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Abstract

While many studies have shown that parental skills are important for child outcomes, whether this derives from non-genetic mechanisms is less clear. We investigate the nurture effects of parental cognitive and socio-emotional skills in producing college attainment of offspring, modeling socio-emotional skills as latent factors based on the Big Five taxonomy of personality. By studying a sample of adopted children whose parents are respondents of the Wisconsin Longitudinal Study, we identify non-genetic effects of parental skills on college attainment. We address possible non-random adoption assignment by accounting for institutional policies regarding the adoption process and the compositional change of adoptees in Wisconsin during the period covered by our sample. We find that parental IQ and Openness act positively on child college attainment, while Agreeableness has a negative impact. A 1 s.d. difference in each of the skills translates to a 5-6 p.p. difference in college attainment, similar to the effect size of income. Finally we find that the nurture effects of IQ and Agreeableness are largely driven by fathers, whilst that of Openness is driven by mothers.

Key words: human capital, intergenerational mobility, cognitive and socio-emotional skills, nurture

JEL codes: I24, J24, J62

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Contents

1 Introduction

There is a long line of research examining the intergenerational transmission of human capital straddling many of the social sciences, focused primarily on documenting similarities between parents and offspring in terms of education attainment (see Black and Devereux (2011) for a review). A more recent literature moves beyond education attainment as the measure of human capital and demonstrates intergenerational similarities in cognitive and socio-emotional skills (Anger, 2012; Anger and Heineck, 2010). Concurrently, a number of papers show that these skills are important for diverse life outcomes such as education attainment, health, and income (Almlund et al., 2011). Taken together, these findings suggest that parental cognitive and socio-emotional skills influence child outcomes and may be key factors in explaining intergenerational mobility. However, it remains unclear if such associations can be attributed primarily to genetic mechanisms.[1]

This paper examines a sample of adopted children to investigate nurture effects of parental skills on the college attainment of offspring. The economic significance of the nurture effects of parental skills is particularly important for understanding the intergenerational effects of policies that seek to improve skills through early childhood interventions or other interventions later in life. In fact, one such intervention is documented in an important recent study by Heckman and Karapakula (2019b), achieving long lasting effects on the positive personality traits of subjects.[2]

The extent that improvements in skills in one generation can impact the next generation should be accounted for when performing cost-benefit analyses for such programs. We note that improvements in skills in one generation through investments can only work through non-genetic channels on the next generation, and the nurture effects we estimate are meant to capture these impacts. Our paper thus informs recent efforts in the

[1] Earlier findings from behavioral geneticists suggest that both cognitive and socio-emotional skills are heritable (Vukasovic and Bratko, 2015).

[2] In a companion paper, Heckman and Karapakula (2019a) find that the program also had intergenerational effects, although whether the impacts were coming from skill improvements versus other channels is not yet clear.

literature to embed skill investments in intergenerational models to evaluate the long-run impacts of such investment policies (Agostinelli, 2018; Lee and Seshadri, 2018a,b).

The sample is based on the Wisconsin Longitudinal Study (WLS), a unique dataset that follows a random one-third sample of high school seniors in Wisconsin in 1957. Our sample of parents are the respondents in the WLS who chose to adopt children. The WLS kept careful record of the respondents' children, in particular distinguishing between adopted, biological, or step children. It also contains rich information on both cognitive and socioemotional skills, including an IQ measure and the Big Five taxonomy of personality (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism).[3] This combination of a sample of adopted children and detailed measures of socio-emotional skills is not available in other datasets to our knowledge.[4]

Our results support the claim that parental skills play a large role in nurturing college attainment in offspring, over and beyond any possible genetic mechanisms that may exist. We find that while parental IQ is an important dimension of skill, it is not the only dimension to have an effect on child's human capital accumulation. Openness and Agreeableness also have statistically significant effects on child's college attainment of similar magnitude, where a 1 s.d. difference in parental skill is linked to a 5-6 p.p. difference in college attainment rates. Other skills may potentially be important as well, but our estimates are less precise for our sample. Furthermore, the variance explained by socio-emotional skills are comparable to that of IQ[5].

We search for potential mechanisms explaining the nurture effects and present evidence suggesting that the nurture effect of parental IQ and Agreeableness act primarily through parental income and education, but this is not the case for the effect of Open-

[3]See Section 5 for a more detailed treatment of the definition of personality skills.

[4]For example, the Health and Retirement Study contains information about parental IQ and the Big Five, but does not distinguish between step and adopted children.

[5]Note that both cognitive and socio-emotional skills are standardized. We cannot say with our data the relative difficulty of effecting a 1 s.d. change in skill, although other papers have suggested that socio-emotional skills are more malleable than IQ (Carneiro and Heckman, 2003; Cunha and Heckman, 2008; Knudsen et al., 2006).

ness (see Table 8). This suggests that income and/or education interventions in one generation (particularly of fathers) can be alternative approaches to improving intergenerational outcomes, although they would not substitute for the nurture effects of mother's Openness.

We also estimate the effect of parental skills specific to different parent-child relationships, i.e., father-daughter, father-son, mother-daughter, and mother-son. Examining the effect of parental skills by different parent-child relationships, we find that the positive effect of parental Openness comes mainly through mothers while the positive effect of parental IQ comes mainly through fathers. This finding applies to both sons and daughters (see Table 7). The role of fathers with regard to parental IQ is consistent with income being the main channel for the nurture effect of IQ.

Interestingly, we find that birth order has an impact on the transmission of parental nurture effects. We find that the first child experienced statistically significantly higher nurture effects from parental Openness than other siblings. The nurture effect of parental IQ and Agreeableness were larger for first borns, but not statistically different. The differential transmission of Openness could be an additional channel explaining the negative effect of birth order on children schooling outcomes.

An important caveat to our findings is the possible lack of external validity. Since our sample consists of adopted children, our results may not be fully applicable to the general population. However, the child development and psychological literature suggests there is considerable overlap in the behaviors of adopted and non-adopted children, particularly in terms of risk for disruptive behavior.[6] We thus consider our results to be suggestive for the broader population of children who are similar to adopted children within the context of their family interactions (this is explored in further detail when we describe our results). Bearing this caveat in mind, we perform a nature-nurture decomposition by comparing adopted and biological children, similar in spirit to Plug

[6]This is a key issue highlighted by the child development and psychological literature regarding adopted children.

and Vijverberg (2003). We find that the nurture effects for socioemotional skills play a stronger role than for IQ, implying that intervening on socioemotional skills may be a more effective way of improving intergenerational mobility than cognitive skills.

2 Background

Studying the role of nurture in the intergenerational transmission of human capital is an important step in understanding the extent to which policy interventions can influence intergenerational mobility and inequality. To this end, researchers have studied the causal effect of parental education on child's educational attainment using instrumental variables (Black et al., 2005b; Currie and Moretti, 2003; Lundborg et al., 2014). Other papers distinguish genetic and nurture effects using twin studies (Behrman and Rosenzweig, 2002; Bjorklund et al., 2007).[7] In this paper, we focus on parental skills rather than parental education and we examine a sample of adopted children and their adoptive parents to break any genetic links between the parents and the children (see Holmlund et al. (2011); Sacerdote (2010) for a review of other papers that take a similar approach). We acknowledge the caveats of using adopted children as an identification strategy and address these concerns in detail (see Section 4). We study the college attainment of these adopted children, since education serves as a useful predictor of broad lifetime socioeconomic outcomes.

Our paper departs from the existing literature on intergenerational mobility by studying the nurture effects of parental cognition and socio-emotional skills instead of traditional measures of parental human capital such as parental college attainment. These skills form a set of fundamental measures of parental human capital that contribute to parenting styles[8], education attainment, and a wide array of other possible channels

[7] See Sacerdote (2010) for a review.

[8] See Browne et al. (2012); Oliver et al. (2009); Prinzie et al. (2009) for examples of associations between parental personality skills and various parenting styles including differential parenting, autonomous support, warmth, and behavioral control.

through which parents influence child outcomes (Almlund et al., 2011). Our paper thus complements the existing literature by examining these alternative measures of parental ability in determining intergenerational mobility. We suggest a different set of possible policy levers other than parental education attainment, as well as guiding future work on identifying the mechanisms for the effect of parental education on child outcomes. Moreover, to the extent that nurture effects of parental skills matter, this would have implications on the intergenerational effects of current efforts to improve cognitive and socio-emotional skills in children.[9]

While a number of papers have studied the effect of parental ability measured by IQ (Bjorklund et al., 2010; Lefgren et al., 2012; Plug and Vijverberg, 2003), less attention has been paid to other non-cognitive dimensions of ability. We study a set of skills including IQ and the Big Five taxonomy of personality to capture both cognitive and non-cognitive skills. Following Cunha and Heckman (2007), we refer to these as skills, rather than traits or abilities, due to the fact that they are malleable at early stages of the life-cycle and are not wholly determined genetically.[10]

Two recent papers estimate a skill production technology for children that includes maternal skills represented by two latent factors capturing cognitive and non-cognitive skills using the National Longitudinal Survey of Youth '79 (Cunha and Heckman, 2008; Cunha et al., 2010). They find a significant effect of maternal skills on child skills particularly at the early stages in the life-cycle, and also show that child skills in turn produce child's education attainment. Other authors also document intergenerational links in cognitive and non-cognitive skills, and show that the intergenerational transmission of skills can explain differences in educational outcomes among offspring (Anger, 2012; Anger and Heineck, 2010; Mendez, 2015). Heterogeneity across parent-child relation-

[9]See the literature regarding the effect of early childhood experiences and interventions with regards to both cognitive and non-cognitive skills (Conti et al., 2013; Cunha et al., 2006; Heckman et al., 2013; Hille and Schupp, 2014).

[10]Recent work in epigenetics and allied fields suggest that the sharp distinction between natural ability and nurtured skills is obsolete, see Pray (2004) for a discussion.

ships has also been documented in some recent work studying the intergenerational transmission of human capital in other contexts (Amin et al., 2015; Anger, 2012; Anger and Heineck, 2010; Holmlund et al., 2011).

Our paper is partially motivated by these findings, but seeks to provide evidence that the relationship between parental skills and child outcomes is not due only to unobserved genetic correlations by examining a sample of adopted children, breaking the genetic channel of transmission. Further, we examine parental skills in the form of IQ and the Big Five. In contrast to other papers that summarize non-cognitive skills into a single scalar variable, this is a richer description of parental skills that would allow for more nuanced and interpretable skill effects. While we would have preferred to estimate the full intergenerational skill transmission technology similar to Cunha et al. (2010), our data does not allow us to do so since we do not observe measures of child skills. Instead we study the effect of parental skills on child's education attainment, bypassing the intermediary role of child skills.

