ID	Country	Wave 1	Wave 2	Wave 4
11	Austria	2004	2006/2007	2011
12	Germany	2004	2006/2007	2011/2012
13	Sweden	2004	2006/2007	2011
14	The	2004	2007	2011
15	Spain	2004	2006/2007	2011
16	Italy	2004	2006/2007	2011
17	France	2004/2005	2006/2007	2011
18	Denmark	2004	2006/2007	2011
19	Greece	2004/2005	2007	-
20, 21, 22	Switzerland	2004	2006/2007	2011
23, 24	Belgium	2004/2005	2006/2007	2011

I use the 1st, 2nd and 4th wave of the SHARE dataset. I used the Cognitive Function (CF) module from all waves. In the computer assisted personal interview cognitive abilities measured by different tests in the cognitive module of the survey. There is a simple *orientation in time test* to filter out people with dementia. The sample is restricted for people who can correctly state the year during the interview.

Another part of the Cognitive Function module contains a simple *test of memory*, where ten words are given to the interviewee. The interviewee listens to the list of words only once, and after that he has to recall immediately the words what he had heard. Little bit later during the interview, the interviewee also has to recall the

heard words once again. Summarizing the immediate and the delaying recall test points through all the three waves, average of the number of recall words is taken and the author created a Memory Score which can have values between 0 and 20 points (the perfect recall), this Memory Score variable is identical to the memory score as Rohwedder and Willis (2010) or Banks and Mazzonna (2012) use in their studies.

Another module used is the Demographics part of the SHARE data. This part contains information on education, highest educational degree achieved, the years of education, year of birth, gender and etc. I restricted the data based on birth year, my dataset include everybody who was born before 1961. **Figure 1** presents the distribution of year of birth in the SHARE Data. The 4th wave of SHARE data surveyed in 2010/2011, and I wanted to restrict my analysis for the 50 year old and older population.

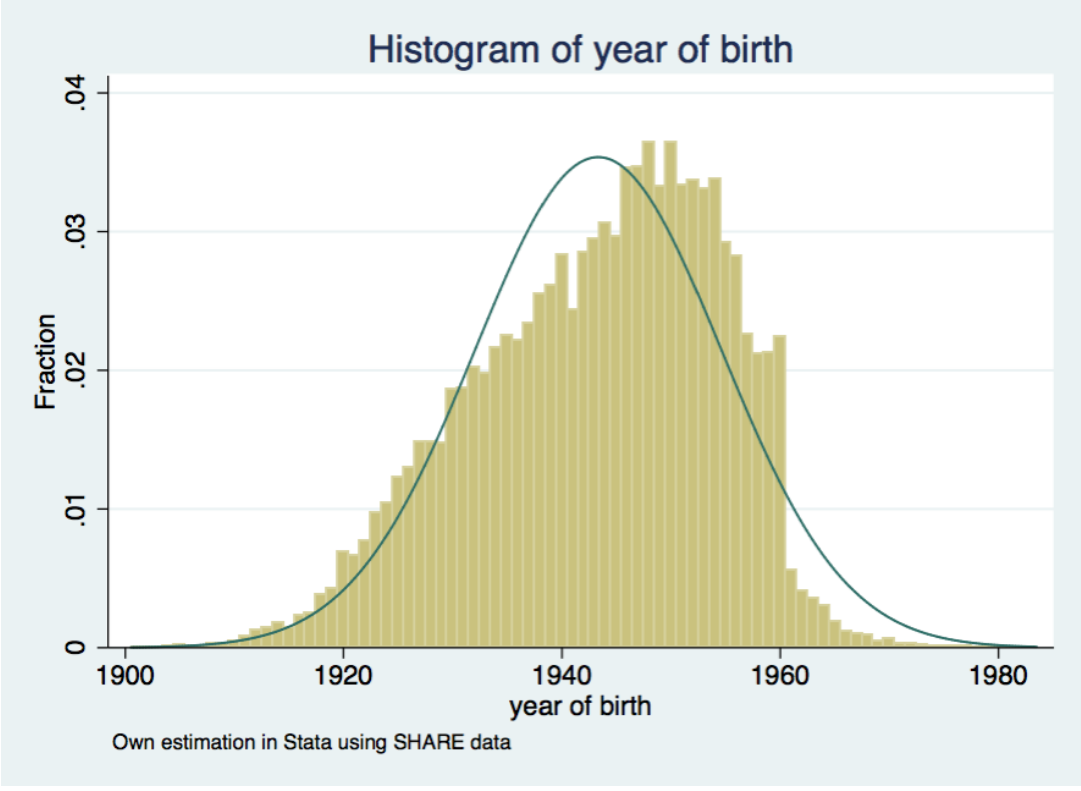

Figure 1 Distribution of year of birth

In all the waves of SHARE data education coded in accordance with the 1997 International Standard Classification of Education (ISCED 97). In the 2nd and 4th waves the number of years of education is asked directly from the participants also. In the 1st wave of SHARE the number of years of education are not asked directly, but they were derived using the ISCED 97 code for the highest educational level achieved. This method is not the most accurate measurement of the factual number of years of education. To overcome this problem in the forthcoming waves the number of years of education was asked.

I differentiate two samples. I use the full sample, and a subsample. The subsample was created based on the number of years of education. My assumption is that increasing the compulsory years of education is mostly affected the lower educated groups who would have been otherwise finished their education earlier. The subsample contains everybody who has less than 13 years of education. This subsample selection criteria is responsible to filter out people with college or university degree. This subsample should include people who increased their number of years of education, and raised their cognitive capabilities since the reform affected their choice of schooling.

Compulsory school reforms in Europe

Compulsory school reforms have an exogenous effect on the number of years of education. It should affect the students who are on the margin of the compulsory educational level. This is the lower end of the distribution of years of education.

I examined several papers which uses compulsory school reforms to identify an effect on health; fertility, mortality, wages and etc.

My research is based on the reform identified in Forth (2006), Brunello et al. (2009) and Gathmann et al (2012) studies. These three papers give detailed and well-presented information on compulsory schooling reforms in European countries. In my analysis I left out the reforms implemented before the 2nd World War, I also did not take into account the reforms which reduced compulsory education (Greece between 1967-1974) and I did not considered reforms which were not implemented, or which were partially implemented in the country (Germany is a good example because it was fragmented due to the final peace settlement after the 2nd World War). I also left out reforms where the first potentially affected birth cohort would be born after 1961, since in the SHARE data there is not enough observations for them.

Table 2 presents the compulsory education reforms analyzed in the thesis. The table is based on Fort (2006), Brunello et al. (2009) and Gathmann et al. (2012) information on the compulsory schooling reforms in Europe.

Table 2 Countries and reforms considered in the analysis

Country	Date of reform	Compulsory YOE before reform	Compulsory YOE after reform	Change in the compulsory YOE	Potentially affected first birth cohort
Austria	1962	8	9	1	**1953**
Denmark	1958	4	7	3	**1948**
Denmark	1971	7	9	2	**1957**
France*	1959	8	10	2	**1953**
Greece	1964	6	9	3	**1952**
Italy	1963	6	9	3	**1949**
Spain	1970	6	8	2	**1957**
Sweden**	1962	7 or 8	9	1 or 2	**1950**
The Netherlands	1975	9	10	1	**1959**
**France 1959 Reform implemented in 1967*					
***Swedish reform was implemented step by step between 1949-1962*					

The table describes the date of the reforms; the potentially affected first birth cohorts/cut-off dates in the relevant countries, and also gives the years of compulsory education (YOE) before and after the reform. Based on Fort (2006); Brunello et al. (2009) and Gathmann et al. (2012) studies I identified the potentially affected first birth cohorts. In the paper I will present only one cut-off point for each reform.

I restricted the samples for 3 years before and after the cut-off date for the potentially affected birth cohorts and I filtered out people who have dementia. **Table 3** shows the mean and standard deviation of memory scores and the number of years of education for the full sample, and the earlier mentioned subsample (under 13 years of education).

Table 3 Mean and standard deviation of memory score and number of years of education by gender around the cut-off date (Own estimation done in Stata using SHARE Data)

	Males		**Females**	
	Mean	*S.D.*	*Mean*	*S.D.*
Full sample				
Education	11.44	4.21	11.02	4.12
Memory	9.65	3.04	10.30	3.16
N	3584		4532	
Less then 13 years of education				
Education	8.90	2.73	8.70	2.85
Memory	9.07	2.99	9.67	3.09
N	2242		2970	

The data shows that the average year of education for males is bigger than for females about 0.2-0.4 years for the full and the subsample. Females performed about 0.6-0.7 points better than males on the cognitive test of recalling the words immediately and delayed for all the samples.

3. Empirical Strategy, Estimation Results

I am after the effect of whether compulsory schooling reforms increase the years of education and the cognitive performance in old ages.

Compulsory school reforms can view as exogenous shocks or natural experiments. This exogeneity comes from the fact that the schooling reforms are introduced after the cohorts were born and around the cut-off date it requires students to stay longer in schools until they fulfil the law. It requires individuals born after the cut-off date to attend school longer than students born before the threshold value. This identification strategy is close to the one that Angrist and Krueger (1991) used in their paper to identify the effect of education and earnings, they used compulsory school attendance differences in educational level, and the season of birth as an instrumental variable.

Probably there are unobserved factors affecting the choice of educational attainment which are correlated with cognitive abilities. To overcome this problem I use compulsory schooling reforms as exogenous variation in the educational attainments. Therefore compulsory schooling reforms should have an effect on education (1^{st} stage) and through the increased educational attainment it should raise memory scores (2^{nd} stage).

In the analysis I compare cohorts born before and after the compulsory schooling reform along the following properties: years of education and memory scores (cognitive function). I use a 3-year window as Walker and Zhu (2008) did in their study when they compared the pre-expansion cohort with the post expansion cohort to estimate college premium difference due to the expansion of higher education.

The simplest comparison is to compare the mean value of education and memory for these cohorts around the threshold. But there are problems with this comparison. First of all, there is a trend in education and also in cognitive performance. Raymond Cattel differentiated cognitive abilities to two parts: fluid intelligence and crystallized intelligence. Horn and Cattel (1967) defined fluid intelligence as

> *"the ability to perceive relationships independent of previous specific practice or instruction concerning those relationships".*

Fluid intelligence is the ability of abstract, logical thinking and problem solving in dependently from acquired knowledge. Meanwhile crystalized intelligence is the ability to use previously acquired knowledge, skills and experience (Horn and Cattel, 1967). It is the stock of knowledge and memory of an individual acquired.

Fluid intelligence is monotonically decreasing with age; meanwhile crystalized intelligence increases with age for some point and becomes stable or declines a little bit (Cattel, 1987; Salthouse 2005; Salthouse 2008; Agarwal et al., 2009; Salthouse 2012). Memory performance does not belong to fluid or crystalized intelligence, but in terms of its nature, memory performance is very closely related to fluid intelligence (see e.g., Agarwal et al. (2009) Figure 2. presents that memory performance is monotonically decreasing with age, as fluid intelligence). Older people generally have more problems with their health, and the probability of dementia is also increasing with age, which causes decline in cognitive performance. To handle this problem, in the analysis I restricted my observations for individuals who are not demented.

Less educated people tend to live less than higher educated people, and through to this health/mortality channel there should be an increase in age-education and age-cognitive abilities profiles. There is a selection in mortality, which is connected with educational attainment, job tenure and cognitive function.

My comparison uses regression analysis and graphical analysis to compare individuals both sides of the compulsory schooling affected cohort. Regression discontinuity analysis allows to control for the trend in education, and to have different slope on both sides near the cut-off date. My main interest is to show if there is any statistically significant difference between the cohorts who are affected or not affected by the compulsory schooling reform. If they differ, we should see a significant first stage, where there is a shift in the years of education and this first stage may implies an increase in cognitive abilities.

Table 4 shows the mean comparison for memory score and educational attainment for the full sample and the subsample 3 year around the cut-off date. I used the t-test to compare the means for the memory score and the number of years of education.

Table 4 Mean memory score and number of year of education comparison by gender (Own estimation in Stata using SHARE Data)

	Males			**Females**		
	Before	*After*	*P value*	*Before*	*After*	*P value*
Full sample						
Education	11.24	11.64	**0.0041**	10.70	11.31	**0.0000**
Memory	9.52	9.78	**0.0093**	10.08	10.51	**0.0000**
N	1484	2100		2174	2358	
Less then 13 years of education						
Education	8.74	9.05	**0.0062**	8.45	8.95	**0.0000**
Memory	8.95	9.19	0.0630	9.44	9.89	**0.0001**
N	1131	1111		1466	1501	

The number of years of education is bigger for females who were born after the cut-off date. According to the t-test p values; there is a significant difference for educational attainment around the cut-off date for males too. For the full sample we could see for both genders that the mean of the memory score is higher for those who were born in the 3 years after period than those who were born in the 3 years before the reform affected cohorts (cut-off) date. I can reject the null hypothesis of equality of means. The educational attainment and memory scores are significantly higher at 5 % level for females and males in the full sample for the reform affected birth cohorts.

