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# The long-lasting effects of early-life cognitive abilities. Evidence from Europe

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**Abstract**

We study the long-term effect of cognitive abilities early in life on human capital in adulthood using the recent Survey of Health, Ageing and Retirement in Europe (SHARE). We look at a sample of individuals aged 50+ in 12 European countries for which we have information on health status, cognitive abilities and socio-economic status at age 10. We consider health and cognitive skills as distinct dimensions of human capital and explore whether human capital investments in childhood influence the efficiency of acquisition and maintenance of health and cognitive functions. Our results show strong and statistically significant effect of early cognitive abilities on later cognitive outcomes. Early cognitive abilities have a milder effect on health status later in life, which appears to be strongly related to health condition early in life.

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# 1 Introduction

Early childhood has been recognized as one of the most important phases of human development throughout the lifespan. A recent strand of literature emphasizes the important role that early life conditions play for health status and labour market outcomes at later ages. The seminal paper of Heckman and Cunha (2007) shows that cognitive and non-cognitive skills – that are essential for later life outcomes – are the results of the interaction of genetic and early environmental factors. Following this strand Almond and Currie (2011) documents that U.S children's cognitive abilities when measured in early life (age 0-5) can predict up to 20% of the variation in wages at age 33.

Although the topic is very important and compelling, the evidence is still scarce, especially for Europe. Understanding the process of human development would help creating policies and programs able to foster the production of skills. In addition, studying the pattern of cognitive abilities is important for countries that are ageing faster (e.g Europe, Japan, etc). Not only cognitive functioning is fundamental for decision making, for it influences individuals' ability to process information but also, cognitive abilities may be considered as one aspect of human capital, along with education, health, and non-cognitive abilities. Taking a broad view of human capital, we consider health and cognitive skills as distinct dimensions of human capital and investigate the association between early life cognitive abilities and later in life health and cognitive functions. We explore whether human capital investments in childhood influence the efficiency of acquisition and maintenance of health and cognitive functions.

One of the reasons for the paucity of evidence on Europe is lack of data, a key ingredient to draw reliable policy recommendations and to suggest the design of programs able to promote cognitive development.

This paper exploits the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a multi-disciplinary survey covering the 50+ population in 12 European countries. Other than being the source of detailed data on various domains of individuals' welfare in the late phase of the life-cycle, the survey also provides information on early childhood circumstances. Therefore, the data allow us to look at the effect of childhood conditions on adulthood for a wide set of countries. In particular, we relate measures of cognitive abilities at the age of 10, with various health and cognitive outcomes measured at later stages of the life-cycle.

After controlling for family backgrounds and general economic circumstances early in life, our results show a strong relationship between early life cognitive abilities and later health and cognitive outcomes. In particular being good in math positively and significantly affects cognitive abilities at older ages. The same pattern is valid for being good in languages. Furthermore, we show that having good health in childhood is relevant for later in life health conditions.

The paper is organized as follows: Section 2 discusses the theoretical underpinnings, Section 3 discusses the data and provides some descriptive evidence. Section 4 introduces the empirical model we adopt. Section 5 and 6 show the results and the potential explanations for these findings in addition to some robustness checks. Section 7 concludes.

## 2 Theoretical underpinnings

A substantial body of research shows that cognitive and non-cognitive abilities are important determinants of schooling and socioeconomic success - see for example Almond and Currie (2011). Cognitive skills are generally defined as mathematical and literacy ability. These measures are generally derived by means of specific tests or there might be self-reported measures. Non-cognitive skills are intended as socio-emotional regulation, time preferences, personality factors (i.e. motivation, discipline, perseverance, sociability, communication etc.). These are harder to measure than cognitive skills and the greatest impact on non-cognitive skills comes during early childhood experiences.

This paper focuses on cognitive skills and leaves non-cognitive skills as an unmeasured factor affecting later human capital development. This amounts to assume that early childhood non-cognitive skills are orthogonal to early childhood cognitive skills, and assumption that is made elsewhere in the literature (see Heckman and Cunha (2007); Cunha and Heckman (2008)) [1]

To study the role of early cognitive skills on later human capital, we assume that human capital at age $a$ depends on human capital at age $a-1$ and investment in human capital at age $a$, according to:

$$H_a = f_1(H_{a-1}, I_a) \tag{1}$$

where $H_a$ and $I_a$ are, respectively, human capital and investment at age $a$. Equation (1) is the law of motion of human capital, and simple example for (1) is obtained assuming geometric depreciation.

Furthermore, we posit that

$$I_a = g_1(H_{a-1}, Y_a) \tag{2}$$

where $Y_a$ is a vector of exogenous variables affecting the investment of human capital (for instance the quality of schools or the accessibility to the health care system). Any model in which individuals invest in human capital to maximize a monotonic transformation of $H_a$ would deliver an equation like (2), where $Y_a$ are variables

[1] If cognitive and non-cognitive skills are positively associated our approach overestimate the effect of cognitive skills.

affecting the investment decision, but outside the individuals' control.

Substituting (2) into (1), one obtains:

$$H_a = f_2(H_{a-1}, Y_a) \tag{3}$$

By repeatedly iterating backward equation (3), one obtains

$$H_a = f_3(H_0, Y_a, Y_{a-1}, \cdots, Y_1) \tag{4}$$

where $H_0$ refers to the human capital at the early stage of human development.

While estimating the functions $f_1(\cdot)$ and $g_1(\cdot)$ is interesting in its own right, in this paper we want to highlight the role of early conditions and accordingly estimate equation (4). The estimation will be driven by the sequence $\{Y_s\}_{s=0}^{a}$ being unobservable, and identification rests on $\{Y_s\}_{s=0}^{a}$ being outside the control of the the individuals. In Section 4 we detail our empirical strategy, after presenting the data in Section 3.

# 3 Data and variables of interest

## 3.1 SHARE and SHARELIFE

Our primary data source is the Survey of Health, Ageing and Retirement in Europe. SHARE is a multidisciplinary, bi-annual cross-national household survey that started in 2004.[2] It collects data on health, SES, social and family networks for nationally representative samples of elderly people (aged 50+) in participating countries, including measures of cognitive functioning based on simple tests of orientation in time, memory, verbal fluency and numeracy. Until now there are four waves available (2004, 2006, 2008, 2011) covering 19 European countries, plus Israel.

In the analysis we consider respondents present in wave 2 and wave 3 – SHARELIFE. The later collects retrospective information on the life history of each respondent before the baseline year of the survey (2004). It contains information on employment and housing histories, participation in the financial market, a wide range of indicators on physical and mental health, household formation and family circumstances around age 10, which is a novelty of SHARELIFE: A special session on childhood has been designed and the respondents are inquired about their accommodation facilities at the age of 10, the main breadwinner's job, the number of books at home, etc, which gives to SHARE an advantage compared to similar surveys.