3 Data

We use the Wisconsin Longitudinal Study (WLS), a representative sample of Wisconsin high school graduates graduating in 1957. Respondents were interviewed first in 1957 (age 18), and tracked through 2011 with information collected in several waves (1975, 1992, 2004, and 2011). Information on the respondents' children come mainly from the 1992 (age 53) wave. The main sample in our paper consist of the respondents who have adopted children. There are a total of 417 respondents with adopted children. Our main variables are the education attainment of respondents' adopted children, constructed from 1992, 2004, and 2011 measures. From the information on educational attainment we created a dichotomous variable indicating whether the child completed college education. We omit children born after 1987 to avoid problems with censored education

attainment information . The long follow-up gives us some confidence that we have the final lifetime education attainment for parents and children in our sample.

The key independent variables include parental skills, child characteristics and parental socioeconomic status. Parental skills are represented by an IQ test score administered state-wide from 1957 and a set of psychological measures from 1992 which we use to construct the five latent factors to capture the Big Five personality traits. Unfortunately, we only observe the psychological measures of the respondent, not his/her spouse. This means we only observe the skills of either the father or the mother for each child. However, we note that whether the father or the mother was surveyed is random and based purely on whether the parent belonged to the cohort of high school graduates in 1957.

Our measures for socio-emotional skills were also only captured in 1992. This could result in our estimates suffering from reverse causality between parental socio-emotional skills and child's college attainment. However, the personality psychology literature has provided considerable evidence that adult personality traits are remarkably rank-order stable over the life-cycle after the age of 25 (Cobb-Clark and Schurer, 2012; Costa and McCrae, 1988, 1994; Rantanen et al., 2007; Roberts and DelVecchio, 2000; Specht et al., 2011). Thus we restrict the children to have been born after 1962 so that the bulk of the child's life was after parental socio-emotional skills have stabilized.

In addition, we only include parents who were married and cohabiting with their spouses in 1975 to account for family structure as a confounding factor.[11] Following Plug (2004), we also include a dichotomous variable in our main regression to account for the change in the United States adoption trend in the post-1970 periods. After 1970, special needs adoptions began to emerge along with an increase in international adoptions at the country level. Special needs adoption involve older children, minority children, and children with physical, mental, or emotional problems. Before 1970, children with special needs were not considered for adoption. Nevertheless, their numbers in absolute

[11]These restrictions are similar to those in Plug (2004); Plug and Vijverberg (2003).

terms at the country level were still very small between 1970 and 1980 (Plug, 2004). In particular, international adoptions and special needs adoptions became much more prevalent in Wisconsin only after 1980 (Adoption Information Center, 1986). We also control for the age, gender and birth order of the child in all regressions to account for child's characteristics. We include adopted children in single-child families as well as children in families with both adopted and biological children. We exclude step-children and other genetic relations such as nephews, nieces, etc. The restrictions along with the controls gave us a final sample of 616 adopted children with 417 number of respondents. The variables used are described in Table 1.

Table 1: Description of Main Variables

	mean	s.d.	obs.		mean	s.d.	obs.
Adopted Children				Parental Variables			
College	0.347	(0.476)	616	IQ	103.609	(14.707)	417
Number of children	3.157	(1.671)	616	Father years of education	14.369	(2.957)	417
First child	0.328	(0.470)	616	Mother years of education	13.622	(2.233)	417
Last child	0.375	(0.485)	616	Log average income	3.974	(0.799)	417
Female	0.493	(0.500)	616	{in USD}	$53,183		
Age in 1992	22.175	(4.156)	616				

Notes: Calculations are based on the WLS data and regression sample. College is a dichotomous variable to indicate whether the adopted child graduated from college (1 if graduated). Family size refers to the average number of children in the adopted child's family in 1992. First and last child are both dichotomous variable to indicate the birth order of the adopted child. Sex (1 if female) and age are both the characteristics of adopted child in 1992. Adoptive parental IQ is obtained from a 1957 state-wide IQ test in Wisconsin. Father's and mother's education refers to years of education. We average parental income from 1975 and 1992 as a measure of permanent family resources.

4 The Adoption Process in Wisconsin

The identification of nurture effects rests on the fact that adopted children do not receive genes from their adoptive parents. We may be worried that some adoptees are close relatives of adoptive parents or may have been foster children before being adopted.

This would reignite concerns about genetic factors confounding our estimates of nurture effects. Fortunately, the WLS contains detailed information about the child's relation to the parent, including whether the child reared by the respondent is a step child, a niece, a nephew, or some other relation. We exclude all these children and only consider adopted children.

Even so, one key assumption is that adopted children are randomly assigned to adoptive parents conditional on our controls. If abler parents were allowed to select adopted children based on observables such as gender and age at adoption that correlated with outcomes , then our estimates would be biased. However, samples of randomly assigned adopted children are rare, with Sacerdote (2007) being the exception. To address this concern, we take two approaches. First, we examine historical documents regarding the adoption policies during the relevant period to our sample and find evidence suggesting that selection on age at adoption is unlikely to be a major concern particularly for adoption before 1975. Second, we perform a series of robustness checks that control for various possible selection criteria suggested by historical records to ensure that our main results are not sensitive to such controls.

To identify the non-genetic effects of parental skills on child outcomes, we study a sample of adopted children who were born between 1962 to 1987. Unfortunately, in our dataset we do not have any information on the birth parents of the adopted child. Hence, to address the possibility of selection present in the assignment of adoptees, we gathered information from official government documents describing the adoption process in Wisconsin during the relevant period.

We find that most adoptions that occurred before 1975 were carried out by private adoption agencies (often associated with religious organizations) or state agencies, with minimal independent adoptions.[12] Independent adoptions are defined as adoptions

[12]In 1975, out of roughly 1207 children adopted by non-relatives, only 22 children were placed independently. 690 were placed by private agencies and the rest by the state (U.S. National Center for Social Statistics, 1975).

that take place directly between birth parents and adoptive parents, allowing for much more selection on both sides. Adoption agencies can be viewed as a barrier preventing adoptive parents making adoption choices based on birth parent characteristics. This suggests that restricting the sample to adopted children who were adopted before 1975 would reduce the degree of selection due to adoptive parents or birth parents directly observing the other party.

Among the private agencies, the major players were religious organizations (mainly Lutheran and Catholic) who were likely to have selected adoptive parents by their religious affiliation (Adoption Information Center, 1986). We therefore consider additional controls for the religion of adoptive parents.

Despite the advantages of agency-based adoption to our identification strategy, there remain many possible characteristics of the adopted child that adoptive parents may have selected on which are unobservable to us. For example, one may think that the child's demeanor or physical attributes may affect the prospective parents' willingness to adopt, and that these attributes may in turn influence later life outcomes.

An important mitigating factor is that before 1975, the supply of healthy infants up for adoption was low relative to demand, since international adoptions were still rare. Indeed, as stated in a report on adoption in Wisconsin (Adoption Information Center, 1986):

> Many families wishing to adopt a healthy infant may not be selected for the adoption study process. Many more families wish to adopt than there are young children with a plan of adoption.

This implies that adoptive parents probably had relatively little say in the type of child they were offered if they wished to be successful at adopting a child. Still, we try our best to address possible selection on the race, gender and age at adoption of the adopted child which have been documented in more recent data by Baccara et al. (2014).

On the issue of selection on race, we note that almost all adoptees in Wisconsin

before 1975 were white. Only 247 out of 2573 adoptees in 1975 were non-white (U.S. National Center for Social Statistics, 1975), with even lower proportions in earlier years. While we are not able to observe the race of the adopted children in our sample, we are reasonably confident that if the children were adopted before 1975, they were white due to the overwhelming selection on race at the state level. Therefore, we do not expect selection on race to lead to a problem with internal validity for our sample.

Another worry we might have is that children who were adopted at later ages suffered from more disadvantageous environments in their early childhood, and if abler parents could select on the age of the child they were adopting at the time of adoption, that would bias our results. Thankfully, the majority of adoptions before 1975 took place when the adopted child was still very young. The median age at adoption in 1968 for the state of Wisconsin was 2.6 months.[13] The median age at adoption only began to rise substantially in the period after 1980, around the same time when independent adoptions, international adoptions, and special needs adoptions became much more prevalent in Wisconsin (Adoption Information Center, 1986).[14]

These statistics suggest that there are unlikely to be meaningful differences in the race, gender and age at adoption of children by adoptive parental characteristics conditional on religious affiliations and parental age, provided the child was adopted before 1975. However, we do not observe the year of adoption in our sample. Hence, we construct a proxy for year of adoption using the information on the *number of reported children* by the respondent in 1975 survey and the *birth year of children* to separate the adopted children into two groups: adopted before 1975 and after 1975 . Specifically, for each adoptive parent, we take the difference between the total number of reported children in 1975 and the total number of respondent's children who are born before 1975. If the

[13]Public agencies had a slightly higher median (4.0) and private agencies had a slightly lower median (2.3). Independent adoptions had a median of 0.5 months. Only 14% of all unrelated adoptions occurred above the age of 1 (U.S. National Center for Social Statistics, 1968).

[14]In 1975, the age at adoption was greater than 1 year for 24% of adoptions (U.S. National Center for Social Statistics, 1975). Between 1981 to 1983, this figure rose to 61% (Office for Children, Youth, and Families, 1985).

difference is zero (total number of reported children in 1975 = total number of children born before 1975), then the adopted children were adopted before 1975. If the difference is negative (total number of reported children in 1975 < total number of children born before 1975), this implies the adopted children who were born before 1975 were actually adopted after 1975 at an older age since they were not part of the respondent's family in the 1975 survey . This is a better proxy than assuming all adopted children born before 1975 were also adopted before 1975, since it is possible that children born before 1975 were in fact adopted at a much older age. Based on our findings, we perform robustness checks on a sub-sample that conditions on adoption before 1975 (see Section 7.1).[15] Further, we consider alternate specifications of our main model which control for adoptive parent's religion (since the majority of adoption agencies were religiously affiliated). Our main results are robust to these alternatives (see Table 6).

In addition to testing on the sub-sample of adoption before 1975, we further investigate the issue of selection on gender and age at adoption by testing if the child's gender (a pre-adoption child characteristic available in the data) is correlated with adoptive parent's characteristics and family structure. We also use the age of the adopted child and test if it is correlated with parental and family characteristics as well. The results of the balancing test on gender and age of the child are tabulated in Table 2. Adoptive parent's early years characteristics include parental college attainment, parental income, parental IQ and church membership in 1975. Adoptive parent's early years family structure includes the presence of male or female children in the family, the age of the parents, and whether the adoptive parent had a child in 1975. From the balancing test, we observe that there is no evidence of selection on gender based on adoptive parent's characteristics.

[15]We also include a dummy variable for adopted children who were born after 1970 in our main regression analysis in line with previous research (Plug, 2004; Plug and Vijverberg, 2003).This is to account for the shift in adoption trend in the United States in the post-1970 periods where international adoptions and special needs adoptions began to emerge at the country level. More details on the shift in adoption trend can be found in Section 3 and Plug (2004); Plug and Vijverberg (2003)

Finally we test for differences in parental characteristics among parents who adopted before 1975 and those who adopted later, documented in Table 3. For each parental characteristic, we regressed the parental characteristic on an indicator for adopting pre-1975. We do not find any evidence that the group of adoptive parents for children adopted before 1975 were different from adoptive parents post-1975.