For the subsample that does not have a university or college degree (who has less than 13 years of education) for males there is a significant difference in educational attainment. I can reject the null hypothesis at 5 % level (equality of means) for number of years of education for males, but I cannot reject the null hypothesis at 5 % level (equality of means) for the memory score. For females I can state that after the cut-off date both the memory score and the years of education are significantly higher than before the cut-off birth cohort. These rows show that those who were born after the cut-off date performed better on the cognitive memory test, and also had higher number of years in school for females.

It is important to mention that cognitive abilities decline with age, and therefore is it not a surprise that the younger group, those who were born after the reform had better test scores. In the meantime it should be true for females and males, but I cannot see any significant difference in the effect on memory score for males, who have less than 13 years of education. This is rather puzzling, but further on, the regression estimates show if there is any effect on them.

Country pooled estimations

I estimated the effect of reform on the memory score and on the years of education with the following regressions around the cut-off birth date

$years\ of education_i = \alpha_1 + \beta_1 reform + \gamma_1 distance + \delta_1 interaction + \varepsilon_1$ (1) and

$memory\ score_i = \alpha_2 + \beta_2 reform + \gamma_2 distance + \delta_2 interaction + \varepsilon_2$ (2)

In the (1) equation the dependent variable is the number of years of schooling an individual have. The dependant variable in the (2) equation is the average of the number of recall words in the cognitive function module in SHARE data. I averaged out the 1st 2nd and 4th wave memory recall scores. The regressions include $reform$, which is a dummy variable takes the value 1 if individual *i was* born in the potentially reform affected birth cohort or after. The $reform$ variable is 0 if the individual was born before the potentially affected birth cohort. $Distance$ measures the difference between the potentially affected birth cohorts and individual *i* birth year. The variable $interaction$ is the multiplication of reform and distance variable. Both in equation (1) and (2) regressions are pooled across countries and estimated for people without dementia, for the full sample and for the restricted sample.

My main interests are the coefficients of the reform: on education β_1, and on memory scores β_2. The expectation is that the reform has a positive effect on education and memory scores, so β_1 and β_2 are positive. It would mean that the compulsory schooling reform has a positive effect on the educational attainment and also on memory performance. On the graphs it should look like there is a shift in the years of education and also in memory scores. The coefficient of the distance γ_1 and γ_2 will control for the trend. The interaction coefficients would give the slope right to the reform affected cohorts on the graphs.

Table 5 shows the number of observations around the cut-off birth cohort for every country. We can see the number of observations for each country 3 years around the potentially affected birth cohorts are between 200-1400 depending on which sample selection we use.

Table 5 The number of observations around the cut-off birth cohort for every country

Country	Date of reform	Potentially affected first birth cohort	Number of observations	
			Full Sample	Under 13 years of education
Austria	1962	**1953**	1250	964
Denmark	1958	**1948**	791	314
Denmark	1971	**1957**	817	234
France*	1959	**1953**	1476	970
Greece	1964	**1952**	945	659
Italy	1963	**1949**	1080	800
Spain	1970	**1957**	659	479
Sweden**	1962	**1950**	777	460
The Netherlands	1975	**1959**	448	208
*France 1959 Reform implemented in 1967				
**Swedish reform was implemented step by step between 1949-1962				

Theoretically if the numbers of observations are increasing then the estimated standard errors are decreasing and the regression estimates give more precise coefficients. With larger number of observations, the estimated coefficients would approximate more accurately the theoretical value of the compulsory schooling reform effect on education and memory. The small number of observations in every country can influence the significance level of the regression estimates.

In the following I will present the regression estimates for the (1) and (2) equation.

Table 6 shows the country pooled regression estimates on the number of years of education. In the subsample of less than 13 years of education the compulsory reform has a positive and significant effect on educational attainment, on average after the reform the number of years of education increased by 0.481 years. The mean number of education who has less then 13 years is 7.55 years and the standard deviation is 3.45 years. The magnitude of the reform on education is 0.481 years, which is about 14 % of the standard deviation. This magnitude is about the same as being younger by 4-5 years.

Table 6 Pooled regressions OLS estimations on Education 3 years around the cut-off date

	Full Sample	Under 13 years of education
	(1)	(2)
VARIABLES	iscedy_r	iscedy_r
reform	0.145	0.481***
	(0.204)	(0.172)
distance	0.199**	-0.0548
	(0.0808)	(0.0670)
interaction	-0.224**	0.0898
	(0.0996)	(0.0833)
Constant	11.34***	8.464***
	(0.176)	(0.148)
Observations	8,151	5,238
R-squared	0.005	0.006

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows by gender the same estimations on education for the full and the restricted samples. Compulsory schooling reform has a significant positive effect on the number of years of education for females, who have less than 13 years of education. The average difference between the reform affected and not affected birth cohorts is 0.568 years of education. The mean number of education for females, who has less then 13 years of education is 7.4 years, the standard deviation is 3.51 years. The magnitude of the reform effect on females who has less then 13 years of

education is 16% of the standard deviation. This magnitude is equivalent about being younger by 6 years.

Table 7 Pooled regressions OLS estimation on Education 3 years around the cut-off date by gender

	Full Sample		Under 13 years of education	
	Males	Females	Males	Females
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	iscedy_r	iscedy_r	iscedy_r
reform	0.0453	0.207	0.352	0.568**
	(0.309)	(0.271)	(0.256)	(0.233)
distance	0.252**	0.167	-0.0105	-0.0827
	(0.121)	(0.108)	(0.0984)	(0.0913)
interaction	-0.367**	-0.120	-0.000636	0.153
	(0.151)	(0.133)	(0.123)	(0.113)
Constant	11.75***	11.03***	8.722***	8.279***
	(0.267)	(0.234)	(0.219)	(0.200)
Observations	3,606	4,545	2,259	2,979
R-squared	0.004	0.006	0.003	0.008

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8 shows the country pooled regression estimates on memory score. The compulsory reform has a positive but statistically not significant effect on both samples. The table shows a difference about 0.232 points on average, between the reform affected and not affected birth cohorts for less than 13 years of education. However because the estimated effect is not statistically significant we could not state that there is a significant effect on memory for the ones who have less than 13 years of education.

Table 8 Pooled regressions OLS estimation on Memory 3 years around the cut-off date

VARIABLES	Full Sample (1) memory	Under 13 years of education (2) memory
reform	0.0487	0.232
	(0.154)	(0.189)
distance	0.119*	0.0465
	(0.0608)	(0.0737)
interaction	-0.0618	-0.0230
	(0.0750)	(0.0916)
Constant	10.07***	9.326***
	(0.133)	(0.163)
Observations	8,116	5,212
R-squared	0.004	0.004

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 9 shows by gender the same estimations for the two samples. In the subsample of less than 13 years of education the reform has a positive, but statistically not significant effect for females on the memory score on average 0.272 points. It is the memory score difference between the compulsory school reforms affected and not affected female birth cohorts.

Table 9 Pooled regressions OLS estimation of Memory 3 years around the cut-off date by gender

	Full Sample		Under 13 years of education	
	Males (1)	Females (2)	Males (3)	Females (4)
VARIABLES	memory	memory	memory	memory
reform	0.00921	0.101	0.205	0.272
	(0.225)	(0.208)	(0.282)	(0.253)
distance	0.0607	0.154*	-0.0392	0.102
	(0.0881)	(0.0832)	(0.109)	(0.0994)
interaction	0.0351	-0.134	0.120	-0.127
	(0.109)	(0.102)	(0.136)	(0.123)
Constant	9.642***	10.38***	8.873***	9.651***
	(0.194)	(0.180)	(0.242)	(0.218)
Observations	3,584	4,532	2,242	2,970
R-squared	0.003	0.006	0.002	0.006

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows that there is a positive and significant effect on education attainment for females, and with the results from **Table 9**, there is also a positive but statistically not significant effect on memory for females who have less then 13 years of education.

Based on the memory and education estimations I can give a two stage least square estimate on the effect of education on memory scores for females under 13 years of education. The *Wald estimator* is the ratio of the effect of compulsory schooling reform on memory score and the effect on educational attainment.

$$\frac{0.272}{0.568} = 0.48$$

It means on average for females who have less then 13 years of education, one more year of education imply a 0.48 points increase on memory scores. **Table 10** presents the two stage least square (2SLS) estimator, which gives the same point estimate, and also shows the standard error. Based on the results I emphasize that I cannot reject the null hypothesis that the Wald estimator is zero, although the calculated effect is positive.

Table 10 2SLS estimation of Memory 3 years around the cut-off date for females

	Females under 13 years of education
VARIABLES	memory
iscedy_r	0.480
	(0.448)
distance	0.143**
	(0.0726)
interaction	-0.206*
	(0.115)
Constant	5.681
	(3.893)
Observations	2,970
R-squared	0.001

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In the country-by-country analysis I estimate the regressions by gender, and also create the graphs by gender, to have the opportunity to compare the difference between males and females.

Graphical and regression analysis of discontinuity around the cut-off date country by country

In this section I present figures and regression estimates, which show the relation of memory score/birth cohorts and educational attainment/birth cohorts. I restrict my analysis to 3 years before and 3 years after the cut-off date for each country. Each figure is designed as the following way. In all figures the vertical black line shows the potentially affected first birth cohort of the compulsory school reform. Either side of the vertical line, there are the generated points from the sample, which represent the mean memory score or mean number of years of education for quarter of birth cohorts. If there is an effect of increasing years of compulsory schooling on memory score and educational attainment, we should see the discontinuity around the cut-off birth cohort.

The graphs relates to the regression equations:

$years\ of education_i = \alpha_1 + \beta_1 reform + \gamma_1 distance + \delta_1 interaction + \varepsilon_1$ (1) and

$memory\ score_i = \alpha_2 + \beta_2 reform + \gamma_2 distance + \delta_2 interaction + \varepsilon_2$ (2)

If the coefficients of the reform dummy β_1 on education and β_2 on memory scores are positive it means that the graphs should show a positive jump/shift at the cut-off birth cohort in the years of education and memory scores. If the coefficients of the distance variables are positive, it means there is a negative trend in education,

and memory scores. It is because the graphs show date of birth on the x axis, so that an increasing trend in terms of distance means a decreasing trend in terms of date of birth to the left in terms of the x axis, while it means an increasing trend in terms of birth to the right in terms of the x axis. On the graph the slope to the right of the cut-off point will be determined by the sum of $\gamma_1 + \delta_1$ for education, and $\gamma_2 + \delta_2$ for memory scores.

My main interest is whether the compulsory schooling reforms have an effect on education and memory performance. This section also presents, that my estimates are not driven by one country.

Austria

In Austria the 1962 reform increased the compulsory schooling from 8 to 9 years and the according to Brunello et al. (2009) and Fort (2006) the compulsory school reform affected the 1947 birth cohort. In contrast Gathmann et al. (2012) states that the first cohort affected by the reform were born in 1953. In the analysis the graphs and regressions are estimated for 1953 as a cut off birth date.

Figure 2 and 3 show the graphs on educational attainment and memory scores. It looks like the first stage effect on education is not big; on the other hand there might be some effect on memory performance for both genders.