[2]For general information on the SHARE survey we remind to Borsch-Supan et al. (2011).

Waves 2 and 3 of SHARE cover 13 European countries representing different European regions: a) Scandinavia (Denmark, Sweden); b) Central Europe (Austria, Belgium, France, Germany, the Netherlands, Switzerland); c) Mediterranean countries (Greece, Italy, Spain); d) Eastern Europe (Poland, Czech Republic). We exclude Austria from our sample due to a limited sample size compared to other countries. Further, we restrict the sample to respondents who are aged below 85, plus their spouses independently from their age. The final sample size is of about 22.500 observations.

In what follows we describe the variables used in this analysis explaining their advantages but also their limitations.

## 3.2 Measures of childhood circumstances and of adulthood outcomes

SHARELIFE arranges the different interview modules based on what is usually most important for the respondent and hence remembered most accurately (Schroder (2011)). This order is based on pilot studies conducted for the ELSA survey; however, it allows each respondent to change the order of the modules according to what is deemed most important.

One novelty is that each interview is supported by a multidimensional life grid which is a computerized version of the LCM that serves as the basis for the SHARELIFE interview. "*Life events are recorded into a large grid, where sets of topics such as children, partners, or work are combined with the time dimension, which is usually on the horizontal*" (Schroder and Borsch-Supan (2008), page 7). The life grid represents an improvement with respect to a simple timeline, which records events on an axis and places other events around it. Indeed, the life grid is a multidimensional version of the timeline because respondents can watch on the screen important events of different areas (children, health, job etc.) in parallel (from early childhood through adulthood). In particular, the information provided by the respondent appears immediately on a computer screen (it can be viewed by both respondents and interviewers), and helps respondents link events in a easier way. That is the whole procedure should allow to limit problems related to recall.

As discussed above, the most interesting source of information in our analysis is given by the socio-economic status of respondent at the age of 10, assessed through a selected number of indicators. In particular, we consider the number of rooms available in the house (excluding common spaces), the number of people living under the same roof, accommodation facilities (presence of fixed bath, cold and hot running water supply, inside toilet and central heating), the number of books at home (which ranges from none or a few to 2 or more bookcases), the occupation of the main breadwinner (10 categories ranging from manager to elementary occupation), the self-reported relative position in mathematics (math) and country's language compared to other children in the same class (much better, better, about the same, worse, much worse). Concerning health status we consider childhood self reported health status and the number of diseases, both referring to the age interval 0–15.

The early childhood conditions that are more relevant to us are the so called cognitive skills - math and language skills - and the health status. Our idea is indeed that skill and health investments in childhood should have long lasting effects in adulthood. Cognitive skills in childhood are measured relative to other class mates: respondent are asked to declare whether they were performing better, the same as, or worse than others. Childhood health status is measured in two ways. A subjective measure is the self reported health status (coded on a 5 points scale), and more objective one is the number of diseases suffered at age 10.

In addition to childhood cognitive skills we consider other early life conditions such as individual and family background characteristics during childhood. These are the number of books at home, number of rooms, number of persons living in the accommodation, family composition, main job of the breadwinner, accommodation characteristics, risky behaviors of parents, mental health of parents – everything measured at the age of 10. With these variables we create, by the principal component technique, a composite indicator for socio- economic status during childhood.

Our outcome variables are measures of human capital in adulthood measured in wave 2 (2006). In particular, we distinguish two different dimensions of adult human capital: health status and cognitive abilities.

For health in adulthood we use different indicators, namely an indicator for being in very good health (very good or excellent), an indicator for having few chronic diseases (less than 2), and a indicator for not being depressed (i.e. not being considered depressed according to the EUROD caseness definition). The survey includes also an assessment of cognitive skills in three domains: numeracy, memory and fluency. The numeracy indicator measures the ability of answering basic and more advanced mathematical questions, its score ranges from 1 to 5 (highest score). To measure memory the interviewer reads a list of 10 items and after a while the respondent is asked to recall the words. The "memory" variable measures the retention of words in memory and is thus the sum of the number of items recalled immediately and delayed, it ranges from 0 to 20, it is a synthetic measure summarizing recall delayed and recall immediate. Fluency, measures the ability of naming examples of animals that a person is able to remember in one minute. In addition to the 3 measured cognitive skills indicators we also consider as another cognitive outcome the level of educational attainment measured by the number of years of education computed.

## 3.3 Descriptive evidence

In this section we provide some descriptive evidence on the relationship between cognitive abilities in childhood and outcomes measured later in adulthood. Table 1 provides summary statistics and is organized in two panels. The top panel shows information for our predictors of interest (math and language skills) and a large number of proxies for the family SES in which each respondent grew up. On average about 34 to 35 % declare to have been better than school mates in either math or language. As for the level of SES we observe that on average about 62% of the respondents were living in a rural area, 41% of them had a few number of books at home, 42% declare that the main breadwinner was a blue collar, 71% had either parents who were smoking or drinking. What emerges from these indicators is that on average respondents had a lower SES around age 10. As for the adulthood conditions, results are shown in the bottom panel. To ensure comparability between the childhood and adulthood period we recoded some of the outcomes. For each of these outcomes we construct an indicator which takes value 1 if the respondent is way above the median computed for the sample of individuals of the same cohort and country, and 0 otherwise (we consider 5 year cohorts and 12 countries).

Since many outcomes we use are scores in objective tests (e.g: numeracy, memory, fluency, etc), we can express everything in relative terms. Mathematical and language skills are expressed in relative terms by design (referring to math and language skills at a given point in time (age 10) compared to own classmates (same cohorts) in the country where they live now (same country)). The percentage of respondents in good health conditions (thus, above the median) range from 28% when considering a subjective measure such as self-reported health, to 14 % when using an indicator for having few chronic conditions (based on what doctors have told to respondent), to 39 % in terms of depression. The average years of schooling is about 10.56, and 41% have an education which is higher than the median.

The table provides summary statistics while pooling all the countries. There is substantial variation of both childhood and adulthood conditions across countries and cohorts which will be taken into account in the next sessions of the paper. In Table 2 we make a step further and report the average value of each outcome by the math level and their mean difference. What emerges from the table is that for almost all the dimensions we consider (health, education, cognitive skills later in life), children who were better than others in math tend to be in better health conditions during adulthood, have higher education and score higher in the numeracy and memory tests. The difference is almost always statistically significant at the 1% level. Next , we report the age-profiles for average scores in cognitive tests and average years of education, separately by the level of math and language skills at the age of 10. The results that we obtain are striking.