Based on our findings above, we summarize our strategy to address the selection issue in our sample as follows:

- Most adoptions that occurred before 1975 were carried out by private adoption agencies with very few independent adoptions. This reduced the risk of selection due to adoptive parents or birth parents directly observing the other party.

- Before 1975, the supply of healthy infants up for adoption was low relative to demand, hence adoptive parents probably had relatively little say in the type of child they were offered if they wished to be successful at adopting a child.

- On the issue of selection on race, we note that almost all adoptees in Wisconsin before 1975 were white. Therefore, we do not expect selection on race to lead to a problem with internal validity for our sample.

- For selection on age at adoption, the majority of adoptions in Wisconsin before 1975 took place when the adopted child was still very young. The median age at adoption in 1968 for the state of Wisconsin was 2.6 months.

- These statistics suggest that there are unlikely to be meaningful differences in the race, gender and age at adoption of children by parental characteristics conditional on religious affiliations and parental age, provided the child was adopted before 1975. Using our constructed proxy for adoption year, we identified adopted children who were adopted before 1975. We perform robustness checks to our main results on this sub-sample that conditioned on adoption before 1975 and parental religion. Our main results remained robust in these specifications.

- We also performed a balancing test on gender and age of adopted child against adoptive parents' early years characteristics and family structure to test if they are correlated. From the balancing test, we observe that there is no evidence of selection on adopted child's gender.

- Finally, we find no evidence for differences in the characteristics of adoptive parents among the adoptions that occured before 1975 versus adoptions after 1975.

5 Understanding Socio-emotional Skills

This paper borrows from the personality psychology literature to capture socio-emotional skills. The most established contemporary categorization of personality is the Big Five taxonomy (John and Srivastava, 1999). This taxonomy reduces the dimensionality of human personality to just five factors: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.[16] This paper follows the personality psychology literature and uses this definition of personality traits to represent parental personality skills. This system of five personality traits is flexible enough to capture the multi-faceted nature of human personality, whilst remaining relatively parsimonious. We do not directly observe socio-emotional skills and therefore model them as latent factors. They are proxied by self-rated psychological *measures* from an inventory (John et al., 1991) designed to capture the Big Five.

We use Confirmatory Factor Analysis (CFA) to construct our latent factors from the psychological ratings available in the Wisconsin Longitudinal Study (see Appendix Section A.1 for more detail). Our CFA estimates a specified factor model given the number of factors and the factor structure based on theoretical considerations. Cunha et al. (2010) show that not accounting for measurement error in the skills has negative consequences

[16] See Digman (1990); McCrae et al. (1986) for evidence regarding the comprehensive and rigorous nature of this taxonomy.

Table 2: Pre-adoption Balancing Test for Child Gender and Age

Adoptive Parent Pre-Adoption Characteristics		Male Adopted Child	Adopted Child's Age (years)
Parental College Attainment	Coefficient	0.022	-0.506
	s.e.	(0.036)	(0.408)
	p-val.	0.538	0.215
Parental Income in 1975		-0.021	-0.021
		(0.021)	(0.213)
		0.323	0.922
Parental IQ		-0.007	0.131
		(0.018)	(0.179)
		0.706	0.463
Parental Church Membership in 1975		0.011	0.957
		(0.053)	(0.688)
		0.838	0.164
Parental Age in 1975 (years)		0.019	.335
		(0.047)	(0.310)
		0.672	0.280
Female Biological Children		0.050	0.217
		(0.064)	(0.600)
		0.431	0.717
Male Biological Children		-0.015	-0.494
		(0.052)	(0.522)
		0.773	0.344
No Biological Children		-0.006	-0.466
		(0.080)	(0.751)
		0.939	0.535
F-test			
Prob> F		0.860	0.176
Sample Size		616	616

Notes: Calculations are based on the WLS data. Parental college attainment is a dummy that equals one if the adoptive parent attended college. Parental income refers to the combined income of adoptive parents in 1975. Adoptive parental IQ is obtained from a 1957 state-wide IQ test in Wisconsin. Parental church membership is a dummy that equals one if the adoptive parent was a church member in 1975. Age refers to parental age (in years). We create indicator variables to denote adoptive parents who were without male or female biological children in 1975, as well as families with no biological children. The omitted category is the set of families who had both male and female biological children.
*** $p < .01$; ** $p < .05$; * $p < .1$

Table 3: Parental Characteristics Pre-1975 versus Post-1975

Adoptive Parent Pre-Adoption Characteristics		Pre-1975 vs Post-1975
Parental College Attainment	Coefficient	0.075
	s.e.	(0.061)
	p-val.	0.235
Parental Income in 1975		0.052
		(0.068)
		0.445
Parental IQ		0.371
		(1.190)
		0.756
Parental Church Membership in 1975		-0.010
		(0.026)
		0.699
Parental Age in 1975		0.000
		(0.001)
		0.956
Female Biological Children		0.138
		(0.091)
		0.130
Male Biological Children		-0.073
		(0.072)
		0.306
No Biological Children		-0.023
		(0.116)
		0.841
Sample Size		417

Notes: Calculations are based on the WLS data. Parental college attainment is a dummy that equals one if the adoptive parent attended college. Parental income refers to the combined income of adoptive parents in 1975. Adoptive parental IQ is obtained from a 1957 state-wide IQ test in Wisconsin. Parental church membership is a dummy that equals one if the adoptive parent was a church member in 1975. Age refers to parental age (in years). We create indicator variables to denote adoptive parents who were without male or female biological children in 1975, as well as families with no biological children. The omitted category is families who had both male and female biological children.

*** $p < .01$; ** $p < .05$; * $p < .1$

on the precision of estimation, and we therefore use CFA to account for measurement error. Table 4 shows the mapping of psychological ratings to Big Five factors in the WLS data.

Table 4: Personality Skills Factor Structure

Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Artistic (+)	**Organized (+)**	**Unreserved (+)**	**Polite (+)**	**Tense (+)**
Imaginative (+)	**Hardworking (+)**	**Noisy (+)**	**Considerate (+)**	**Unstable Emotion (+)**
Sophisticated (+)	**Focused (+)**	**Uninhibited (+)**	**Forgiving (+)**	**Worries (+)**
Inventive (+)	**Thorough (+)**	**Sociable (+)**	**Not Find Fault (+)**	**Nervous (+)**
			Cooperative (+)	**Stressed (+)**

Table 5: Skill Covariances

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	IQ
Openness	**1**					
Conscientiousness	**.169**	**1**				
	(.082)					
Extraversion	**.109**	**.119**	**1**			
	(.082)	(.070)				
Agreeableness	**.249**	**.317**	**.106**	**1**		
	(.093)	(.084)	(.081)			
Neuroticism	**-.034**	**-.244**	**-.196**	**-.313**	**1**	
	(.084)	(.093)	(.069)	(.093)		
IQ	**.175**	**.024**	**.055**	**-.101**	**-.138**	**1**
	(.017)	(.015)	(.028)	(.019)	(.020)	

Notes: Calculations are based on the WLS data. The Big Five are the estimated five factor structure for adoptive parent.

We present covariances between our estimated socio-emotional skills and IQ in Table 5. While the Big Five and IQ are correlated (particularly Openness), the covariances are not large. It is therefore valuable to include the Big Five in our attempt to uncover key parental skills that have nurture effects on child education, first to improve explanatory power and second to avoid omitted variable bias.

6 Model

The workhorse model for the intergenerational mobility literature is based on Becker and Tomes (1986). Parents are budget constrained and choose between consumption and investment in children with some weight on consumption and some weight on child's human capital given a mechanical transmission of scalar ability across generations. We generalize this to a vector of skills, $\boldsymbol{\theta}$ representing the six skills, θ^s for $s \in IQ, O, C, E, A, N$. The system of equations governing the skills law of motion is therefore:

$$\theta_t^s = b_0^s + \boldsymbol{b^s \theta_{t-1}} + b_2^s x_t + v_t^s \tag{1}$$

where t refers to the generation. x refers to control variables. The human capital production function is as follows:

$$h_t = c_0 + \boldsymbol{c_1 \theta_t} + c_2 x_t + \omega_t \tag{2}$$

and combining we obtain:

$$\begin{aligned} h_t &= c_0 + \boldsymbol{c_1 b_0} + \boldsymbol{c_1 b \theta_{t-1}} \\ &+ (c_2 + \boldsymbol{b_2 c_1}) x_t + \omega_t + \boldsymbol{c_1 \nu_t} \end{aligned} \tag{3}$$

We consider a multidimensional vector of skills that includes IQ and OCEAN rather than a scalar measure of ability. We allow parental skill s' to enter the production of child skill s for all $s', s \in IQ, O, C, E, A, N$.

Equation 3 motivates our estimation equation:

$$h_t = c_0 + \beta_0 + \boldsymbol{\beta_1 \theta_{t-1}} + \beta_2 x_t + \epsilon \tag{4}$$

We assume that since the children are adopted, β_1^s captures only non-genetic effects for

all $s \in IQ, O, C, E, A, N$. The estimated effects can thus be interpreted as nurture effects (rather than nature) as long as we have uncorrelatedness between ϵ and $\boldsymbol{\theta_{t-1}}$.

The majority of adoption studies exploit the lack of a genetic link between parents and adopted children to decompose the importance of nature and nurture in some socioeconomic or health outcome. While this can be an informative exercise, our paper focuses instead on the nurture effects, because nature versus nurture decompositions are not identified without further strong assumptions in the case of multidimensional parental skills. In particular, if we allow for cross-skill productivity[17] (parental IQ contributes to child's Conscientiousness, for example), we are unable to obtain the type of decomposition proposed by Plug and Vijverberg (2003) and others (see Section E of the Appendix for an illustration) unless we observe child skills, which we unfortunately do not observe in our data.

Ideally, we would estimate the full technology of parental skills producing child's skills and hence child's human capital, similar to Cunha et al. (2010). However, we do not observe measures of children skills in the data, only parental skills. Our estimates for the effect of parental skills thus act through unobserved child skills, although they may also be working through direct effects in the human capital production function (we did not include this possibility in Equation 2 for simplicity but can easily do so).

We note that in the model set up, we had included the effect of the portion of income orthogonal to parental skills. In reality, income is not orthogonal to skill and is likely a mediator through which parental skills affect child outcomes. Including it may attenuate the estimated nurture effects of parental skills incorrectly. In the estimation we therefore omit parental income altogether which should not affect our results as long as random assignment of the adopted children holds. An alternate specification would be to account for the possibility of parental skills acting through parental income on child outcomes and compute the effect of parental skills to include the indirect effect through income.[18]

[17] These are likely to be substantial based on results from Cunha et al. (2010).

[18] We estimate this alternate specification where parental income is modelled as a linear-in-parameters

We model parental skills as latent factors (see Appendix Section A.1) and jointly estimate the factor model and the linear probability model[19] described in Equation 4 for a sample of adopted children by maximum likelihood. The joint estimation allows us to explicitly account for measurement error in the latent factors, hence avoiding attenuation bias in our estimates.