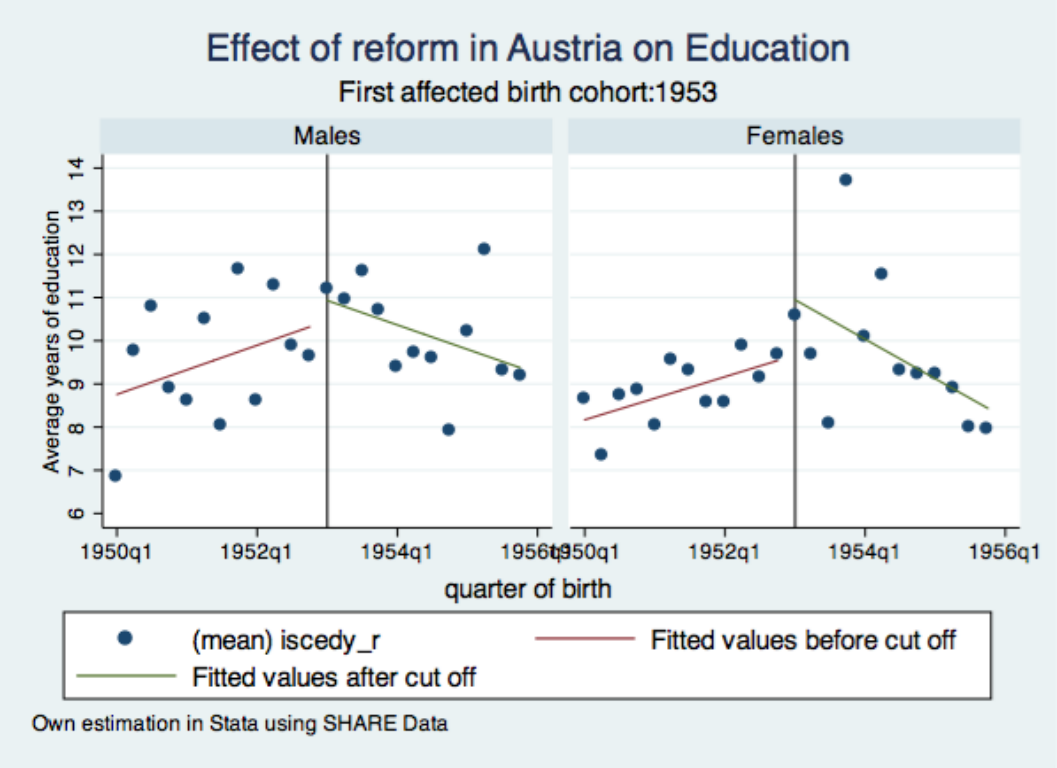

Figure 2 Effect of 1962 reform in Austria on Education around the 1953 birth cohort

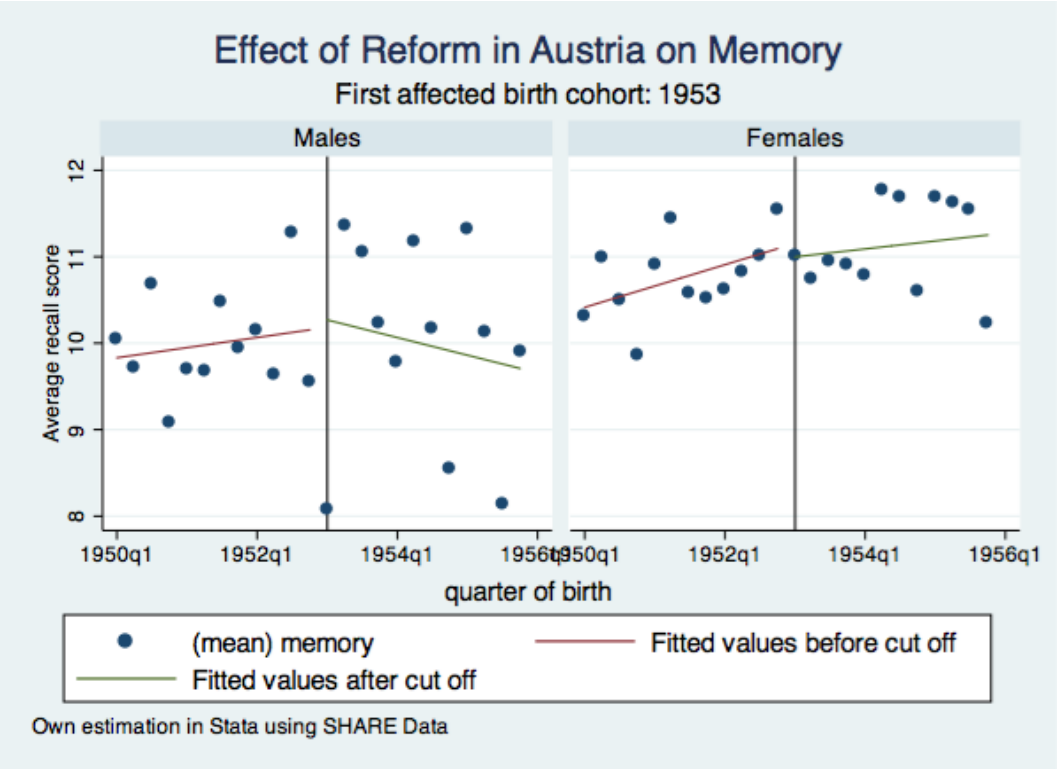

Figure 3 Effect of 1962 reform in Austria on Memory around the 1953 birth cohort

Gathmann et al. (2012) states that the first cohort affected the reform were born in 1953. I also run the same regression for this cohort on memory and education and **Table 11** shows that the compulsory schooling reform doesn't have any significant effect on memory score or education neither for the full sample or the restricted samples.

Table 12 and **Table 13** present the calculated effect of the compulsory schooling reform by gender; the effect of compulsory schooling was positive but statistically not significant on education and neither significant on memory scores neither for the full or the restricted sample.

Denmark

In Denmark the 1958 reform increased the compulsory schooling from 4 to 7 years and according to Fort (2006) the compulsory school reform affected the 1948 birth cohort.

In Denmark the next reform in 1971 increased the number of years of compulsory schooling from 7 to 9 years. According to Brunello et al. (2009) and Fort (2006) the first reform affected cohort born in 1957. Fort (2006) also control for 1961 cohort, because Arendt (2005) argues for that the implementation of the reform took place in 1975, so the affected birth cohort born in 1961. Unfortunately my dataset does not have individuals born in the 1960`s, so I cannot control for Arendt (2005) assumption.

The following **Figure 4-5** show the memory score and the educational attainment around the 1948 cut-off date for the 1958 reform in Denmark.

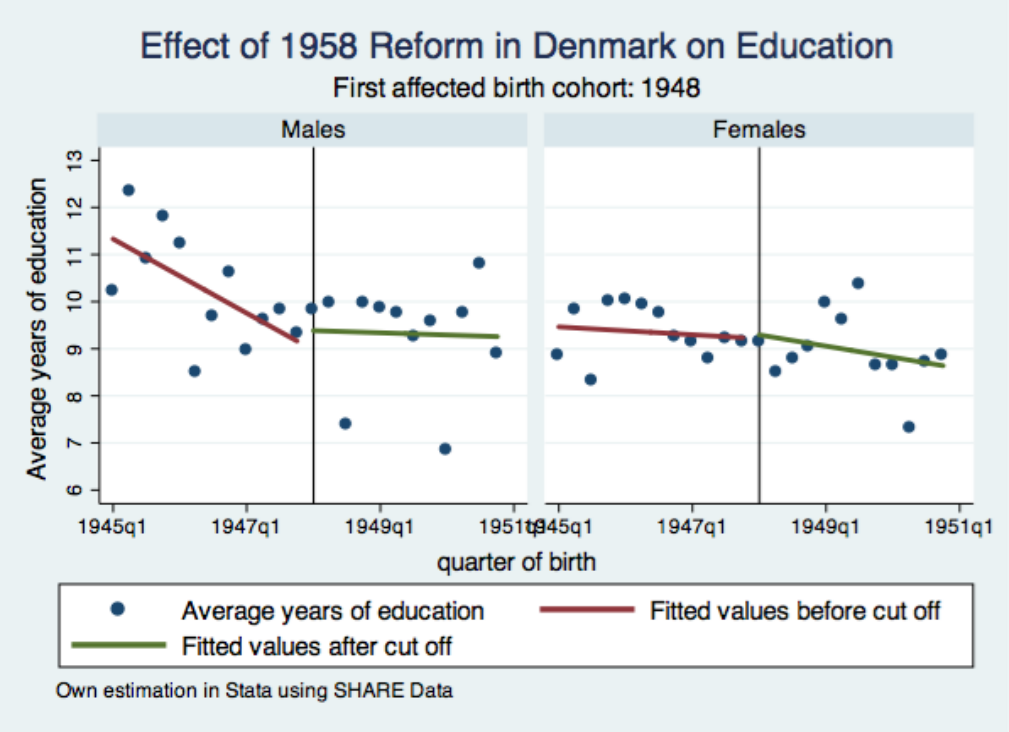

Figure 4 Effect of 1958 reform in Denmark on Education around the 1948 birth cohort

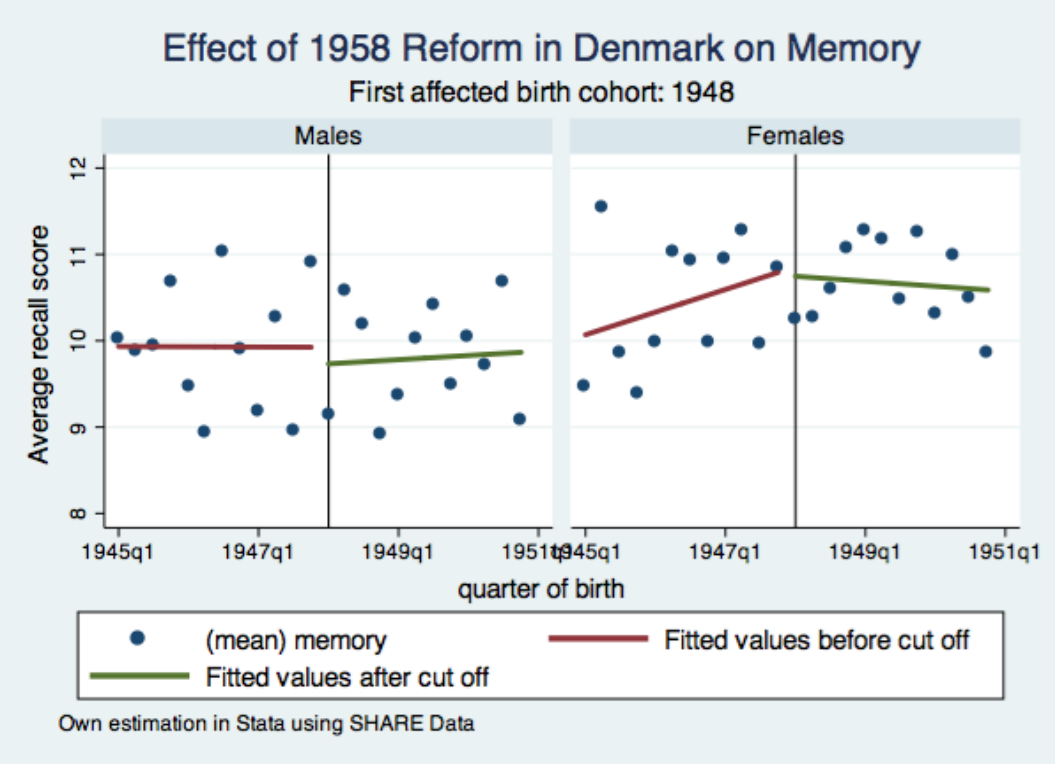

Figure 5 Effect of 1958 reform in Denmark on Memory around the 1948 birth cohort

From the **Figures 5-6** we could see that there might be some effect on female memory scores, but this is not due to the compulsory schooling reform since there is no significant increase in the educational attainment after the first potentially affected birth cohort.

Table 14 presents the regression estimation results on education attainment assuming that the 1958 compulsory schooling reform affected the cohort born in 1948. We can see that compulsory schooling reform doesn't have any significant effect on the years of education neither for the full sample or the restricted sample.

Table 15 presents the regression estimation results on memory assuming that the first reform affected the cohort born in 1948. We can see that the compulsory schooling reform doesn't have any significant effect on memory score neither for the full sample or the restricted sample.

Table 16 and 17 present the estimated the effect of the 1958 compulsory schooling reform separately for females and males on memory and education. From **Table 16** we could see for males there is no significant effect of the reform neither for the educational attainment or the memory score for the whole sample. Interestingly for the subsample: under 13 years of education, there is a negative weakly significant effect of the reform on educational attainment. But in this case we could not see any significant effect on memory score. **Table 17** presents the estimations for females. We could state that the 1958 compulsory schooling reform does not have any significant effect on education attainment or memory score neither for the full sample or the restricted subsample.

The following **Figure 6 and 7** show the memory score and the educational attainment for the 1971 reform affected birth cohort born in 1957.

