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the role of skills and health

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Abstract

We provide new evidence on the causal mechanisms reflected in the intergenerational transmission of human capital. Applying both an adoption and a twin design to rich data from the Swedish military enlistment, we show that greater parental education increases son's cognitive and non-cognitive skills, as well as their health. The estimates are in many cases similar across research designs and suggest that a substantial part of the effect of parental education on the children's education works through improving children's skills and health.

JEL Classification: I12, I11, J14, J12, C41

Keywords: Intergenerational Transmission; Human Capital; Education; Health; Cognitive Skills; Non-Cognitive Skills; Adoptees; Twins

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I Introduction

How much does the adult success of children depend on their family background? This question is of long-standing interest in the social sciences partly because the answer reveals something about the degree to which inequality is transmitted across generations in society. An extensive literature has tackled the question by providing estimates of the relationship between parental education and children's education.[1] Such estimates reflect both the influence of 'nature' and 'nurture' but a recent literature, mostly based on a twin and an adoption design, has established that a substantial part of the transmission of education across generations reflects a causal effect of parental education (e.g. Behrman and Rosenzweig 2002; Sacerdote, 2002; Plug, 2004; Björklund et al. 2006; Holmlund et al., 2011).[2]

While the recent literature has enhanced our understanding of the intergenerational transmission of human capital, we still know very little about what it is that well-educated parents bring to their children. In other words, what are the particular causal *mechanisms* that are involved in the intergenerational transmission of human capital? Do the estimates reflect, for instance, that mother's and father's education improves the health of their children, who, in turn, go on to obtain more schooling? A growing literature points to the importance of early health capital for education and earnings (see Currie 2009 and Almond and Currie 2010 for recent overviews). Or do the estimates reflect that more educated parents get smarter children or children with greater social skills? Studies by Heckman and others emphasize the importance of skill acquisition early in life for later life outcomes (Heckman et al. 2006). Other mechanisms may be at work as well, where education is mainly transmitted through nepotism or through having access to networks.

In this paper, we provide new evidence on the mechanisms involved in the transmission of education across generations by investigating the relationship between parental education and children's outcomes. Specifically, we exploit rich administrative data from the Swedish military enlistment records, where cognitive skills, non-cognitive skills, and health have been measured for almost the entire population of Swedish 18 year old males. To these data, we have merged register-based information on parental education, including informa-

[1]The particular interest in education reflects the common belief that the education of one's parents is a major determinant of one's success in life (Haveman and Wolfe 1995).

[2]See Black and Deveraux (2010), Björklund and Salvanes (2010), and Holmlund et al. (2011) for recent overviews on the literature on intergenerational mobility.

tion on parents who are twins and parents who have adopted a child.

Our analysis contributes to the existing literature in mainly two ways. Firstly, we contribute to the literature on the effect of parent's education on their children's skills and health. While there is growing evidence for the importance of skills and health during childhood and adolescence, we know less about their determinants. Many descriptive studies point to the importance of parental education but there exists little evidence whether the relation between parental education and their children's outcomes is confounded by environmental and genetic influences.

Secondly, we contribute to the literature on the intergenerational transmission of human capital by providing new evidence on possible causal mechanisms. With our data, we are able to open the black box of possible mechanisms and examine the role of skills and health in the transmission of human capital. If parental schooling is found to affect their children's skills and health, this may also provide some clues to how the intergenerational transmission of education arises. Moreover, this would suggest that poor health and poor skills during childhood and adolescence are important mechanisms for the intergenerational transmission of human capital and economic status. Since we are able to use both an adoption and a twin design, we are thus able to directly address the possible mechanisms reflected in the previous twins and adoption-based literature on the transmission of education across generations.

We believe that improving the understanding of the underlying mechanisms is a natural next step for the literature on intergenerational mobility.[3] As argued by Currie (2009), it is only by opening the black box of the family that we can understand why it is that better backgrounds promote success in life. But improved knowledge about the mechanisms could also be useful information for policy-makers. For instance, policies that increase the level of education in society could be considered as more *valuable* if they also improve the education of people's offspring through increasing the offspring's skills and the health, rather than only through improving their study results in a narrower sense or through nepotism. The reason

[3]The importance of understanding the mechanisms is also argued in a recent overview by Black and Deveraux (2010), where the authors write: 'The focus of current research is on establishing a link between parent and child education; understanding the underlying mechanisms is a clear direction for future research.' A similar view is expressed by Holmlund et al. (2011), who conclude that: 'From our perspective, the roadmap for future research lies in a better understanding of the mechanisms that explain how parental schooling is passed on to the next generation.

is that improved skills and health may have benefits that stretches way beyond increased educational attainment. For instance, improved skills have been linked to reduced crime and risky behaviour, in addition to higher education and earnings (Heckman et al. 2006; Lundborg et al. 2011).

Besides being more *valuable*, policies that encourage people to invest in education may also be more *desirable* to society if education promotes intergenerational mobility through improving the skills and health of children and youth, rather than through, for instance, only promoting access to higher education or through nepotism.[4] Note that while the estimates from the recent literature on the transmission of education across generations suggest a role for policy in improving education across generations, this may not be automatically desirable if the mechanisms mainly reflect nepotism.

Our results favour the view that skills and health during childhood and adolescence are important mechanisms through which the intergenerational transmission of education arises. We show that parental education increases son's cognitive and non-cognitive skills, as well as their health. Moreover, across a number of outcomes, the estimates are rather similar using both the adoption and twin design. In addition, we obtain some pronounced gender differences, where the education of the father matters more for the formation of cognitive and non-cognitive skills, whereas the mother's education matters more for the son's health.

We believe that our estimates appear reasonable, given the results obtained in previous studies on the intergenerational transmission of human capital and on the returns to skills. Taking the example of cognitive skills, we show that the effect of parental education on such child skills could explain a substantial part of the causal effect of parental schooling on children's schooling obtained in previous studies. Given the other positive benefits that parental schooling have, this suggests that a major part of the causal transmission of education across generations runs through improved capacities of children.

This paper is organized as follows. The next section reviews some of the relevant literature on the intergenerational transmission of human capital. Section 3 describes the data used in this study. Section 4 describes and discusses the two empirical strategies used

[4]This also relates to the discussion on the socially optimal level of intergenerational mobility (Black and Devereaux 2010). In order to determine a socially optimal level of mobility, it is crucial to understand the underlying causes of the intergenerational transmission of education.

in this paper: the adoption design and the twin design. Section 5 presents the results and Section 6 summarizes our findings and draws some conclusions.

II Related Literature

Several strands of literature are relevant to our study. First, we have the mostly adoption and twins-based literature on the intergenerational transmission of human capital. Secondly, we have the mostly instrumental-variables based literature on the causal effect of parental education on children's outcomes. Below, we will review the key studies in the literature.