7 Results

We present our main results in Figure 1. We find that a standard deviation increase in parental IQ (+), Openness (+), or Agreeableness(-) would lead to a change in the probability of college attainment by roughly 5-6 p.p respectively, out of a mean college attainment rate of 35%. Note that the effect of Openness and Agreeableness are conditional on IQ and other socio-emotional skills.

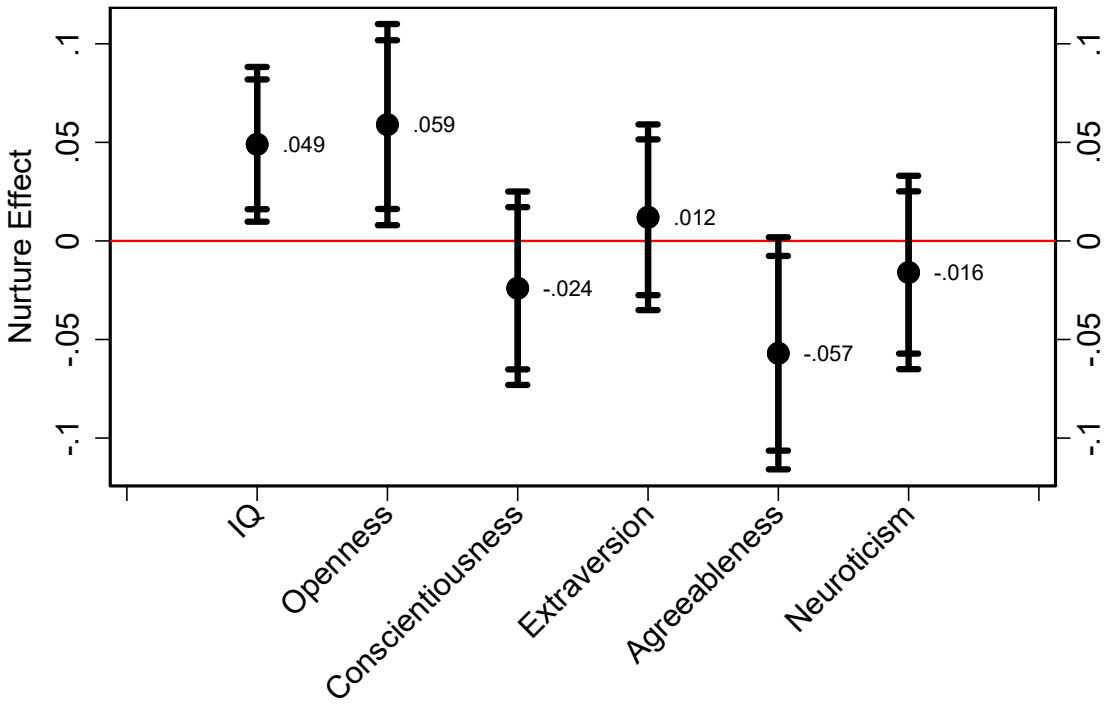
In order to have a better understanding of the relative importance of parental skills, we also perform a variance decomposition exercise where we calculate the variance explained by each skill including/excluding covariances with other regressors in the model (see Figure 2). Our findings suggest that it is not just parental IQ that matters, but parental personality as well. Taken together, the combined importance of socio-emotional skills swamps that of IQ. The estimates bear out our suspicion that previous research limiting the analysis of intergenerational human capital transmission to only measures of parental intelligence is likely incomplete.

Our findings suggest that the broad correlations between parental skills and children skills documented in the literature are not driven purely by genetic channels. This has two major policy implications. First, it implies that current efforts to intervene in the skills of children may have long-term intergenerational benefits to their future offspring,

function of parental skills and find no qualitative difference in our results. See Section D of the Appendix.

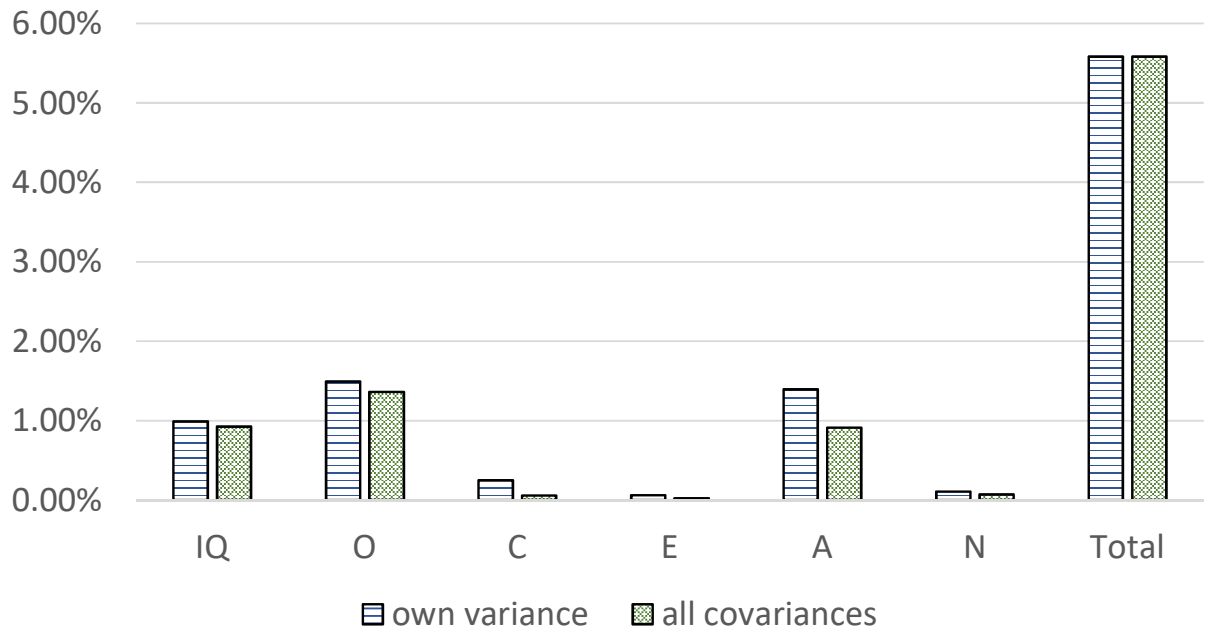
[19] In Section C of the Appendix, we estimate the logit specification instead. The nurture effects estimated at the sample means are not qualitatively different from our main results. We are unable to compute average marginal effects due to the presence of latent factors in the model.

Figure 1: The Nurture Effect of Parental Skills on Child College Attainment



Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted child. Bars represent 90% and 95% confidence intervals. All skills are standardized to be centered at 0 and have a standard deviation of 1. Independent variables include child characteristics such as sex, age and birth order. We also include a dummy variable for adopted children who were born before 1970 in our main regression analysis in line with previous research (Plug, 2004; Plug and Vijverberg, 2003) to account for the shift in adoption trend at the country-level.

Figure 2: Variance Explained by Skills



Notes: Calculations are based on the WLS data. "Own variance" indicates the share of variance that is attributable to the direct effect of a skill, while "All covariances" indicates the share of variance explained by the direct effect in addition to all covariances with other regressors. Estimates from Figure 1 are used for the calculation. See Appendix B for more detail.

which would not be present if intergenerational skill effects were purely genetic. The education of offspring should thus also be considered as potential long-term outcomes in future program evaluation studies for skill interventions (Conti et al., 2013; Cunha et al., 2006; Heckman et al., 2013).

Further, it implies that if we can effectively intervene on parental skills, then we can improve child outcomes. An important recent study by Heckman and Karapakula (2019b) show that the Perry program, an intervention from the 1960s, achieved long lasting effects on the positive personality traits of subjects that were present at age 55.

Focusing on Openness, recall that the factor we examine is defined by a combination of artistry, imaginativeness, sophistication, and inventiveness (see Table 4). Encouraging this socio-emotional skill in potential future mothers through exposure to music or culture may have large intergenerational effects, and there is recent evidence that this is indeed possible (Mendez, 2015). In addition, despite the dearth of studies in this area, recent evidence from the literature suggests that there are drugs (Tang et al., 2009) and cognitive exercises (Jackson et al., 2012) that can have an effect on Openness as well. However, we acknowledge that the target groups for (Tang et al., 2009) and (Jackson et al., 2012) were older adults and in the case of (Tang et al., 2009), were affected by depression. Their findings may therefore not be generalizeable to younger parents. More work is needed to understand the mechanisms through which Openness works. Shedding light on these pathways would bolster the confidence that improving Openness in mothers would have integenerational effects, and also allow us to target certain parental behaviors that may affect child development.

We also note that while the economics literature has focused on elements of non-cognitive skill captured by a wide variety of psychological measures including self-esteem, locus of control, self-control, Conscientiousness, grit, and others, less attention has been paid to Openness and Agreeableness as important skills in their own right. One reason for the various definitions of non-cognitive skills examined in the literature

is simply that different datasets contain different measures.[20] Regardless, our finding draws attention to two socio-emotional skills that are less studied in economics but widely studied in the personality psychology literature.

One important caveat to our implications is that our estimates may not reflect the causal effect of parental skills on child college attainment. Potentially, parental skills may be correlated to a third non-genetic factor that generate child outcomes. On the other hand, these skills are, in some sense, fundamental to many behaviors as demonstrated in the literature, and we believe it is likely that the skills impact some parental interaction with children that affect outcomes. Unfortunately, our data is limited and does not allow us to pin down the mechanisms at work behind mother's Openness, but we hope that our findings will inspire future work in this direction.

7.1 Robustness to Selective Adoption

As explained in Section 4, our estimates may be biased due to non-random adoption assignment. In particular, our estimates would be upward biased if: (1) higher IQ parents tend to adopt more able children, (2) more Open parents tend to adopt more able children, and (3) more Agreeable parents tend to adopt less able children.

Our main specification includes a control for the adoption child being born after 1970 as a way to account for the changing nature of adoptions nationally, as argued by previous work using the WLS (Plug, 2004; Plug and Vijverberg, 2003). We provide three additional robustness checks to tackle this concern.

First, we include controls for parental religion to check for bias due to non-random assignment by religious adoption agencies (see column 2 in Table 6). We create two dichotomous variable indicating whether the adoptive parents is Roman Catholic or Lutheran in 1975. We find that our main results are unaffected. Second, we analyze a

[20] While we do not wish to reify the Big Five taxonomy, we note that having consistent definitions of non-cognitive skills allow for better comparisons across studies in the literature.

sample of adopted children adopted before 1975 (see column 3 in Table 6). As argued in Section 4, this gives us some assurance that the children were plausibly randomly assigned conditional on parental religion, and that the children were likely adopted at young ages. In this specification, the effect of Openness is less precisely estimated due to the smaller sample size. However, the overall results are qualitatively similar and in fact the estimated effects appear larger. Third, we include controls for total number of both biological and adopted children to address the issue of endogenous fertility and adoption choice (see column 4 in Table 6). Finally, we also include controls for parental age, parental age at marriage, , (see column 5 in Table 6). In all of our specifications, the main results do not qualitatively change.