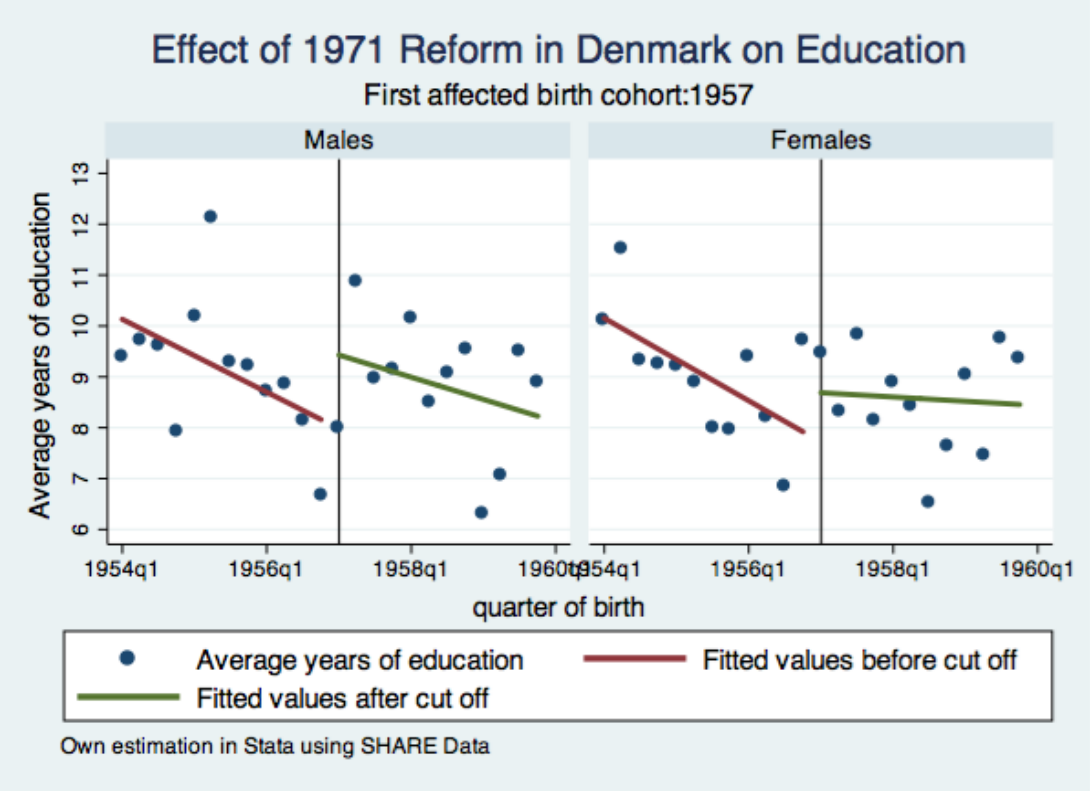

Figure 6 Effect of 1971 reform in Denmark on Education around the 1957 birth cohort

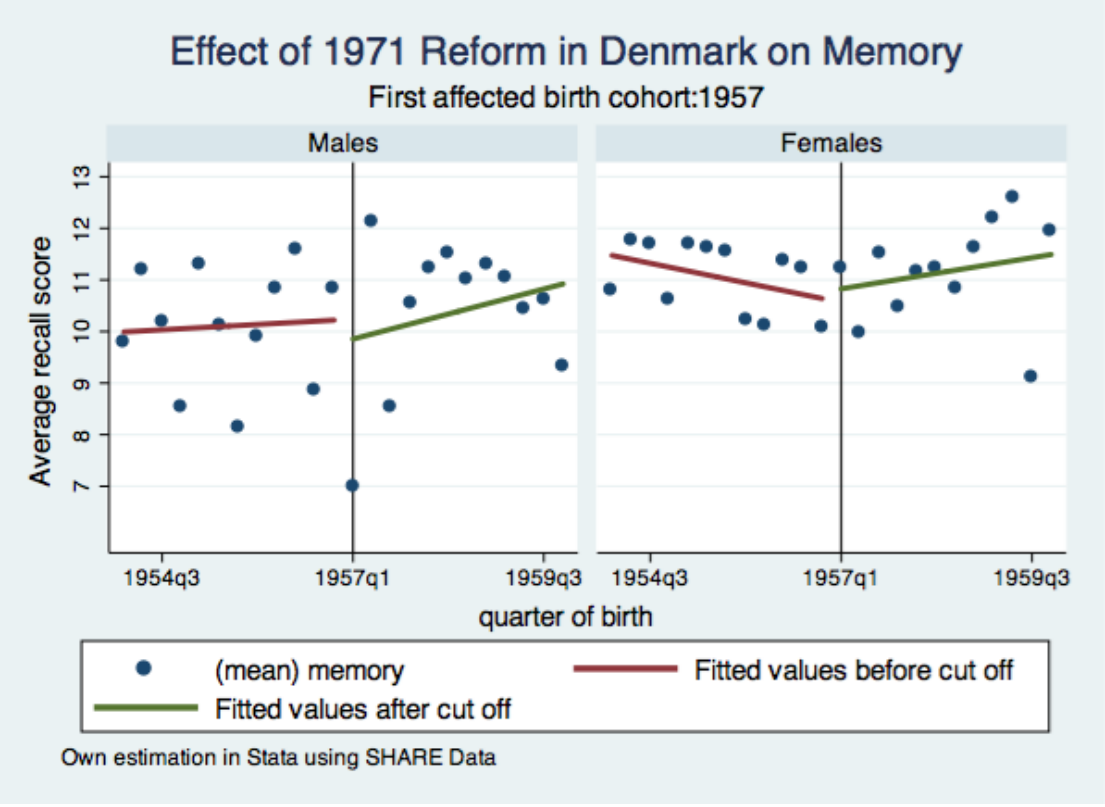

Figure 7 Effect of 1971 reform in Denmark on Memory around the 1957 birth cohort

From the **Figures 6-7** we could see that there might be some effect on male and female memory scores, but this is not due to the compulsory schooling reform since there is no significant increase in the educational attainment after the first potentially affected birth cohort.

Tables 18-19 present the regression estimation results on education attainment and memory assuming that the 1971 reform affected the cohort born in 1957. There is positive but not significant effect of the reform on educational attainment for both samples. For the memory scores there is no significant effect of the reform on cognitive capabilities for neither of the samples.

The next two tables **Table 20 and Table 21** show the effect of the 1971 compulsory schooling reform around the 1957 birth cohort separated by gender on educational attainment and memory scores.

We could state that the 1971 compulsory schooling reform does not have any significant effect on educational attainment or cognitive capabilities on males. It has a positive but not significant effect on the subsample for males who have less then 13 years of education.

For females the reform does not have any significant effect on educational attainment or memory performance for the full sample. The reform has a positive but not significant effect on the under 13 years of education subsample.

France

In France the 1959 Berthoin reform[2] increased the compulsory schooling from 8 to 10 years. The potentially first affected birth cohort was born in 1953 according to Fort (2006), Brunello et al. (2009) and Gathmann et al. (2012).

The following **Figure 8 and 9** show the memory score and the educational attainment around the 1953 birth cohort in France.

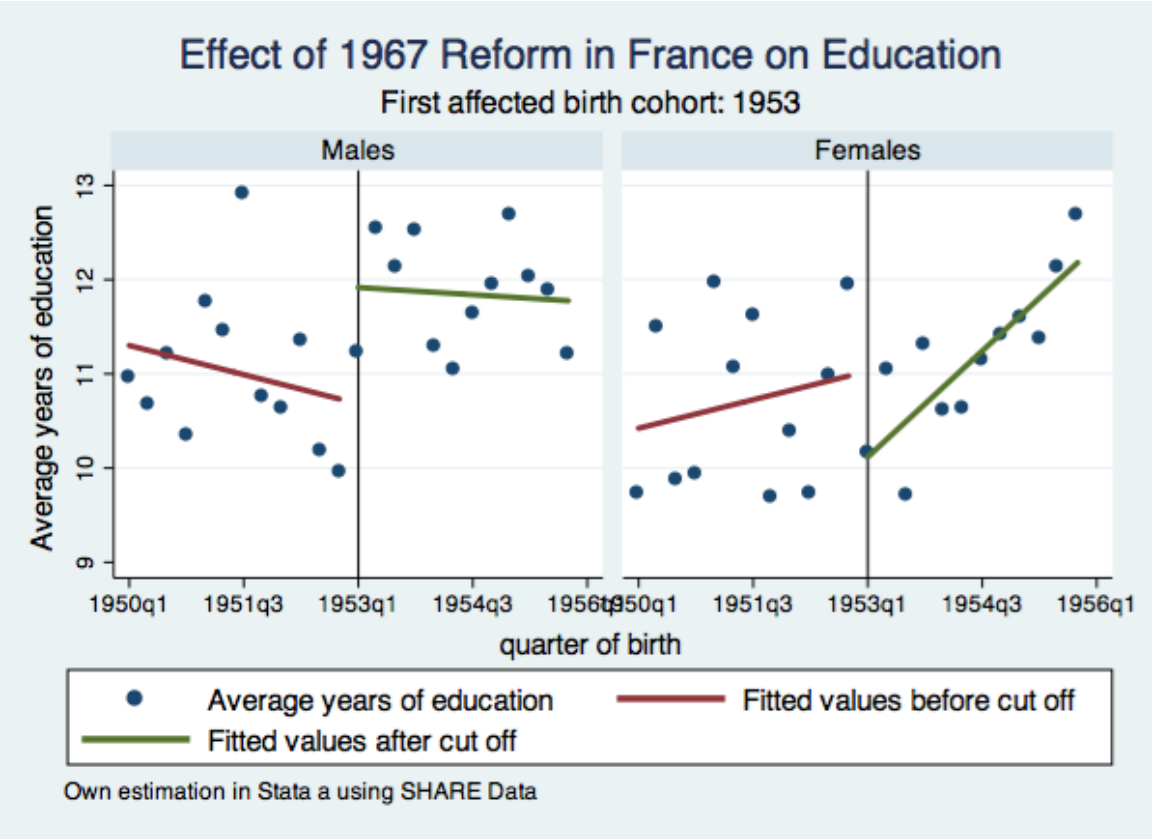

Figure 8 Effect of 1967 Reform in France on Education around the 1953 birth cohort

From the **Figure 8-9** it looks like the compulsory schooling reform has a positive effect on the educational attainment both for males and females. It also

[2] The reform was implemented in 1967 according to Fort (2006)

looks true that the compulsory schooling reform has a positive impact on memory scores for both genders.

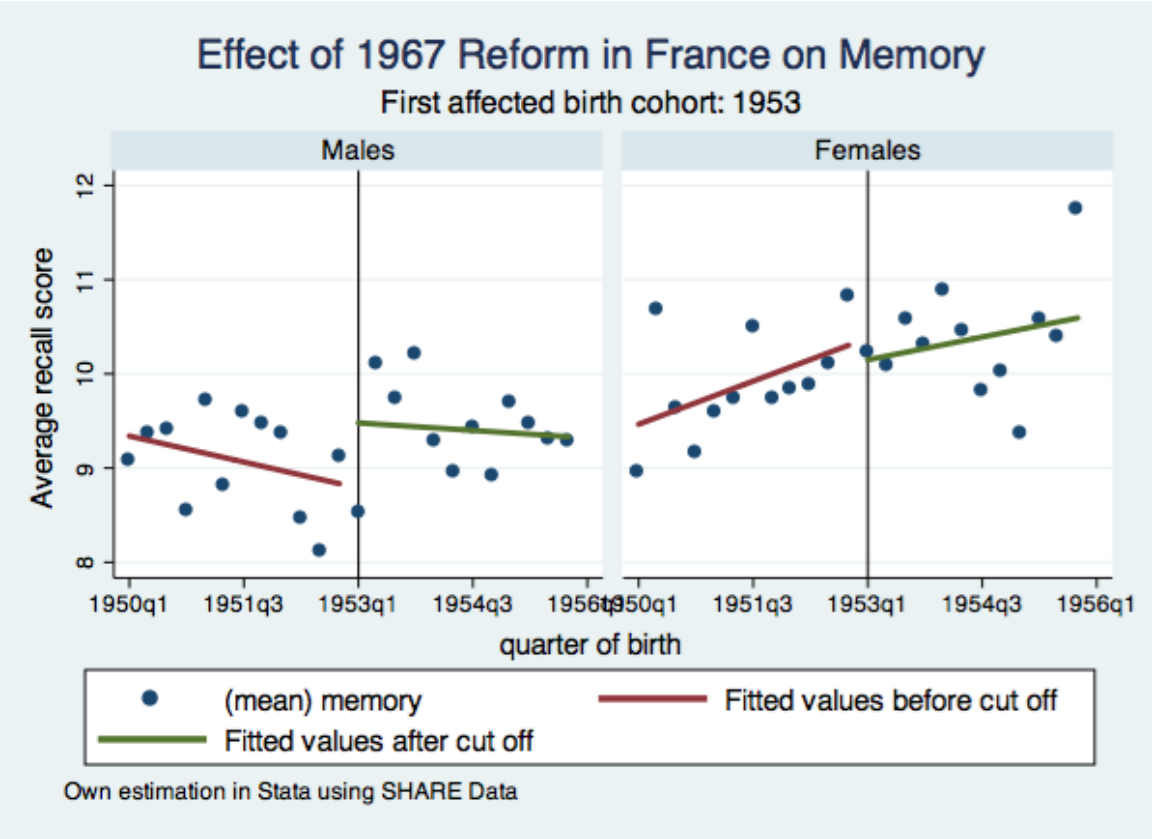

Figure 9 Effect of 1967 Reform in France on Memory around the 1953 birth cohort

The regression estimation results show that the reform has not got a significant effect on the full sample neither for the educational attainment or the memory performance. For the restricted sample we could see that the reform might have a positive, but not significant effect on the years of education and memory scores.

From **Table 23** we could state for males the compulsory schooling reform does not have a significant effect on education or memory scores for both samples.

For females the results are a little bit confusing. From **Table 24** for the full sample of females it looks like that the compulsory schooling reform has a significant

negative effect on educational attainment. Also the effect of the reform on memory performance also has a negative, but not significant effect. For the subsample effect of the reform looks positive, but not significant on the dependent variables.

Greece

In Greece the 1964 reform increased the compulsory schooling from 6 to 9 years. The potentially first affected birth cohort was born in 1952 according to Fort (2006).

The following **Figure 11 and 12** show the memory score and the educational attainment around the 1952 birth cohort in Greece.