Starting with the adoption-based literature, most studies have identified positive and significant nurturing effects of parental schooling on children's schooling, although the magnitude varies across studies and across contexts. In early adoption studies, such as Dearden et al (1997), Sacerdote (2000, 2002) and Plug (2004), relatively large nurturing effects were obtained in a U.S. and UK context. Later adoption studies usually obtain smaller 'nurturing' effects. For the U.S., Sacerdote (2007) used data on Korean adoptees who were randomly assigned to families, where the smaller effect perhaps reflect that there was less parent-child matching taking place. Smaller effects, although significant, were also reported in the novel study by Björklund et al. (2006), where data on both the biological and adoptive parents of adopted children were used. Similar estimates were obtained in a recent paper by Holmlund et al. (2011), using data on both internationally adopted children and children adopted within Sweden.

Significant nurturing effects have also been obtained in the twin-based literature. Using data on monozygotic twin parents, Behrman and Rosenzweig (2002) showed that no significant association between the mother's schooling and children's schooling remained when genes and common environment were accounted for, however. Similar results were later obtained in Holmlund et al. (2011) and Pronzato (2010), using samples of pooled MZ and DZ twins in Sweden and Norway, respectively. Contrasting evidence on the role of maternal education was obtained in a recent paper by Amin et al. (2011a), where the results showed that only the mother's education mattered, when using a sample consisting of MZ twins only. Bingley et al. (2009), using data on Danish MZ twins, also showed that the importance of the maternal education became larger in more recent cohorts. In a paper related to ours, Haegeland et al. (2010) used both an adoption and a twin design and found using the adoption design that mother's education mattered more for the child's exam scores at age 16 than father's education. When they exploited the twin design, however neither parent's education had a significant effect on the child's education.

Besides the adoption and twin studies, there are a few studies that uses an IV design to study the intergenerational transmission of schooling. Black et al. (2005) used a reform of the Norwegian schooling system as an instrument for parental schooling and found no causal relationship between the father's education and the child's education level. For mothers they report a small effect on the son's education (but not on the daughter's). Similar IV-results were obtained by Holmlund et al. (2011), where the mother's education was found to be slightly more important.[5] De Haan (2011) used a non-parametric bounds analysis and found that increasing mother's and father's schooling to a college degree had a positive effect on child's schooling.

The studies cited above have established that there exists a 'nurturing' effect of parental education on children's education. But what are the mechanisms behind this effect? To shed light on potential mechanisms, it would be informative to consider the relation between parental education and intermediate child outcomes, such as skills and health. In the adoption literature, one of the few studies doing so is Sacerdote (2000), who shows significant nurturing effects of parental years of schooling on children's cognitive test scores in a small sample of Korean adoptees in the U.S. No significant nurturing effects were found in Sacerdote (2007), however, where the relation between mothers' education and children's BMI and drinking behaviour was estimated.

In the twin-based literature, the only study on potential mechanisms that we are aware of is a working paper by Bingley et al. (2009). They use Danish data and estimate the effect of parental schooling on the birth weight of the offspring. The results show that the mother's schooling increases the birth weight of their offspring but that the father's schooling has no effect.

Most of the evidence on a causal effect between parental education and child outcomes

[5] A number of additional studies have used an IV-strategy to study the effect of parental education on various educational outcomes of children, such as grades, grade repetition and post-compulsory school attendence (Chevalier 2004; Oreopoulos et al. 2006; Maurin and McNally 2008; Carneiro et al. 2012). These studies find a positive effect of education, the exception being Chevalier, where a negative effect on the likelihood of the child having post-compulsory schooling was obtained for fathers' education.

instead comes from instrumental-variables studies.[6] The first IV study on the topic was Currie and Moretti (2003), who used the expansion in the number of colleges across U.S. states as an instrument for mothers' schooling. They found that the increase in college attendance of women improved their children's health, in terms of birth weight and gestational age, and led to less smoking among mothers.

In a study using U.K. data, Lindeboom et al. (2009) exploited a compulsory schooling reform to estimate the causal effect of schooling on child health. They found no evidence of a causal effect of parental schooling on child health outcomes at birth and at ages 7, 11, and 16. Chevalier and Sullivan (2007), however, found that the reform had heterogeneous effects and that the most impacted groups experienced larger changes in infant birth weight.

Carneiro et al. (2012) used U.S. data and instrumented mothers' education with the presence of colleges at age 17 in the state of residence and with local labor market conditions. They found a strong effect of maternal education on child cognitive outcomes, but also on measures of behaviour problems. Finally, McCrary and Royer (2011) combined data on exact birth dates and age-at-school entry policies in the spirit of Angrist and Kreuger's quarter of birth instrument. Using data on all births in California during the years 1989–2002, and using birth date as an instrument for schooling, they find no evidence of a causal effect of schooling on infant health outcomes.

The literature review above suggests that there is rather mixed evidence regarding the causal effect of parental schooling on child outcomes such as health and cognitive skills in developed countries. In a comprehensive survey on the literature on children's health and parental socioeconomic status, Currie (2009) concludes that it is still difficult to prove that the relationship between parental background and children's health is a causal relationship and that more research is needed.[7]

[6] Note, however, that the results from this literature may be hard to generalize to the twin and adoption literature, since the IV-estimates reflect Local Average Treatment Effects, where the instruments used normally affect people at the lower end of the educational distribution, while results using adopted children effectively exploit variations in education in a group of well-educated parents. The twin design exploits differences in education between twin parents, where the differences are often found to be quite evenly distributed across the distribution of education.

[7] There are also a number of studies that estimate the relationship between various outcomes across generations, where the goal is not to establish causality, but where the results

III Data

For the purpose of this study, we merged a number of different registers. This includes the Register of the Total Population (RTB, with information on birth date, date of immigration, sex, country of birth, and parental country of birth), the Multi Generation Register (Flergenerationsregistret, with identification of siblings on the mothers side through a family ID), the Swedish National Service Administration, the Swedish Register of Education (UREG), the National Tax Records, and the Swedish Twin Registry (with information on twin zygosity).

We identify adopted children through an adoption indicator that is available in the RTB register from Statistics Sweden. From this register, we select all male foreign-born adoptees born between 1965 and 1978. In our sample, most adopted children came from South Korea (24%), India (14%), Chile (10%), Thailand (9%), Colombia (7%), or Sri Lanka (6%). In order to avoid the risk that some foreign-born adoptees are adopted by relatives, which would create a genetic link, we only include adoptees adopted by Swedish-born parents. By further restricting the sample to those who have enlisted in the military, and who have non-missing data on parental education and on our outcome measures, our sample of adoptees varies between 3,375 and 3,741, depending on the outcome studied.

Our twin sample consists of all children born to twin parents between 1950–1978 and who have enlisted.[8] In order to determine zygosity of the twins, we have merged our data with zygosity information from the Swedish twin registry. In this manner, we are able

may still point to potentially important mechanisms for the intergenerational transmission of education. These include, for instance, Black et al. (2009), Anger and Heineck (2009), Grönqvist et al. (2010), and Björklund et al. (2010), who all study the transmission of IQ across generations, and Lindqvist and Hjalmarsson (2010) and Lindqvist and Hjalmarsson (2011a), who study the intergenerational transmission of criminality and the practice of drunk driving. In a recent paper, however, Lindqvist and Hjalmarsson (2011b) use an adoption design, including both information on the adopted and biological parents, to study the intergenerational transmission of criminality. Moreover, Amin et al. (2011b), studies the intergenerational transmission of income, using a twin design. Corak and Piraino (2011) study the intergenerational transmission of employers.