7.2 Parent-Child Relationships

We hypothesize that the parental skill effect may depend on the gender of the parent and the child. We therefore estimate a version of our model for sons and daughters separately, allowing mothers and fathers to have different effects:

$$h_t^{child} = \gamma_0^{child} + \boldsymbol{\gamma_1^{child}\theta_{t-1}} + \boldsymbol{\gamma_2^{child}\theta_{t-1}} Mom + \gamma_3 Mom + \gamma_4 x_t + \xi \tag{5}$$

where $child \in \{son, daughter\}$ and Mom is an indicator for a female respondent. This specification allows us to compare the relative importance of the effect of mother's skills and father's skills for each gender of the child.[21]

We present our results in columns 2-5 of Table 7. One important caveat in the comparisons we make is that the standard errors for the estimates are large, so we cannot statistically rule out that different parent-child relationships have different effects. However, we think that the disparity in the magnitudes of the estimated coefficients are still

[21] Alternatively we could perform separate regressions for each gender pair, i.e. father-son, father-daughter, mother-son, and mother-daughter, but comparing coefficients of skill across regressions is problematic since the scales on the latent parental skills may be different across regressions.

Table 6: Nurture Effects of Parental Skills (with Robustness Checks)

		Main Result	w/ Religion	Pre-1975 Adopted Child	w/ Number of Children	All Controls
IQ	Coefficient	0.049**	0.049**	0.067**	0.05**	0.054***
	s.e.	(0.020)	(0.020)	(0.026)	(0.020)	(0.020)
	p-val.	0.016	0.014	0.011	0.012	0.007
Openness		0.059**	0.062**	0.064	0.062**	0.071***
		(0.026)	(0.027)	(0.075)	(0.026)	(0.026)
		0.026	0.019	0.395	0.019	0.007
Conscientiousness		-0.024	-0.026	0.012	-0.023	-0.028
		(0.025)	(0.026)	(0.042)	(0.025)	(0.026)
		0.354	0.315	0.775	0.359	0.282
Extraversion		0.012	0.013	-0.018	0.007	0.007
		(0.024)	(0.023)	(0.036)	(0.024)	(0.024)
		0.599	0.574	0.616	0.757	0.761
Agreeableness		-0.057*	-0.059**	-0.101**	-0.055*	-0.054*
		(0.030)	(0.030)	(0.051)	(0.031)	(0.032)
		0.058	0.050	0.047	0.073	0.095
Neuroticism		-0.016	-0.016	0.012	-0.019	-0.015
		(0.025)	(0.025)	(0.047)	(0.025)	(0.027)
		0.522	0.514	0.801	0.439	0.572
Adoptive Parents Pre-Adoption Characteristics Controls						
Religion		No	Yes	Yes	Yes	Yes
Total number of children		No	No	No	Yes	Yes
Total number of adopted children		No	No	No	Yes	Yes
Other controls		No	No	No	No	Yes
Sample Size		616	616	266	616	616

Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted child. All skills are standardized to be centered at 0 and have a standard deviation of 1. Column 1 is the main result as shown in Figure 1. Column 2 is the result after controlling for adoptive parent's religion in 1975. Column 3 is the result on the sub-sample of adoption before 1975 that were plausibly randomly assigned conditioned on parental religion. Column 4 is the result after controlling for fertility and number of adopted children. Column 5 includes all controls. In all regressions we include the controls for child characteristics such as sex, age, birth order and a dummy variable for adopted children who were born before 1970.

*** $p < .01$; ** $p < .05$; * $p < .1$

informative. We find that the effects of parental skills are indeed heterogeneous.

Table 7: Nurture Effects by Gender of Parent and Child

		Parent-Child (Main)	Son		Daughter	
		All Parents	Mother	Father	Mother	Father
IQ	Coefficient	0.049**	-0.018	0.085***	0.007	0.084**
	s.e.	(0.020)	(0.043)	(0.032)	(0.040)	(0.041)
	p-val.	0.016	0.677	0.009	0.855	0.040
Openness		0.059**	0.112***	0.025	0.087**	0.031
		(0.026)	(0.040)	(0.053)	(0.044)	(0.072)
		0.026	0.005	0.632	0.051	0.664
Conscientiousness		-0.024	-0.070	0.002	-0.058	0.025
		(0.025)	(0.045)	(0.045)	(0.053)	(0.066)
		0.354	0.122	0.961	0.278	0.707
Extraversion		0.012	0.001	-0.012	0.050	0.007
		(0.024)	(0.046)	(0.045)	(0.047)	(0.046)
		0.599	0.989	0.792	0.281	0.878
Agreeableness		-0.057*	-0.005	-0.054	-0.067	-0.049
		(0.030)	(0.054)	(0.058)	(0.063)	(0.075)
		0.058	0.929	0.358	0.286	0.517
Neuroticism		-0.016	-0.009	-0.006	-0.074	0.041
		(0.025)	(0.053)	(0.049)	(0.053)	(0.061)
		0.522	0.859	0.908	0.161	0.507
Sample Size		616	311		305	

Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted child. All skills are standardized to be centered at 0 and have a standard deviation of 1. Equation 5 is estimated for male and female adopted children separately. Child's characteristics such as age and birth order are included in the regressions. We also include a dummy variable for adopted children who were born before 1970 in the regression analysis to account for the shift in adoption trend at the country-level (Plug, 2004; Plug and Vijverberg, 2003).
*** $p < .01$; ** $p < .05$; * $p < .1$

The positive nurture effects of IQ are much larger for fathers than mothers (8.5 p.p. vs 1 p.p for both sons and daughters). For Openness, it is the reverse and mothers dominate (11 p.p. vs 2 p.p. for sons and 9 p.p. vs 3 p.p. for daughters). For Agreeableness, the estimates by gender are less precise.

We find larger effects for mother's Openness than father's Openness. This is in line with the personality psychology literature, which suggests that mother's personality

traits are more highly correlated with child's personality traits (Loehlin, 2005). Our results also support findings in the literature that mother's socio-emotional skills[22] are important for child's outcomes (Cunha et al., 2010; Gronqvist et al., 2017). Our paper contributes by making clearer which aspects of mother's socio-emotional skills (as captured by the Big Five) drive the effect on children.

Despite the widely held view that mother's IQ is important for child development, we find that it is mother's Openness rather than IQ that has large nurture effects. [23] Agreeableness and IQ are the skills likely to be at play for fathers. A few recent studies have noted that Agreeableness is negatively associated with life-cycle earnings for males (Gensowski, 2013; Judge and Hurst, 2011; Savelyev and Tan, 2017).

7.3 Mechanisms Behind the Effect of Parental Skills

We explore possible mechanisms that may be behind our estimated nurture effects for the various parental skills, in particular parental income and education. Table 8 reports the nurture effects after the inclusion of parental income and education. The extent to which nurture effects are attenuated by the inclusion of these characteristics gives an indication of whether they may be channels explaining our effects. We find that the positive effect of parental IQ is attenuated by roughly two-thirds (from 5 p.p. to 1.4 p.p.) and the negative effect of Agreeableness is attenuated by roughly a half (from 5.7 p.p. to 3.5 p.p.) when we include parental income and education as regressors. IQ (Agreeableness) are well-known to be positively (negatively) associated with income, hence it is unsurprising that the inclusion of income attenuates their effect substantially. The effect of Openness is less attenuated (roughly one-third). This suggests that channels other than education or income could be at work for Openness.

The literature in psychology offers parenting styles as a possible explanation for why

[22] Different taxonomies of socio-emotional skills were used.

[23] While Openness has a 0.175 correlation with IQ (see Table 5), the two concepts are still distinct.

Table 8: Nurture Effects with Controls for Parental Characteristics

		Main	w/ Mechanisms	
IQ	Coefficient	0.049**	0.037*	0.014
	s.e.	(0.020)	(0.021)	(0.022)
	p-val.	0.016	0.077	0.534
Openness		0.059**	0.055**	0.042*
		(0.026)	(0.027)	(0.026)
		0.026	0.040	0.090
Conscientiousness		-0.024	-0.025	-0.028
		(0.025)	(0.025)	(0.025)
		0.354	0.315	0.257
Extraversion		0.012	0.011	0.011
		(0.024)	(0.023)	(0.023)
		0.599	0.632	0.648
Agreeableness		-0.057*	-0.046	-0.035
		(0.030)	(0.031)	(0.030)
		0.058	0.135	0.245
Neuroticism		-0.016	-0.009	-0.011
		(0.025)	(0.025)	(0.024)
		0.522	0.727	0.651
Parental Characteristics				
Parental College Attainment		No	Yes	Yes
Parental Income		No	No	Yes
Sample Size			616	

Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted child. All skills are standardized to be centered at 0 and have a standard deviation of 1. We contrast the baseline results against results with additional controls for parental education and income. Parental education is represented by whether the adoptive parent attended college. We average parental income from 1975 and 1992 as a measure of permanent family resources.

parental socio-emotional skills could have a nurture effect on child college attainment. For the most part, our results are in agreement with the literature, in that higher Openness is associated with positive parenting styles (Prinzie et al., 2009). However we are unable to test this directly since we do not observe measures of parenting styles in our data.

Furthermore, the links between Agreeableness and parenting styles are mixed in the literature (see Prinzie et al. (2009) for a review), with some papers finding positive impacts to high parental Agreeableness and others negative. For instance, consistent with the estimate for mother's Agreeableness on daughters, Prinzie et al. (2004) find that higher maternal Agreeableness is linked to more frequent externalizing problem behavior. Fully understanding the pathways of Agreeableness to child outcomes is therefore important. While lowering father's Agreeableness may improve outcomes due to higher levels of parental income, it may have ambiguous effects on parenting styles.

It is also possible that a part of these effects act through assortative mating (either positive or negative) on these skills. There is some evidence in the literature for assortative mating on the Big Five (McCrae et al., 2008), where Openness and Agreeableness were found to have large assortment effects (spousal correlations higher than 0.4). A more Agreeable father might be more likely to match with a more Agreeable mother, and the combined effect may be substantial and negative if both parents are too Agreeable to discipline their children. Since we only observe the skills of one parent per household, we are unable to explore this further, even though it may be of interest.

An additional point of note is that interventions on parental income and education could potentially close nurture-based gaps in child's college attainment for parental IQ but is less likely to reduce inequalities driven by parental Openness and Agreeableness.