From Figure 1 we see that being better than the classmates in math skills lead to better numeracy skills, memory, fluency and higher years of schooling during adulthood compared to those who were "scoring" worse. Not only, the discrepancy remains persistent throughout all ages and it is statistically significant and different from zero (we construct 95% confidence intervals indicated by the shading area). The same pattern is also observed for language skills. Figure 2 in fact shows that the difference in cognitive test scores is even higher when we compare those who were better than their classmates in language skills with those who were worse than their classmates. We do not report a graphs for adult health because it does not come as a result of an objective test, which are generally more reliable in this type of analysis. Although not conclusive, our descriptive evidence points towards a strong relationship between strong math and language capacities earlier in life and adult cognitive abilities.

# 4 Estimation strategy

To perform our empirical exercise, we take the linear approximation of (4), which leads to estimate the linear projections of $H_a$ on $H_0$.

We proxy $H_a$ and $H_0$ with cognitive abilities and health indicators at the age $a$ and at the age 10, respectively. We thus regress cognitive abilities (and health) indicators on cognitive abilities and health indicators measured at the age of 10. Our main equation is the following:

$$\begin{aligned} y^c_{a,i} &= \alpha^c_0 + \alpha^c_1 y^c_{0,i} + \alpha^c_2 y^h_{0,i} + u^c_i \\ y^h_{a,i} &= \alpha^h_0 + \alpha^h_1 y^c_{0,i} + \alpha^h_2 y^h_{0,i} + u^h_i \end{aligned} \tag{5}$$

where $y^c_{a,i}$ is in turn measured by cognitive abilities indicators (numeracy, orientation and memory -as the sum of recall delayed and recall immediate, fluency and educational attainment) and $y^h_{a,i}$ by health indicators (self-reported health status, chronic diseases and good mental health status). Furthermore, we assume that $u^c_i$ (and $u^h_i$) are made of unobservable variables orthogonal to $y^c_{0,i}$ and $y^h_{0,i}$. To make these assumption more credible, in several specifications we also control for variables dated at age 0. The list of these variables include number of books at home, father's occupation, accommodation facilities, number of rooms, being born in a rural area, having parents with mental health or behavioral problems and the number of siblings. In addition, we control for gender and year of birth, arguably exogenous variable, and we add full set of country dummies to account for unmeasured differences between countries.

Finally, we measure cognitive abilities at age 10 using proxies for mathematical and language ability at that age, and health status at age 10 with self-reported status at the age interval $0 - -15$ and by the number of diseases around the same period.

# 5 Results

In this section we show some results concerning the long-term effects of mathematical, abilities in language and health status in childhood on a set of outcomes including health status, education and cognitive skills measured later in life. In all the regressions we control for a full series of controls including demographics, family characteristics and childhood conditions. These controls are meant to net out the effects of confounders related to disadvantaged conditions. Furthermore, we control for a female dummy, country and year of birth fixed effects, survey year fixed effects and education level. As indicators of family background we use the number of books at home, whether breadwinner was a white/blue collar, accommodation features, the mental health status of the parents, number of siblings. We recode the original variables of "math" and "language" as dummies taking value 1 if answered "better than others" , and 0for "same as others or worse than others". As childhood health indicator we use whether health in childhood was good or more.[3] For sake of consistency with the childhood explanatory variables, we express these outcomes in relative terms. The outcome variables are dummy variables taking the value of 1 if the respondent is performing (ranked) above the median computed for the sample of individuals of the same cohort and country, and 0 otherwise. We also show results from standardized regressions where we express in standardized terms both the dependent and the independent variables.

A priori, we would expect a positive effect of math at age 10 on cognitive outcomes such as numeracy, orientation and recall total for those scoring high. Additionally, we would expect that having better childhood health positively affects health status in adulthood.

Table 3 , Panel A, reports the marginal effects of a probit analysis. From the coefficients, it is evident that having reported better health in childhood significantly increases the probability of being in good health, having few chronic diseases or of not-being depressed in adulthood. Ceteris paribus, the predicted probability of being in good health in adulthood is 0.385 greater for the individuals who reported being in good health in childhood, as well as the predicted probability of being in good mental health is 0.214 points higher. Good cognitive abilities in childhood also help: being better than others in math increases the probability of being in good health or in good mental health status. Panel B of table 3, replicates the analysis using the same specification but expressing the variables in standard deviations, in order to make the interpretation more straightforward. The standardized regression coefficients measure the expected standard deviation change in the dependent

[3]This variable is a dummy variable that takes value 1 if the respondent reported childhood health to be excellent, very good or more and 1 whether childhood health was reported as good, poor or very poor. We have replicated our results using also another more objective measure of childhood health: whether the respondent had disease(s) in childhood. Results are in line with the one obtained with our main specification.

variable associated to one standard deviation change in the independent variable. A standard deviation change in the health status during childhood is associated to a 0.157 standard deviation increase in health status during adulthood and to a 0.1 standard deviation increase in mental health status.

Looking at cognitive outcome, table 4, we see that, in both panel A and B, cognitive abilities in childhood are relevant determinants of cognitive abilities in adulthood. Being better than others in math or in language increases the probability of getting higher scores in numeracy (above the median of its own country and cohort), memory and fluency and significantly increase the probability of obtaining higher qualifications (measured in terms of years of education), respectively by 0.482, 0.137, 0.223 and 0.366 percentage points. The same effect is found with better literacy performance at age 10 but reduced in size for all the outcomes except for memory. Reporting good health in childhood is positively associated only to obtaining a college degree. These results are confirmed by panel B of Table 3, which reports the results of the standardized regression: a standard deviation change in math performance in childhood increase by 0.248 points numeracy score (i.e. 0.222 S.D.(numeracy)), by 0.224 points memory score, by 0.681 points fluency score and by 0.578 points years of education. Very similarly, one standard deviation change in literacy performance (i.e. language) at age 10 translates into a 0.036 points increase in numeracy score, 0.373 points increase in memory score, 0.491 points increase in fluency and by 0.526 points increase in the years of education.

Concerning the effect of other childhood conditions, specifically the socioeconomic status of the household during childhood, all the variables have the expected effect. Worse socioeconomic conditions such as having few books in the house, having a blue collar father, being born in a rural area or having parents with mental health or behavioral problems (drinkers or smokers), decrease the probability of having better health outcome and decrease the probability of better cognitive skills or performing social activities in adulthood.

## 5.1 Accounting for Cross-Country Differences in Returns to cognitive skills

Up to now, in our assessment of childhood conditions on adulthood outcomes we have considered the pooled set of countries including country fixed effects so that all estimates rely just on within-country variation. However, we have to consider that returns to skills can differ slightly across the 12 countries in our sample. Table A1 in the appendix A2 shows the beta coefficient of math variable on numeracy score on individual countries. This pattern tends to be similar within most countries, with the only exception of Poland. However, interacting country dummies with skills and health in childhood shows some differences. Looking at table 5, that reports the F statistics and the relative p-value of the coefficient of language, math, and health status interacted with the 11 country dummies, it is evident that for some particular outcomes of interest, namely health in adulthood, numeracy and college degree there are significantly differences across countries. This raises the question whether there are features of country economies such as educational or health system regulations, or different cultural norms that are systematically related to differences in skill and health returns. Thus, in this final section, we consider a few stylized facts about country characteristics that are systematically related to differences in the returns to skills and health across countries. Over the past two decades, there have been significant changes in educational and health systems/policies across Europe. These changes have been largely motivated by a desire to improve the functioning of the economies and, by implication, the economic well-being of individuals making both health and education accessible to more people. In particular, here we focus on two different country characteristics, each one related to a different type of outcome, and we investigate whether these commonly identified aspects of different countries interact with the returns to early conditions.