[8]Note that for adopted children, the sample only includes those born 1965 and onwards. The reason is that there were almost no international adoptions taking place in Sweden before 1965.

to determine zygosity for 82% of the parents in our dataset.[9] Our dataset includes between 2,983 and 3,216 children of monozygotic twin parents, depending on the outcome studied.

Our third sample consists of the population of 'own-birth' sons born during the periods corresponding to the periods used in the adoptee and twin samples. With this sample, we are able to provide 'baseline' estimates for a sample of sons with biological parents. Restricting the sample of own-birth sons to those with non-missing observations on parental education gives us between 851,128 and 903,891 observations depending on the outcome studied.

In our empirical analyses, we focus on three set of outcomes; cognitive skills, non-cognitive skills, and health. These are measured at age 18, during the military enlistment tests. It should be noted that during our study period, in principle every male Swedish citizen enlisted in the military when turning 18. Enlistment was mandatory and there is very little attrition in the data. Refusal to enlist leads to a fine, and eventually to imprisonment. Individuals are only exempted from enlistment if they are imprisoned, if they have ever been convicted for grave crimes (which mostly concerns violence-related and abuse-related crimes), or if they are in care institutions and are deemed to be unable to function in a war situation. During our study period, the annual cohort size of men turning 18 was about 50,000. Per cohort, around 1,250 (i.e., 2.5%) were exempted from enlistment.[10]

Cognitive skills are measured using a test similar to the AFQT in the U.S. The test is called the Enlistment Battery 80 and includes four separate tests: Instructions, Synonyms, Metal Folding, and Technical Comprehension. The separate scores of these tests are aggregated into a standard composite measure calculated by the military enlistment service. In our analyses, we use a normalized version of this score. Non-cognitive skills are measured through interviews carried out by certified psychologists employed by the Swedish army. The ultimate purpose of the interview is to evaluate the conscript's ability to perform military service and to function in a war situation. This is achieved through an assessment

[9]The twin registry determines zygosity based on survey questions regarding co-twin similarity. The method used has been found to classify twins with an accuracy of 95

[10]Note also that the incentives to deliberately underperform at the enlistment tests are rather limited. The reason is that during our study period, the results of the tests had no impact on the probability of performing military service or not, since almost all people who enlisted during our study period also completed military service. Instead, the test results merely influenced the individual's placement within the army, meaning that poorer results typically led to a worse placement.

of the enlistee's psychological stability and endurance, capability of taking initiatives, responsibility, and social competence. The assessment results in a composite enlistment score of non-cognitive skills, ranging from 1 to 9, which we then normalize in our analyses. The character traits valued by the military psychologists are similar to the traits usually included in measures of non-cognitive skills. The measure has also been found to be a strong predictor of adult earnings, independently of cognitive skills (Lindqvist and Vestman 2011).

We consider two health outcomes in our empirical analyses: height and a measure of overall health.[11] The latter is a unidimensional global health measure, which is based on the severity of the individual's health conditions (both physical and mental) and which is used by the military to determine the enlistee's suitability for different types of military service. In our analyses, we transform their ordered categories into a 13-step scale, ranging from worst possible health to perfect health. The measure of height is taken by the staff at the enlistment offices. Table 1 reports descriptive statistics for our three samples: own-birth sons, adopted sons, and own-birth sons with a monozygotic twin-parent.

IV Empirical Model

A The Adoption Approach

The typical reduced form equation used to estimate the intergenerational transmission of human capital from an adoptive parent *ap* to a adopted child *ac* can be written:

$$Y^{ac} = \alpha_{AD} + \delta_{AD} S^{ap} + \Gamma_{AD} g^{bp} + \gamma_{AD} f^{ap} + \upsilon^{ac} \tag{1}$$

In this paper, Y^{ac} represents the adopted child's outcomes, such as cognitive and non-cognitive skills a non-cognitive skills and health, whereas S^{ap} represents the schooling of the adoptive parent. Moreover, g^{bp} represents any genetic endowments that are passed on from the biological parent to the child, whereas f^{ap} represents any non-genetically transmitted characteristic of the adoptive parent other than schooling, such as child-rearing skills. Unobserved child-specific factors are denoted υ^{ac}. The δ_{AD} coefficient measures the causal effect of adoptive parental education, S^{ap}, on child outcomes. The Γ_{AD} and γ_{AD} coefficients measure

[11] An adult individual's height has been called probably the best single indicator of his or her dietary and infectious disease history during childhood (Elo and Preston, 1992).

the extent to which genetic endowments and non-genetic endowments are transmitted to the adopted child.

In this specification, only the education of one of the adoptive parents is included but in our empirical analysis, we will also employ specifications where we include the spouse's education. In order to identify δ_{AD}, the adoption literature employs two standard assumptions. First, adopted children are assumed to be randomly allocated to their adoptive parents. If the adoption agency instead matched the adoptive child with the adoptive parents, or if the education of the adoptive parents is related to characteristics of the biological parents, an artificial genetic link may be constructed and $cov(S^{ap}, g^{bp}) \neq 0$. This would also be the case if adoptive parents were able to choose who to adopt and more were able to choose who to adopt and more well-educated parents were to choose healthier children or children with more innate skills.[12] Besides controlling for observable characteristics of the adoptees, through the inclusion of country of adoption fixed effects and age at adoption fixed effects, we will conduct a sensitivity analysis in order to examine whether child–parent matching is a problem in our study. It should be noted that adoptive parents in Sweden are not able to choose a particular child for adoption.[13,14]

[12] Another worry is that the parents or the adoption centers in the home countries of the adoptees will choose adoptive parents based on certain characteristics. It is very common, however, that the children given up for adoption are children that have been abandoned by their mother, in which case the mother is unknown (SOU 2003). Even if the mother is known, it seems that she has little influence over the selection of adoptive parents, once she has given a written approval to the organization to adopt away her child.

[13] Instead, a strict procedure is followed, where the parents seeking to adopt first have to seek permission from the social authorities, who will undertake a thorough investigation about the person's or couple's ability to take care of an adopted child (SOU 2003). If granted permission, the couple can contact a government-accredited adoption organization and file an application to adopt. By choosing a particular organization, which often specialises in children from particular countries, the parents are able to choose what country to adopt from. They are also able to state a preference regarding the gender and age of the child, although there is no guarantee that this preference will be fulfilled. Thus, the parents may influence certain characteristics of the adoptive child, but these characteristics are observable to us.

[14] Holmlund et al. (2010) used data on international adoptees in Sweden and found some weak evidence of selection of adoptees. For instance, more highly educated mothers seemed

The second assumption required in the adoption design is that any non-genetic characteristics of the parents that might also directly affect the outcomes of the adopted child are unrelated to parental schooling, i.e., that $cov(S^{ap}, f^{ap}) \neq 0$. There is nothing in the adoption design that guarantees this and one can only speculate on the likely direction of the bias that arises from violating this assumption. For child-rearing skills, for instance, it is not clear a priori if such skills are negatively or positively related to parental education (Björklund et al. 2006). If there is a trade-off between investing in child-rearing skills and schooling they may be negatively related. On the other hand, education is often assumed to be related to an increased efficiency of household production, which may include child-rearing. In any case, if the second assumption needed in the adoption design is violated, the estimated 'nurturing' effect would include both the effect of parental education and any other non-genetic factors that are related to both parental schooling and child outcomes.