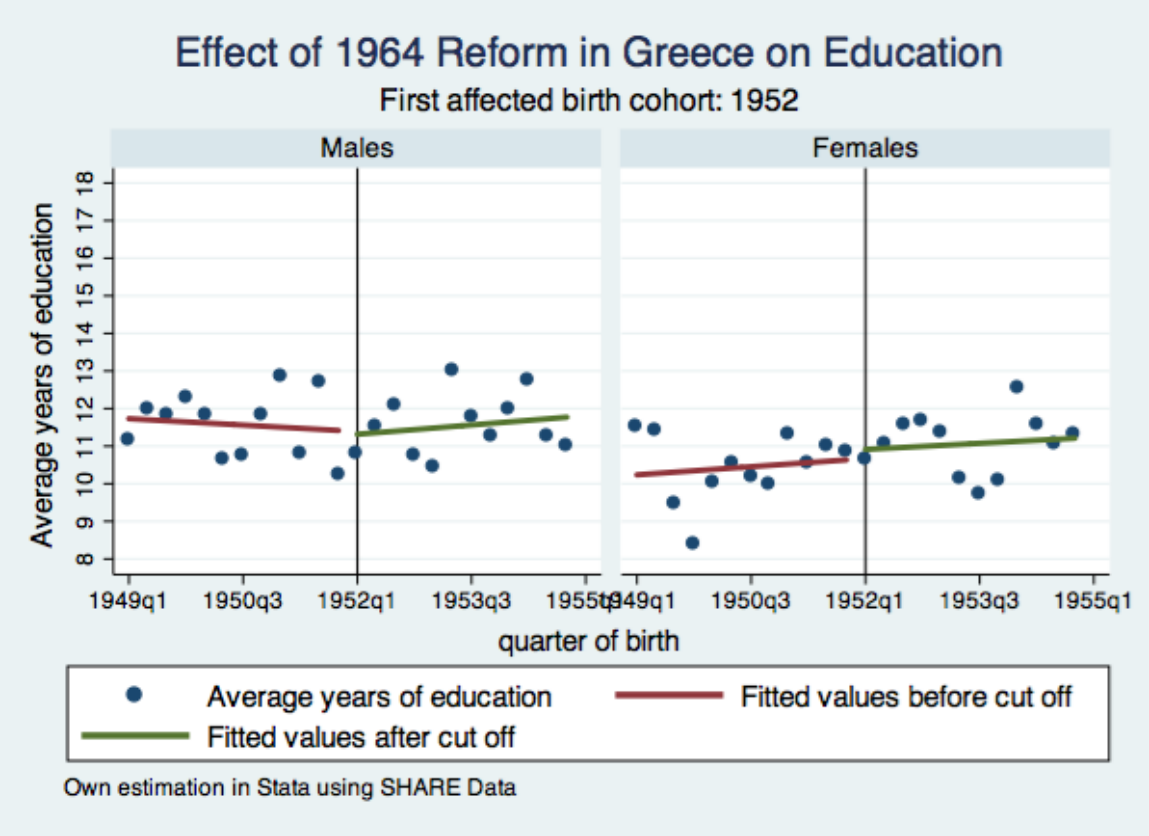

Figure 10 Effect of 1964 Reform in Greece on Education around the 1952 birth cohort

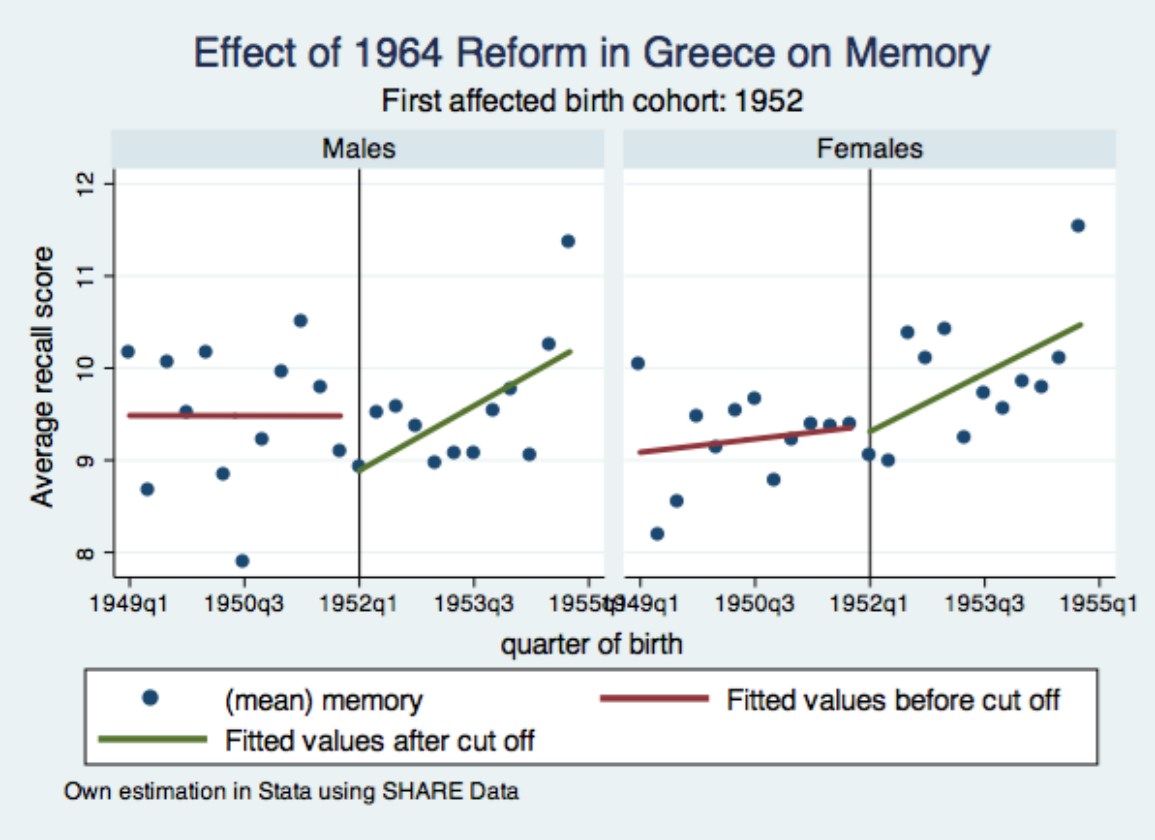

Figure 11 Effect of 1964 Reform in Greece on Memory around the 1952 birth cohort

The figures show that there is a slight increase in the years of education both for males and females. The memory score figure plots a big increase after the cut-off date for both genders. Nevertheless, the regression results do not show this connection.

Table 25 presents the regression estimations. The results show that the compulsory schooling reform does not have a significant effect on educational attainment or memory scores.

Table 26 and 27 shows the estimation results by gender, and the effect of the reform in these cases are not statistically significant neither on education nor on memory.

Italy

In Italy the 1963 reform increased the compulsory schooling from 6 to 9 years. The potentially first affected birth cohort was born in 1949 according to Brunello et al. (2009) and Gathmann et al. (2012). Fort (2006), states that the potentially reform affected birth cohort was born between 1949-1957. In my analysis I will analyse the effect of the reform around the 1949 birth cohort.

Figure 12 and 13 show the average years of education and memory scores around the potentially reform affected birth cohort. The graphs clearly show that there is an increase after the reform affected birth cohort in the educational level and memory scores both for males and females. This increase is bigger for females according to the graphs.

Table 28 shows the estimation results from the regression analysis. The estimated coefficients on education and memory have a positive sign, which is consistent with the graphical analysis, but the effect of the reform is not statistically significant neither for the educational attainment nor for the memory scores.

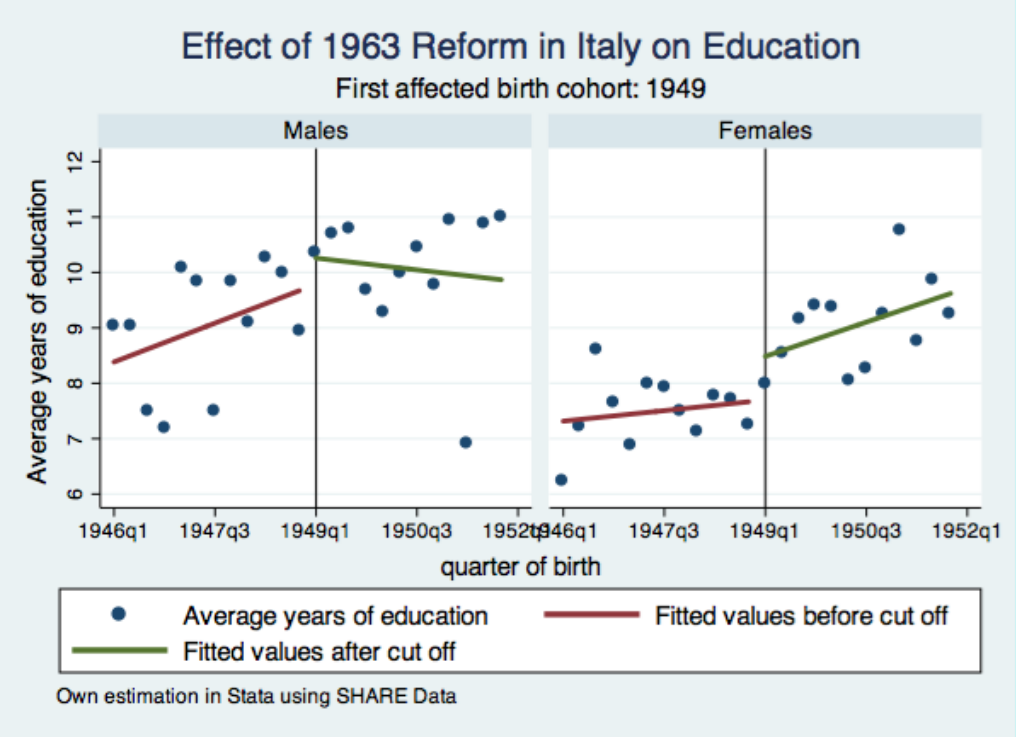

Figure 12 Effect of 1963 Reform in Italy on Education around the 1949 birth cohort

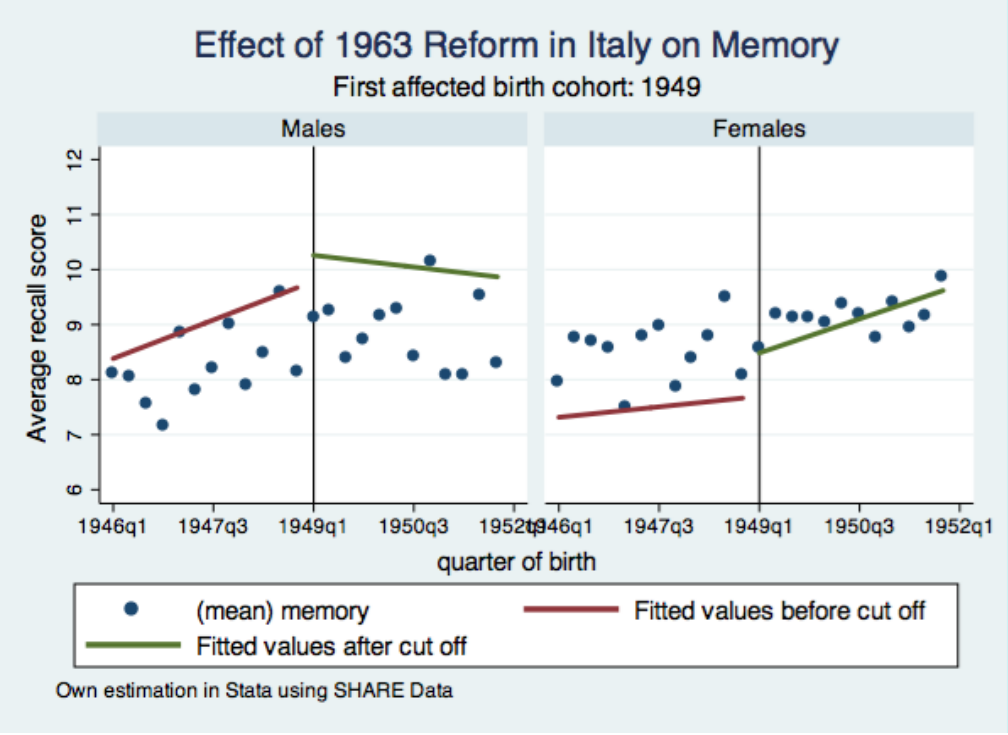

Figure 13 Effect of 1963 Reform in Italy on Memory around the 1949 birth cohort

Table 29 and 30 present the estimation results from the regression analysis by genders. In these cases the estimated coefficients on education and memory also

have a positive sign, which is consistent with the graphical analysis and with the expectations, but the effect of the reform is not statistically significant for males or females neither for the educational attainment nor for the memory scores.

Spain

In Spain the 1970 reform increased the compulsory schooling from 6 to 8 years. The potentially first affected birth cohort was born in 1957 according to Fort (2006), Brunello et al. (2009) and Gathmann et al. (2012).