Concerning health, we look at the different availability of physicians per capita.[4] For differences in college degree we look at differences in tertiary education system, in particular at the different degree in university autonomy.[5] For the sake of the analysis, we begin with a baseline model –equation (1), pooled across all countries and including country fixed effects for all the 12 countries ($\gamma_c$) and including interaction terms between the vector of individual human capital measures in childhood $\Phi$ (Language, Math and Health) and two measures of country characteristics $N$ – number of physicians and university autonomy.

$$y_{ic} = \alpha_1 f_{ic} + \alpha_2' YoB_{ic} + \alpha_4' x_{i0c} + \beta_1' \Phi_{i0c} + \beta_2' \Phi_{i0c} * N_c + \gamma_c + \varepsilon_{ic} \tag{6}$$

While the main effects of the country-level features are absorbed in the country fixed effects $\gamma_c$, the coefficients of $\beta_2$ show how returns to childhood conditions vary with different country characteristics according to the outcome of interest. From Table 6 we see that the analysis of the various aggregate institutional factors produces an interesting pattern of results. Countries with a larger share of physicians per capita and greater university autonomy within individuals have systematically higher returns to health and to skills in adulthood. For example, estimates in column (2) suggest that a point increase in the degree of university autonomy is associated with a higher probability of getting a college degree when being good in math and in language.

[4] Data are taken from OECD(2013). This is a measure of health accessibility. We ranked the countries increasingly with the number of physicians per capita.

[5] Data are taken from EURIDICE.

# 6 Robustness

## 6.1 Family socio-economic status and educational attainment

In the main analysis we estimated the long-lasting effects of cognitive abilities in early-life while accounting for a large set of family background characteristics. We have noticed that socio-economic staus can matter, nevertheless, it would be interesting to quantify the effects of family socio-economic status, that is whether growing up in a wealthy family exacerbates the effect of cognitive skills at age 10 on adult outcomes. For this purpose we create a unique measure of family SES via principal component analysis using the following indicators: i) having more than few books in the house, ii) having a high-skilled breadwinner, iii) large number of rooms per capita, iv) being born in a urban area. We identify individuals from rich households as the ones with a SES status above the median of the same country and cohort, and we run the analysis for the two sub-groups. Results are shown in Table 7. It is interesting to observe that Socioeconomic status do not make a big difference

We have seen that good early cognitive abilities are a good predictor of good cognitive abilities later in life. It is interesting to see whether investing in schooling can actually be a way of "catching up" or not. That is: investing in schooling can help a person with lower cognitive abilities in early childhood filling the gap or everything is already predetermined? Table 8 shows that also in this case there is not so much scope for the successive cognitive abilities, in the sense that the effect of early cognitive abilities it has the same importance despite the different schooling attainments. The table includes as control high educational attainment (measured as having attained a number of years of education greater that the median of its own country and cohort), and the interaction between this variable and the early childhood conditions. Achieving high education seems to matter (positively) for all the outcome variables- namely numeracy, memory, having good health and few chronic diseases in adulthood, however the coefficients of the intereacted variables are non significant. Additionally, the coefficients of childhood cognitive abilities are very similar in size of the one obtained in the main analysis, suggesting that their effect is not mediated through schooling.

# 7 Conclusions

The importance of childhood circumstances in determining individuals' future health and economic status is well documented in the literature. In this paper, we take a broader view of the human capital accummulation process and explore whether investments in childhood influence the efficiency of acquisition and maintenance of health, cognitive skills and the depreciation of skills over the life cycle.

The data we use come from the SHARE survey for cohorts born between 1930-1955 in about 12 European countries. This creates the possibility to investigate whether different health or educational policies matter lead to different returns of human capital investment in early life. We find that, being good in mathematics or language compared to own classmates lead to better physical and mental health conditions later in life. The most striking results emerge when we analyze outcomes such as cognitive abilities, which are a result of objective tests submitted to each SHARE respondent. Descriptive evidence and regression analysis show that being good in math or language leads to huge advantages in numeracy, fluency and memory skills later in life. Our results are robust to different specifications.

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# Tables and figures

Table 1: Summary statistics

| Variable | Mean | Std. Dev. | N |
|---|---|---|---|
| **Early life conditions** | | | |
| Language best | 0.364 | 0.481 | 20874 |
| Math best | 0.349 | 0.477 | 20874 |
| Child good health | 0.682 | 0.465 | 22456 |
| Risky parents | 0.717 | 0.584 | 20874 |
| Parents with mental health problem | 0.024 | 0.152 | 20858 |
| Bad accommodation | 0.914 | 0.28 | 20874 |
| Few books | 0.417 | 0.493 | 20874 |
| Father blue coll. | 0.425 | 0.494 | 20874 |
| Born rural area | 0.627 | 0.484 | 20874 |
| Siblings (+3) | 0.667 | 0.471 | 20874 |
| **Adulthood conditions** | | | |
| ***Health outcomes*** | | | |
| Good health | 0.2890 | 0.453 | 22456 |
| Few chronic dis. | 0.147 | 0.354 | 22456 |
| Depression | 0.392 | 0.488 | 22456 |
| ***Cognitive outcomes*** | | | |
| Years of education | 0.418 | .493 | 22456 |
| Numeracy | 0.293 | 0.455 | 22456 |
| Memory | 0.441 | 0.496 | 22456 |
| Fluency | .468 | 0.499 | 22456 |

Notes: The table shows the summary statistics in our working sample. The top panel report mean, standard deviation, and number of non missing observations for the early-life conditions, the bottom for the adulthood outcomes.