The external validity of adoption-based estimates may be threatened for a number of reasons. For instance, adoptees may be less affected by parental nurturing if they face emotional problems from adoption. Similarily, nurturing may be less effective if adoptees are already hurt by adverse conditions during pregnancy and during the first years of life (i.e. prior to adoption). Nurturing skills may, however, be greater among adoptive parents, since they are screened prior to adoption. Also, they are more highly educated on average (as shown in Table 1). On the other hand, the same type of screening also means that there may be less variation in nurturing skills within the group of adoptive parents, which would push the estimated nurturing effect downwards. One also needs to recognise the possibility that adoptive parents treat their adopted children differently from how they treat, or would have treated, their biological children. We will investigate these issues in a sensitivity analysis.[15]

B The Twin Approach

to prefer older children and boys. The estimated effects were very small, however, and when controlling for these observable factors, the estimated intergenerational associations hardly changed at all.

[15]If adopted children has lower ability on average, as Table 1 suggests, and if there are positive interactions between genes and environment, adopted children may also benefit less from an improved environment. Since we have no information on the biological parents of the adoptees, we cannot investigate this possibility.

In the twin approach, data on monozygotic twin parents, who share genes and early family environment, is used. Here, the influence of such shared factors is removed by relating differences in schooling between monozygotic twin parents to differences in their children's skills and health. We may thus write the intergenerational transmission equation as

$$\Delta Y^c = \delta_{TW} \Delta S^p + \Gamma_{TW} \Delta g^p + \gamma_{TW} \Delta f^p + \Delta \upsilon^c. \tag{2}$$

When using only data on monozygotic twin parents who are genetically identical, we have that $\Delta g^p = 0$. In this specification, we allow the effect of parental education to also include effects that run through assortative mating. This means that we still get an unbiased estimate of the schooling of the twin parent but that the effect also includes the endowments and schooling of the spouse. We will contrast the results obtained using this specification to those obtained when controlling for the education of the spouse. Since it is not possible to difference out the endowments that vary between the spouses, however, these results will most likely be upward biased. The reason is that more highly educated parents are also more likely to marry spouses with favourable endowments, generating a positive correlation between the education of the twin parent and the error term.

In order for the twin approach to provide an estimate of the causal effect, a number of additional assumptions need to be made. In our case, the most important assumption is that schooling differences between identical twin parents are unrelated to differences in non-genetic characteristics that may also affect the outcomes of the child. To achieve this, the twin literature also assumes that $\Delta f^p = 0$ within twin pairs. Thus, by differencing out g^p and f^p, one may obtain an estimate of the causal effect δ_{TW}.

The assumption that schooling differences within twin pairs are unrelated to differences in unobserved non-genetic characteristics has been questioned by, for instance, Bound and Solon (1999). It would fail, for instance, if schooling differences within twin pairs are associated with differences in ability, parenting skills, or birth weight. There is some evidence suggesting that birth weight differences between twins may be associated with schooling differences (Black et al. 2007). The estimated effects are usually very small however. Royer (2009) finds a small significant effect, where increasing birth weight by 250 grams (which would be quite a policy achievement), only leads to 0.03-0.04 of a year of additional schooling. Black et al. (2007) find that a 10 percent increase in birth weight increases the probability of high school completion by just 1 percentage point. Behrman and Rosenzweig (2004) find a slightly larger effect with a 1 pound (453 grams) increase in birth weight increasing schooling by a third of a year. Miller et al (2005), using data from the Australian twin registry, find no significant relationship between birth weight and schooling, however.

Ability differences may also exist between monozygotic twins. Sandewall et al. (2009) used similar data as ours and showed that IQ test differences between twins predicted later schooling. If the same IQ test differences directly affect the children's skills and health, omitting IQ from the regression would bias our results. Since we only have IQ test information for a very small subsample of fathers, we cannot test for this, but we note that Amin et al. (2011a), using a larger sample of Swedish twins, showed that including fathers' IQ in an intergenerational schooling regression did not affect the schooling coefficient.[16] To the extent that there remain important omitted characteristics between twins, however, the estimated coefficient on parental education should be interpreted as the combined effect of parent's schooling and all other factors that are correlated with parent's schooling and who also have an independent effect on child's schooling, net of genetic transmission.

Another assumption commonly made in twin designs is that measurement errors do not play an important role. As shown by Griliches (1979), the downward bias induced by normally distributed measurement errors will be exaggerated when using sibling or twin-fixed-effects models. Any reduction in the estimated coefficients when imposing sibling-fixed effects may therefore be caused by the more severe downward bias resulting from measurement errors, rather than from removal of twin-pair-specific unobserved heterogeneity. Since we rely on register data on education, we believe that the measurement error issue is

[16]Bias may also be induced if there is differential treatment of twins by parents. For instance, parents may try to compensate for, or amplify differences between the twins by investing more or less in the less able or less healthy twin. Such compensating behavior would for instance be present in a model in which the returns to child investments are greater for the least able child in the family and the parents only care about maximizing the returns to the investments (Becker and Tomes, 1976; Behrman et al., 1982; Rosenzweig and Schultz, 1982). Results from a small twin-based literature, using various measures of parental inputs, does not suggest that parents systematically reinforce or compensate for early life insult, however (see for instance Royer 2009 and Almond and Currie 2010). Isacsson (1999) finds no relation between psychological instability early in life, being an imperfect proxy of parental rearing skills, and years of schooling among Swedish twins.

less of a problem in this study.[17][18]

V Results

A Adopted Sons

We start our analyses by estimating the relationship between parental education and child outcomes for own-birth sons and adopted sons. Table 2 shows the results, where separate regressions for maternal and paternal schooling are estimated. Table 3 shows the corresponding results when controlling for the spouse's education. All regressions on adoptees include fixed effects for age at adoption and country of origin.

Focusing first on the results for cognitive and non-cognitive outcomes, the significant estimates for own-birth sons suggest that one additional year of paternal schooling increases cognitive and non-cognitive skills by 0.099 and 0.057 of a standard deviation, respectively. The corresponding estimates for maternal education are almost identical, being 0.096 and 0.056, respectively. Moving on to the adoptees, the estimates are substantially lower. Moreover, the relative importance of paternal versus maternal years of schooling changes. For cognitive skills, the estimate for paternal education now decreases to 0.027, while the corresponding estimate of maternal education decreases to 0.014, both being statistically significant at the 5% level.