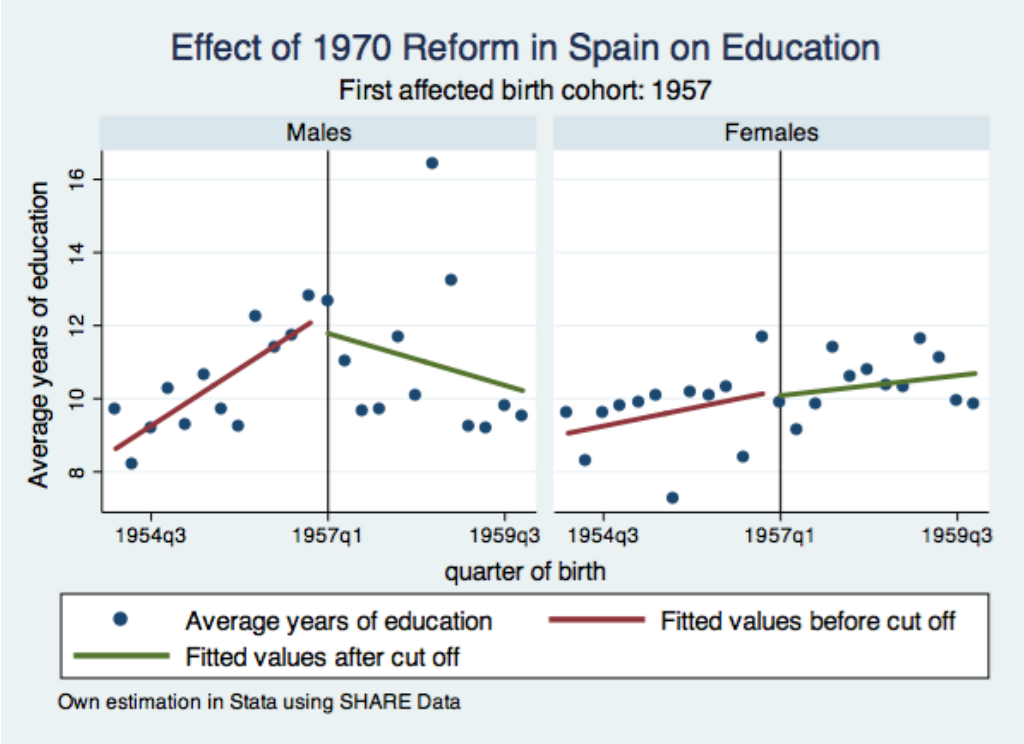

Figure 14 Effect of 1970 Reform in Spain on Education around the 1957 birth cohort

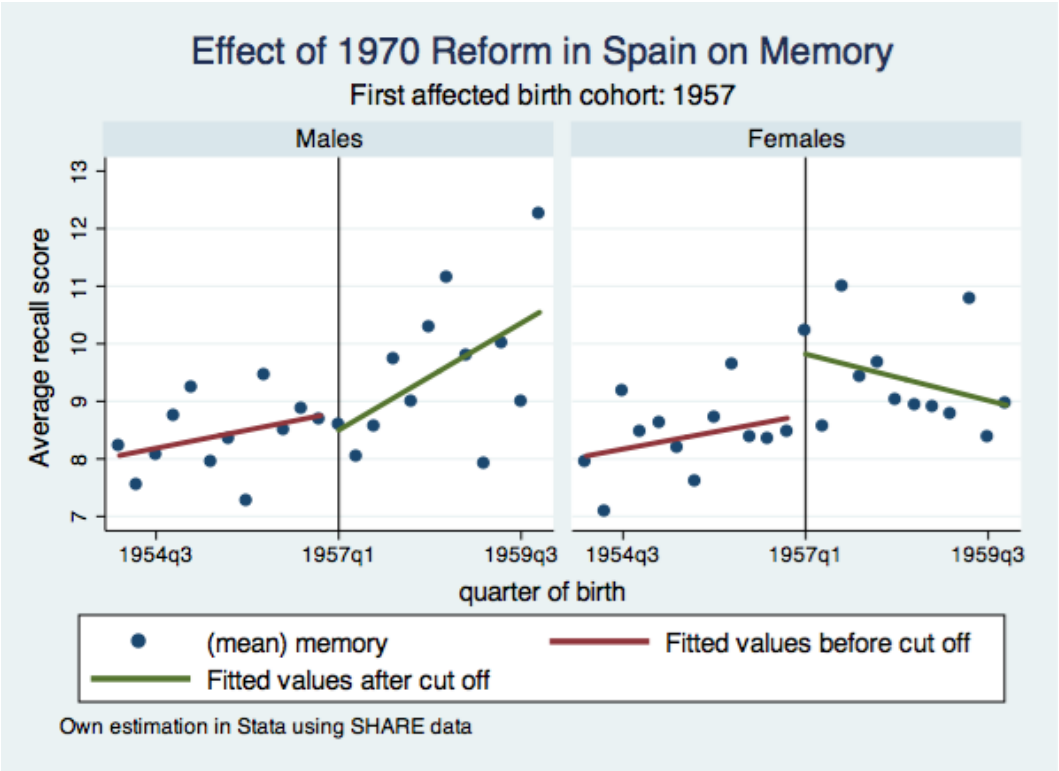

Figure 15 Effect of 1970 Reform in Spain on Memory around the 1957 birth cohort

From the **Figure 14 and 15** on educational attainment and memory scores we can conclude, that the average years of education increases after the cut-off birth date both for males and females. It is also true that the cognitive abilities are better - memory scores are higher; for the cohorts born after 1957.

Table 31 presents the estimation results for the full and the restricted sample. The effect of the compulsory schooling reform is not significant for both samples. For the restricted sample the magnitude of the effect is consistent with the expectation, positive but not significant.

Table 32 and 33 present the estimation results by gender. The effect of the compulsory schooling reform on education or memory score is not significant neither for males or females. For the restricted sample the magnitude of the effect on

education and memory scores is consistent with the expectation, positive but not statistically significant.

Sweden

In Sweden the compulsory schooling reform was implemented step by step between 1949-1962 (Meghir and Palme, 2005). The compulsory schooling years were increased up to 9 years. The potentially first affected birth cohort was born in 1949 according to Fort (2006), Brunello et al. (2009). Gathmann et al. (2012) states that the first potentially effected birth cohort was born in 1950.

The following part is calculated, as the first reform affected birth cohort was born in 1950 in Sweden. **Figure 16 and 17** present the effect of the compulsory schooling reform around the 1950 birth cohort. It looks like compulsory schooling reform has an effect on educational attainment for both genders. After the reform affected birth cohort, the years of education are bigger than before both for males and females. For the memory scores there is an effect also, but mostly on males.

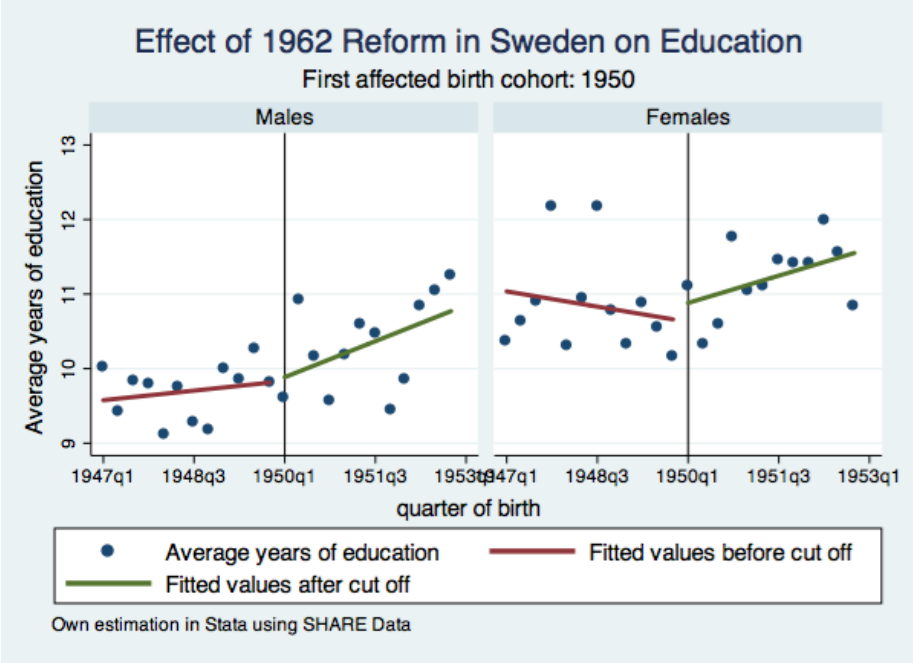

Figure 16 Effect of 1962 Reform in Sweden on Education around the 1950 birth cohort

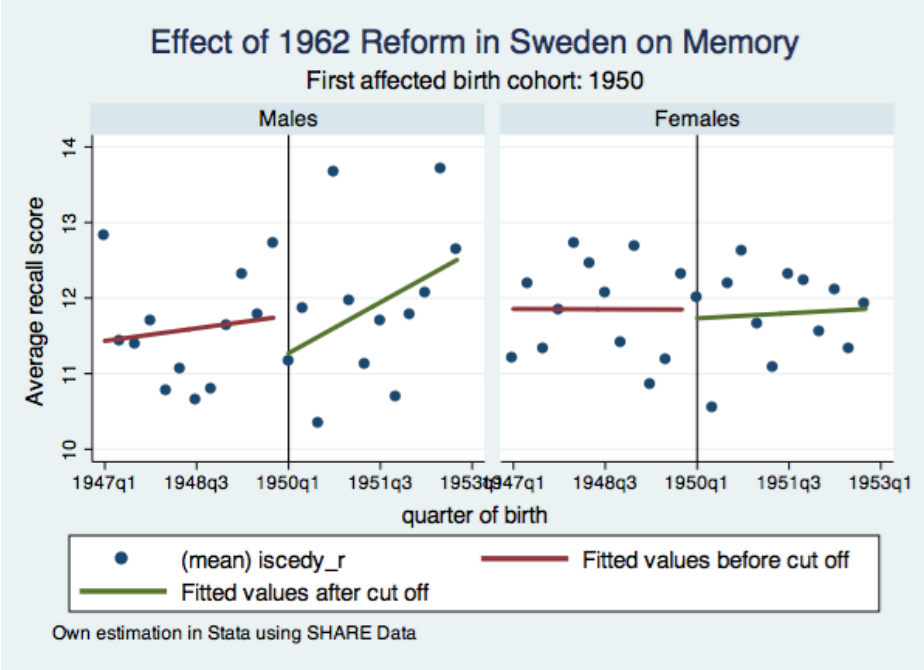

Figure 17 Effect of 1962 Reform in Sweden on Memory around the 1950 birth cohort

Table 34 presents the estimates for the full and restricted sample. There is no significant first stage effect on education, and the effect of compulsory schooling reform is also not significant on memory performance.

From the **Figures 16 and 17**, it looks like there might be a significant effect on education and memory for males. Let`s take a closer look on the regression estimates. The estimated coefficients are not in line with the expectations. The results in **Table 35** show that the compulsory schooling reform does not have a significant effect on educational attainment or cognitive abilities for males.

Table 36 presents the regression estimates for females. For the full sample the effect of the compulsory schooling reform is not statistically significant neither for educational attainment nor for memory scores. For the restricted sample the effect of the reform is positive and significant on the years of education. Nevertheless the effect on memory scores is positive and significant for females who have less than 13 years of education.

The Netherlands

In the Netherlands the 1975 compulsory schooling reform increased the compulsory years of education from 9 to 10 years. The potentially first affected birth cohort was born in 1957 according to Fort (2006), Brunello et al (2009), and Gathmann et al. (2012).

In the figures there are missing observations on males, since the SHARE Data contains individuals who were born before 1961. For females the observations are not missing, because most likely they are the younger partners of older

husbands. But due to this problem, the results should be interpreted with caution. From the **Figures 18 and 19**, it looks like there might be a slight increase for females in the years of education after the cut of point. In terms of the memory scores there is an increase for woman. For males we cannot say with certainty that the compulsory schooling reform has a positive impact on the years of education and the memory performance.

