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Diploma Thesis

Education and Health in Western Germany
Correlation and Causation

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1. Introduction

According to Grossman 2005 [8] education and health are the two most important sources of human capital. At the latest since Becker's research on the effects of education on non-market outcomes, researchers' interest in the relationship between education and health has grown. Feinstein et al. 2006 [4] report to the OECD that the effect of education on health is causal, substantial and universal. Whether or not this can be confirmed for Western Germany's school reforms during 1949 to 1969, using the SHARE data set from 2004[1], is the main purpose of this paper.

Based on human capital theory I explain theories on the direction and nature of the relationship between education and health and address issues of measurement, endogeneity and omitted variables. To test theories I use three main identification methods beside straight Ordinary Least Squares (OLS): Regression Discontinuity (RD), Difference in Difference Estimation (DID) and Instrumental Variable Estimation (IV).

Results are quite ambiguous for the selected health outputs and vary in significance, direction, strength and robustness. This topic needs more research using data sources with a larger sample size.

2. Human Capital Theory

Education and health can be viewed as stocks of human capital which can be increased by investments in one or the other. Since every investment has costs of opportunity and a return, human capital investments also have diverse effects on productivity, quality of life and individuals' decisions.

To know whether there are causal relationships, that is direct effects of education on health or vice versa, has important policy implications. By furthering investments in education it could be possible to increase the health status or the health behaviour of people or the other way around. This would be a great increase in the effectivity of policy measures, subsidiaries and human capital investments.

By finding simple correlations between educations and health, we may be tempted to assume causality which in fact cannot be concluded

[1]See http://www.share-project.org/ for more information.

straight away. To conclude causality we have to check for omitted variables, find good proxies for possible unobservable variables and assure exogeneity of the regressors. Policy recommendation should only be given based on such a causality analysis.

The two variables of interest, education and health, can be defined in various ways. Education is often simply defined as the years of formal schooling, which is the way I use it in this paper, and its different stages and certificates[2]. Also it can be a professional education just as well as the work or life experience, and general or health specific knowledge. Health also can be defined in a very general way as well as we can focus on either more objective or more subjective health measures. The former could be physical performance, chronical diseases, infections or nutrition, while the latter could be self rated health, overall well-being, and more or less psychic indications. In general the definition of the health variables can be conducted in terms of consciousness, status and behaviour concerning health.

It is obvious that a causality analysis is sensitive to the definition and measurement of both variables.

Becker 1960 [1] and 1965 [2] can be viewed as a pioneer in the research on the effects of education on non-market outcomes. Inter alia he assumes that education increases the efficiency of the production of non-market goods, which he calls commodities, in a very broad sense. Commodities are produced by consumers using market goods and services as well as their own time. Knowledge, aquired by schooling, could have an effect on individual decisions in many areas of life and may therefore also affect non-market outcomes, such as individuals' consumption-leisure-decisions and health.

Grossman 1972 [6] develops a basic model of the demand for *healthy life time*. He understands health as a human capital stock which produces healthy life time as an output. Individuals inherit primal endowments of health which generally decrease with age. Health investments lower the marginal decrease or may even increase the human captial stock of health.

[2]See sections below for documenation about how the two education measures used in this paper, *total years of education* - `TOTYEDU` - and *years of secondary education* - `SECEDU`, are generated from individuals' announcements about their degrees.

The demand for medical goods and services may rather be determined by the demand for health in general and in principal both demands underlie a trade-off: healthier people demand fewer medical goods and services. Grossman 1972 uses the same definitional distinction of non-market and market goods as his predecessors. [6, p. 224]

2.1. **Productive Efficiency - Exogenous Inputs.** In his model Grossman 1972 [6], 2000 [7], 2005 [8] explains an efficiency increase in the production of health, again with medical goods and services and time as inputs, caused by education. Health is not bought or consumend by people on the market. Rather they produce their own health using time and medical inputs. Individuals' health determines the loss of productive time. Illness decreases the time that can be used for the production of market and non-market goods. Here education is understood as individual stock of human capital which increases the efficiency of the production of health ceteris paribus, that is without any change in inputs.

Let h be the total amount of time that can be used for market and non-market production and is a positive function of health H. [3] In addition $h(H)$ be concave . [4] $H = e^{\rho_H S} P(M, T)$, whereas ρ be a positive parameter, S be an exponential measure of productive efficiency and $P(M, T)$ be a function dependant on the inputs *medical goods and services* M and *time* T. H be linear homogenous with respect to inputs M and T. [8, p. 10]

Consumers maximize $Wh(H) - \pi_H H$ over H, according to the following first order condition: $W\frac{\delta h}{\delta H} = \pi_H$, where W be the *wage rate* and π_H be the *marginal costs of health production.* [8, p. 11] The *marginal return of health on the labour market* equals the *marginal costs of health production* in the utility maximum.

The human capital stock of school education is a technology which increases the marginal product of health production. This increases the demand for health and decreases the demand for medical goods and services. More health reduces the time lost due to illness and by that school education leads to less demand for medical goods and services.

[3] $\frac{\delta h}{\delta H} > 0$
[4] $\frac{\delta^2 h}{\delta H^2} < 0$

2.2. **Allocative Efficiency - Endogenous Inputs.** Rosenzweig and Schultz 1982 [12, p. 59] and Deaton 2002 [3, p. 21] question whether the efficiency of health production may increase without any change in inputs. The theory of *allocative efficiency* assumes that better educated people choose a more efficient mixture of inputs in the production of health. Here it is not a technology that increases the efficiency of the production of health but rather the allocative efficiency of individuals' health investment decisions rises. They choose their mixture of inputs more efficiently with respect to productivity of the health production process.

Education therefore furthers the efficiency of investment decisions which then lead to a higher production of health. Following this, here efficiency stems from an advantage in informaton that better educated people have. Education may be associated with a better health knowledge and health behaviour.

Still, both efficiency theories do contain a positive relationship betweeen education and health. These theories explain health as stock of human capital which can be increased by inputs of medical supply and health behaviour to a certain extent.

3. Theories on Correlations and Causalities

Both theories actually assume some causal effect of education on health but the theory of allocative efficiency further assumes that this effect is not direct or ceteris paribus. The two theories must not be viewed as contradicting each other. It may be that better educated people are healthier because they choose their health inputs more efficiently but when holding health inputs constant the direct effect may remain significant. Anyhow these theories help us to investigate the role of health knowledge and health behavior, as well as various omitted variables, in the education-health-relationship.

Again it is generally possible that there is a causal effect of health on education, maybe because healthier people have more time to invest in or to consume education. In terms of investments in education two other theories to justify reverse causaltiy exist: Healthier people live longer and therefore have a larger horizon of lifetime. Thus they

are more able to benefit from future returns of investments. Life expectancy consequently should increase the incentive to invest in education. Furthermore healthier individuals may have a stronger preference for future payoffs relative to current payoffs, that is they have a relatively higher discount factor than less educated individuals which also increases incentives to invest in education. It is important to mention that the possibility of such a reverse causality does not contradict the original causality from education to health. In fact they may exist both. The reason why we have to check for this is the assumption of exogenous regressors, specifically the education variable in our regression. Reverse causality would destroy this assumption.

The relationship between education and health may be biased also due to omitted variables. Omitting variables happens sometimes simply by accident, when an important implicit relationship is not considered. Also quite simply there may be some more or less obvious implicit relationships: First, we may assume an obvious relationship but may not be able to measure it in any way. Second, there may be still unobservable influences on health which bias the education coefficient because we are unable to conceive them.

As mentioned above, life expectancy and time preference may cause endogeneity problems and may be important controls for our analysis. Obviously both parameters are not easily observable. We would have to find good proxy measures for them. For life expectancy we would have to distingiush between perceived and actual life expectancy. The former could be asked for in a survey and the latter would have to be estimated using medical measures. Time preference is not that easy to measure or estimate. Asking people for their time preference doesn't really work well because their time preference probably changed over life time and they often do not decide in the same way they think or state they do. Fuchs 1982 [5] conducts a telephone survey and tests people's decicisions over receiving different payoffs either right now or in the future. He is not successful in proving a significant effect of time preference on education. Experimental economics certainly play an important role to find proxies for time preference.

