The Nurture Effect: Like Father, Like Son. What about for an Adopted Child?

A Study of Korean-American Adoptees
on the Impact of Family Environment and Genes

Suanna Seung-yun Oh[1]
Advisor: Dr. Marjorie McElroy

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1 Email: suanna.oh@gmail.com, Class of 2011, Trinity School, Duke University.
I will be joining the MA program in Economics at the University of Toronto next year.

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Abstract

In this paper, I investigate the effect of nature and nurture by studying the relationship between parental education and adoptee's educational outcomes. Sacerdote's data on Korean American adoptees is appropriate for such an approach, since the children were all adopted as babies from South Korea between 1970 and 1980. Also, the adoptees were randomly assigned to families, so there was no correlation between parental characteristics and adoptee's characteristics. Hence, the first part of my analysis identifies the causal effect of being assigned to a certain family environment. I confirm that a mother's level of education has a positive effect on an adoptee's educational attainment. More specifically, a one year increase in the mother's education increases the adoptee's education by 0.099 years. The second part of my analysis focuses on the differences between the educational attainment of adoptees and biological children, of which I find a larger positive effect of parental education on biological children's education. This may signify the genetic inheritability of intelligence.

JEL Classification: J; J12; J13; J24

Keywords: environmental influence, adoption, child development, education

Section I. Approaching the Nature vs. Nurture Debate

The importance of family environment on children’s outcomes has been documented in many fields of research such as psychology, sociology and economics. Currently there exist many government policies that are aimed towards improving the home and school environment of children. In many cases, possessing knowledge of certain variables and their influences on children’s environment can assist policy makers to implement more appropriate and effective policies. For instance, if child intelligence was largely determined by nature, policy makers would agree that providing special educational programs for “gifted children” would help each child to realize his/her potential. If child intelligence can be greatly increased by improving the home and school environment, policy makers would choose to improve general public education for all children. Hence, social scientists have done much research on the relative importance of genes and family environment on child development. However, it has been difficult to analyze the sole impact of family environment, due to the genetic relationship between parents and children. Using the data on Korean American adoptees who are quasi-randomly assigned to their families, I attempt to provide a comprehensive model that separately accounts for the genetic and hereditary influences on children’s outcomes. I find the impact of altering parental characteristics on both the adoptees’ and biological children’s educational outcomes and then compare both results to identify any disparities.

Many researchers have investigated the relationship between parental characteristics—such as health, income, and educational attainment—and children’s outcomes. For example, researches have shown that mother's education has a causal link to children's health (Currie and Moretti [2003]), and parental wealth is linked to educational attainment of children (Becker and Tomes [1986]). Researchers such as Davis-Kean [2005] found that the socioeconomic status, especially the education and income of parents, indirectly relates to children’s academic achievement. To separately analyze the environmental influences on children's outcomes, some researchers have used the socioeconomic status of the neighborhood as an indicator of the parental wealth and education level. Lapointe, Ford and Zumbo [2007] conducted a research project examining the relationship between neighborhood environment and school readiness of kindergarten children. They found that neighborhood culture, stability and heterogeneity were significant in promoting better school readiness outcomes for kindergarten children.

Among the many parental characteristics that are linked to children's education, I focus on the relationship between parent's educational attainment and that of their children. The ideas that intelligence is heritable (Scarr and Weinberg [1978]) and that more educated parents provide better home environment both make intuitive sense and such observations have been well documented in past research. I focus on the observation that children with more educated parents tend to attain a higher level of education (Haveman and Wolfe [1995]), and try to separately account for the influence of family environment, using data on the sample of Korean American adoptees and their non-adoptive siblings. Non-adoptive siblings refer to the adoptive parents' biological children, siblings of the Korean-American adoptees.