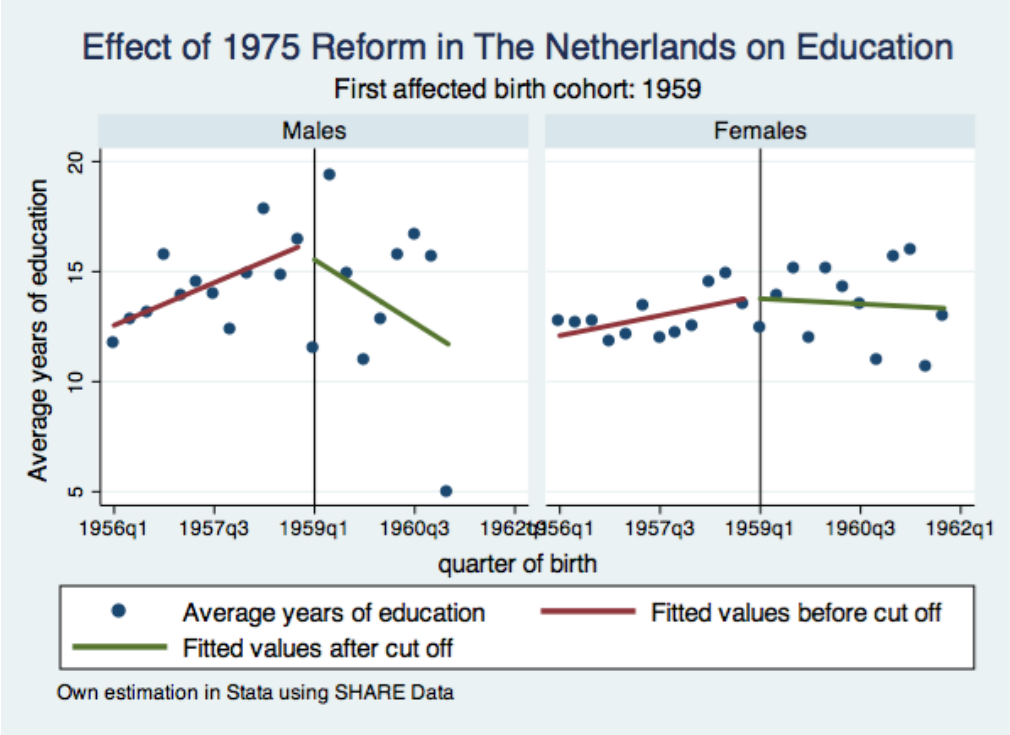

Figure 18 Effect of 1975 Reform in The Netherlands on Education around the 1959 birth cohort

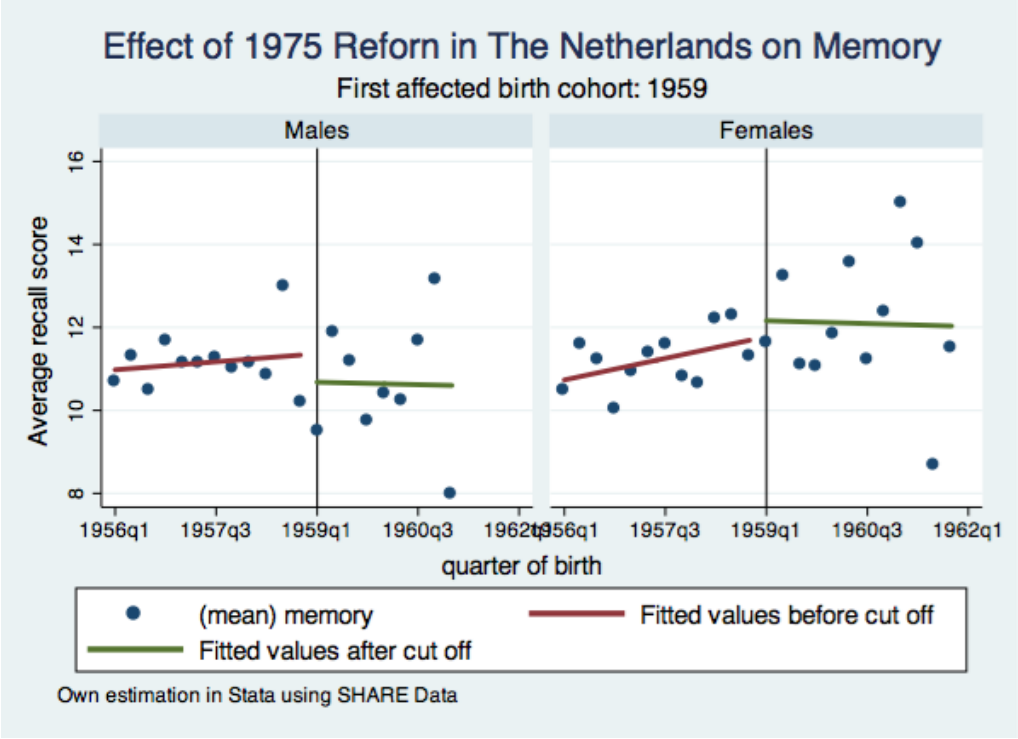

Figure 19 Effect of 1965 Reform in The Netherlands on Memory around the 1959 birth cohort

Table 37 presents the regression estimation. The results are controversial, it look like that the compulsory schooling reform has a negative effect on the educational attainment. The compulsory schooling reform has a negative but not significant effect on memory performance too. **Table 38 and 39** present the regression estimates by genders. The results show that the compulsory schooling reform has a negative but not significant effect on educational attainment and memory scores for males and females.

Robustness checks

I estimated the regressions and plot the graphs to show that, the results are not driven by one country or by few countries. **Table 5** showed that the numbers of observations are not large, and this could lead that my coefficient estimates on education and memory scores are not statistically significant. On the other hand, most of the estimated coefficients $\beta_1$on education and β_2 on memory have the same

positive sign and similar magnitudes, which are consistent with the theory and also with the country pooled estimates.

With respect to the environment around the cut off birth cohort I examine broader intervals with 4-7 years around the first potentially reform affected birth cohort. The estimations were similar to the 3 year before after period, which i use in the first place.

4. Conclusions

In this paper, I use data from the Survey of Health, Ageing and retirement In Europe dataset to examine the effect of compulsory schooling reforms in Europe on educational attainment and cognitive abilities. My work fits in the topic of economics of education. To be more precise in my thesis I wanted to examine the return on education on cognitive abilities. I use a similar model as Banks and Mazzonna (2012) used in their analysis they estimated the compulsory schooling reform effect in England on cognitive abilities. I also use compulsory schooling reforms; the reforms allow me to compare birth cohorts born before and after the reform affected birth cohort. I compare the cohorts' mean with simple T-test, and with more precise estimate as regression discontinuity design.

The main results are the following: the country pooled regression estimates show that the compulsory schooling reforms have a statistically significant effect on education, and have a positive but statistically not significant effect on memory (most likely due to not enough observations). The effect of compulsory schooling reforms on education attainment is about 0.4-0.5 years of additional education. Compulsory

schooling reforms have significantly increased females' educational level. This study is not designed to explore why this is the case, but it is true that the average level of education is lower for females in my sample. My assumption is that compulsory schooling reforms has effect on the less educated part of the distribution in the sample. Still there is a puzzle why the reforms don't have significant positive effect on males' education.

The results on memory are not fully conclusive. Compulsory schooling reform most likely has positive impact on cognitive abilities also, but my estimations cannot underlie it with the regular significance levels.

The country-by-country graphical and regression analysis show that the compulsory schooling reforms have similar effects in every country, and the estimated effects have similar magnitudes on education and memory performance.

The scope of my analysis is clearly defined, but it would be worth to consider the possible channels that have influence on females' education and cognitive performance, but does not have impact on males.

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Appendix

Austria 1962 Reform

Table 11 OLS estimations in Austria on Education and Memory 3 years around the 1953 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1953	0.705	-0.259	0.526	-0.217
	(0.560)	(0.438)	(0.494)	(0.494)
distance53	0.226	0.223	-0.000269	0.190
	(0.219)	(0.171)	(0.189)	(0.189)
interaction53	-0.795***	-0.120	-0.309	-0.0800
	(0.276)	(0.216)	(0.240)	(0.240)
Constant	10.05***	10.95***	7.995***	10.61***
	(0.479)	(0.375)	(0.419)	(0.419)
Observations	1,261	1,250	973	964
R-squared	0.012	0.004	0.005	0.004

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 12 OLS estimations in Austria on Education and Memory 3 years around the 1953 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1953	0.835	-0.310	1.076	-0.210
	(0.836)	(0.662)	(0.734)	(0.770)
distance53	0.210	0.150	-0.150	0.132
	(0.325)	(0.258)	(0.279)	(0.294)
interaction53	-1.002**	0.00726	-0.197	0.141
	(0.411)	(0.326)	(0.352)	(0.369)
Constant	10.32***	10.32***	7.682***	9.833***
	(0.713)	(0.566)	(0.622)	(0.656)
Observations	547	538	415	408
R-squared	0.019	0.003	0.009	0.008

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 13 OLS estimations in Austria on Education and Memory 3 years around the 1953 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1953	0.590	-0.245	0.0990	-0.167
	(0.754)	(0.577)	(0.670)	(0.633)
distance53	0.242	0.280	0.120	0.216
	(0.296)	(0.226)	(0.258)	(0.243)
interaction53	-0.622*	-0.242	-0.399	-0.245
	(0.373)	(0.285)	(0.328)	(0.310)
Constant	9.833***	11.45***	8.244***	11.15***
	(0.646)	(0.495)	(0.567)	(0.535)
Observations	714	712	558	556
R-squared	0.009	0.005	0.004	0.003

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Denmark 1958 Reform

Table 14 OLS estimations in Denmark on Education 3 years around the 1948 birth cohort

VARIABLES	Full Sample (1) iscedy_r	Under 13 years of education (2) iscedy_r
dummy1948	-0.482	-0.0804
	(0.503)	(0.423)
distance48	0.117	0.182
	(0.204)	(0.171)
interaction48	0.205	-0.130
	(0.244)	(0.208)
Constant	13.50***	10.21***
	(0.438)	(0.369)
Observations	791	314
R-squared	0.009	0.015

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 15 OLS estimations in Denmark on Memory 3 years around 1948 birth cohort

VARIABLES	Full Sample (1) memory	Under 13 years of education (2) memory
dummy1948	-0.0211	0.124
	(0.461)	(0.762)
distance48	0.169	0.0417
	(0.187)	(0.308)
interaction48	-0.187	0.0473
	(0.224)	(0.375)
Constant	10.89***	9.877***
	(0.402)	(0.666)
Observations	791	314
R-squared	0.004	0.004

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 16 OLS estimations in Denmark on Education and Memory 3 years around 1948 birth cohort for Males

VARIABLES	Full Sample (1) iscedy_r	Full Sample (1) memory	Under 13 years of education (2) iscedy_r	Under 13 years of education (2) memory
dummy1948	-0.544	-0.281	-0.954*	-0.387
	(0.742)	(0.690)	(0.549)	(1.070)
distance48	-0.0291	0.261	0.526**	0.227
	(0.314)	(0.293)	(0.238)	(0.464)
interaction48	0.305	-0.302	-0.530*	-0.0322
	(0.365)	(0.340)	(0.275)	(0.536)
Constant	13.47***	10.60***	11.35***	9.848***
	(0.663)	(0.617)	(0.494)	(0.963)
Observations	382	382	163	163
R-squared	0.007	0.003	0.030	0.008

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 17 OLS estimations in Denmark on Education and Memory 3 years around 1948 birth cohort for Females

VARIABLES	Full Sample (1) iscedy_r	Full Sample (1) memory	Under 13 years of education (2) iscedy_r	Under 13 years of education (2) memory
dummy1948	-0.325	0.332	0.602	0.659
	(0.693)	(0.610)	(0.632)	(1.100)
distance48	0.200	0.133	-0.128	-0.0229
	(0.269)	(0.237)	(0.239)	(0.416)
interaction48	0.153	-0.182	0.252	-0.0242
	(0.331)	(0.291)	(0.310)	(0.540)
Constant	13.45***	11.19***	9.184***	10.06***
	(0.587)	(0.517)	(0.533)	(0.929)
Observations	409	409	151	151
R-squared	0.019	0.010	0.024	0.008

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Denmark 1971 Reform

Table 18 OLS estimations in Denmark on Education 3 years around the 1957 birth cohort

	Full Sample	Under 13 years of education
	(1)	(2)
VARIABLES	iscedy_r	iscedy_r
dummy1957	0.504	0.589
	(0.487)	(0.456)
distance57	0.0596	0.0101
	(0.196)	(0.172)
interaction57	-0.0942	-0.304
	(0.239)	(0.220)
Constant	13.97***	10.12***
	(0.414)	(0.371)
Observations	817	234
R-squared	0.008	0.022

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 19 OLS estimations in Denmark on Memory 3 years around the 1957 birth cohort

	Full Sample	Under 13 years of education
	(1)	(2)
VARIABLES	memory	memory
dummy1957	-0.211	0.364
	(0.437)	(0.808)
distance57	0.0694	-0.225
	(0.176)	(0.305)
interaction57	-0.114	0.227
	(0.215)	(0.389)
Constant	11.60***	10.26***
	(0.372)	(0.657)
Observations	817	234
R-squared	0.001	0.003

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 20 OLS estimations in Denmark on Education and Memory 3 years around the 1957 birth cohort for Males

	Full Sample	Full Sample	Under 13 years of education	Under 13 years of education
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1957	0.0587	-0.0542	0.676	0.503
	(0.805)	(0.638)	(0.747)	(1.312)
distance57	0.373	0.119	-0.0746	-0.313
	(0.306)	(0.243)	(0.255)	(0.448)
interaction57	-0.388	-0.272	-0.131	0.0758
	(0.381)	(0.302)	(0.339)	(0.596)
Constant	14.57***	11.02***	9.938***	9.854***
	(0.677)	(0.536)	(0.601)	(1.055)
Observations	350	350	101	101
R-squared	0.018	0.003	0.013	0.018