Finally we have to consider the possibilty of some negative effects of education on health. Such effects are conceivable for alcohol and drug

consumption. The same is generally thinkable for the reverse direction: Healthier people may have less preference for desk work and therefore could avoid corresponding education investments.

4. Identification of Causal Effects in Western Germany

This paper tests whether there are significant health improvements associated with and possibly stemming from the compulsory schooling reforms in Western Germany during 1949 to 1969. The data I use is from the SHARE 2004 dataset which focuses on people aged 50 or more and their households. The full sample contains 2408 observations which obviously already shows one of its major disadvantages - its small sample size for Germany, even more so if Eastern Germany is excluded which has to be done due to a lack of reform information and the fact that the legislated increase of compulsory secondary schooling from 8 to 9 years at that time did only affect Western Germany. The differences between the East and West in education, health and in the gradients of the relationship of our two variables of interest are not discussed here but definately are of interest for future research.

Beside the full sample of 2408 Western German individuals, I use another one restricted to 1395 people who only went through the minimum of compulsory secondary schooling (*school restricted sample*) plus one that is additionally restricted to 817 people living in the four federal states Nordrhein-Westfalen, Hessen, Rheinland-Pfalz and Baden-Württemberg[5] (*school and state restricted sample*), and a third sub-sample that is even further restricted to 128 individuals born from 1950 to 1955 (*school, state and cohort restricted sample*).[6]

4.1. **Overview on the selected Input Variables.**

While the health outputs are discussed along with presenting the results further below, I introduce here the education input variables, such as *total years of education* (`TOTYEDU`) and *years of secondary education* (`SECEDU`), along with two control variables to control for *gender* (`GENDER`) and *age* (`YRBIRTH`) specific effects.

[5]In all these states the reforms are assumed to have become effective in 1967.
[6]See the explanatory section about *Ordinary Least Squares and Regression Discontinuity* for more information.

An *individual treatment indicator* (YRSEDU9), two other treatment indicators for the Difference in Difference Estimation, a *location-specific treatment indicator* (TREATM) and a *time-specific treatment indicator* (TRPERBEF) and their role in the different identification strategies are discussed in the corresponding sections below.

Variable	Description
SECEDU	Years of completed secondary education [8,...,13]
TOTYEDU	Years of completed total education including tertiary academic and practical education [8,...,18]
YRSEDU9	Dummy variable, indicating whether or not an individual was affected by the reform {0=not affected;1=affected}
TREATM	Dummy variable, indicating whether or not an individual belongs to the reform treatment group {0=control group;1=treatment group}
TRPERBEF	Dummy variable, indicating whether an individual belongs to the cohorts who received treatment if they are in the treatment group or they were born earlier {0=before treatment;1=during treatment}

FIGURE 1. Selected Input Variables

Variable	Description
GENDER	Gender {0=female;1=male}
YRBIRTH	Year of Birth, cohort [1907,...,1974]

FIGURE 2. Selected Control Variables

4.1.1. *Education Input Variables.* One of the major advantages of the SHARE data set is the abundance of various health variables available. Unfortunately the information about *total years of education* (TOTYEDU) and *years of secondary education* (SECEDU) are generated variables which ignore the schooling reform and the differences in the lags of their legislation and their enforcement between the different Western German federal states. They are therefore generated using information about individuals' degrees from the data set and information about the actual reform treatment of specific birth cohorts in the different Western German federal states (Bundesländer).[7]

Compulsory schooling was increased from 8 to 9 years in Western Germany between 1949 and 1969. Since education is regulated on

[7]See figures 3 and 4 for descriptive statistics.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	13.00	9.00	9.00	9.00
3rd Quartile	10.00	8.00	8.00	9.00
Mean	9.37	8.10	8.05	8.26
Median	8.00	8.00	8.00	8.00
1st Quartile	8.00	8.00	8.00	8.00
Minimum	8.00	8.00	8.00	8.00
N	2337	1395	817	128

FIGURE 3. Descriptive Statistics of the Years of Secondary Education

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	18.00	16.00	16.00	15.50
3rd Quartile	14.50	11.00	11.00	12.00
Mean	12.37	10.44	10.40	10.96
Median	11.00	11.00	11.00	11.00
1st Quartile	11.00	8.00	8.00	11.00
Minimum	8.00	8.00	8.00	8.00
N	2337	1395	817	128

FIGURE 4. Descriptive Statistics of the Total Years of Education

state level in Germany, I have to identify whether an individual was affected by the school reform or not, assuming that every individual still lives in the same state as it did at the time when the reform was actually enforced there. Following Pischke and von Wachter (2005) [11] and Siedler (2007) [13] I assign either 8 or 9 years of schooling to every individual who only holds a basic secondary school degree (Hauptschulabschluss), according to its state affiliation and cohort. Figure 5 shows which birth cohorts are assumed to have been affected by the reform first in the different federal states.

State	Effective year of refom	First affected birth cohort
Hamburg	1949	1934
Schleswig-Holstein	1956	1941
Bremen	1958	1943
Niedersachsen	1962	1947
Saarland	1964	1949
Nordrhein-Westfalen	1967	1953
Hessen	1967	1953
Rheinland-Pfalz	1967	1953
Baden-Württemberg	1967	1953
Bayern	1969	1955

Source: Pischke and von Wachter (2005), Siedler (2007)

FIGURE 5. Reform Overview by Federal States and Birth Cohorts

4.1.2. *Control Variables.* In all regressions in this paper I control for gender and age specific effects by including the two variables `GENDER` and `YRBIRTH`, as long as they proof to belong into the regressions, that is their coefficients are significant.

Gender and age obviously contribute to a variety of health measures. Health generally decreases with age and it is well known that males are confronted with other health risks or suffer more frequently from certain diseases than women and vice versa. Descriptive statistics in figures 6 and 7 show that the male share in the samples varies from 39% to 46% and age varies from 52 to 66 years.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	1.00	1.00	1.00	1.00
Mean	0.46	0.42	0.42	0.39
Median	0.00	0.00	0.00	0.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	2408	1395	817	128

FIGURE 6. Descriptive Statistics of Gender

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1974	1969	1969	1955
3rd Quartile	1948	1945	1946	1953
Mean	1940	1938	1939	1952
Median	1941	1939	1940	1952
1st Quartile	1934	1932	1932	1950
Minimum	1907	1910	1910	1950
N	2401	1390	817	128

FIGURE 7. Descriptive Statistics of Year of Birth

4.2. **Ordinary Least Squares and Regression Discontinuity.** As described above I use 3 sub-samples: a school restricted, a school and state restricted and a school, state and cohort restricted sample. The school restricted sample allows us to look solely at the effects for people who only received the minimum secondary school degree (Hauptschulabschluss)[8] One might eventually expect the coefficient of the individual reform indicator `YRSEDU9` to be strongest and most robust for

[8]This does not exclude the possibility of additional practical education after graduation from secondary school.

this sub-sample. For all school and further restricted samples SECEDU is correlated with YRSEDU9 by exactly 1, since the reform indicator by definition determines whether these individuals received 8 or 9 years of secondary schooling.

Further restricting this sub-sample to individuals from Hessen, Rheinland-Pfalz, Nordrhein-Westfalen and Baden-Württemberg allows us to exclude unwanted influences stemming from the variation of 20 years between federal states in enforcing the reform legislation. In these 4 states the reform is assumed to have become effective in 1967. Then restricting this sub-sub-sample again to birth cohorts that were born from 1950 to 1955 permits us to exclude any other major differences that may not be caused by the reform.

This last step of downsizing the sample to a school, state and cohort restricted sub-sample serves the method of Regression Discontinuity (RD) as data source. It is a very simple method to identify differences in the means of the outcome caused by a reform. By comparing 3 cohorts before and 3 cohorts after the reform we minimize irrelevant differences, assuming that these 6 cohorts are sufficiently similiar in terms of anything else but the reform effect. Comparing the means before and after the reform and controlling for gender and age effects should give us a clue whether or not the schooling reform had a significant effect on individuals' health. Sample size here is an issue because we are restricting the sample to only 6 cohorts. I decide to use this method as a first hint to possible causal effects.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	0.00	0.00	0.00	1.00
Mean	0.15	0.10	0.05	0.26
Median	0.00	0.00	0.00	0.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	2401	1390	817	128

FIGURE 8. Descriptive Statistics of the Individual Reform Indicator

Descriptive statistics in figure 9 show that individual reform affection, indicated by YRSEDU9, varies between 5% and 26% across samples. This information is used for OLS regressions and RD, whose results are presented in figures 9, 10 and 11.