7.4 The Impact of Birth Order on the Effect of Parental Skills

There is an extensive theoretical literature on the trade-off between child quality and

quantity, dating back to the models of Becker and Lewis (1973) and Becker and Tomes (1976). These theories were introduced to explain the observed negative correlation between family income and family size: given a budget constraint, when there is an increase in the number of children, the marginal cost of achieving quality will increase and this generates a trade-off between quality and quantity. In particular, the negative effect of family size on child's educational attainment is more likely to affect the marginal child through the effect of birth order (Black et al., 2005a; Kantarevic and Mechoulan, 2006). This observation is also supported in the WLS data, as shown by de Haan (2010) who found that higher birth order is associated with lower educational attainment regardless of family size, with parents providing fewer financial transfers for educational purposes to later born children. Building upon this finding, we investigate whether the nurture effects of parental skills are also affected by the birth order of children. Specifically, we estimate the following equation to capture the differential effect between first and non-first child:

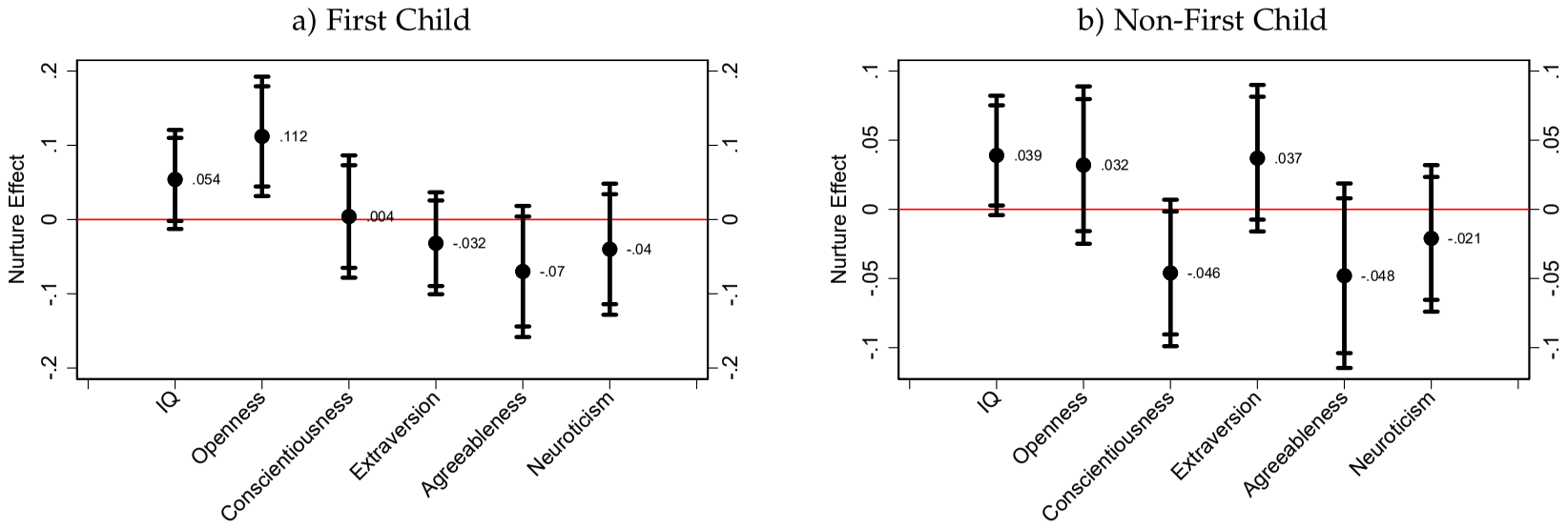
$$h_t = \delta_0 + \boldsymbol{\delta_1 \theta_{t-1}} + \boldsymbol{\delta_2 \theta_{t-1}} Firstborn + \delta_3 First - born + \delta_4 x_t + v \tag{6}$$

where *Firstborn* refers to an indicator for being the first child in the family.

Figure 3 shows the results of Equation 6. Interestingly, we find that first child adoptees experienced statistically significantly higher nurture effects from parental Openness than the rest of the children at the 10% level (11.2 p.p. vs 3.2 p.p.). The nurture effects of parental IQ and Agreeableness are larger for first borns, in line with the quality/quantity trade-off hypothesis, but are not statistically different due to large standard errors.

If Openness were working through parenting styles, it may depend on the amount of time spent with children. For example, Price (2007) finds that a first-born child on

Figure 3: Nurture Effects For First-Child vs Non-First Child



Notes:

Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted child. All skills are standardized to be centered at 0 and have a standard deviation of 1. We contrast the results for adopted child who are the first-child (Chart a) against results for adopted child who are not the first-child (Chart b). We control for child characteristics such as sex and age as well as family size. We also include a dummy variable for adopted children who were born before 1970 in our main regression analysis in line with previous research (Plug, 2004; Plug and Vijverberg, 2003) to account for the shift in adoption trend at the country-level.

average receives 20-30 more minutes of quality time each day than a second-born child of the same age from their parents. The greater amount of quality time spent with parents by the first child potentially translates into a higher positive nurture effects from Openness. This differential transmission of parental Openness could be an additional channel explaining the negative effect of birth order on children schooling outcomes besides the traditional financial-dilution channel. Nevertheless, more work is needed to identify the mechanisms behind the negative impact of birth order in order to leverage on parental skills as a tool to mitigate its negative effect on childs educational attainment.

7.5 Comparing Adopted and Biological Children

We interpret our estimates based on adopted children to illuminate the presence of sizeable nurture effects. However, a natural question that arises from our results is: how comparable are the nurture effects we estimate for adopted children versus overall associations for biological children. To do this, we estimate the following equation:

$$h_t = \delta_0 + \boldsymbol{\delta_1}\boldsymbol{\theta_{t-1}} + \boldsymbol{\delta_2}\boldsymbol{\theta_{t-1}}Bio + \delta_3 Bio + \delta_4 x_t + v \tag{7}$$

where *Bio* refers to an indicator for being a biological child in a family with an adopted child.

Our estimates in Table 9 show that the links between parental IQ (13.4 p.p. vs 5 p.p.) and Openness (8.5 p.p. vs 6.1 p.p.) and child college attainment are substantially larger for biological children in an adoptive family. The negative effect of Agreeableness is qualititavely similar. It is tempting to use these comparisons to make inferences about the relative importance of nature and nurture. For instance, the fact that the coefficient for adoptees is roughly a third of the coefficient for biological children may suggest that one third of parental IQ's effect on college attainment is "nurture" and two thirds is

Table 9: Comparing Skill Effects for Adopted and Biological Children in an Adoptive Family

		Adopted Children	Biological Children
IQ	Coefficient	0.05**	0.134***
	s.e.	(0.020)	(0.030)
	p-val.	0.015	0.000
Openness		0.061**	0.085**
		(0.027)	(0.038)
		0.023	0.026
Conscientiousness		-0.024	0.016
		(0.026)	(0.040)
		0.353	0.689
Extraversion		0.012	0.037
		(0.024)	(0.034)
		0.629	0.277
Agreeableness		-0.055*	-.062
		(0.030)	(0.042)
		0.069	0.139
Neuroticism		-0.014	0.021
		(0.025)	(0.037)
		0.583	0.571
Intercept		0.729***	0.877***
		(0.118)	(0.036)
		0.000	0.000
Sample Size		1108	

Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adopted and biological child. All skills are standardized to be centered at 0 and have a standard deviation of 1. We only use biological children in a family with an adopted child for comparison. We include controls for child's sex, age, birth order, a dummy variable for adopted children who were born before 1970 and an intercept for biological children in the regression.
*** $p < .01$; ** $p < .05$; * $p < .1$

"nature". A similar exercise for Openness suggests two thirds of the effect is "nurture". However, these inferences rely on strong assumptions regarding the underlying model with respect to college attainment, as well as assumptions on the orthogonality of genes and environment (see (Golberger, 1977; Jencks et al., 1972) for example). A conservative interpretation of the estimates from biological children is to treat them as illustrative of the presence of broader effects (including genetic effects) without taking a stand on issues regarding heritability.

Another important concern regarding the comparability of adopted children and biological children is the external validity of our results. Adopted children are likely to face different challenges growing up than non-adopted children. On the other hand, we argue that our results can still be informative for non-adoptive children and parents who are similar to adoptive families. For example, while adopted youths may be more likely to suffer from behavioral and emotional problems compared to non-adopted youths, such differences are moderate and there are substantial overlaps in the risk of disruptive behavior disorders (Keyes et al., 2008). Furthermore, a number of studies show that the differences are smaller as the age at adoption decreases (Sharma et al., 1996a,b), and we argue in Section 4 that most of the adoptions in Wisconsin for the period relevant to our sample were at young ages.

7.6 Estimating Nurture Shares for IQ

Bearing the caveats of comparing results for adopted and biological children in mind, it may still be of interest to recover nurture shares for IQ, bridging previous findings in the literature by Plug and Vijverberg (2003).[24] Earlier analysis by Plug and Vijverberg (2003) used the same data to compute the nurture-share of IQ's effect without distinguishing between fathers and mothers and concluded that education attainment is largely deter-

[24] In Section E of the Appendix, we revisit the nature-nurture analysis in Plug and Vijverberg (2003) and discuss the assumptions necessary in the case of multidimensional parental skills.

mined by nature. We present a replication of Plug and Vijverberg (2003) where the full sample of biological children is used (see Table 10). Our replication is in the ballpark of their estimate (36% versus 46%) and we find little difference in the nurture share of IQ even after including the other parental skills. Based on the small share of nurture compared to nature, Plug and Vijverberg (2003) express pessimism about the prospects of policy interventions aiming at alleviating intergenerational inequality.

However, we find that examining the heterogeneity of nurture shares across parent-child relationships reveals a different story. In particular, we find that the IQ nurture share of the father-son relationship is actually much larger than that of the full sample (65% versus 36%). This suggests that there are important nuances to the nature-nurture debate that were previously overlooked. This is of particular importance since much of the intergenerational mobility literature has focused on fathers and sons (Black et al., 2009; Corak and Piraino, 2011; Lefgren et al., 2012), although recent work has also examined other parent-child relationships (Olivetti and Paserman, 2015). Combined with our finding that income and education drive the nurture effects of father's IQ, this suggests that income and education interventions could potentially close more than half the gap in college attainment among children with high versus low IQ fathers.

Our finding that the genetic share of the effect of mother's IQ on sons is much larger than that of father's on sons is also in line with research regarding the X-chromosome transmission of IQ from mothers to sons (Gecz and Mulley, 2000; Lehrke, 1972; Lubs et al., 2012; Skuse, 2005; Turner, 1996).

8 Conclusion

This paper investigates the nurture role of multidimensional parental cognitive and socio-emotional skills in explaining intergenerational mobility. Our analysis contains several important findings, bearing in mind the caveats discussed in Section 4. First, we

Table 10: Nurture Shares of Parental IQ's Effect on Child's College Attainment

Dependent variable		Plug and Vijverberg	Parent-Child		Father-Daughter		Father-Son		Mother-Daughter		Mother-Son	
Child's college		Nurture	Full Effect	Nurture	Full Effect	Nurture	Full Effect	Nurture	Full Effect	Nurture	Full Effect	Nurture
IQ only	est.	46%	0.127***	36%	0.127***	65.0%	0.127***	58.4%	0.121***	0.6%	0.132***	13.0%
	s.e.	(.229)	(.005)		(.009)		(.008)		(.009)		(.009)	
	p-val.		.000		.000		.000		.000		.000	
IQ with other skills			0.119***	39%	0.123***	72.1%	0.125***	64.4%	0.105***	-5.5%	0.122***	8.7%
			(.005)		(.009)		(.009)		(.009)		(.009)	
			.000		.000		.000		.000		.000	
Sample Size			17095		4087		4280		4277		4451	

Notes: Calculations are based on the WLS data. We regress child's college attainment on parental IQ and control variables for a sample of both adopted and biological children allowing for different coefficients for IQ. Each effect comes from a separate regression. The nurture ratio is computed by taking the ratio of IQ coefficients for adopted and biological children. The second row repeats the exercise but includes the other psychological skills as well. The IQ results are robust to the addition of other psychological skills.