Table 2: Measures of human capital by math best

| | Math best=1 | Math best=0 | difference |
|---|---|---|---|
| **Health outcomes** | | | |
| Adult good health | 0.273 | 0.364 | -0.091 *** |
| Few chronic | 0.582 | 0.549 | 0.032*** |
| Not depressed | 0.683 | 0.602 | 0.081*** |
| **Cognitive outcomes** | | | |
| Education (yrs) | 12.098 | 9.778 | 2.320*** |
| Numeracy best | 0.666 | 0.424 | 0.242*** |
| Memory | 9.503 | 8.329 | -1.173** |
| Fluency | 21.15 | 18.304 | 2.849*** |

Notes: The table shows health (top panel) and cognitive outcomes (bottom panel) by whether one is above (column 1) or below (column 2) the average level in math at the age of 10. Column 3 shows the difference between column 1 and 2. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Health outcomes

| | *Good health* | *Few Chronic* | *Good MH status* |
|---|---|---|---|
| **Panel A** | | | |
| Lang better | 0.079*** | −0.008 | −0.118*** |
| | (0.022) | (0.031) | (0.021) |
| Math better | 0.104*** | 0.007 | 0.157*** |
| | (0.022) | (0.031) | (0.021) |
| child good health | 0.385*** | 0.070* | 0.214*** |
| | (0.022) | (0.029) | (0.020) |
| Bad accomm. | −0.046 | −0.019 | −0.019 |
| | (0.026) | (0.032) | (0.024) |
| Few books | −0.192*** | −0.018 | −0.054* |
| | (0.022) | (0.030) | (0.021) |
| Father blue coll. | −0.112*** | −0.018 | −0.040* |
| | (0.019) | (0.027) | (0.018) |
| Born rural area | −0.042* | 0.006 | 0.058** |
| | (0.021) | (0.029) | (0.020) |
| Risky parents | −0.017 | −0.066** | −0.063*** |
| | (0.016) | (0.022) | (0.016) |
| Parents with MH problems | −0.064 | −0.148 | −0.196** |
| | (0.065) | (0.110) | (0.063) |
| At least 3 siblings | 0.017 | 0.006 | −0.046* |
| | (0.020) | (0.028) | (0.019) |
| constant | −0.606*** | −0.834*** | −0.383*** |
| | (0.049) | (0.066) | (0.047) |
| Pseudo R2 | 0.035 | 0.275 | 0.020 |
| N | 20901 | 20901 | 20901 |
| **Panel B** | | | |
| Std math | 0.049*** | 0.015* | 0.095*** |
| | (0.007) | (0.007) | (0.007) |
| Std language | 0.040*** | 0.008 | −0.031*** |
| | (0.007) | (0.008) | (0.007) |
| Std child health | 0.157*** | 0.080*** | 0.100*** |
| | (0.007) | (0.007) | (0.007) |
| Bad accomm. | −0.067*** | −0.034 | −0.029 |
| | (0.017) | (0.018) | (0.018) |
| Few books | −0.147*** | −0.031 | −0.097*** |
| | (0.015) | (0.016) | (0.016) |
| Father blue coll. | −0.080*** | −0.052*** | −0.030* |
| | (0.013) | (0.014) | (0.014) |
| Born rural area | −0.019 | 0.013 | 0.038** |
| | (0.014) | (0.015) | (0.014) |
| Risky parents | −0.031** | −0.061*** | −0.052*** |
| | (0.011) | (0.012) | (0.011) |
| Parents with MH problems | −0.071 | −0.110* | −0.225*** |
| | (0.042) | (0.045) | (0.044) |
| At least 3 siblings | −0.030* | −0.010 | −0.051*** |
| | (0.014) | (0.014) | (0.014) |
| constant | −0.317*** | −0.228*** | 0.078* |
| | (0.031) | (0.033) | (0.033) |
| r2 | 0.198 | 0.096 | 0.100 |
| N | 20773 | 20764 | 20502 |

Notes: Coefficients report marginal effect from a probit analysis. Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue

Table 4: Cognitive outcomes

| | *Numeracy* | *Memory* | *Fluency* | *Education* |
|---|---|---|---|---|
| **Panel A** | | | | |
| Lang better | 0.052* | 0.260*** | 0.188*** | 0.341*** |
| | (0.022) | (0.021) | (0.021) | (0.021) |
| Math better | 0.482*** | 0.137*** | 0.223*** | 0.366*** |
| | (0.021) | (0.021) | (0.021) | (0.021) |
| child good health | 0.041 | 0.004 | 0.028 | 0.076*** |
| | (0.021) | (0.020) | (0.020) | (0.021) |
| Bad accomm. | −0.124*** | −0.110*** | −0.079** | −0.258*** |
| | (0.026) | (0.024) | (0.024) | (0.026) |
| Few books | −0.261*** | −0.216*** | −0.282*** | −0.549*** |
| | (0.022) | (0.021) | (0.021) | (0.022) |
| Father blue coll. | −0.069*** | −0.056** | −0.041* | −0.171*** |
| | (0.019) | (0.018) | (0.018) | (0.019) |
| Born rural area | −0.062** | −0.105*** | −0.064*** | −0.270*** |
| | (0.021) | (0.019) | (0.019) | (0.020) |
| Risky parents | −0.022 | −0.036* | −0.011 | −0.061*** |
| | (0.017) | (0.015) | (0.015) | (0.016) |
| Parents with MH problems | −0.053 | 0.012 | 0.113 | 0.087 |
| | (0.064) | (0.060) | (0.060) | (0.062) |
| At least 3 siblings | −0.140*** | −0.062** | −0.068*** | −0.170*** |
| | (0.020) | (0.019) | (0.019) | (0.020) |
| constant | −0.574*** | 0.012 | 0.061 | 0.059 |
| | (0.049) | (0.046) | (0.046) | (0.048) |
| Pseudo R2 | 0.054 | 0.028 | 0.029 | 0.114 |
| N | 20901 | 20901 | 20901 | 20901 |
| **Panel B** | | | | |
| Stt. dev math | 0.222*** | 0.065*** | 0.093*** | 0.135*** |
| | (0.007) | (0.007) | (0.007) | (0.006) |
| Stt. dev language | 0.030*** | 0.108*** | 0.067*** | 0.123*** |
| | (0.007) | (0.007) | (0.007) | (0.006) |
| Stt. dev child health | 0.029*** | 0.003 | 0.013* | 0.025*** |
| | (0.006) | (0.006) | (0.006) | (0.006) |
| Bad accomm. | −0.125*** | −0.079*** | −0.055*** | −0.168*** |
| | (0.016) | (0.016) | (0.016) | (0.014) |
| Few books | −0.210*** | −0.186*** | −0.251*** | −0.359*** |
| | (0.014) | (0.014) | (0.014) | (0.013) |
| Father blue coll. | −0.036** | −0.034** | −0.044*** | −0.106*** |
| | (0.012) | (0.012) | (0.012) | (0.011) |
| Born rural area | −0.028* | −0.083*** | −0.050*** | −0.180*** |
| | (0.013) | (0.013) | (0.013) | (0.012) |
| Risky parents | −0.007 | −0.023* | 0.001 | −0.032*** |
| | (0.011) | (0.010) | (0.010) | (0.009) |
| Parents with MH problems | −0.047 | 0.010 | 0.130** | 0.053 |
| | (0.041) | (0.040) | (0.039) | (0.036) |
| At least 3 siblings | −0.090*** | −0.040** | −0.026* | −0.127*** |
| | (0.013) | (0.013) | (0.013) | (0.011) |
| constant | 0.102*** | −0.212*** | 0.101*** | 0.517*** |
| | (0.030) | (0.030) | (0.029) | (0.026) |
| r2 | 0.226 | 0.256 | 0.293 | 0.381 |
| N | 20719 | 20639 | 20584 | 20671 |