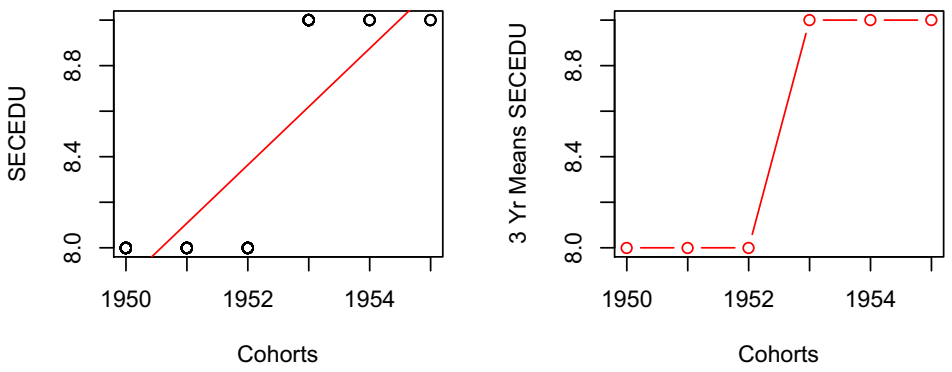

FIGURE 9. Univariate RD of Secondary Education

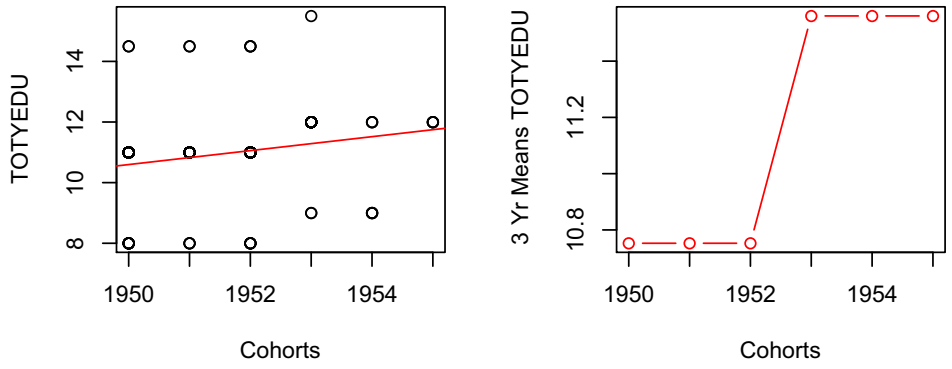

FIGURE 10. Univariate RD of Total Education

	Years of Secondary Education						Total Years of Education					
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**OLS**	**OLS**	**RD**	**DID**	**DID**
Reform indicator	0.60	1.00	1.00	1.00			0.60	0.98	0.74	0.81		
p value	*0.00*	*0.00*	*0.00*	*0.00*			*0.00*	*0.00*	*0.00*	*0.00*		
DID estimator					0.59	0.82					0.70	0.58
p value					*0.01*	*0.00*					*0.08*	*0.10*
School restricted	no	yes	yes	yes	no	yes	no	yes	yes	yes	no	yes
...and state restricted	no	no	yes	yes	no	no	no	no	yes	yes	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	yes	no	no
DOF	2326	1388	815	126	2133	1318	2326	1386	813	126	2133	1317
Adjusted R^2	0.09	1.00	1.00	1.00	0.07	0.49	0.13	0.16	0.15	0.05	0.12	0.14
F-Test p value	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.00*	*0.00*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.
A constant is always included in the regressions.

FIGURE 11. Comparison of Secondary and Total Education

Figure 9 shows the univariate RD of secondary education. Obviously the birth cohorts from 1953 to 1955 had all exactly 1 year more of secondary education than those from 1950 to 1952. This result is of course not surprising as we have discussed above already.

The univariate RD of total education is illustrated in figure 10. After the reform sample members experienced on average 0.81 more total years of education.

Finally in figure 11 the RD, OLS and also the DID[9] results of both education variables are presented in comparison. OLS coefficients of the individual reform indicator are not surprisingly 1 for secondary education, except for the full sample which contains also people whose education investment decisions were assumingly not as much influenced by the reform as those from people holding only the lowest secondary school degree. Comparing the coefficients of the left and the right hand side table in figure 11 reveals that for lower educated people, in terms of secondary education, the 1 year increase in secondary education did not cause a proportional increase in total education. On average this means that the mandatory 9 instead of 8 years of secondary school lead the lower secondary school graduates to invest less in further education beyond secondary school. One conceivable reason would be that individuals' preferences about the maximum duration of total education did not change according to the expansion of compulsory secondary schooling.

4.3. **Difference in Difference Estimation.** Difference in difference (DID) estimation may serve as a quite elegant tool to possibly identify direct effects of education on health. In principal it is a regression of the health outcome on two dummy variables and their interaction, namely a *location-specific* (`TREATM`) and a *time-specific* (`TRPERBEF`) *treatment indicator*. The first indicates whether or not an individual lives in one of the states which introduced 9 years of compulsory schooling before 1967. The latter indicates whether an individual belongs to a birth cohort (1949-1952) which would have been affected by the reform in the selected states or it was born too early. The interaction term `TREATM*TRPERBEF` then isolates the true effect of the schooling reform on health in the selected states.

There are several conditions which have to be fulfilled for the DID estimator to be correct: The error term ϵ is on average zero, that is $E[\epsilon] = 0$, and uncorrelated with the other variables in the equation, that is $cov(\epsilon, \texttt{TREATM}) = 0$, $cov(\epsilon, \texttt{TRPERBEF}) = 0$ and

[9]DID results will be discussed in the following section.

$cov\,(\epsilon, \texttt{TREATM*TRPERBEF}) = 0$. All of these conditions are fulfilled for every DID estimation here.

4.3.1. *Location-specific Treatment Indicator.* I define all residents of Schleswig-Holstein, Hamburg, Niedersachsen, Bremen and Saarland as the treatment group because they all had 9 years of compulsory schooling for cohorts born in 1949 and later. Residents of Nordrhein-Westfalen, Hessen, Rheinland-Pfalz, Baden-Württemberg and Bayern did not receive this treatment, if born before 1953. This means that cohorts born from 1949 and 1952 were only affected by the school reform, if they lived in the states of the treatment group. Of course here we have to assume that they live in the same federal state today as they did when they went to secondary school, since we have no information about where they actually went to school.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	0.00	0.00
3rd Quartile	0.00	0.00	0.00	0.00
Mean	0.23	0.22	0.00	0.00
Median	0.00	0.00	0.00	0.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	2408	1395	817	128

FIGURE 12. Descriptive Statistics of the Location-specific Treatment Indicator

4.3.2. *Time-specific Treatment Indicator.* The time indicator is 1 for cohorts born from 1949 and 1952 and 0 for cohorts born earlier. Cohorts born later are omitted from the regression because they received treatment no matter where they lived and we cannot allow anyone in this experiment's sample to have received treatment without being part of the treatment group.

4.3.3. *Location-Time-Interaction - True Effect of Treatment.* The interaction term is most simply explained by an example: Whenever an individual does either not belong to the treatment group or was born too early, either the location- or the time-specific treatment indicator is 0. This forces the interaction term `TREATM*TRPERBEF` to be 0 as well. So the only case when the interaction term becomes 1 is in fact when an individual belongs to the treatment group and was born at

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	0.00	0.00	0.00	1.00
Mean	0.18	0.14	0.16	1.00
Median	0.00	0.00	0.00	1.00
1st Quartile	0.00	0.00	0.00	1.00
Minimum	0.00	0.00	0.00	1.00
N	2206	1323	775	95

FIGURE 13. Descriptive Statistics of the Time-specific Treatment Indicator

the right time. Whether one lives in the right state or was born at the right time, separately does not count. For the same reason I exclude people born later than 1952 because otherwise it would be possible to live somewhere else than in the above selected states and have received treatment anyway.