Similar patterns as those concerning cognitive skills are obtained for the effect of the adoptive father's education on non-cognitive skills, where the point estimate is reduced to 0.017, while the corresponding estimate for the mother's education is close to zero and statistically insignificant. When we control for the spouse's education in the regressions on cognitive and non-cognitive skills, as shown in Table 3, the effect of the adoption mother's education on either type of skill approaches zero, whereas the effects of the adoption father's

[17] Holmlund et al. (2008) addressed the measurement error problem in the Swedish data using the approach suggested by Ashenfelter and Kreuger (1994): instrumenting the education measure with another, independent, measure of the same education did not affect the results. Moreover, Holmlund et al. (2011) found the reliability ratio in the education measure to be relatively high.

[18] Downward bias would also occur if children of twin parents, i.e. cousins, interact more frequently, since they may then be affected by their uncle's or aunt's education.

education on cognitive and non-cognitive skills remain almost unchanged. Our results for adoptees thus suggest that only the education of the father has a nurturing impact on the child's cognitive and non-cognitive test scores. For mothers, we interpret the association between the mother's education and the children's skills to mainly reflect inherited abilities and assortative mating.

We can only speculate on the mechanism behind the finding that only paternal education matters. One possible explanation would be that there exists a negative correlation between child-rearing skills and education among mothers but not among fathers.[19] Another explanation could be that the result reflects specialization within the household, where fathers take a greater responsibility for helping with tasks that improve the children's cognitive and non-cognitive skills, whereas mothers take a greater responsibility for other household work. Yet another explanation could be that there is a stronger correlation between education and income for fathers than for mothers, so that the effect of paternal education also picks up the effect of income to a greater extent.[20] We can test this by including controls for income in the regressions. This only marginally affected the estimates for parental education and the decline in the size of the coefficients was almost identical for mothers and fathers.[21]

[19]A downward bias would also arise if there is a negative correlation between education and certain favourable unobserved characteristics in the sample of adoptive parents (Black et al. 2010). The reason is that adoptive parents who are allowed to adopt despite poor observable characteristics are likely to have better on average unobserved characteristics that compensate for their poor observable characteristics. This would imply that the estimated effect for the sample of adoptive parents is downward biased. If the negative correlation between education and favourable unobserved characteristics is stronger for mothers than fathers, one reason being that the screening procedure prior to adoption may put more emphasis on maternal characteristics, this could explain why the estimated effects are smaller for mothers. There is nothing in the formal guidelines for adoption, however, which supports such a differential treatment of males and females.

[20]Yet another explanation for this result would be that measurement errors are more severe for the measure of maternal years of schooling. Since our measures are based on register data, we see no reason why this would be the case in our study. Moreover, Holmlund et al. (2008) report that the reliability ratio for education in these register is 0.95 for both mothers and fathers.

[21]For cognitive skills, the effects of paternal and maternal education declined to 0.022 and 0.009 when controlling for income. The corresponding estimates for non-cognitive skills were

Finally, role model effects would also be possible, where the sons look up more to the father than to the mothers. A causal effect would then be implied if father's schooling act as a standard for the child.

The relative importance of paternal versus maternal education changes quite drastically when we instead consider health outcomes. Although paternal education seems to matter more than maternal education for the overall health of their for own-birth sons, this result does not hold up in the sample of adoptees. Here, maternal education is associated with a greater increase in health and the effect is significant at the 10% level, although it should be noted that the difference in point estimates between mothers and fathers is rather small. When accounting for spouse's education, however, the point estimates of both maternal and paternal education decrease in magnitude and are insignificant.

The absence of a significant effect of maternal education on children's health may seem surprising, given the prominent role it is often believed to have for children's health (Haveman and Wolfe 1995). Our result may of course suggest that the relation is driven mainly by genetic factors. Another possibility would be that maternal education is ineffective in 'producing' child health for adopted children or at least for children who were adopted at a later age. By comparing the effect of maternal education for those adopted late to the effect on those adopted at an early age, we can get some indications whether nurturing is less effective for those adopted late and, thus, if maternal education is affecting the health of those adopted early.[22] The estimates in Table 4 suggest so. For health, the effect of maternal education is large and significant for those adopted before the age of 1, whereas the effect is small and insignificant for those adopted later. The effect is similar whether or not controlling for spouse's education. For fathers, however, the effect of education becomes insignificant when controlling for spouse's education. Thus, when restricting the sample to those adopted early, our estimates confirm the common claim that maternal education

0.013 and 0.000.

[22] This would suggest that there are critical periods in development, where the absence of certain inputs at certain development phases make it difficult for a child to cath up at a later stage. Evidence from Romanian adoptees adopted in the U.K., for instance, suggests that if the adoption took place during the first six months of life, the catch-up in terms of height and IQ was almost complete (Rutter et al. 1998). For those adopted later, the catch-up was less, but still substantial. Similar results for height were obtained in van den Berg et al. (2009) using data on siblings immigrating to Sweden at different ages.

matters more for children's health than paternal education. This result also supports the idea that parental education has less of an effect on health if the child had been exposed to adverse living conditions early in life.[23] Note that this could also reflect that those adopted later face more emotional problems, which may render nurturing less effective.

We obtain similar results for children's cognitive and non-cognitive skills. The effect of paternal education on these skills is at least double in magnitude, and significant, for those adopted before the age of 1 in the specifications that control for spouse's education. This is in line with evidence of the importance of early life inputs for the development of both cognitive and non-cognitive skills (Knudsen et al. 2006). For maternal education, the estimates are small and insignificant whether or not one restricts the sample to those adopted early. In sum, restricting the sample to adoptees that are more likely to be affected by parental education provided clear patterns regarding the role of maternal and paternal education. Clearly, maternal education matters more for child health, whereas paternal education matters more for child skills.[24]

How does our results regarding the relative importance of paternal versus maternal education match up with previous adoption-based studies on the transmission of education across generations? Adoption studies in general tend to find that the effect of mother's schooling is smaller than the effect of father's schooling when spouse's schooling is controlled for (e.g. Plug 2004; Björklund et al. 2006). Our results suggest that part of the reason for this gender pattern may be that the education of adoptive mothers matters less than the education of adoptive fathers for the development of the children's skills.

As discussed in the methods section, a crucial assumption in the adoption design is that adopted children are randomly allocated to their adoptive parents. Before proceeding with the results for twins, we will shed some light on the credibility of this assumption by regressing parental education on various observable characteristics of the adopted children. The results, reported in Table 5, suggest that some matching appears to be taking place, since 4 out of 12 coefficients from the regressions come out as significant. The magnitudes of the coefficients are quite small, however. These results suggest, for instance, that parental education is positively and significantly related to the probability of adopting a child from

[23] For our other health measure, height, the estimates were not greatly affected by restricting the sample to those adopted before the age of 1.

[24] We also tried finer divions of age at adoption but above the age of 3, the sample size becomes small and the estimates imprecise.

Colombia. On the other hand, there is a negative correlation between parental education and the probability of being adopted from South Korea. Since children from South Korea outperform Swedish-born children in some of the enlistment tests, this rather suggests that, if anything, some negative selection is present.

Further evidence that the magnitude of the matching is limited is revealed by the fact that including country of birth fixed effects in the regressions in Table 2 does not change the results to any important extent. In fact, some of the resulting estimates for the adopted children become somewhat stronger in magnitude, which is what one would expected if there is a negative relation between parental education and the probability of adopting a child from 'high-quality' countries.