Notes: Coefficents report marginal effect from a probit analysis. Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue

Table 5: Country interactions

| Outcomes | Language x country | Math x country | Health x country |
|---|---|---|---|
| *Health adulthood* | 0.64 | 1.41 | 2.99 |
| | (0.797) | (0.158) | (0.00) |
| *ADL +2* | 0.50 | 0.68 | 1.86 |
| | (0.90) | (0.757) | (0.04) |
| *Chronic disease +2* | 1.38 | 0.74 | 1.61 |
| | (0.172) | (0.70) | (0.09) |
| *Depression* | 0.74 | 0.82 | 1.06 |
| | (0.70) | (0.62) | (0.39) |
| *Numeracy best* | 2.02 | 3.64 | 1.08 |
| | (0.23) | (0.000) | (0.37) |
| *Memory* | 2.95 | 0.65 | 1.53 |
| | (0.000) | (0.78) | (0.112) |
| *Fluency* | 2.24 | 1.61 | 0.90 |
| | (0.013) | (0.08) | (0.54) |
| *College degree* | 4.90 | 5.53 | 2.34 |
| | (0.000) | (0.000) | (0.007) |
| *Educational activities* | 1.95 | 0.91 | 0.51 |
| | (0.029) | (0.52) | (0.89) |

Notes: This table reports F-statistcs and F stat p-value in parenthesis obtained from anova regressions with full set of controls and with early child conditions interacted with country dummies. Horizontal lines divide separately estimated models shown in tables 4 to 6. All regressions control for gender, age group and country dummies and other early conditions measured at age 10.

Table 6: Institutional differences: What accounts for differences across countries?

| | *Good Health in adulthood* | *College degree* |
|---|---|---|
| Language better, age 10 | 0.161*** | 0.068*** |
| | (0.034) | (0.013) |
| x #. physicians | −0.013** | |
| | (0.005) | |
| x uni. autonomy | 0.010*** | |
| | | (0.002) |
| Math better, age 10 | 0.149*** | 0.074*** |
| | (0.035) | (0.013) |
| x #.physicians | −0.004 | |
| | (0.005) | |
| x uni. autonomy | | 0.008*** |
| | | (0.002) |
| Good health, age 10 | 0.281*** | −0.034*** |
| | (0.024) | (0.010) |
| x #. physicians | 0.011*** | |
| | (0.003) | |
| x uni. autonomy | | 0.007*** |
| | | (0.001) |
| R-squared | 0.114 | 0.171 |
| N | 20887 | 19767 |

Notes: The table reports the coefficients of the early childhood conditions interacted with institutional variables measuring the efficiency of the health system, university schooling system and the trust level in the different countries. Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue collar, a dummy for parents with mental health problem, whether parents were smokers or drinkers and whether born rural area.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: By socio-economic status

| | *Numeracy* | *Memory* | *Good Health* | *Few Chronic* |
|---|---|---|---|---|
| **Panel A : Poor** | | | | |
| Lang better | 0.092** | 0.283*** | 0.141*** | 0.033 |
| | (0.028) | (0.027) | (0.029) | (0.041) |
| Math better | 0.458*** | 0.135*** | 0.101*** | 0.014 |
| | (0.028) | (0.028) | (0.029) | (0.041) |
| child good health | 0.013 | 0.002 | 0.388*** | 0.068 |
| | (0.029) | (0.028) | (0.030) | (0.041) |
| Pseudo R squared | 0.038 | 0.018 | 0.032 | 0.261 |
| N | 10511 | 10511 | 10511 | 9628 |
| **Panel B: Rich** | | | | |
| Lang better | 0.047 | 0.272*** | 0.037 | −0.057 |
| | (0.033) | (0.031) | (0.033) | (0.047) |
| Math better | 0.533*** | 0.152*** | 0.132*** | 0.011 |
| | (0.033) | (0.031) | (0.033) | (0.045) |
| child good health | 0.080** | 0.010 | 0.385*** | 0.072 |
| | (0.031) | (0.028) | (0.031) | (0.040) |
| Pseudo R-squared | 0.043 | 0.015 | 0.028 | 0.266 |
| N | 10457 | 10457 | 10457 | 10457 |

Notes: The table reports marginal effect from probit analysis. Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue collar, a dummy for parents with mental health problem, whether parents were smokers or drinkers and whether born rural area.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

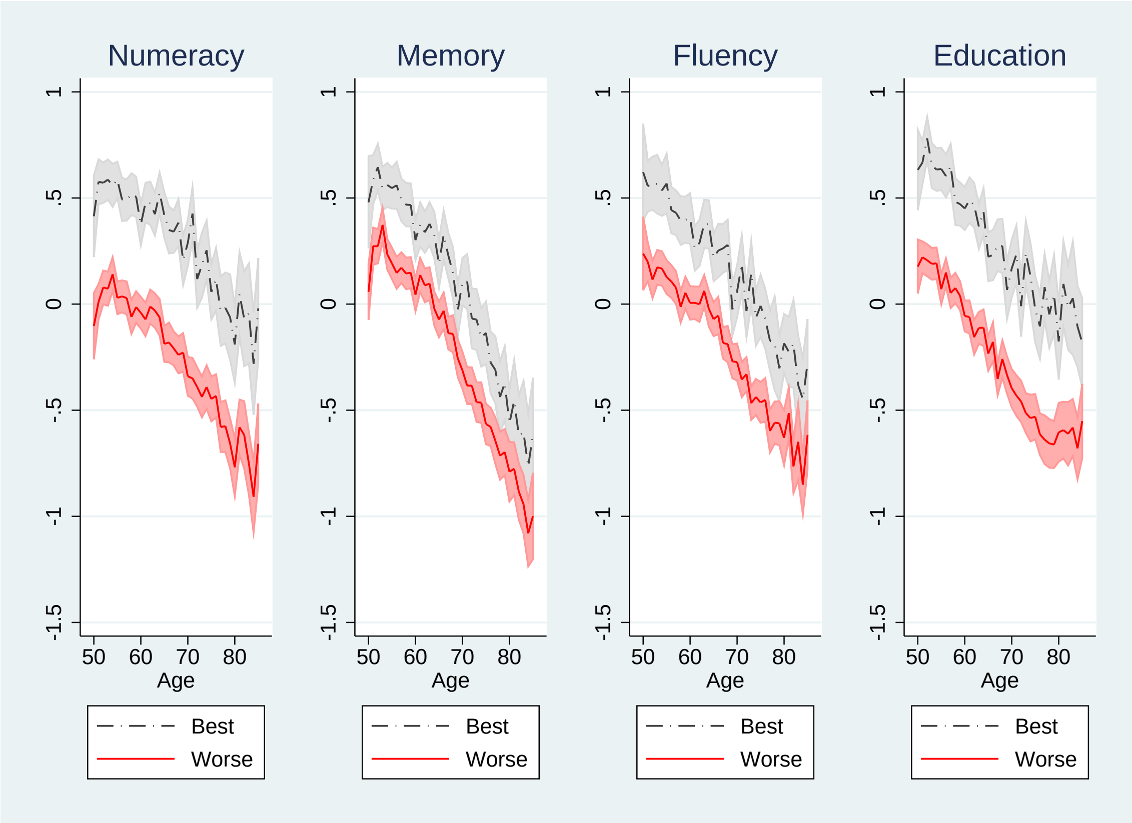
Table 8: Does educational attainment affect the returns to cognitive abilities in early life? (Cognitive outcomes)