Figure 11 contains the DID results for secondary and total education. While the DID estimator of secondary education is not significantly different from its OLS counterpart for the full sample, a Hausman test shows them to be significantly different in the school restricted sample. Not so for the total education. Here the DID estimators are not significantly different from their OLS counterparts. One reason for a possible lack in accuracy may be the small sample sizes with just 23% of full sample members and 22% of school restricted sample members being assigned to the location treatment group and between 14% to 18% being assigned to the time treatment group, as can be seen in figures 12 and 13. My suggestion therefore is to see DID results with caution, at least for secondary education and the full sample.

4.4. **Two Stage Least Squares.** To identify possible endogeneity issues for the two education variables `TOTYEDU` and `SECEDU`, I first run OLS regressions of the various health outputs on each of these two variables and some controls `GENDER` and `YRBIRTH` and compare the relevant coefficients with those from a Two Stage Least Squares (2SLS) regression. One assumption of the classical linear regression model is exogeneity of the right hand side variables. Assuming that `SECEDU` or `TOTYEDU` are endogenous with respect to a specific health output, I can estimate them using an appropriate instrument variable Z which has to be sufficiently correlated with our variable of interest X, that

is $cov(Z, X) \neq 0$, but must not be correlated with the error term ϵ of the population, that is $cov(Z, \epsilon) = 0$. While the first condition can be tested very easily by running simple OLS regressions as first stage estimation for `TOTYEDU` and `SECEDU` and checking for significant coefficients of the instrument Z, the second condition can not be tested since the population's error ϵ term is not known.

I use the reform indicator `YRSEDU9` as an instrument to estimate `SECEDU` and `TOTYEDU` and in the first stage.[10] These estimates then serve as inputs in the second stage regressions of the various health outputs. Since `YRSEDU9` is solely determined by legislation I assume it to be exogenous. First state OLS regressions of `SECEDU` and `TOTYEDU` show the relevance of `YRSEDU9` as an instrument in these cases. Using the `tsls` function contained in the R package `sem`, I run 2SLS to receive the second stage coefficients with the correct standard errors.[11] 2SLS results are presented in the following corresponding subsections for each health output.

5. Results

As health variables I select the Body Mass Index (BMI), Maximum Grip Strength (MGS), Chronic Lung Disease (CLD), Eyesight, High Blood Pressure (HBP), Smoking and Self-rated Health (SRH).

Variable	Description
BMI	Body Mass Index [13,..., 66] kg/m^2
MAXGRIP	Maximum Grip Strength [1,...,92] kg
PH006D06	Chronic Lung Disease Incidence Sample share [0,...,1]
PH042	Eyesight Index [excellent=1,...,blind=6]
PH006D02	High Blood Pressure Incidence Sample share [0,...,1]
BR002	Current Smoking Incidence Sample share [0,...,1]
SRHGEN	Self-rated Health [excellent=1,...,poor=5]

Figure 14. Selected Output Variables

[10]First stage regressions are included in figure 11.

[11]2SLS requires a correction of standard errors in the second stage due to a change in the variance-covariance-matrix. Most econometric or statistic software packages offer a special function for running 2SLS with correct standard errors. In my case I use R which is available for free at http://www.r-project.org/

Overviews on the results for the full and the school restricted sample can be found in figures 36 ,38 and 37 in the appendix.

5.1. **Body Mass Index (BMI).** The Body Mass or Quetelet Index, calculated as $BMI = \frac{weight}{height^2}$ in $\frac{kg}{m^2}$, is a measure of the body's weight relative to its height. In the light of broad international concerns about obesity in developed countries, I would consider a finding of a decrease in mean BMI an improvement. Contrary to any concerns about obesity, older people often suffer of lower BMI and a higher BMI is surely valued differently than for younger people. Since I control for age effects, a possible ceteris paribus BMI decrease is nevertheless considered as an improvement.

Figure 15 reveals that the BMI is on average higher for individuals who only hold the lowest secondary school degree.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	65.31	65.31	53.40	41.91
3rd Quartile	28.34	28.84	29.02	28.54
Mean	26.35	26.91	26.91	26.74
Median	25.76	26.37	26.37	26.11
1st Quartile	23.53	24.03	24.03	24.27
Minimum	13.02	16.46	16.46	18.42
N	2383	1387	812	128

FIGURE 15. Descriptive Statistics of BMI

5.1.1. *OLS and RD on the Individual Reform Indicator.* Figure 16 shows an insignificant -1.11 decrease of mean BMI for the fully restricted sample. The F-Test also fails. As can be seen in figure 17 controlling for age and gender effects decreases the coefficient to -0.96 with insignificance but a passed F-Test. OLS results reveal significant decreases between -0.70 and -2.51, being largest in the school and state restricted sample.

5.1.2. *Difference in Difference Estimation.* The DID results in the same figure contradict those OLS results, not much surprisingly though with insignificance[12].

[12]DID estimators are often not significant due to the high noise that cannot be avoided when calculating differences of differences. Nonetheless DID estimators may still give a hint whether the effect is positive or negative.

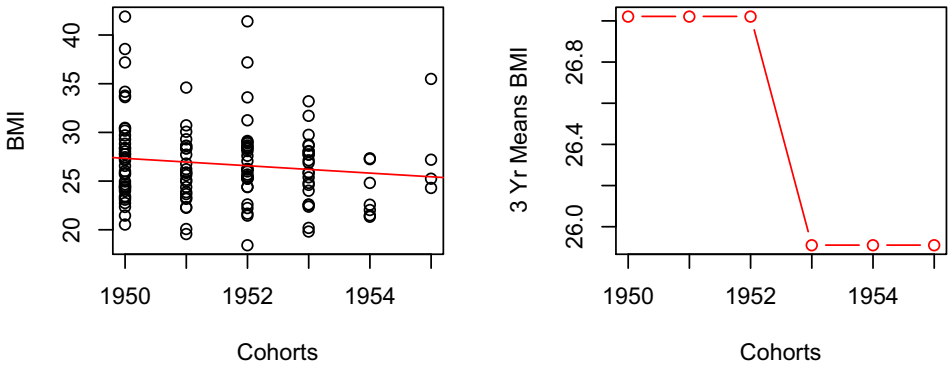

FIGURE 16. Univariate RD of BMI

	Body Mass Index												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.70	-0.99	-2.51	-0.96									
p value	*0.01*	*0.02*	*0.00*	*0.26*									
DID estimator					0.34	0.79							
p value					*0.56*	*0.40*							
Secondary education							-0.47	-1.40	-0.99				
p value							*0.00*	*0.01*	*0.02*				
Total education										-0.26	-1.37	-0.13	-1.02
p value										*0.00*	*0.02*	*0.08*	*0.03*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2373	1378	808	125	2178	1309	2314	2314	1378	2314	2314	1378	1378
Adjusted R^2	0.04	0.02	0.02	0.02	0.01	0.02	0.05		0.02	0.04		0.02	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.10*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.06*			*0.05*		*0.06*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insignificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 17. Results for BMI

5.1.3. *OLS and Instrumental Variable Estimation.* Significant decreases between -0.47 and -1.40 for secondary education and -0.13 and -1.37 for total education appear for all samples. In all cases the 2SLS coefficients are significantly different from their OLS counterparts which lets me conclude that there are some issues of omitted variables or endogeneity when regressing BMI on secondary or total education using OLS. Anyhow both 2SLS and OLS show significant decreases in mean BMI without exception.

5.1.4. *Conclusion for Body Mass Index.* Although DID results are contradicting the results of all other applied methods, there is a clear evidence for some slight decreases in mean BMI for all samples.

5.2. **Maximum Grip Strength (MGS).** According to a study of Hank et al. (2006) [9], who also used the SHARE data set, grip strength is a very reliable objective health measure and is highly predictive for other health measures such as mortality.