Behavioral geneticists who take interest in this issue have investigated how much variance in children's IQ is attributable to genetics, using samples of identical and fraternal twins. Notably, Devlin [1997] found that 50 to 60 percent of the variation in adult IQ is explained by genetic factors. However, their methods and conclusion have been criticized by other researchers. One critique was that their methods were biased toward overstating the importance of genes (Jencks et al [1972], Jencks [1980], and Goldberger [1979]). In response to such critiques, some researchers deliberately chose to stay away from such variance break-downs and find the environmental effect instead by working with a sample of adoptees. For instance, Plug and Vijverberg [2003] and Sacerdote [2007] regressed adoptees' years of education on mothers' years of schooling to determine their relationship.

Sacerdote's research [2007] is notable in that it used a natural experimental setting in which Korean-American adoptees were assigned to different family backgrounds on a first-come, first-serve basis, without regards to a child's particular genetic endowment. Given this quasi-random assignment, the adoptees' genetic endowments and all other pre-adoption characteristics were independent of the income and socioeconomic status of the adoptive families. The details of this quasi-random assignment are listed in Appendix A. Furthermore, the fact that they were children adopted from South Korea during the same time span of 10 years between 1970 and 1980 places this control group in a unique homogenous setting unlike many other adoptee samples. Sacerdote [2007] used various methods to analyze this data, including the traditional variance break-down by behavioral geneticists, treatment effect, regression coefficients and transmission coefficients. He found that 14 percent of the variation in children's educational attainment is explained by family environment. He also found the treatment effect of being assigned to a family of a particular socioeconomic type as well as different regression coefficient for adoptees and biological children (Sacerdote [2007]).

Although his latter three approaches employ different regression forms, I note the similarities in their approaches and derive an amalgamated single-equation model to be used in a few specific cases. Comparing the educational attainment of adoptees in different family environment is one of such specific cases to which my model can be applied. Using the same data set, I find the effect of being assigned to a family with a certain characteristic, specifying the number of children, sibling composition, or parental health status, while controlling for other family and individual characteristics. I confirm that mother's education has a positive effect on adoptee's education. A one year increase in mother's education increases the adoptee's education by 0.099 years. I also find that having a large number of siblings depresses adoptee's educational attainment, and that the presence of a biological child in the family negatively impacts a male adoptee's education.

The second part of my analysis employs the model to compare the educational attainment of biological and adoptive children in the same family. The fixed effect regression allows me to control for the effect of different rearing environment in each family, which creates a bias when some children are simply placed under those with “better parenting skills.” I find that an increase in parents’ education has an additional positive effect on biological children, possibly signifying the genetic influences of parental intelligence, apart from environmental influences.

Section II reviews related literature on the impact of genetics and family environment, introducing twin studies and studies with adopted children. This section also discusses Sacerdote’s methods in detail. Section III explains my comprehensive model, and the six specific comparison cases that can be derived from the model. Section IV describes our my data set and provides key statistics regarding the sample. Section V discusses two specific cases derived from my model: the treatment effect on adoptees who are assigned to a particular family environment, and the fixed effect regressions that compare the influence of parental education on adoptive and biological children’s outcomes. For each part of the analyses, regression forms and variables of interest are specified. Section VI presents the major results of my analysis, and provides interpretations of the results. Conclusions appear in Section VII.

Section II. Review on the Studies with Twins and Adopted Children

Behavioral geneticists' theory

The transmission of parental characteristics to children has long been studied by social scientists. For example, psychologist Davis-Kean [2005] found that the education and income of parents shows significant correlation to children's academic achievement. Other researchers also have confirmed that children with more educated parents tend to attain a higher level of education (Haveman and Wolfe [1995]). Such findings lead to the discussion of the relative significance of nature and nurture in this transmission of parental "success" attributes. Behavioral geneticists sought to separate the effects of nature and nurture by working with data on twins. Identical twins share almost exactly the same genetic traits while fraternal twins share genes just as regular siblings do. Hence, researchers such as Behrman and Taubman [1989]; Behrman, Rosenzweig, Taubman [1994] studied the variance in twins' educational outcomes to determine the effect of genes and nurturing environment.