| | *Numeracy* | *Memory* | *Good Health* | *Few Chronic* |
|---|---|---|---|---|
| Lang better | 0.011 | 0.241*** | 0.058 | −0.086* |
| | (0.032) | (0.029) | (0.031) | (0.044) |
| Math better | 0.452*** | 0.116*** | 0.088** | 0.027 |
| | (0.031) | (0.029) | (0.031) | (0.043) |
| child good health | 0.053 | −0.012 | 0.360*** | 0.044 |
| | (0.028) | (0.025) | (0.028) | (0.037) |
| High education | 0.537*** | 0.343*** | 0.278*** | 0.021 |
| | (0.038) | (0.036) | (0.040) | (0.053) |
| High edu. math | −0.035 | −0.033 | −0.029 | −0.058 |
| | (0.043) | (0.041) | (0.043) | (0.061) |
| High edu. lang | 0.019 | 0.021 | 0.017 | 0.129* |
| | (0.043) | (0.041) | (0.043) | (0.061) |
| High edu. health | −0.043 | 0.023 | 0.049 | 0.057 |
| | (0.041) | (0.039) | (0.042) | (0.057) |
| Pseudo R-squared | 0.069 | 0.032 | 0.039 | 0.275 |
| N | 20968 | 20968 | 20968 | 20968 |

Notes: The table reports marginal effect from probit analysis. Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue collar, a dummy for parents with mental health problem, whether parents were smokers or drinkers and whether born rural area.

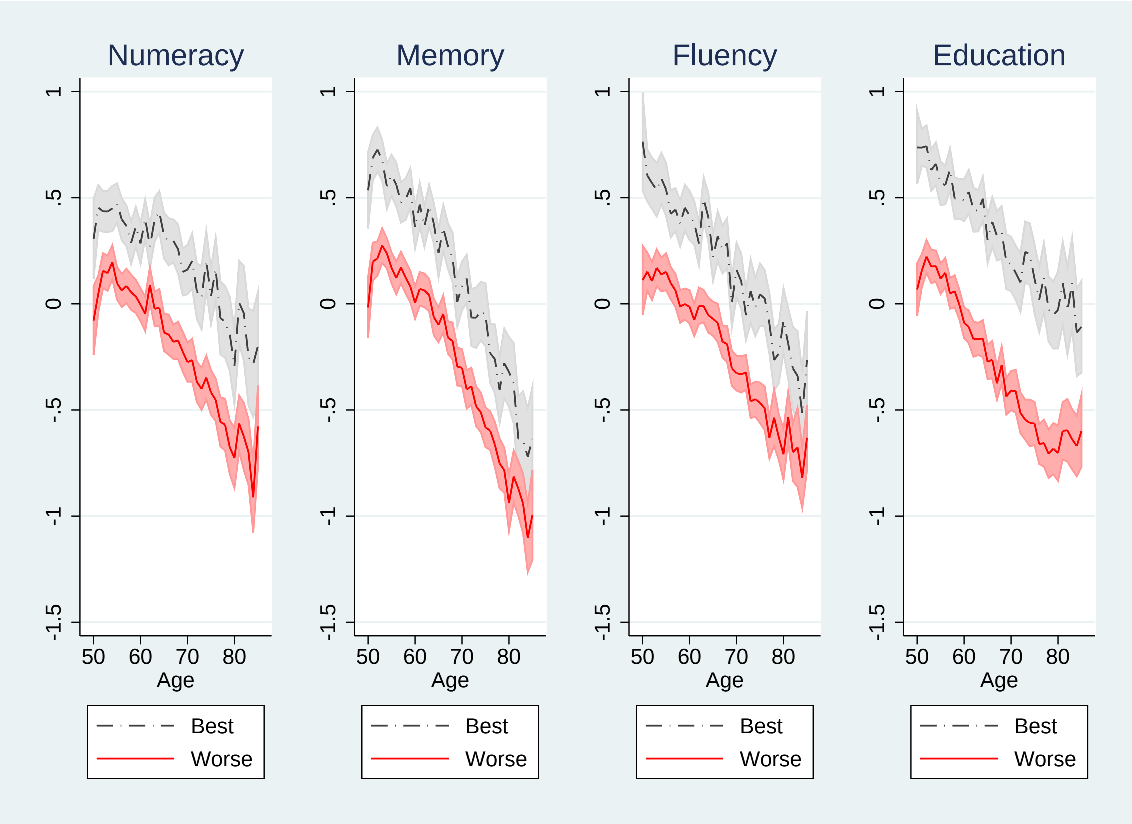
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1: Age profiles for cognitive skills by math level




Notes: The figure shows the age-profile of numeracy, memory, fluency, and years of education by level of mathematical skills at the age of 10.

Figure 2: Age profiles for cognitive skills by language level




Notes: The figure shows the age-profile of numeracy, memory, fluency, and years of education by level of language skills at the age of 10.

# Appendix

## A1: Data construction

### Cognitive variables in adulthood

The measures of cognitive ability in SHARE are the outcomes of simple tests of orientation in time, memory, verbal fluency and numeracy. These tests are administered to all respondents and are carried out after the first four modules (Cover Screen, Demographics and Networks, Physical Health, and Behavioral Risks) of the questionnaire. The test of **orientation in time** consists of four questions about the interview date (day, month, year) and day of the week. This test shows very little variability across respondents. Almost 87 percent of the baseline sample answered correctly all four questions, with 86 percent of the errors concerning the question about the day of the month. The test of **memory** consists of verbal registration and recall of a list of 10 words (butter, arm, letter, queen, ticket, grass, corner, stone, book, stick). The respondent hears the complete list only once and the test is carried out two times, immediately after the encoding phase (immediate recall) and at the end of the cognitive function module (delayed recall). The raw total scores of both tests correspond to the number of words that the respondent recalls.