Figure 18 shows a lower maximum grip strength for the school and the school and state restricted sample but not so for the school, state and cohort restricted sample used for RD. The latter has only a sample size of 122 which may explain the higher mean MGS by randomness. Mean MGS varies from about 36 kg to about 40 kg across the samples.

	Full	school restricted	school and state restricted	school, state and cohort restricted
Maximum	92.00	92.00	92.00	80.00
3rd Quartile	45.00	44.00	44.00	50.00
Mean	37.46	35.82	35.90	40.27
Median	36.00	34.00	34.00	36.00
1st Quartile	28.00	27.00	27.00	30.00
Minimum	1.00	1.00	7.00	12.00
N	2181	1242	724	122

FIGURE 18. Descriptive Statistics of MGS

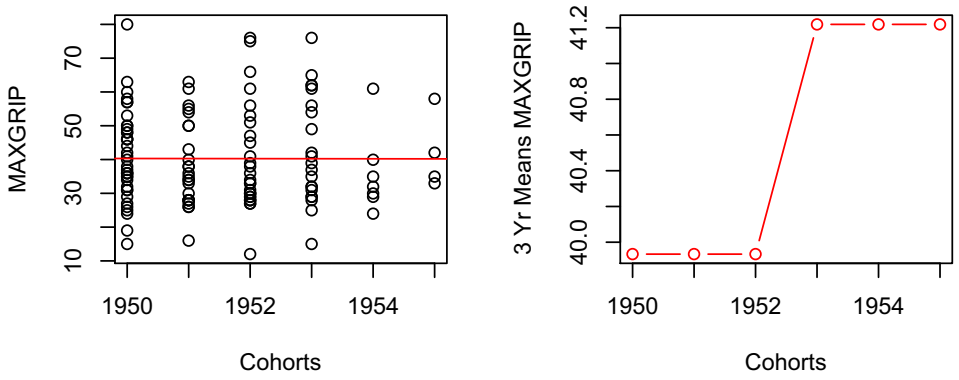

FIGURE 19. Univariate RD of MGS

5.2.1. *OLS and RD on the Individual Reform Indicator.* Figure 20 shows no significant effects of the reform on the Maximum Grip Strength (MGS) for OLS, except for the school, state and cohort restricted RD sample. RD returns a significant 3.51 kg increase in MGS due to the reform. F-test is passed and the adjusted R^2 is with 0.6 unusually high compared to the results for other health outputs. Figure 19 depicts the univariate RD and shows an insignficant 1.29 increase.

	Maximum Grip Strength												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.03	0.65	0.11	3.50									
p value	*0.95*	*0.44*	*0.94*	*0.06*									
DID estimator					0.41	2.53							
p value					*0.72*	*0.15*							
Secondary education							0.10	-0.30	0.65				
p value							*0.31*	*0.76*	*0.44*				
Total education										0.05	-0.29	0.05	0.67
p value										*0.40*	*0.76*	*0.71*	*0.44*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2173	1235	720	119	1995	1173	2119	2119	1235	2119	2119	1235	1235
Adjusted R^2	0.57	0.56	0.57	0.60	0.57	0.56	0.57		0.56	0.57		0.56	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.68*			*0.72*		*0.47*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 20. Results for MGS

5.2.2. *Difference in Difference Estimation.* DID confirms the above and partially high increases in MGS with an increase of 2.53 kg with a p value of 0.15 for the school restricted sample.

5.2.3. *OLS and Instrumental Variable Estimation.* OLS and 2SLS regressions on secondary and total education do not return any significant effects. Hausman tests are not passed so that I cannot reject the hypothesis that the OLS and 2SLS coefficients are equal. In this case 2SLS does not add any new information.

5.2.4. *Conclusion for Maximum Grip Strength.* RD and DID results suggest a high increase in MGS among people who only received the lowest degree of secondary school.

5.3. **Chronic Lung Disease (CLD).** CLD incidence varies between 2% and 5% between the samples and is higher for lower educated people. Again the school, state and cohort restricted sample is an exception which may be explained by randomness due to the small sample size of 128.

5.3.1. *OLS and RD on the Individual Reform Indicator.* RD results in figure 23 and figure 22 show a significant 5% increase in CLD incidence but F- and T-tests are only passed with 90% significance.

5.3.2. *Difference in Difference Estimation.* DID returns nothing even close to significance. While it suggests a 1% increase CLD incidence

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	0.00	0.00	0.00	0.00
Mean	0.05	0.06	0.07	0.02
Median	0.00	0.00	0.00	0.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	2408	1395	817	128

FIGURE 21. Descriptive Statistics of CLD

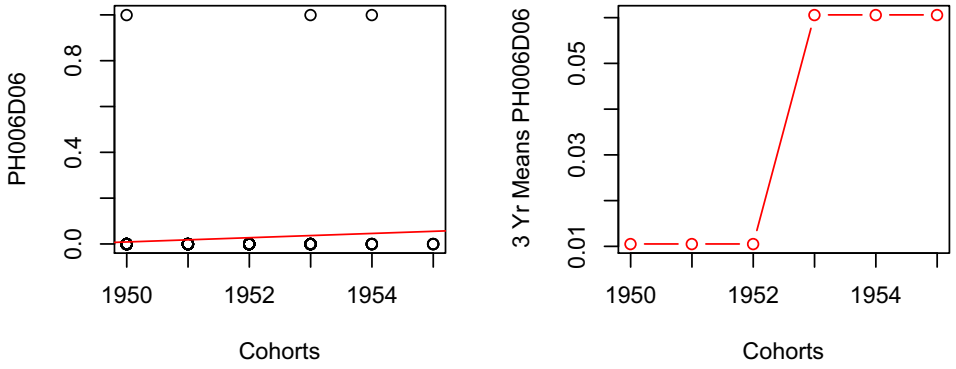

FIGURE 22. Univariate RD of CLD

	Chronic Lung Disease												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	0.00	-0.01	0.05	0.05									
p value	*0.72*	*0.73*	*0.26*	*0.10*									
DID estimator					0.01	-0.02							
p value					*0.73*	*0.75*							
Secondary education							0.00	0.00	-0.01				
p value							*0.17*	*0.96*	*0.74*				
Total education										0.00	0.00	0.00	-0.01
p value										*0.06*	*0.96*	*0.91*	*0.74*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2398	1387	814	126	2201	1318	2326	2326	1386	2326	2326	1386	1386
Adjusted R^2	0.01	0.01	0.02	0.01	0.01	0.01	0.01		0.01	0.01		0.00	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.10*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.92*			*0.94*		*0.75*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 23. Results for CLD

for the full sample, it points to a 2% decrease for the school restricted sample.

5.3.3. *OLS and Instrumental Variable Estimation.* Hausman tests all fail so that 2SLS does not contribute anything. Only OLS on total education shows a tiny significant increase in the full sample.

5.3.4. *Conclusion for CLD.* Results point to some increases in CLD incidence. These may be due to a positive time trend in smoking which is the major cause of CLD. This is certainly a point where controlling for smoking as a health risk behavior variable seems reasonable. Doing so turns the positive coefficients into negative, although they stay insignificant and the coefficient of the smoking control variable is not significant as well. Therefore the results here do not provide a clear view about the effect of education of CLD incidence. A larger sample size and appropriate control variables may still reveal a possible decrease in CLD incidence.