Such an approach is referred to as the behavioral geneticists' approach. This approach isolates the environmental effect from the hereditary one based on a variance decomposition model. Their model is founded on the key assumption that the effect on a child's outcome is produced as "a linear and additive combination of genetic inputs (G), environmental inputs (F), and unexplained factors (S)" (Sacerdote [2008]). This implies that a child's educational attainment can be expressed as follows:

$$\text{Effect on Child's years of education (Y)} = G + F + S$$

Sacerdote [2008] explains that in the simple version of the model one assumes G and F are not correlated for a given child. On an empirical level, F represents the aspects of family environment uncorrelated with genes, and G represents both the effects of genes and the correlation between genes and environment. Since G, F, and S are not correlated with one another, one can take the variance of both sides of equation and divide by the variance in the outcome to get:

$$1 = h^2 + c^2 + e^2 \quad \text{where}$$

$$h^2 = \sigma_G^2/\sigma_Y^2, \qquad c^2 = \sigma_F^2/\sigma_Y^2, \qquad e^2 = \sigma_S^2/\sigma_Y^2 \;.$$

Hence, the variance of a child's outcome can be expressed as the sum of the variance from the genes (h^2), variance from family environment (c^2), and the residual (e^2). By expressing the correlation of outcomes among identical twins and among other siblings in these variance measures, researchers can determine the composition of the total variance to better understand the significance of each variance factor. Then, one can express many of the variances and co-variances in a child's outcome as functions of h, c, and e. The details of such an approach can be found in Sacerdote [2007], [2008]; Behrman and Taubman [1989]; Behrman, Pollack, Taubman [1982]; Hernnstein and Murray [1994]; and Jensen [1972].

Many of the studies that employ this behavioral geneticists' model attribute much of the total variance in a child's outcome to the variance in genes, emphasizing the role of genetic influences (Scarr and Weinberg [1994], Björkland, Jäntti and Solon [2007]). The finding by Devlin [1997] that 50 to 60 percent of the variation in adult IQ is explained by genetic factors is commonly cited in related literature. However, this model is not adopted in this research due to the following serious limitations pointed out by other economists.

In his review paper, Sacerdote [2008] summarizes the following criticisms on the behavioral geneticists' approach. One of the key criticisms is that the assumptions of the model may bias the results toward overstating the importance of genes, due to the existing correlation between family environment and genes (Jencks et al [1972], Jencks [1980] and Goldberger [1979]). Therefore, for my research, the decomposition for biological children in the data is likely to have higher heritability estimates than what the researchers intend to determine through the model. Also, family environment is likely endogenous, so it is difficult to interpret the variance breakdown and simply attribute each to nature and nurture (Jencks [1980], Scarr and McCartney [1983], Dickens and Flynn[2001]). Furthermore, Sacerdote points out in his paper [2008] that the variance breakdown only deals with variation in the sample. For example, considering adoptees who remained in Korea—instead of just children who were adopted by American parents—will increase the variation in inputs and outcomes, thereby increasing the proportion of the variation in outcomes that is due to environment. Hence, obtaining a correct decomposition through such a model may be a “difficult and elusive task,” as Feldman and Otto [1997] noted.

Studies with adopted children

Some researchers thought that by studying a sample of adoptees and their adoptive parents, they would not have to deal with the genetic heritability variable, thereby eliminating the need to perform a complicated variance breakdown. This allowed them to lower the bias from the endogeneity problem as well as avoid making complicated assumptions. Hence, Plug and Vijverberg [2003] and Plug [2004] looked at how parental education is correlated with the educational attainment of their adopted children and biological children. They concluded that ability, as measured by IQ, is the dominant factor behind the transfer of education from parents to children; they found that parental IQ is important for children’s educational attainment, and ability is largely inherited. However, they noted that there were biases in the results since some of the adopted children were genetically related to their adoptive parents due to adoption by relatives. Also, there could have been a selection bias if high-ability parents managed to select high-ability children for adoption.