The test of **numeracy** consists of a few questions involving simple arithmetical calculations based on real life situations. Respondents who correctly answer the first question are asked a more difficult one, while those who make a mistake are asked an easier one. The last question is about compound interest, testing basic financial literacy. The resulting raw total score ranges from 0 to 4. The set of questions asked in the SHARE numeracy test are:

1. If the chance of getting a disease is 10 percent, how many people out of one thousand would be expected to get the disease?

2. In a sale, a shop is selling all items at half price. Before the sale a sofa costs 300 Euro. How much will it cost in the sale?

3. A second hand car dealer is selling a car for 6,000 Euro. This is two-thirds of what it costs new. How much did the car cost new?

4. Let's say you have 2,000 Euro in a saving account. The account earns ten percent interest each year. How much would you have in the account at the end of two years?

All respondents start from question 1. If a respondent answers this question correctly, then she is asked 3. Otherwise, she is asked 2 and the test ends. If the respondent answers 3 correctly, then she is asked 4 and the test ends. Otherwise, the test ends with 3. For each question, interviewers are asked to code the answers provided by respondents on a grid of possible answers which always includes ”other” as a category. The grid of possible answers is never shown to the respondent. The raw total score of this test is computed as follow. Answering 2 incorrectly gives a score of 0, while answering correctly gives a score of 1. Answering 3 incorrectly gives a score of 2, answering 4 incorrectly gives a score of 3, while answering 4 correctly gives a score of 4.

## Institutional characteristics

In order to perform a cross country comparison depending on the accessibility to health system and educational system we use data from the OECD and from EURYDICE.

**The number of physicians per capita** is a measure of the number of generalist and specialist medical practitioners (per 1.000 people). Data are taken form the OECD Health Statistics 2013 (available at *http://www.oecd.org/health/healthdata*). The number of physicians per capita has increased in all OECD countries since 2000. For the sake of our analysis we have made a ranking of the countries in terms of number of physicians per capita based on the 2000 statistics.

**Index of university autonomy** measures autonomy at tertiary level in the following dimensions: budget, recruitment, organization, logistic, courses organization, self -evaluation and development plans. This data is taken from Braga, Checchi, and Meschi (2013) who used Eurydice (2000) "Two decades of reforms in higher education in Europe: 1980 Onwards" (p.91) as source. It is a continuous measure from 0 to 1, which is simply a normalized sum of indexes characterizing seven separate dimensions (budget, recruitment, organization, logistic, courses organization, self-evaluation and development plans), which are then rescaled in order to retain unitary variation. Full autonomy in the different areas is understood as meaning that the institutions are able to: freely spend any income derived from government grants, fees and contracts; decide on the employment of academic staff and their salaries (even if all legal requirements for minimum qualifications and minimum salaries have to be met); be responsible for internal management with- out the obligation to include specific external members on governing boards or similar bodies; own buildings and equipment used for teaching purposes; freely change course structure and content; determine when and how to assess the quality of their educational provision and, finally, determine any policy significantly affecting the institution’s future development. We measure the average degree of university autonomy between 1980 and 2000 and we rank the countries on this.

## A2: Additional evidence

Table A1. Estimated effects of math on numeracy, by country

| Country | $\beta_{math}$ |
|---|---|
| Germany | 0.193 *** |
| Sweden | 0.209 *** |
| Netherlands | 0.230 *** |
| Spain | 0.210 *** |
| Italy | 0.192 *** |
| France | 0.295 *** |
| Denmark | 0.268 *** |
| Greece | 0.196 *** |
| Switzerland | 0.140 *** |
| Belgium | 0.274 *** |
| Czech Republic | 0.236 *** |
| Poland | 0.096 *** |

Table A2. Health outcomes by gender

| | *Good health* | *Few Chronic* | *Depressed* |
|---|---|---|---|
| **Panel A: Males** | | | |
| Language better , age 10 | 0.091** | 0.082 | −0.049 |
| | (0.033) | (0.047) | (0.032) |
| Math better, age 10 | 0.106*** | −0.033 | 0.100*** |
| | (0.031) | (0.044) | (0.030) |
| child good health, age 10 | 0.379*** | 0.059 | 0.193*** |
| | (0.032) | (0.043) | (0.030) |
| Pseudo R2 | 0.032 | 0.318 | 0.026 |
| N | 9483 | 9483 | 9483 |
| **Panel B: Females** | | | |
| Language better , age 10 | 0.111*** | −0.013 | −0.057 |
| | (0.030) | (0.043) | (0.029) |
| Math better, age 10 | 0.058 | −0.030 | 0.094** |
| | (0.031) | (0.044) | (0.030) |
| child good health , age 10 | 0.380*** | 0.049 | 0.197*** |
| | (0.029) | (0.039) | (0.028) |
| Pseudo R2 | 0.041 | 0.243 | 0.017 |
| N | 11418 | 11418 | 11418 |

Notes: Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue collar, a dummy for parents with mental health problem, whether parents were smokers or drinkers and whether born rural area.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A3. Cognitive outcomes by gender

| | *Numeracy* | *Memory* | *Fluency* | *Education* |
|---|---|---|---|---|
| **Panel A: Males** | | | | |
| Lang better | 0.119*** | 0.233*** | 0.200*** | 0.438*** |
| | (0.032) | (0.032) | (0.032) | (0.033) |
| Math better | 0.394*** | 0.187*** | 0.169*** | 0.360*** |
| | (0.030) | (0.030) | (0.030) | (0.031) |
| child good health | 0.029 | 0.002 | −0.016 | 0.047 |
| | (0.031) | (0.031) | (0.030) | (0.031) |
| Pseudo R2 | 0.056 | 0.031 | 0.026 | 0.120 |
| N | 9483 | 9483 | 9483 | 9483 |
| **Panel B: Females** | | | | |
| Language better, age 10 | 0.127*** | 0.217*** | 0.200*** | 0.347*** |
| | (0.031) | (0.028) | (0.028) | (0.029) |
| Math better, age 10 | 0.458*** | 0.155*** | 0.247*** | 0.303*** |
| | (0.031) | (0.029) | (0.029) | (0.030) |
| child good health, age 10 | 0.011 | 0.025 | 0.052* | 0.073** |
| | (0.029) | (0.026) | (0.026) | (0.028) |
| Pseudo R2 | 0.055 | 0.033 | 0.036 | 0.122 |
| N | 11418 | 11418 | 11418 | 11418 |

Notes: Other controls include a full set of age group and country dummies and other early conditions measured at age 10. These early life conditions are: number of siblings, a dummy for living in a bad accommodation, a dummy for having few books in the household, whether father blue collar, a dummy for parents with mental health problem, whether parents were smokers or drinkers and whether born rural area.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.