5.4. **Eyesight.** As can be seen in figure 24 eyesight is on average worse for lower educated people and means vary between 2.4 and 2.7, where 2 stands for *very good* and 3 stands for *good*.[13]

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	6.00	6.00	6.00	6.00
3rd Quartile	3.00	3.00	3.00	3.00
Mean	2.60	2.71	2.70	2.41
Median	3.00	3.00	3.00	2.00
1st Quartile	2.00	2.00	2.00	2.00
Minimum	1.00	1.00	1.00	1.00
N	2393	1395	817	128

FIGURE 24. Descriptive Statistics of Eyesight

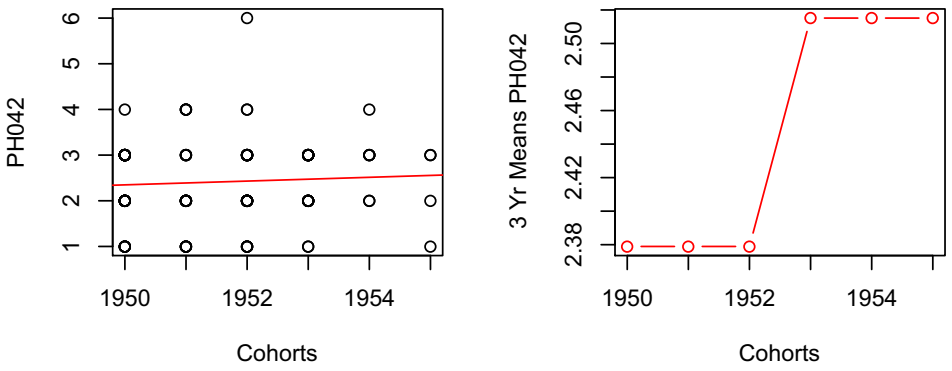

FIGURE 25. Univariate RD of Eyesight

[13]Apart from the exceptional result for the smallest subsample.

	Eyesight												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.07	-0.09	0.24	0.14									
p value	*0.20*	*0.28*	*0.09*	*0.45*									
DID estimator					0.10	-0.06							
p value					*0.37*	*0.73*							
Secondary education							-0.05	-0.10	-0.09				
p value							*0.00*	*0.26*	*0.28*				
Total education										-0.03	-0.10	-0.04	-0.09
p value										*0.00*	*0.27*	*0.00*	*0.28*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2382	1386	813	126	2188	1317	2323	2323	1386	2323	2323	1386	1386
Adjusted R^2	0.07	0.06	0.09	0.00	0.07	0.07	0.09		0.06	0.09		0.07	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.45*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.58*			*0.46*		*0.53*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.

A constant is always included in the regressions.

OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.

The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 26. Results for Eyesight

5.4.1. *OLS and RD on the Individual Reform Indicator.* RD suggests an insignificant worsening of eyesight by 0.14 index points, as can be seen in figures 25 and 26. The F-test fails for RD as well. OLS shows a significant worsening of eyesight by 0.24 index points for the school and state restricted sample.

5.4.2. *Difference in Difference Estimation.* DID suggests a slight improvement of eyesight by -0.06 index points for the school restricted sample and a worsening by 0.10 index points for the full sample. Both coefficients are not significant.

5.4.3. *OLS and Instrumental Variable Estimation.* Hausman tests fail for all 2SLS regressions. OLS results show significant eyesight improvements by -0.05 index points for the full sample using secondary education as input variable and by -0.03 and -0.04 index points for the full and the school restricted sample using total education.

5.4.4. *Conclusion for Eyesight.* The results for eyesight are quite ambiguous. Only OLS regressions on secondary and total education show some slight improvements of eysight.

5.5. **High Blood Pressure (HBP).** Chronic high blood pressure is commonly known as one of the major causes of coronary diseases and strokes. Figure 27 shows a HBP incidence between 20% and 39%, being larger for lower educated people except for the last sub-sample.[14]

[14]See discussion of the descriptive statistics of the other health measures above.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	1.00	1.00	1.00	0.00
Mean	0.35	0.39	0.39	0.20
Median	0.00	0.00	0.00	0.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	2408	1395	817	128

FIGURE 27. Descriptive Statistics of HBP

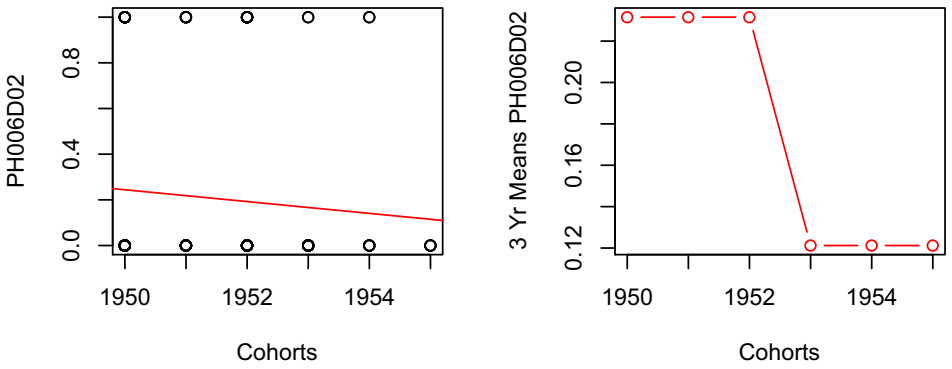

FIGURE 28. RD of HBP

	High Blood Pressure												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.07	-0.07	-0.12	-0.12									
p value	*0.01*	*0.14*	*0.16*	*0.16*									
DID estimator					0.00	0.07							
p value					*0.97*	*0.52*							
Secondary education							-0.02	-0.12	-0.07				
p value							*0.00*	*0.03*	*0.13*				
Total education										-0.01	-0.12	-0.02	-0.07
p value										*0.00*	*0.06*	*0.06*	*0.14*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2398	1387	814	814	2201	1318	2326	2326	1386	2326	2326	1386	1386
Adjusted R^2	0.05	0.03	0.04	0.04	0.03	0.03	0.05		0.03	0.05		0.03	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.06*			*0.08*		*0.23*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insignificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 29. Results for HBP

5.5.1. *OLS and RD on the Individual Reform Indicator.* RD in figures 28 and 29 show an insignificant fall in HBP incidence by tentative -12% possibly related to the reform. OLS shows a significant fall by -7% in HBP incidence for the full sample.

5.5.2. *Difference in Difference Estimation.* DID results return nothing significant but point to an increase rather than to a decrease in HBP incidence, at least for the school restricted sample.

5.5.3. *OLS and Instrumental Variable Estimation.* Hausman tests for both secondary and total education are passed for the full sample so that I reject the hypothesis that the corresponding 2SLS coefficients are equal to their OLS counterparts. Concerning the full sample 2SLS results show a significant decrease in HBP incidence by -12% for both education variables. OLS returns a -2% decrease for total education in the school restricted sample.

5.5.4. *Conclusion for HBP.* The results differ much concerning the size of the effect across the different samples. Therefore the results should be considered with caution. Most methods reveal significant decreases in HBP incidence possibly related to the reform.

5.6. **Smoking.** Due to the fact that tobacco consumption is widely known as a major cause of chronic lung, heart and other severe diseases, German federal states are now more and more prohibiting smoking in public areas following partly EU and international policies. Smoking is unlike other objective health measures rather an indicator for health risk behavior, like consumption of other drugs and alcohol, and it is widely used in analyses for this reason. [4, pp. 185-186] Here people were asked whether they smoke or not. As can be seen in figure 30 the sample share of people smoking is higher for lower educated people, ranging from 40% to 58%.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	1.00	1.00	1.00	1.00
3rd Quartile	1.00	1.00	1.00	1.00
Mean	0.40	0.41	0.45	0.58
Median	0.00	0.00	0.00	1.00
1st Quartile	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00
N	1100	591	360	74

FIGURE 30. Descriptive Statistics of Smoking

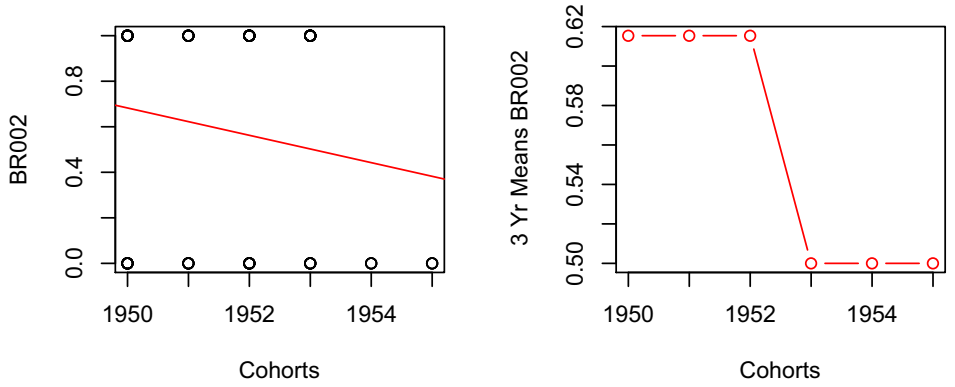

FIGURE 31. RD of Smoking

	Smoking												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.03	-0.02	-0.10	-0.12									
p value	*0.42*	*0.74*	*0.33*	*0.37*									
DID estimator					0.01	-0.08							
p value					*0.88*	*0.60*							
Secondary education							-0.02	-0.09	-0.02				
p value							*0.01*	*0.42*	*0.74*				
Total education										-0.01	-0.08	-0.01	-0.02
p value										*0.00*	*0.43*	*0.67*	*0.74*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	1093	584	356	72	981	541	1068	1068	584	1068	1068	584	584
Adjusted R^2	0.06	0.06	0.06	0.00	0.07	0.07	0.06		0.06	0.06		0.06	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.36*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.53*			*0.52*		*0.81*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 32. Results for Smoking

5.6.1. *OLS and RD on the Individual Reform Indicator.* RD shows a -12% decrease in smoking incidence, although not significant and with a bad F-test result. OLS for the other samples does not show anything significant either, although the coefficients are all negative.