For age at adoption, we do not find any significant relationship with parental education. In sum, we believe that the results presented in Table 5, do not suggest any problematic matching that we cannot deal with. Remember also that parents are not able to choose a particular child, besides stating preferences for gender and country of birth, which we observe, and that parents who give children away for adoption are normally not allowed to state preferences for adoptive parents. We also note that our results on potential non-random allocation of adoptees are similar to the results found in Holmlund et al. (2011), where there was no evidence of any important parent–child matching.[25]

B Sons with a Monozygotic Twin Parent

We continue to explore the intergenerational transmission of human capital using the twin design. The results are shown in Table 2, where we also include the OLS results for the twin sample in order to get some idea about the representativeness of the twin sample. Ideally, the OLS estimates should not differ by much compared to the result for the main sample of own-birth children, which is also what most of the results in Table 2 suggest. For cognitive skills, for instance, the own-birth estimates of paternal and maternal education are 0.099 and 0.096, which is very similar to the OLS estimates obtained for the twin sample of 0.097 and 0.100.

[25] Recall also that Sacerdote (2007) and Björklund et al. (2006) explicitly controlled for potential selective placement of adoptees and still found that the adoptive parent's education had an effect on their children's education.

Moving on to the twin fixed-effect results, and starting with cognitive skills, the results suggest a similar 'nurturing' effect of both maternal and paternal education of 0.050 and 0.044, respectively. For fathers, this estimate is rather similar to the corresponding estimate obtained in the sample of adoptees. For mothers, the differences are somewhat larger. The results for cognitive skills do not change much when controlling for spousal education, as shown in Table 6. Note that this result differs from the result obtained for adoptive mothers, where the effect approached zero when accounting for the spouse's education.

The results for non-cognitive skills are also much in line with the results obtained for adoptees. While the OLS estimates on the twin sample suggest an equal effect of maternal and paternal educations on their children's non-cognitive skills, the fixed effects estimates again suggest that paternal education matters more. An additional year of schooling increases the non-cognitive test results by 0.041, whereas the corresponding estimate for mothers is 0.019 and insignificant. Accounting for the spouse's education does, again, not change this pattern.

For our overall health measure, the twin-based estimates clearly suggest that the mother's education matters more. While the OLS estimates suggests an equal effect of twin mothers' and twin fathers' schooling, the fixed effects estimates are only significant for twin mothers. Moreover, the estimated coefficient differs substantially from that for fathers, which is small and has the wrong sign. The estimate, 0.168, suggests that one additional year of maternal schooling increases the child's health by about 5% of a standard deviation. Note that this estimate is very similar to the corresponding estimate obtained for adoptive mothers. For height, the estimates are roughly halved in magnitude when imposing fixed effects and similar, but imprecisely measured, for twin fathers and twin mothers. None of these results change to any dramatic extent when accounting for the spouse's education.

Again, we find a rather pronounced pattern regarding the importance of maternal and paternal education. Here, as was the case for the adoptees, there is a tendency towards maternal education being more important for children's health outcomes, whereas father's education seems more important for the development of skills. Does this pattern line up well with previous twin-based estimates of the transmission of education across generations? In Amin et al. (2011a), the effect of maternal and paternal education on son's education was found to be roughly equal, between 0.05-0.06, when using a sample of MZ twin parents in Sweden and focusing on years of schooling. When accounting for assortative mating, however, the estimates became less precise and paternal education instead appeared somewhat more important. If cognitive and non-cognitive skills are important mechanisms behind the transmission of education, our results can thus provide some clues to what is going on, as father's education mattered more for the development of these skills. Even though our results suggest that mother's education matters more for the development of health, this is perhaps a less important mechanism in a country such as Sweden, with universal health insurance coverage. In fact, this is what the findings in a recent paper by Lundborg et al. (2011) suggest, where the effect of early life health on educational attainment was estimated in a sample of MZ twins. When accounting for genetics and early life environment, the effects of various early life health measures on later educational attainment were small and insignificant.[26] Note, however, that Amin et al. (2011a) found a significant effect of mother's education on their daughter's education that was larger than the effect of paternal education. Since we do not have females in the military enlistment register, we cannot test if mother's education affects daughter's skills to a larger extent than son's skills or if there is an effect of early life health on educational attainment among females.

In sum, the results obtained using the twin sample and the adoptee sample suggest that cognitive skills, non-cognitive skills, and health may be important mechanisms through which the intergenerational transmission of schooling arises. A picture that emerges is that the paternal education seems to matter more for the development of their sons' skills, whereas the mother's education matters more for the development of their health.

C Comparing the Twin and Adoption Results

Although the results came out as rather similar across research designs, there were also some clear differences. Maternal education did not significantly affect the child's cognitive skills in the sample of adoptees. On the other hand, the effect of paternal education on skills was greater in magnitude in the sample of adoptees adopted before the age of 1 compared to the effect in the sample of sons to twin parents. Do these differences reflect that adoptive parents, for some reason, are less or more efficient in transmitting skills, or prefer to transmit less or more skills, to their adopted children compared to biological parents? If so, the

[26] The paper by Lundborg et al. (2011) also used data from the military enlistment register in Sweden. Of course, one cannot rule out that the effect of early life health would have been different in the sample of children of twin parents used in this paper.

external validity of the adoption-based estimates may be called into question. Note that our aim with this paper is *not* to explain why the estimates for adoptees come out as somewhat different than the estimates for sons of twins parents, but it may still be of interest to shed some light on possible reasons for the difference in results. We will therefore next address some hypotheses that relate to the external validity of the adoption results.

In order to investigate whether adoptive parents are more or less nurturing than other parents, we can compare the effect of education on own-birth sons with an adopted sibling with the effect on own-birth sons without an adopted sibling (see, e.g., Plug 2004; Holmlund et al. 2011).[27] If adoptive parents are more nurturing, we would expect a greater effect for the group of own-birth children with an adopted sibling. As shown in the upper panel of Table 7, the effect of paternal education on their biological child's cognitive skills, non-cognitive skills, health, and height is in all cases less in magnitude if the child has an adopted sibling compared to the estimates for biological children shown in Table 2. For mothers, the estimates for non-cognitive skills and height are also substantially smaller in magnitude if the child has an adopted sibling, while the estimate for health is larger. In the case of height and health, the estimates are imprecisely measured, however. Thus, we obtain no evidence that adoptive parents are more nurturing, as is often assumed, but rather the opposite. As discussed in the Methods section, this may reflect that adoptive parents are more alike in terms of unobserved characteristics, due to the screening process, which pushes the estimated nurturing effect downwards.

We next test for any evidence that adoptive parents treat adopted children differently from own-birth children by comparing the effect of parental education for adopted sons with an own-birth sibling to the corresponding effect for those without a own-birth sibling (Holmlund et al. 2011). In the former case, the adoptee compete for parental attention with the biological child. If the latter effect is greater, this would support the idea that parents treat adopted children worse. Since the sample size shrinks substantially when we single out adoptees with biological siblings, however, the estimates are imprecise, as shown in the lower panel of Table 7. There is a clear tendency towards smaller point estimates for a number of outcomes, but since all estimates are imprecisely measured, we refrain from any definitive statements in this case. What we can say is that the results do not provide any strong evidence that adoptive parents treat their adoptees better than their biological children but,

[27] These regressions do not control for spouse's education.

if anything, treat them worse.