In his studies with Korean-American adoptees ([2002], [2007]), Sacerdote minimized the selection bias, since the adopted children in his study were randomly assigned to families, independent of a child's pre-adoption characteristics. Working with data on approximately 300 Korean adoptees who graduated from high school during 1998-2000, he concluded that being raised in a family of high socioeconomic-status greatly increases the probability that a child (biological or adopted) will attend college, and also increases the selectivity of the college attended [2002]. Sacerdote then began collecting a larger set of data in 2003, finding that a college-educated mother increases an adoptee's probability of graduating from college; however, the effect is much greater for a biological child [2007].

In his latest paper [2007] with the Holt data set, Sacerdote performed the behavioral geneticists' variance decomposition on the children's outcomes. He also employed three different regression methods to analyze the impact of family environment on children's outcomes. The first estimated the treatment effect. Sacerdote clarified his meaning of the treatment effect by referring to Rubin's causal model [1974]; Rubin explained that there has to be an identifiable intervention, which can be implemented or not implemented, in order to estimate a causal effect. For the Holt sample of adoptees, the parents raised their adopted children—who had no genetic relation to them—and the process of assigning an adoptee to a family was effectively randomized. Hence the adoptees' genetic endowments and all other pre-adoption characteristics were independent of the income and socioeconomic status of the adoptive families (refer to Appendix A). Since being assigned to one type of family versus another served as an exogenous shock to the family environment, the coefficients on the types of family could have a causal interpretation. This allowed him to analyze the causal effect of being assigned to a family of certain socioeconomic characteristics. The specific equation was the following:

(1) $E_i = \alpha + \beta 1 * T1_i + \beta 2 * T2_i + Male_i + A_i + C_i + \varepsilon_i$

E_i is educational attainment for child i, $T1_i$ is a dummy for being assigned to a family with three or fewer children and high parental education, T2 is a dummy for being assigned to a family that either has three of fewer children OR has one or more college educated parents, A_i is full set of single year of age dummies, and C_i are a full set of cohort (year of adoption) dummies. The omitted category is children assigned to large families in which neither parent has a college education. This form allowed him to have a clear interpretation of the slope β1 as the effect of being assigned to the specific family type.

The second regression looks at the correlations between parents' and adoptive children's outcomes.

$$(2)\ E_i = \alpha + \beta 1 * MomsEd_i + \beta 2 * DadsEd_i + \beta 4 * Log(Family\ Income) + \beta 5 * Birth\ Order_i + \beta 6 * Male_i + \varepsilon_i$$

Here E_i represents adoptee i's years of education, and $MomsEd_i$ and $DadsEd_i$ represent adoptive mother and adoptive father's years of education. Sacerdote explained that this approach loses the simplicity of the treatment effect approach in equation (1) but allows one to compare the degree of correlation between adoptive family characteristics and a child's outcomes.

Sacerdote's third and final approach calculated transmission coefficients of various outcomes from parents to adoptees, using the following equation:

$$(3)\ E_i = \alpha + \delta 1 * E_{Mi} + \gamma * X_i + \varepsilon_i$$

Ei and E_{Mi} are adoptive child's and adoptive (or biological) mother's education, respectively, and X_i is a set of control variables such as child gender or age. According to Sacerdote, δ1 captures the degree to which additional years of education for the mother are transmitted to the child. Since there was no genetic relationship between the parents and the children, Sacerdote was interested in seeing the degree to which parental education transfers to the adoptees solely from the parents raising them. According to Sacerdote, the great advantage of using this approach is that economists have a good understanding of transmission coefficients. Becker's theory of parental endowment transfer in *A Treatise on the Family* [1981] provides a fundamental ground for understanding the literature on transmissions coefficients.

Section III. Putting the Three Equations Together into a Comprehensive Model

The desired goal of this paper is to come up with a method to estimate the environmental effect and hereditary effect on children's educational attainment. The great advantage of Sacerdote's data is that it contains information on the non-adoptive siblings of the adoptees, in other words, the biological children of the adoptive parents. Hence, I can first estimate the treatment effect of adoptees being assigned to a certain family environment, and then compare their outcomes with those of the biological children from the same families.