5.6.2. *Difference in Difference Estimation.* DID results point to an insignficant decrease in smoking incidence at least for the school restricted sample.

5.6.3. *OLS and Instrumental Variable Estimation.* OLS returns a signficant decrease by -2% using secondary education and by -1% using total education for the full sample. Hausman tests are all not significant and therefore 2SLS estimates do not contribute anything further here.

5.6.4. *Conclusion for Smoking.* The results rather point to a decrease in smoking incidence by -1% at least for the full sample.

5.7. **Self-rated Health.** Self-rated health is widely used as a general subjective health measure which is broadly recognised as being highly predictive for objective health measures, such as chronic diseases, body mass index or grip strength. [10], cited in [8, p. 95] Here people were asked to rank their general health from *poor*, which is 5 here, to *excellent*, which is 1 here. The variable `SRHGEN` used here was generated by merging the two other variables `PH052` and `PH003` from the SHARE data. The questions for both variables are exactly the same but for each respondent it was randomly determined to which one of the two variables his answer was assigned. The only difference between the two variables is that they were asked at two different places in the questionnaire - one at the beginning and one at the end. So random 50% of the sample answered `PH003` and the other 50% answered `PH052`. This was done to exclude any effect that could stem from the position of the question within the questionnaire.

In figure 33 one can see that SRH is on average worse for lower educated people.[15] Average SRH varies from 2.8 to 3.3, with 2 meaning *very good*, 3 meaning *good* and 4 meaning *fair*.

	Full	School restricted	School and state restricted	School, state and cohort restricted
Maximum	5.00	5.00	5.00	4.00
3rd Quartile	4.00	4.00	4.00	4.00
Mean	3.11	3.29	3.26	2.84
Median	3.00	3.00	3.00	3.00
1st Quartile	3.00	3.00	3.00	2.00
Minimum	1.00	1.00	1.00	1.00
N	1185	692	412	68

FIGURE 33. Descriptive Statistics of SRH

5.7.1. *OLS and RD on the Individual Reform Indicator.* Figures 34 and 35 show a small insignficant worsening in SRH by 0.09 index points. Note that the F-test is not passed. Running OLS on the individual reform indicator does not return any significant coefficients either. They are almost all positive, only the one for the full sample is negative.

[15]With exception of the last sub-sample. See discussions for the other health outcomes above.

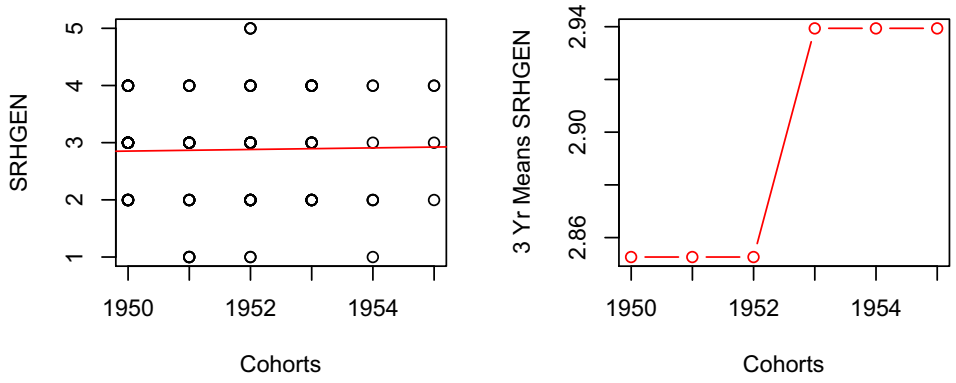

FIGURE 34. RD of SRH

	Self-rated Health												
	OLS	**OLS**	**OLS**	**RD**	**DID**	**DID**	**OLS**	**2SLS**	**OLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.05	0.05	0.03	0.09									
p value	*0.44*	*0.56*	*0.82*	*0.64*									
DID estimator					0.05	-0.06							
p value					*0.67*	*0.75*							
Secondary education							-0.11	-0.05	0.05				
p value							*0.00*	*0.59*	*0.57*				
Total education										-0.07	-0.05	-0.06	0.05
p value										*0.00*	*0.59*	*0.00*	*0.57*
School restricted	no	yes	yes	yes	no	yes	no	no	yes	no	no	yes	yes
...and state restricted	no	no	yes	yes	no	no	no	no	no	no	no	no	no
...and cohort restricted	no	no	no	yes	no	no	no	no	no	no	no	no	no
DOF	2382	1387	814	126	2188	1318	2323	2323	1386	2323	2323	1386	1386
Adjusted R^2	0.14	0.09	0.09	-0.01	0.12	0.08	0.17		0.09	0.18		0.10	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.64*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*		*0.00*	
Hausman-Test p value								*0.60*			*0.88*		*0.19*

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.
A constant is always included in the regressions.
OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.
The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 35. Results for Self-rated Health

5.7.2. *Difference in Difference Estimation.* The insignificant DID results suggest a slight improvement for the school restricted sample and a slight worsening for the full sample.

5.7.3. *OLS and Instrumental Variable Estimation.* Hausman tests all fail and therefore I focus on the OLS results here. They show a significant improvement by -0.11 index points using secondary education for the full sample and significant improvements of -0.07 and -0.06 index points using total education for both the full and the school restricted sample.

5.7.4. *Conclusion for SRH.* The results from the different methods are quite ambiguous. Only OLS using the education variables point to

some slight significant improvements in self-rated health in the full and the school restricted sample.

6. Overall Conclusion

For each of the selected health outputs simple Ordinary Least Squares, Regression Discontinuity, Difference in Difference and Instrumental Variable estimations are run. The results are summarized in figures 36, 37 and 38.

I find slight decreases in Body Mass Index (BMI) by about -0.47 to -1.4. For Maximum Grip Strength (MGS) only Regresssion Discontinuity (RD) returns an significant +3.51 kg increase. Chronic Lung Disease (CLD) incidence apperars to have risen somehow by up to +5% during the reform treatment, although controlling for smoking does at least change the sign of the effect but does not return anything significant. For Eyesight I find some slight improvements by -0.03 to -0.05 index points. High Blood Pressure (HBP) incidence may have fallen due to the schooling reform by -2% up to -12%, being larger for the full sample. This result should be considered with caution. Also only for the full sample, I find -1% to -2% decreases in Smoking incidence. Finally Self-rated Health (SRH) appears to have risen by -0.06 to -0.12 index points.

This topic requires more research with respect to representative health variables and appropriate education and control variables. Sample size definately restricts the explanatory power of my results. To know in which federal state individuals where actually educated, would surely be a good contribution to the data.