*** $p < .01$; ** $p < .05$; * $p < .1$

provide evidence that both parental cognitive and socio-emotional skills matter and that non-genetic channels play a large role in their effects on child outcomes. The positive effects of IQ and Openness, and the negative effect of Agreeableness, are similar in size to that of income, where a 1 s.d. difference in skill corresponded to a 5-6 p.p. difference in college attainment. Second, their effects differ across parent-child relationships by gender and by birth order. In particular, mother's Openness and father's IQ are the drivers of nurture effects. Third, we find that the positive effect of IQ and negative effect of Agreeableness are largely explained by parental income, but this does not hold for Openness.

Our results serve to inform research on key parental traits that determine child outcomes, with an emphasis on non-genetic factors. We speak to the personality psychology and parenting literature which has been focused mainly on the predictive power of parent personality on parenting style, with less concern toward estimating effects on college attainment of children and later life success. Whichever mechanisms underlie our results, parental cognitive and socio-emotional skills are an important non-genetic factor in determining the human capital of future generations.

Our findings therefore suggest that parental socio-emotional skills are a possible lever for intervention to alleviate intergenerational inequality. However, they also imply that policy recommendations should be careful to distinguish between parent-child relationships and birth order as efforts to raise specific parental skills may be beneficial for one child but ineffective for the other. Our results also underscore the importance of both cognitive and socio-emotional skills, and suggest that current efforts to improve such skills in children may have far-reaching effects across generations. More work is needed to understand the mechanisms through which parental skills act, and to examine if there are ways to exploit the advantages of a skill while mitigating the harmful effects.

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APPENDIX

A Factor Analysis

This section explains the Confirmatory Factor Analysis we perform in our estimation. The major goal of factor analysis is to explain the variability of a set of variables called *measures* into two components: a *common* portion explained by a set of latent variables called *factors*, and a *unique* portion that is due to idiosyncratic variation particular to each measure. In this study, the vector of common factors are constructed from multiple psychological measures in the Wisconsin Longitudinal Study data from 1992 (John et al., 1991). With this system of dedicated measures, we can interpret the resulting factors as personality skills consistent with the Big Five taxonomy.

The psychological measures we use are self-reported ratings with a 6-point scale. WLS data came from two channels, through a phone survey and a mail survey. We use the 1992 psychological measures collected from these two channels. There are two reasons why we choose measures from 1992 instead from the later waves. First, we want to study the effect of parental skills on their children' human capital development, thus it is preferable to use parental skills during the child's development period. Since 1992 is the earliest wave with the data on personality measures, this is the most suitable wave for our study. Second, the 1992 measures have the fewest missing observations. Since the literature argues that adult personality skills are remarkably rank-order stable over the life-cycle after the age of 25 (Cobb-Clark and Schurer, 2012; Costa and McCrae, 1988, 1994; Rantanen et al., 2007; Roberts and DelVecchio, 2000; Specht et al., 2011), the psychological measures from 1992 are sufficient to capture the lifetime parental personality skills. Table A.1 shows the summary of the psychological measures that we use in this study.

Given the factor structure, we perform CFA and present the model fit statistics including the Comparative fit index (CFI), the Tucker-Lewis fit index (TLI), and the root

Table A.1: Description of Psychological Measures, Adoptive Parents

Psychological Measures							
	mean	s.d.	obs.		mean	s.d.	obs.
Openness				**Agreeableness**			
Artistic	4.654	(1.215)	361	Polite	4.634	(1.349)	369
Imaginative	4.724	(1.158)	369	Considerate	5.239	(.915)	373
Sophisticated	3.410	(1.494)	366	Cooperative	5.273	(.729)	374
Inventive (Phone)	4.490	(1.521)	443	Forgiving (Phone)	5.326	(.993)	442
Conscientiousness				Not Find Fault (Phone)	4.636	(1.457)	440
Organized	4.492	(1.536)	364				
Hardworking	4.087	(1.433)	368				
Focused	4.108	(1.408)	370	**Neuroticism**			
Thorough (Phone)	4.921	(1.400)	441	Tense	4.220	(1.265)	369
Focused (Phone)	4.749	(1.396)	442	Unstable Emotion	2.132	(1.129)	372
Extraversion				Worries	3.635	(1.598)	370
Unreserved	2.874	(1.373)	365	Nervous	3.136	(1.494)	367
Noisy	3.371	(1.425)	367	Worries (Phone)	3.742	(1.814)	442
Uninhibited	3.549	(1.470)	366	Stressful (Phone)	2.572	(1.594)	439
Noisy (Phone)	3.610	(1.803)	436				
Sociable (Phone)	5.068	(1.261)	440				

Notes: Calculations are based on the 1992 WLS data. A higher score indicates a higher skill for that measure.

mean squared error of approximation (RMSEA) to provide statistical evidence justifying the factor structure. The fit indices are largely in line with the acceptable cut-off in the current literature. (see Table A.2).

A.1 Model for Latent Factors

Our factor structure is defined as follows: we allow factors, $s \in S = \{O, C, E, A, N\}$, to enter into a set of multinomial logit measurement equations, 5 for each ordinal psychological measure $j \in \mathcal{J} = \{1, \ldots, J\}$ corresponding to the 6-point scale that each measure captures with the 6th point being the reference point.[25] The factor model is thus defined by the following equations:

$$\begin{aligned} M_1^j &= log\frac{\pi_1^j}{\pi_6^j} = \alpha_1^j + \phi_1\theta_s \\ &\vdots \\ M_5^j &= log\frac{\pi_5^j}{\pi_6^j} = \alpha_5^j + \phi_5\theta_s, \end{aligned} \tag{8}$$

where M refers to the log-odds for each ordinal category of a given measure. We have no requirement of orthogonality between traits: $\theta^s \not\perp\!\!\!\perp \theta^{s'}$ for $s \neq s'$. In addition, for all $s \in S$ and $j \in \mathcal{J}$, $\mathbb{E}(\theta^s) = 0$. Finally, we assume that $\theta^s \sim \mathcal{N}(0,1), \forall s \in S$.

The factor model is identified by normalizing the variance of each latent factor ($Var(\theta^s) = 1, s \in S$), and imposing a set of exclusion restrictions for each measurement equation ($\phi_j^s = 0$ for some j, s). The variance normalization is a standard technique that allows us to interpret factor loadings as the effect of changing the factor by one standard deviation. The exclusion restrictions are based on theoretical considerations which lead us to conclude that certain latent factors have no relationship with respect to certain measures. Measures are therefore affected by only one latent factor, and hence are *dedicated* measures. With these exclusion restrictions and a sufficient number of measures,

[25] For example, "artistic", "considerate", and so on (see Table A.1).

Table A.2: CFA Factor Loadings and Model Fit

Confirmatory Factor Analysis							
	coef.	s.e.	p-val.		coef.	s.e.	p-val.
Openness				**Agreeableness**			
Artistic	.706	(.039)	***.000***	Polite	.601	(.037)	***.000***
Imaginative	.592	(.043)	***.000***	Considerate	.741	(.035)	***.000***
Sophisticated	.713	(.036)	***.000***	Cooperative	.601	(.036)	***.000***
Inventive (Phone)	.515	(.044)	***.000***	Forgiving (Phone)	.508	(.040)	***.000***
				Not Find Fault (Phone)	.692	(.036)	***.000***
Conscientiousness							
Organized	.466	(.040)	***.000***	**Neuroticism**			
Hardworking	.521	(.039)	***.000***	Tense	.699	(.023)	***.000***
Focused	.813	(.032)	***.000***	Unstable Emotion	.663	(.028)	***.000***
Thorough (Phone)	.561	(.038)	***.000***	Worries	.863	(.016)	***.000***
Focused (Phone)	.768	(.027)	***.000***	Nervous	.817	(.019)	***.000***
				Worries (Phone)	.759	(.020)	***.000***
Extraversion				Stressed (Phone)	.714	(.025)	***.000***
Unreserved	.685	(.027)	***.000***				
Noisy	.852	(.016)	***.000***	**CFI**	.831		
Uninhibited	.767	(.021)	***.000***	**TLI**	.810		
Noisy (Phone)	.773	(.023)	***.000***	**RMSEA**	.083		
Sociable (Phone)	.626	(.028)	***.000***				

Notes: $^{(a)}$: "CFI" refers to the Comparative Fit Index. $^{(b)}$: "TLI" refers to the Tucker–Lewis Index. $^{(c)}$: "RMSEA" refers to the root mean squared error of approximation.

the factor model is identified.[26] Table 4 documents the structure of the factor model.

B Variance Decomposition

To compute variance explained by each skill, we start with the standard variance formula, where z denotes regressors including θ and x and p is the total number of regressors:

$$var(h) = \sum_{j=1}^{p} \beta_j^2 var(z_j) + 2 \sum_{j=1}^{p-1} \sum_{k=j+1}^{p} \beta_j \beta_k \sqrt{var(z_j) var(z_k)} \rho_{jk} + \sigma_\epsilon^2 \tag{9}$$

For the calculation of 'own variance', we report $\beta_j^2 var(z_j)$ for $z \in \{IQ, O, C, E, A, N\}$.

[26] For a more formal identification proof of a model with correlated factors, see, for instance, Web Appendices of Heckman, Pinto, and Savelyev (2013) or Conti, Heckman, and Urzúa (2010).

For the calculation of 'all covariances' we report the sum of 'own variance' and

$$\sum_{j=1}^{p-1} \sum_{k=j+1}^{p} \beta_j \beta_k \sqrt{var(z_j) var(z_k)} \rho_{jk}$$

.

C Logistic Regression Model

As a robustness check, we employ the logistic regression specification for our binary outcome regressions. Below, we present the figures and tables that mirror our main results. We find little qualitative difference in our estimated nurture effects.

D Income Indirect Effects

We perform a robustness check with regard to the indirect effect of parental skills through the income channel in the estimation of the nurture effects. One approach used in our main paper is to omit income completely and assume that all of the parental income effect originate from parental skills. Another approach is where we include parental income orthogonal to parental skills, so that the estimated nurture effects *include* the indirect nurture effects through income. To do this, we regress parental income on parental skills to recover residualized income (that is, income purged of skills). We use this alternate approach here and find that our nurture effect estimates are qualitatively similar (See Table D.4).