While Sacerdote notes the advantages and disadvantages of the three approaches and employ all of them in his research [2008], the three approaches are closely related. Thanks to the guidance of Dr. McElroy, I found that these three approaches can be seen as specific cases of a comprehensive model. Sacerdote's dummies used in (1) yield interesting interpretations as they help compare the effect of being assigned to a family of a certain socioeconomic status and the number of siblings; now, I can easily change the problem into estimating the effect of being assigned to a family with a certain number of children, certain sibling composition, or parents with certain years of education. Each of the coefficients on these variables can have a causal interpretation, since children are assigned to families without regards to the current family size, sibling composition, or parental characteristics.

Furthermore, the parental education variables can be added as control variables. Then, the slopes for these variables can be seen as transmission coefficients with corresponding interpretations. The only difference between (3) and my general equation would be that my equation introduces additional controls variables for the number of siblings and parental characteristics while estimating the rate of transmission. Hence, Sacerdote's first and third method of estimation can be combined into one model that includes more control variables. The resulting equation has a form similar to (2), with multiple parental characteristics and dummy variables in the equation. Hence, the comprehensive model can be applied on the sample of adoptees, and yield the useful interpretations depending on the nature of the variables.

Applying the same model on biological children of course loses the causal interpretations of the treatment effect. However, I can still compare the difference in for transmission coefficients for biological children and adoptees in the same family. If the slope on mother's education turns out significantly greater for biological children than for adoptees, it would indicate that having highly educated mothers has additional positive effect on child's education, which can be attributed to genetic relationship between the mother and the biological children. This is explicated in detail in the related empirical specification in Section V. However, simple comparisons between the transmission coefficients do not allow a clear estimate of the additional positive effect on the biological children.

Furthermore, it is necessary that I extend my interpretation of treatment effect coefficients based on Lindert's idea [1977]. Lindert [1977] claims many of the earlier studies that have examined the relationship between the number of siblings and achievement are subject to omitted variable bias. The most serious omitted variables are unobserved parental characteristics related to child orientation, or tastes and ability for developing achievement in individual children. According to Lindert [1977], it could well be that parents with better "tastes or abilities for grooming achievers" than other parents with the same observed attributes may prefer to have fewer children. If so, then studies showing that greater family size depresses achievement may really be showing only the relevance of unobserved parental tastes and abilities for grooming achievers. In relation to my studies, this suggests that what I regard as treatment effect or additional hereditary effect on child's education may significantly depend on individual parenting style. Hence Lindert's idea on the parental ability for grooming achievers suggests that there is a fixed effect within each family that impact the outcomes for the children. Children under parents with better ability to groom achievers will be under more positive environmental influences, as opposed to those under the parents with poor skills. Hence I need to consider that the coefficients on the variables regarding parental characteristics may serve as an indicator for different parental skills.

To account for the other unobservable parental characteristics, I can also introduce dummies that correspond to each family in order to compare the educational attainment of children in different family environment. This method is only feasible in this case, because an average family in my sample has a large number of siblings. Therefore, in order to estimate the relative importance of hereditary influence, I compare the outcomes of biological children to the outcomes of the adoptees in the same family, rather than other adoptees from similar family backgrounds. I introduce dummies that correspond to each family to perform a fixed effect regression, and also introduce variables that are interactions between family characteristics and dummies that indicate that the child is a biological child.

Therefore, the general model employed in this research has the following form:

$$y_{if} = \alpha + \beta_0 B_{if} + \sum_{k=1}^{m} [\beta_k x_{kif} + \theta_k x_{kif} * B_{if}] + \sum_{j=1}^{n} \delta_j c_{jif} + \eta_f F_{if} + \mu_{if} \quad (4)$$

The meanings of the terms are explicated in the following table:

Table 1. Meanings of the Variables in the Comprehensive Model (4)