D Are Earlier Grades and Tracking Affecting Child Skills and Health at 18?

Our results so far are consistent with the idea that parental education matters for children's education partly because parental education improves children's skills and health. One could not rule out the possibility, however, that children's skills and health, as measured at age 18, are affected by earlier study results or choice of track in school, so that parental education affects children's skills and health by improving their study outcomes. Note, however, that this would still imply a causal effect of parental education on children's skills and health, only that part of it run through early life educational attainment. We analysed this by analysing the link between parental education and children's final grades in math and Swedish from compulsory school (at age 16). This information is available for the cohorts born 1972-1979.[28] The results showed small and insignificant effects of parental education on grades, however, in both the sample of adoptees and cousins (results available on request). So, even if there is an effect of earlier educational attainment on skills and health, these results provide no evidence that the effect of parental education on children's skills and health runs through earlier educational attainment of the children. These results are similar to those of Haegeland et al. (2010), who found no effect of twin parent's education on their children's grades and tiny effects of adoptive mother's education.[29]

E How Large are the Effects and How do They Relate to Previous Findings?

Our twin and adoption based estimates may appear rather small, but so are the recent estimates on the effect of parental education on children's education in the literature. But are the magnitudes of our estimates *reasonable*, given the previous estimates on the intergenerational transmission of human capital? We can shed some light on this, by examining to

[28] The sample sizes therefore shrinked to 2,748 adoptees and 222 and 190 children of twin mothers and twin fathers, respectively.

[29] The effect was such that one year of additional schooling increased exam marks by 2 percent of a standard deviation and the estimated coefficient was only significant at the 10 percent level.

what extent our estimates, together with previous estimates on the returns to skills, could generate the observed transmission of schooling.

Taking cognitive skills and twins as our example, our twin-based estimates for paternal and maternal schooling converge around 0.05 in most specifications. This means that one additional year of paternal schooling is associated with a 5 percent of a standard deviation increase in the child's cognitive skills. Sandewall et al. (2009) and Lundborg et al. (2011) provide twin-based estimates of the schooling returns to cognitive skills, where in both studies a one standard deviation increase in cognitive skills is associated with about 0.5 additional years of schooling. Note that both these studies are based on the Swedish enlistment data. The results suggest that a 5 percent of a standard deviation increase in cognitive skills, which resulted from one additional year of parental schooling, is associated with 0.025 additional years of schooling by the child. Since Amin et al. (2011a) reported that one additional year of paternal schooling is associated with 0.04-0.06 additional years of schooling by the child, depending on whether spouse's education is controlled for or not, our estimate for cognitive skills would thus alone be able to explain about half of the causal transmission of schooling across fathers and sons. This is reassuring and makes our twin-based estimates appear very reasonable.

Are our results for adoptees also reasonable? We are not aware of any previous adoptee-based estimates of the returns to skills or health. Since there are also very few families who adopt twins, it is also not possible to provide twin-based estimates on the returns to skills for adoptees. With our data, we can, however, provide cross-sectional estimates of the returns to skills for adoptees. We can also use a smaller sample of sibling adoptees and examine to what extent the estimates change when imposing family fixed effects. Our cross-sectional estimates suggest that a one standard deviation increase in cognitive skills is associated with 0.77 additional years of schooling (not shown but available on request). When we impose adoptee-sibling fixed effects, for the sample with several adoptees in the same family, the point estimate declines somewhat to 0.73. This is most likely still an overestimate, as the adoptee-siblings differ in genetics and early childhood conditions, i.e before entering Sweden. While we do not know what the corresponding adoptee-twin estimates would have been, we note that the cross-sectional estimates of the schooling returns to cognitive skills in Lundborg et al. (2011) were roughly halved in magnitude when imposing twin-pair fixed effects. If this decrease is indicative of what would have happened also among our adoptees, an estimate of about 0.4 would be indicated. This, again, means that our adoptee-based estimates on the effect of parental education on cognitive skills could explain a substantial part of the transmission of education from adoptive parents to their adopted sons.

VI Summary and Conclusions

Recent literature has established that the intergenerational transmission of education partly reflects a causal effect of parental education. In this paper, we provide some clues regarding what it is that well-educated parents bring to their children, so that their children obtain more education. We focused on youth skills and health that could plausibly be important mechanisms for the intergenerational transmission of education and employed the most common methods used in the recent literature: the adoption and the twin design.

Our results suggest that cognitive and non-cognitive skills, as well as health, may be important factors in understanding the intergenerational transmission of human capital. In both the adoption and the twin design, parental schooling had a positive impact on at least some of these child outcomes and the estimates were many times similar across the twin and adoption designs. Our results also suggest that paternal education was of greater importance for the development of the child's cognitive and non-cognitive skills, whereas the mother's education matter more for the child's health. Since it is well established that skills and health affect educational attainment, our results thus suggest that part of the causal effect of parental schooling on children's schooling reflects an effect of parental schooling on children's skills and health.

We believe that our estimates appear very reasonable, given the previous estimates using an adoption and a twin design that estimate the intergenerational transmission of schooling in Scandinavian countries. Using our estimates of the effect of paternal schooling on skills, and in addition using previous findings on the returns to skills, we showed that our estimates fitted nicely with those obtained for the transmission of education in previous adoption and twin studies in Scandinavian countries.

Our child outcomes were measured at age 18, which means that one cannot rule out that the effect of parental education on children's skills and health runs through earlier educational attainment of the child. We found no evidence of this being the case, however, as we found no effect of parental education on grades at age 16. While it is still possible that other measures of early educational attainment were affected, this would only suggest that part of the causal effect of parental education on children's skills and health works through increasing early educational attainment of the child. This would not change our main conclusion that skills and health are important mechanisms through which the intergenerational transmission of schooling arises. Also, we believe that showing an effect of parental education on children's skills and health is interesting in own right.

Returning to some of the policy issues discussed in the introduction, our results suggest that interventions that increase the level of schooling in society may have benefits that not only span generations but also across a range of child outcomes. This is a useful finding since the level of education in society is something that can be manipulated by policy-makers. For many reasons, it also appears more desirable that the transmission of human capital occurs mainly through children's skills and health, rather than through nepotism or other less desirable mechanisms. A fruitful path for future research will be to continue to try to understand the mechanisms behind the intergenerational transmission of human capital.

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Table 1: Descriptive statistics.

	Own-birth sons		Adopted sons		Sons of twins	
	Mean	St. dev	Mean	St. dev	Mean	St. dev
Cognitive ability	5.20	1.90	4.22	1.91	5.24	1.83
Non-cognitive ability	5.19	1.66	4.74	1.71	5.33	1.59
Health	2.69	4.23	4.20	4.8	2.22	3.69
Height	179.6	6.48	170.2	6.59	179.68	6.19
Age at adoption			1.69	1.92		
Paternal education	1.69	1.92	12.69	2.73	10.56	3.12
Maternal education	11.49	2.30	12.80	2.61	10.63	2.71

Notes: This table reports descriptive statistics.