E Nature Versus Nurture

A natural question to ask is whether the non-genetic effects we estimated are more or less important than the genetic channels for parental skill effects. Plug and Vijverberg (2003)

Table C.3: The Nurture Effect of Parental Skills (Logit)

		Parent-Child	Son		Daughter	
		All Parent	Mother	Father	Mother	Father
IQ	Coefficient	0.200**	-0.075	0.377**	0.030	0.373**
	s.e.	(0.089)	(0.214)	(0.152)	(0.185)	(0.192)
	p-val.	0.024	0.724	0.013	0.873	0.051
Openness		0.284**	0.597**	0.110	0.427*	0.118
		(0.122)	(0.259)	(0.238)	(0.241)	(0.309)
		0.019	0.021	0.644	0.076	0.702
Conscientiousness		-0.141	-0.321	0.002	-0.287	0.109
		(0.112)	(0.228)	(0.209)	(0.265)	(0.306)
		0.210	0.158	0.991	0.279	0.722
Extraversion		0.078	-0.005	-0.046	0.234	0.028
		(0.104)	(0.224)	(0.203)	(0.228)	(0.198)
		0.451	0.984	0.820	0.307	0.888
Agreeableness		-0.258*	-0.029	-0.238	-0.342	-0.210
		(0.135)	(0.269)	(0.269)	(0.319)	(0.324)
		0.056	0.913	0.377	0.283	0.517
Neuroticism		-0.134	-0.040	-0.035	-0.375	0.190
		(0.114)	(0.265)	(0.230)	(0.282)	(0.278)
		0.238	0.879	0.879	0.182	0.495
Sample Size		616	311		305	

Notes: Calculations are based on the WLS data. Effects are represented by changes in the log-odd ratio of attaining a degree by adoptive child. All skills are standardized to be centered at 0 and have a standard deviation of 1. Independent variables include child characteristics such as sex (for column Parent-Child), age and birth order. We also include a dummy variable for adopted children who were born before 1970. *** $p < .01$; ** $p < .05$; * $p < .1$

answer the nature versus nurture question for parental IQ by considering both adopted and biological children in their model of intergenerational human capital transmission.

We present a multidimensional version of the model in Plug and Vijverberg (2003). Consider a law of motion for skills, where d refers to an indicator for being adopted, a refers to adopted child, b refers to biological child, and suffix e refers to 'environmental'

Table D.4: The Nurture Effect of Parental Skills

		Parent-Child (Main)	Son		Daughter	
		All Parents	Mother	Father	Mother	Father
IQ	Coefficient	0.049**	-0.024	0.089***	0.006	0.084**
	s.e.	(0.020)	(0.044)	(0.032)	(0.041)	(0.041)
	p-val.	0.015	0.590	0.006	0.890	0.039
Openness		0.057**	0.112***	0.022	0.078*	0.034
		(0.027)	(0.040)	(0.053)	(0.046)	(0.069)
		0.031	0.005	0.673	0.092	0.618
Conscientiousness		-0.022	-0.066	0.000	-0.054	0.024
		(0.025)	(0.046)	(0.045)	(0.054)	(0.066)
		0.378	0.148	0.998	0.324	0.714
Extraversion		0.012	0.002	-0.012	0.052	0.006
		(0.024)	(0.046)	(0.045)	(0.047)	(0.045)
		0.610	0.974	0.789	0.261	0.893
Agreeableness		-0.058*	-0.008	-0.056	-0.059	-0.063
		(0.030)	(0.053)	(0.057)	(0.063)	(0.076)
		0.057	0.881	0.326	0.349	0.404
Neuroticism		-0.016	-0.010	-0.012	-0.071	0.030
		(0.025)	(0.053)	(0.049)	(0.054)	(0.062)
		0.531	0.850	0.810	0.190	0.627
Log Parental Income		0.062*	0.065		0.062	
		(0.034)	(0.048)		(0.041)	
		0.073	0.171		0.128	
Sample Size		616	311		305	

Notes: Calculations are based on the WLS data. Effects are represented by changes in the probability of attaining a degree by adoptive child. All skills are standardized to be centered at 0 and have a standard deviation of 1. Independent variables include child characteristics such as sex (for column Parent-Child), age and birth order. We also include a dummy variable for adopted children who were born before 1970. In addition, we also include the parental income variable in the main regression. We average parental income from 1975 and 1992 as a measure of permanent family resources.
In this specification, we capture the indirect effect of parental skills through the income channel by estimating a separate income regression as a linear-in-parameter function of parental Big Five latent skills. The total nurture effect (coefficients in the Table D.4) of a parental skill will be the sum of the *direct effect* of skill on child's education and the *indirect* effect of skill on child's education through parental income.
*** $p < .01$; ** $p < .05$; * $p < .1$

while g refers to 'genetic':

$$\theta_t^s = b_0^s + \boldsymbol{b_e^s \theta_{t-1}} + \boldsymbol{b_g^s \theta_{t-1}} + d_t \boldsymbol{b_g^s (\theta_{t-1}^* - \theta_{t-1})} + b_{2b}^s y_{t-1} + b_{2a}^s d_t y_{t-1} + b_3^s x_t + v_t^s \quad \text{(E.1)}$$

where $\boldsymbol{\theta^*_{t-1}}$ refers to skills of the adopted child's biological parent. However, we do not observe this in our data and therefore replace this with b^s_{0*} following Plug and Vijverberg (2003) to capture the mean difference in the skills of adopted and biological children due to differences in their biological parents' skills. Thus we obtain:

$$\theta^s_t = b^s_0 + b^s_{0*}d_t + \boldsymbol{b^s_e\theta_{t-1}} + \boldsymbol{b^s_g\theta_{t-1}} - d_t\boldsymbol{b^s_g\theta_{t-1}} + b^s_{2b}y_{t-1} + b^s_{2a}d_ty_{t-1} + b^s_3x_t + \nu^s_t \quad \text{(E.2)}$$

The technology for human capital h is assumed to be identical for adopted and biological children except for the effect of income, again to account for possible differential investment[27]:

$$h_t = c_0 + \boldsymbol{c_1\theta_t} + c_{2b}y_{t-1} + c_{2a}d_ty_{t-1} + c_3x_t + \omega_t \quad \text{(E.3)}$$

and combining yields:

$$\begin{aligned} h_t = {} & c_0 + \boldsymbol{c_1(b_0 + b_{o*}d_t)} \\ & + \underbrace{\boldsymbol{(c_1(b_e + b_g))}}_{\textbf{full effect}}\boldsymbol{\theta_{t-1}} - d_t \underbrace{\boldsymbol{c_1b_g}}_{\textbf{genetic effect}}\boldsymbol{\theta_{t-1}} \\ & + r_{by}y_{t-1} + r_{ay}d_ty_{t-1} + (c_3 + \boldsymbol{b_3c_1})x_t + \omega_t + \boldsymbol{c_1\nu_t} \end{aligned} \quad \text{(E.4)}$$

where r_{by}, r_{ay} are reduced form parameters for income to simplify notation.

From the reduced form estimates of the "full effect" and the "genetic effect", we can compute the nurture ratio defined as:

$$\textbf{nurture ratio} = 1 - \frac{\textbf{genetic effect}}{\textbf{full effect}} = \frac{\boldsymbol{c_1b_e}}{\boldsymbol{c_1(b_e + b_g)}} \quad \text{(E.5)}$$

which can be viewed as a measure of heritability.

Plug and Vijverberg (2003) examine the one dimensional case where $s = s' = IQ$ and

[27] See Case et al. (2001) for evidence of differential spending on food for adopted children.

take the ratio of coefficients for parental IQ on adopted and biological children:

$$\textbf{nurture ratio} = 1 - \frac{c_1^{IQ} b_g^{IQ}}{c_1^{IQ}(b_g^{IQ} + b_e^{IQ})} = \frac{b_e^{IQ}}{b_e^{IQ} + b_g^{IQ}} \tag{E.6}$$

to compute the share of nature and nurture for the effect of parental IQ on child's IQ.

In the multidimensional case, the ratio $\frac{b_e^s}{b_e^s + b_g^s}$ is not identified by the reduced form parameters from estimating Equation (E) without further restrictions.[28] Taking the ratio of coefficients for parental skill s would still give some indication of the relative roles of nature and nurture but we will not be able to distinguish between the portion of nature or nurture working through cross-skill production (parental skill s producing child skill s') and own-skill production (parental skill s producing child skill s).

E.1 Assumptions for Decomposition

We note that this approach requires strong assumptions both on the production technology of skills and on the comparability of adopted and biological children. Holmlund et al. (2011) discuss these issues in detail and raise the "identical distributions" assumption as one of the key concerns, where comparing adopted and biological children requires us to believe that the distribution from which adopted children outcomes are drawn is identical to that of biological children. In reality, adopted children are probably drawn from a select sample with "range restrictions", a concept introduced by Stoolmiller (1999) in the behavioral genetics literature, since adoptive families are generally more educated and richer than the rest of the population.

We find that there are some statistically significant difference in means between adoptive and non-adoptive parents for IQ and income (see Table E.5). Although it is an important caveat to the analysis in this section, we find that the magnitudes are not large.

[28] Two possible assumptions that would maintain the identification of the nurture share in the skills production technology are first, eliminating cross-productivities in skills ($b_{s,g}^{s'} = b_{s,e}^{s'} = 0$ for $s \neq s'$), and second, assuming that child skills are scalar while maintaining the multidimensional nature of parental skills.

Furthermore, the fact that adoptive families tend to provide better family environments *downward biases* the proportion of variance attributed to family environment (Stoolmiller, 1999).

Table E.5: Selection on Adoptive Parents

Dependent Variable : Adoptive Family			
	Coefficient	s.e.	p-val.
IQ	0.008*	(0.005)	0.068
Openness	0.007	(0.006)	0.225
Conscientiousness	0.002	(0.006)	0.752
Extraversion	-0.002	(0.005)	0.703
Agreeableness	0.001	(0.006)	0.852
Neuroticism	-0.001	(0.005)	0.828
Father education	0.003	(0.002)	0.153
Mother education	0.004	(0.003)	0.123
Log average income	0.008**	(0.004)	0.042
{in USD}	$1,008		

Notes: Calculations are based on the WLS data. Personality skills and IQ are mean 0 and standard deviation 1. We regress parental characteristics on an indicator for adopting children. We only include parents who were married and cohabiting with their spouses in 1975 and with only biological or adopted children. We omit children born after 1987 to avoid problems with censored education attainment information. We also restrict the sample of children to have been born after 1962 so that the bulk of the child's life was after parental socio-emotional skills have stabilized. We find statistically significant differences in the means for IQ and income but the magnitudes are small. We did not find any significant difference in the means for psychological skills between the parents who adopted and those that did not.
*** $p < .01$; ** $p < .05$; * $p < .1$

Furthermore, although Plug and Vijverberg (2003) refer to this exercise as a decomposition, there is no guarantee that the estimated ratio falls between the bounds of 0 and

1. For this to be true, there must be further restrictions on the magnitudes of cross-skill production, and the assumption that both b_g^s and b_e^s work in the same direction for all s. In the case of Plug and Vijverberg (2003) with IQ as the scalar measure of ability and no heterogeneity in the effect across parent-child relationships, they estimate ratios that happen to fall between 0 and 1 which we replicate, but this will not be true for our results in general.