7. Appendix

	Body Mass Index					Maximum Grip Strength					Chronic Lung Disease					Eyesight				
	RD	DID	OLS	OLS	2SLS	RD	DID	OLS	OLS	2SLS	RD	DID	OLS	OLS	2SLS	RD	DID	OLS	OLS	2SLS
Reform indicator	-0.96					3.50					0.05					0.14				
p value	*0.26*					*0.06*					*0.10*					*0.45*				
DID estimator		0.79					2.53					-0.02					-0.06			
p value		*0.40*					*0.15*					*0.75*					*0.73*			
Secondary Education			-0.99					0.65					-0.01					-0.09		
p value			*0.02*					*0.44*					*0.74*					*0.28*		
Total education				-0.13	-1.02				0.05	0.67				0.00	-0.01				-0.04	-0.09
p value				*0.08*	*0.03*				*0.71*	*0.44*				*0.91*	*0.74*				*0.00*	*0.28*
DOF	125	1309	1378	1378	1378	119	1173	1235	1235	1235	126	1318	1386	1386	1386	126	1317	1386	1386	1386
Adjusted R^2	0.02	0.02	0.02	0.02		0.60	0.56	0.56	0.56		0.01	0.01	0.01	0.00		0.00	0.07	0.06	0.07	
F-Test p value	*0.10*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*		*0.10*	*0.00*	*0.00*	*0.00*		*0.45*	*0.00*	*0.00*	*0.00*	
Hausman-Test p value					*0.06*					*0.47*					*0.75*					*0.53*

	Smoking					Self-rated Health					High Blood Pressure				
	RD	DID	OLS	OLS	2SLS	RD	DID	OLS	OLS	2SLS	RD	DID	OLS	OLS	2SLS
Reform indicator	-0.12					0.09					-0.12				
p value	*0.37*					*0.64*					*0.16*				
DID estimator		-0.08					-0.06					0.07			
p value		*0.60*					*0.75*					*0.52*			
Secondary Education			-0.02					0.05					-0.07		
p value			*0.74*					*0.57*					*0.13*		
Total education				-0.01	-0.02				-0.06	0.05				-0.02	-0.07
p value				*0.67*	*0.74*				*0.00*	*0.57*				*0.06*	*0.14*
DOF	72	541	584	584	584	126	1318	1386	1386	1386	814	1318	1386	1386	1386
Adjusted R^2	0.00	0.07	0.06	0.06		-0.01	0.08	0.09	0.10		0.04	0.03	0.03	0.03	
F-Test p value	*0.36*	*0.00*	*0.00*	*0.00*		*0.64*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*	
Hausman-Test p value					*0.81*					*0.19*					*0.23*

All samples are just school restricted, except for RD regression, which is also state and cohort restricted.

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insignificant.

A constant is always included in the regressions.

OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.

The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

Figure 36. Results for the School Restricted Sample, including RD

FIGURE 37. Results for the School Restricted Sample

	Body Mass Index					Maximum Grip Strength					Chronic Lung Disease					Eyesight				
	OLS	**DID**	**OLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**OLS**	**2SLS**
Reform indicator	-0.99					0.65					-0.01					-0.09				
p value	*0.02*					*0.44*					*0.74*					*0.28*				
DID estimator		0.79					2.53					-0.02					-0.06			
p value		*0.40*					*0.15*					*0.75*					*0.73*			
Secondary education			-0.99					0.65					-0.01					-0.09		
p value			*0.02*					*0.44*					*0.74*					*0.28*		
Total education				-0.13	-1.02				0.05	0.67				0.00	-0.01				-0.04	-0.09
p value				*0.08*	*0.03*				*0.71*	*0.44*				*0.91*	*0.74*				*0.00*	*0.28*
DOF	1378	1309	1378	1378	1378	1235	1173	1235	1235	1235	1386	1318	1386	1386	1386	1386	1317	1386	1386	1386
Adjusted R^2	0.02	0.02	0.02	0.02		0.56	0.56	0.56	0.56		0.01	0.01	0.01	0.00		0.06	0.07	0.06	0.07	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*	
Hausman-Test p value					*0.06*					*0.47*					*0.75*					*0.53*

	Smoking					Self-rated Health					High Blood Pressure				
	OLS	**DID**	**OLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**OLS**	**2SLS**
Reform indicator	-0.02					0.05					-0.07				
p value	*0.74*					*0.56*					*0.14*				
DID estimator		-0.08					-0.06					0.07			
p value		*0.60*					*0.75*					*0.52*			
Secondary education			-0.02					0.05					-0.07		
p value			*0.74*					*0.57*					*0.13*		
Total education				-0.01	-0.02				-0.06	0.05				-0.02	-0.07
p value				*0.67*	*0.74*				*0.00*	*0.57*				*0.06*	*0.14*
DOF	584	541	584	584	584	1387	1318	1386	1386	1386	1387	1318	1386	1386	1386
Adjusted R^2	0.06	0.07	0.06	0.06		0.09	0.08	0.09	0.10		0.03	0.03	0.03	0.03	
F-Test p value	*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*		*0.00*	*0.00*	*0.00*	*0.00*	
Hausman-Test p value					*0.81*					*0.19*					*0.23*

All samples are just school restricted.

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.

A constant is always included in the regressions.

OLS and 2SLS generate exactly the same results when SECEDU and the school restricted sample are used.

The reason is the perfect correlation between YRSEDU9 and SECEDU in the school restricted sample.

FIGURE 38. Results for the Full Sample

	Body Mass Index						Maximum Grip Strength						Chronic Lung Disease						Eyesight					
	OLS	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.70						-0.03						0.00						-0.07					
p value	*0.01*						*0.95*						*0.72*						*0.20*					
DID estimator		0.34						0.41						0.01						0.10				
p value		*0.56*						*0.72*						*0.73*						*0.37*				
Secondary education			-0.47	-1.40					0.10	-0.30					0.00	0.00					-0.05	-0.10		
p value			*0.00*	*0.01*					*0.31*	*0.76*					*0.17*	*0.96*					*0.00*	*0.26*		
Total education					-0.26	-1.37					0.05	-0.29					0.00	0.00					-0.03	-0.10
p value					*0.00*	*0.02*					*0.40*	*0.76*					*0.06*	*0.96*					*0.00*	*0.27*
DOF	2373	2178	2314	2314	2314	2314	2373	1995	2119	2119	2119	2119	2398	2201	2326	2326	2326	2326	2382	2188	2323	2323	2323	2323
Adjusted R^2	0.04	0.01	0.05		0.04		0.04	0.57	0.57		0.57		0.01	0.01	0.01		0.01		0.07	0.07	0.09		0.09	
F-Test p value	*0.00*	*0.00*	*0.00*		*0.00*		*0.00*	*0.00*	*0.00*		*0.00*		*0.00*	*0.00*	*0.00*		*0.00*		*0.00*	*0.00*	*0.00*		*0.00*	
Hausman-Test p value				*0.06*		*0.05*				*0.68*		*0.72*				*0.92*		*0.94*				*0.58*		*0.46*

	Smoking						Self-rated Health						High Blood Pressure					
	OLS	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**DID**	**OLS**	**2SLS**	**OLS**	**2SLS**
Reform indicator	-0.03						-0.05						-0.07					
p value	*0.42*						*0.44*						*0.01*					
DID estimator		0.01						0.05						0.00				
p value		*0.88*						*0.67*						*0.97*				
Secondary education			-0.02	-0.09					-0.11	-0.05					-0.02	-0.12		
p value			*0.01*	*0.42*					*0.00*	*0.59*					*0.00*	*0.03*		
Total education					-0.01	-0.08					-0.07	-0.05					-0.01	-0.12
p value					*0.00*	*0.43*					*0.00*	*0.59*					*0.00*	*0.06*
DOF	1093	981	1068	1068	1068	1068	2382	2188	2323	2323	2323	2323	2398	2201	2326	2326	2326	2326
Adjusted R^2	0.06	0.07	0.06		0.06		0.14	0.12	0.17		0.18		0.05	0.03	0.05		0.05	
F-Test p value	*0.00*	*0.00*	*0.00*		*0.00*		*0.00*	*0.00*	*0.00*		*0.00*		*0.00*	*0.00*	*0.00*		*0.00*	
Hausman-Test p value				*0.53*		*0.52*				*0.60*		*0.88*				*0.06*		*0.08*

This table is for the full sample only.

All regressions contain the controls GENDER and YRBIRTH unless their coefficients are insgnificant.

A constant is always included in the regressions.

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