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 21 OLS estimations in Denmark on Education and Memory 3 years around the 1957 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1957	0.899	-0.0998	0.493	0.390
	(0.610)	(0.583)	(0.597)	(1.047)
distance57	-0.222	-0.131	0.0975	-0.267
	(0.258)	(0.246)	(0.253)	(0.443)
interaction57	0.162	0.201	-0.449	0.437
	(0.309)	(0.295)	(0.307)	(0.538)
Constant	13.48***	11.76***	10.28***	10.38***
	(0.523)	(0.499)	(0.495)	(0.867)
Observations	467	467	133	133
R-squared	0.006	0.003	0.034	0.006

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

France 1959 Berthoin reform

Table 22 OLS estimations in France on Education and Memory 3 years around the 1953 birth cohort

	Full Sample		Under 13 years of education	
VARIABLES	(1) iscedy_r	(1) memory	(2) iscedy_r	(2) memory
dummy1953	-0.0839	0.139	0.412	0.493
	(0.415)	(0.339)	(0.315)	(0.412)
distance53	0.101	0.107	-0.0888	-0.0179
	(0.163)	(0.133)	(0.123)	(0.160)
interaction53	0.140	-0.103	0.296*	-0.0333
	(0.233)	(0.191)	(0.177)	(0.231)
Constant	11.80***	9.874***	9.373***	9.101***
	(0.356)	(0.291)	(0.271)	(0.354)
Observations	1,484	1,476	976	970
R-squared	0.004	0.004	0.012	0.005

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 23 OLS estimations in France on Education and Memory 3 years around the 1953 birth cohort for Males

	Full Sample		Under 13 years of education	
VARIABLES	(1) iscedy_r	(1) memory	(2) iscedy_r	(2) memory
dummy1953	0.844	0.489	0.479	0.208
	(0.606)	(0.467)	(0.419)	(0.553)
distance53	-0.180	-0.175	-0.0783	-0.188
	(0.233)	(0.180)	(0.159)	(0.210)
interaction53	0.113	0.137	0.229	0.334
	(0.352)	(0.272)	(0.243)	(0.323)
Constant	11.27***	8.961***	9.357***	8.509***
	(0.510)	(0.392)	(0.347)	(0.457)
Observations	714	711	474	471
R-squared	0.004	0.002	0.014	0.002

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 24 OLS estimations in France on Education and Memory 3 years around the 1953 birth cohort for Females

	Full sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1953	-1.010*	-0.372	0.346	0.368
	(0.569)	(0.481)	(0.482)	(0.608)
distance53	0.410*	0.436**	-0.0956	0.244
	(0.227)	(0.192)	(0.191)	(0.241)
interaction53	0.0733	-0.442*	0.350	-0.426
	(0.312)	(0.263)	(0.260)	(0.328)
Constant	12.39***	10.90***	9.399***	9.919***
	(0.496)	(0.420)	(0.428)	(0.540)
Observations	770	765	502	499
R-squared	0.013	0.014	0.012	0.018

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Greece 1964 Reform

Table 25 OLS estimations in Greece on Education and Memory 3 years around the 1952 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1952	-0.289	-0.260	-0.407	-0.529
	(0.560)	(0.378)	(0.473)	(0.442)
distance52	0.141	0.102	0.0634	0.148
	(0.230)	(0.155)	(0.193)	(0.181)
interaction52	0.0861	0.199	0.326	0.251
	(0.321)	(0.216)	(0.274)	(0.256)
Constant	11.44***	9.626***	9.299***	9.404***
	(0.487)	(0.330)	(0.409)	(0.382)
Observations	946	945	659	659
R-squared	0.002	0.006	0.007	0.009

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 26 OLS estimations in Greece on Education and Memory 3 years around the 1952 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1952	-0.666	-0.691	-0.180	-0.734
	(0.816)	(0.542)	(0.708)	(0.680)
distance52	0.0625	0.153	-0.113	0.175
	(0.327)	(0.217)	(0.287)	(0.275)
interaction52	0.216	0.0994	0.247	0.0855
	(0.467)	(0.310)	(0.406)	(0.390)
Constant	11.90***	9.873***	9.232***	9.614***
	(0.707)	(0.471)	(0.619)	(0.594)
Observations	452	451	298	298
R-squared	0.003	0.005	0.004	0.005

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 27 OLS estimations in Greece on Education and Memory 3 years around the 1952 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1952	-0.0831	0.114	-0.661	-0.392
	(0.766)	(0.529)	(0.634)	(0.582)
distance52	0.296	0.0673	0.243	0.142
	(0.322)	(0.223)	(0.262)	(0.240)
interaction52	-0.109	0.269	0.356	0.364
	(0.439)	(0.303)	(0.370)	(0.340)
Constant	11.17***	9.422***	9.414***	9.265***
	(0.669)	(0.462)	(0.545)	(0.500)
Observations	494	494	361	361
R-squared	0.010	0.016	0.022	0.018

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Italy 1963 Reform

Table 28 OLS estimations in Italy on Education and Memory 3 years around the 1949 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1949	0.652	0.178	0.520	0.292
	(0.521)	(0.381)	(0.344)	(0.416)
distance49	0.267	0.237	0.0782	0.0827
	(0.204)	(0.149)	(0.131)	(0.158)
interaction49	-0.0863	-0.204	0.100	-0.0511
	(0.311)	(0.227)	(0.210)	(0.253)
Constant	8.723***	8.867***	6.570***	8.141***
	(0.433)	(0.317)	(0.280)	(0.339)
Observations	1,085	1,080	804	800
R-squared	0.028	0.015	0.033	0.008

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 29 OLS estimations in Italy on Education and Memory 3 years around the 1949 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(1)	(2)	(2)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1949	-0.301	0.103	0.170	0.796
	(0.812)	(0.588)	(0.571)	(0.672)
distance49	0.713**	0.377*	0.290	0.0726
	(0.315)	(0.228)	(0.214)	(0.252)
interaction49	-0.793*	-0.522	-0.342	-0.273
	(0.478)	(0.346)	(0.340)	(0.399)
Constant	10.50***	9.005***	7.276***	7.746***
	(0.685)	(0.496)	(0.477)	(0.561)
Observations	478	473	315	311
R-squared	0.026	0.021	0.028	0.020

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 30 OLS estimations in Italy on Education and Memory 3 years around the 1949 birth cohort for Females

	Full Sample		Under 13 years of education	
VARIABLES	(1) iscedy_r	(1) memory	(2) iscedy_r	(2) memory
dummy1949	1.116*	0.252	0.623	0.0728
	(0.662)	(0.503)	(0.431)	(0.530)
distance49	0.0122	0.115	-0.0195	0.0410
	(0.260)	(0.198)	(0.165)	(0.204)
interaction49	0.418	0.0544	0.358	0.138
	(0.399)	(0.303)	(0.266)	(0.328)
Constant	7.550***	8.742***	6.215***	8.289***
	(0.544)	(0.413)	(0.346)	(0.425)
Observations	607	607	489	489
R-squared	0.041	0.013	0.042	0.004

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Spain 1970 Reform

Table 31 OLS estimations in Spain on Education and Memory 3 years around the 1957 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1957	-0.680	0.152	0.341	0.427
	(0.716)	(0.493)	(0.495)	(0.575)
distance57	0.782***	0.373**	0.0262	0.270
	(0.261)	(0.180)	(0.175)	(0.204)
interaction57	-0.919**	-0.311	-0.0942	-0.410
	(0.418)	(0.288)	(0.283)	(0.329)
Constant	11.66***	9.192***	8.195***	8.550***
	(0.571)	(0.394)	(0.394)	(0.458)
Observations	662	659	482	479
R-squared	0.021	0.033	0.004	0.025

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 32 OLS estimations in Spain on Education and Memory 3 years around the 1957 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1957	-1.530	-0.161	0.475	0.381
	(1.153)	(0.737)	(0.805)	(0.865)
distance57	1.424***	0.392	-0.0827	0.0991
	(0.430)	(0.276)	(0.287)	(0.310)
interaction57	-2.092***	-0.0597	-0.229	-0.0406
	(0.704)	(0.450)	(0.463)	(0.498)
Constant	13.25***	9.173***	8.171***	8.147***
	(0.929)	(0.594)	(0.654)	(0.704)
Observations	269	268	193	192
R-squared	0.050	0.036	0.004	0.014

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 33 OLS estimations in Spain on Education and Memory 3 years around the 1957 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1957	-0.104	0.395	0.225	0.518
	(0.907)	(0.665)	(0.629)	(0.769)
distance57	0.316	0.363	0.112	0.380
	(0.324)	(0.238)	(0.221)	(0.271)
interaction57	-0.0688	-0.490	-0.0351	-0.686
	(0.517)	(0.379)	(0.359)	(0.440)
Constant	10.50***	9.212***	8.228***	8.803***
	(0.717)	(0.526)	(0.493)	(0.604)
Observations	393	391	289	287
R-squared	0.013	0.033	0.014	0.035

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Sweden 1962 Reform

Table 34 OLS estimations in Sweden on Education and Memory 3 years around the 1950 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1950	-0.142	0.394	0.375	0.429
	(0.453)	(0.405)	(0.396)	(0.532)
distance50	0.0963	-0.0802	-0.0324	0.0349
	(0.179)	(0.160)	(0.156)	(0.210)
interaction50	-0.0449	0.308	0.0316	0.0955
	(0.259)	(0.232)	(0.224)	(0.301)
Constant	11.91***	10.16***	9.573***	9.871***
	(0.392)	(0.350)	(0.346)	(0.464)
Observations	779	777	461	460
R-squared	0.001	0.010	0.007	0.016

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 35 OLS estimations in Sweden on Education and Memory 3 years around the 1950 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1950	-0.135	0.119	-0.504	0.129
	(0.725)	(0.619)	(0.613)	(0.776)
distance50	0.0473	0.0957	0.383	0.209
	(0.286)	(0.244)	(0.249)	(0.315)
interaction50	0.289	0.202	-0.354	-0.00361
	(0.411)	(0.351)	(0.357)	(0.452)
Constant	11.60***	9.883***	10.42***	9.511***
	(0.624)	(0.533)	(0.530)	(0.671)
Observations	341	340	212	211
R-squared	0.006	0.019	0.017	0.026

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 36 OLS estimations in Sweden on Education and Memory 3 years around the 1950 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1950	-0.172	0.552	1.058**	0.344
	(0.580)	(0.521)	(0.519)	(0.702)
distance50	0.132	-0.196	-0.335*	0.0365
	(0.228)	(0.206)	(0.200)	(0.271)
interaction50	-0.289	0.452	0.313	0.0907
	(0.335)	(0.301)	(0.287)	(0.387)
Constant	12.13***	10.38***	8.911***	10.47***
	(0.502)	(0.452)	(0.458)	(0.619)
Observations	438	437	249	249
R-squared	0.002	0.010	0.019	0.012

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Netherlands 1975 Reform

Table 37 OLS estimations in The Netherlands on Education and Memory 3 years around the 1959 birth cohort

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1959	-0.802	-0.263	-1.007*	-0.555
	(0.747)	(0.583)	(0.547)	(0.977)
distance59	0.783***	0.260	0.393**	0.244
	(0.257)	(0.200)	(0.181)	(0.321)
interaction59	-1.132**	-0.0196	-0.372	-0.285
	(0.563)	(0.439)	(0.399)	(0.712)
Constant	15.07***	11.79***	11.29***	11.20***
	(0.615)	(0.477)	(0.450)	(0.800)
Observations	452	449	209	208
R-squared	0.030	0.010	0.023	0.003

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 38 OLS estimations in The Netherlands on Education and Memory 3 years around the 1959 birth cohort for Males

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1959	-0.642	-0.204	-0.952	0.404
	(1.435)	(0.955)	(1.107)	(1.580)
distance59	1.142**	0.0676	0.536	-0.210
	(0.488)	(0.323)	(0.356)	(0.508)
interaction59	-2.643**	-0.157	-1.179	-0.612
	(1.197)	(0.798)	(0.812)	(1.158)
Constant	16.60***	11.30***	11.74***	10.16***
	(1.194)	(0.790)	(0.914)	(1.305)
Observations	166	165	69	69
R-squared	0.061	0.001	0.045	0.023

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 39 OLS estimations in The Netherlands on Education and Memory 3 years around the 1959 birth cohort for Females

	Full Sample		Under 13 years of education	
	(1)	(2)	(3)	(4)
VARIABLES	iscedy_r	memory	iscedy_r	memory
dummy1959	-1.070	-0.188	-1.027	-0.853
	(0.836)	(0.738)	(0.633)	(1.230)
distance59	0.666**	0.354	0.352*	0.424
	(0.290)	(0.254)	(0.212)	(0.409)
interaction59	-0.478	-0.0769	-0.115	-0.187
	(0.606)	(0.535)	(0.461)	(0.895)
Constant	14.40***	12.03***	11.15***	11.58***
	(0.683)	(0.599)	(0.520)	(1.003)
Observations	286	284	140	139
R-squared	0.023	0.021	0.023	0.010

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1