Table 2: Estimates of the relationship between parental education level and sons' outcomes.

	Cognitive skills				Non-cognitive skills			
	Own-birth	Adopted	Twins		Own-birth	Adopted	Twins	
			OLS	FE			OLS	FE
Paternal	0.099	0.027	0.097	0.044	0.057	0.017	0.061	0.041
education	(0.000)***	(0.006)***	(0.008)***	(0.019)**	(0.000)***	(0.006)**	(0.009)***	(0.021)*
N (pair, diff)	748,598	3,692	1,245	1,245	721,017	3,375	1,165	1,165
				(475, 239)				(449, 226)
Maternal	0.096	0.014	0.100	0.050	0.056	0.003	0.055	0.019
education	(0.000)***	(0.006)**	(0.008)***	(0.017)***	(0.000)***	(0.007)	(0.008)***	(0.019)
N (pair)	880,791	3,692	1,928	1,928	851,128	3,375	1,818	1,818
	Health				Height			
	Own-birth	Adopted	Twins		Own-birth	Adopted	Twins	
			OLS	FE			OLS	FE
Paternal	0.046	0.040	0.012	-0.057	0.177	0.070	0.250	0.114
education	(0.002)***	(0.030)	(0.035)	(0.084)	(0.002)***	(0.037)*	(0.056)***	(0.118)
N (pair, diff)	769,031	3,631	1,303	1,303	745,841	3,741	1,228	1,228
				(492, 248)				(468, 238)
Maternal	0.018	0.054	0.013	0.168	0.216	0.032	0.207	0.112
education	(0.002)***	(0.031)*	(0.031)	(0.076)**	(0.002)***	(0.039)	(0.055)***	(0.299)
N (pair)	903,891	3,631	1,982	1,982	877,845	3,741	1,913	1,913
				(716, 310)				(694, 296)

Notes: Each coefficient represents a separate regression. The dependent variables are the son's cognitive skills, non-cognitive skills, health, and height at age 18. For adopted children, age at adoption and country of birth fixed effects are included in the model. In the twin regressions, the sample size refers to the number of children of complete pairs of twin parents. The numbers within parentheses refer to the number of complete pairs of twin parents and the number of twin parents where there exists a difference in education. Standard errors are shown below the coefficients.

Table 3: OLS estimates of the relationship between parental education level and son's outcomes when accounting for assortative mating. Adopted sons.

	Cognitive	Non-cognitive	Health	Height
Paternal education	0.027	0.021	0.019	0.073
	(0.006)***	(0.007)**	(0.034)	(0.043)*
Maternal education	-0.001	-0.008	.044	-0.007
	(0.007)	(0.008)	(0.036)	(0.045)
N	3,692	3,375	3,631	3,741

Each coefficient represents a separate regression. The dependent variables are the son's cognitive skills, non-cognitive skills, health, and height at age 18. The models include fixed effects for age at adoption and country of birth. Standard errors are shown below the coefficients.

Table 4: Estimating the relationship between parental education level and country of birth and age at adoption.

	Age at migration ≥ 1				Age at migration < 1			
	Cognitive	Non-cognitive	Health	Height	Cognitive	Non-cognitive	Health	Height
Not controlling for spouse's education								
Father's	.020	.008	.003	.079	.034	.030	.097	.047
education	(.007)***	(0.008)	(.036)	(.045)*	(.010)***	(.012)**	(.053)*	(.067)
Mother's	.014	-.003	-.006	.052	.014	.017	.163	-.017
education	(.017)**	(.008)	(.038)	(.047)	.014	(.012)	(.055)***	(.070)
N	2,555	2,341	2,494	2,587	1,137	1,034	1,137	1,154
Controlling for spouse's education								
Father's	0.034	0.021	0.008	0.072	0.068	0.050	0.026	0.072
education	(.015)**	(0.015)	(0.042)	(0.052)	(0.022)***	(0.023)**	(0.060)	(0.077)
Mother's	0.009	-0.016	0.010	0.014	-0.008	0.003	0.15	-0.053
education	(0.016)	(0.016)	(0.044)	(0.055)	(0.023)	(0.024)	(0.063)**	(0.080)
N	2,555	2,341	2,494	2,587	1,137	1,034	1,137	1,154

Notes: The dependent variable is shown in the top of the column. Linear probability models. Standard errors in parenthesis.

Table 5: Estimating the relationship between parental education level and country of birth and age at adoption.

	Chile	Columbia	India	South Korea	Sri Lanka	Thailand	Age adopted
Paternal education	0.002	0.003	0.001	-0.007	-0.005	-0.002	-0.016
	(0.002)	(0.002)*	(0.002)	(0.003)**	(0.002)***	(0.002)	(0.013)
Maternal education	-0.003	0.005	0.001	-0.012	0.003	0.000	0.004
	(0.002)	(0.002)**	(0.003)	(0.003)***	(0.002)*	(0.002)	(0.014)

Notes: The dependent variable is shown at the top of the column. Linear probability models. Standard errors in parenthesis.

Table 6: Estimates of the relationship between parental education level and son's outcomes when accounting for assortative mating. Twin fathers and mothers.

	Cognitive	Non-cognitive	Health	Height
Twin fathers				
Paternal education (twins)	0.033	0.041	-0.055	0.115
	(0.019)*	(0.022)*	(0.061)	(0.119)
Maternal education	0.056	0.001	-0.009	0.000
	(0.016)***	(0.019)	(0.073)	(0.102)
N	1,245 (475)	1,165 (449)	1,303 (492)	1,228 (468)
Twin mothers				
Maternal education (twins)	0.043	0.013	0.159	0.092
	(0.017)***	(0.019)	(0.076)**	(0.100)
Paternal education	0.052	0.038	0.067	0.139
	(0.013)***	(0.016)**	(0.061)	(0.081)*
N	1,928 (698)	1,818 (661)	1,982 (716)	1,913 (694)

Notes: The dependent variables are the son's cognitive skills, non-cognitive skills, health, and height at age 18. Standard errors are shown below the coefficients.

Table 7: External validity of adoptee estimates.

The effect of parental education for own-birth sons with an adopted son				
	Cognitive	Non-cognitive	Health	Height
Father's education	0.058	0.015	0.033	0.111
	(0.009)***	(0.009)	(0.042)	(0.070)
Mother's education	0.097	0.018	0.049	0.105
	(0.009)***	(0.010)*	(0.047)	(0.068)
N	1,444	1,389	1,278	1,450
The effect of parental education for adopted sons with a biological son				
Father's education	0.016	0.020	0.002	0.097
	(0.011)	(0.013)	(0.063)	(0.077)
Mother's education	0.019	0.012	0.037	-0.049
	(0.012)	(0.014)	(0.069)	(0.085)
N	819	754	797	823

Notes: In all columns, age at adoption and country of birth fixed effects included in the model. Standard errors are shown below the coefficients.