Variable	Meaning
y_{if}	*years of education for child i in family f*
B_{if}	*dummy that equals 1 if child i in family i is a biological child.*
β_k	*effect of* x_{kif} *if i is an adopted child*
x_{kif}	k^{th} *family specific chracteristic (e.g. mom's education)* $x_{ki'f} = x_{kif}$ *for child i and i' in the same family f*
θ_k	*extra effect of* x_{kif} *if i is a biological child*
$x_{kif} * B_{if}$	*interaction of* x_{kif} *and* B_{if}
δ_j	*effect of* c_{jif}
c_{jif}	j^{th} *individual specific chracteristic (e.g. child's age)* $c_{ki'f} \neq c_{kif}$ *for child i and i' in the same family f*
η_f	*fixed effect of family f*
F_{if}	*dummy that equals 1 if child i is in family f*

This model becomes the basis on which the cases of treatment effect for adopted children, and the analyses of environmental and hereditary effects are based. Given two different children i and i's, I can come up with six different comparison cases dependent upon whether each child is adopted and whether they belong to the same family. Two of these specific cases will relate to the two parts of my analyses. The following section shows what each of the comparison identifies by working out the differences from the general model.

First Comparison

i' is a biological child; i is adopted. Both children are in the same family f.

$$y_{i'f} - y_{if} = 0 + \beta_0(B_{i'f} - B_{if}) + \sum_{k=1}^{m}[\beta_k(x_{ki'f} - x_{kif}) + \theta_k(x_{ki'f} * B_{i'f} - x_{kif} * B_{if})] + \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (\eta_f - \eta_f) + (\mu_{i'f} - \mu_{if})$$

$$y_{i'f} - y_{if} = 0 + \beta_0(1-0) + \sum_{k=1}^{m}[\beta_k(0) + \theta_k(x_{ki'f} * B_{if})] + \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (0) + (\mu_{i'f} - \mu_{if})$$

$$= \beta_0 + \sum_{k=1}^{m}\theta_k(x_{ki'f}) + \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (\mu_{i'f} - \mu_{if})$$

Comparison identifies β_0, θ_k, k=1, … , m;and δ_j, j = 1, … , n.

Second Comparison

i' and i are two adopted children from the same family f.

$$y_{i'f} - y_{if} = 0 + \beta_0(0-0) + \sum_{k=1}^{m}[\beta_k(0) + \theta_k(0)] + \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (0) + (\mu_{i'f} - \mu_{if}) = \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (\mu_{i'f} - \mu_{if})$$

Comparisonidentifies δ_j, j = 1, … , n.

Third Comparison

i' and i are two biological children from the same family f.

$$y_{i'f} - y_{if} = 0 + \beta_0(1-1) + \sum_{k=1}^{m}[\beta_k(0) + \theta_k(x_{ki'f} * 1 - x_{kif} * 1)] + \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (0) + (\mu_{i'f} - \mu_{if})$$

$$= \sum_{j=1}^{n}\delta_j(c_{ki'f} - c_{kif}) + (\mu_{i'f} - \mu_{if})$$

Comparison identifies δ_j, j = 1, … , n.

Fourth Comparison

i' and i are two adopted children from different families f' and f.

$$y_{i'f'} - y_{if} = 0 + \beta_0(0-0) + \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif}) + \theta_k(x_{ki'f'} * 0 - x_{kif} * 0)] + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if})$$

$$= \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif})] + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if})$$

Comparison identifies β_k, k=1, … , m; δ_j, j = 1, … , n; and $(\eta_{f'} - \eta_f)$

Fifth Comparison

i' and i are two biological children from different families f' and f.

$$y_{i'f'} - y_{if} = 0 + \beta_0(1-1) + \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif}) + \theta_k(x_{ki'f'} - x_{kif})] + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if})$$

$$= \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif}) + \theta_k(x_{ki'f'} - x_{kif})] + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if})$$

Comparison identifies β_k, θ_k, k=1, … , m; δ_j, j = 1, … , n; and $(\eta_{f'} - \eta_f)$

Sixth Comparison

i' is a biological child; i is adopted. Children are from different families f' and f.

$$
\begin{aligned}
y_{i'f'} - y_{if} &= 0 + \beta_0(1-0) + \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif}) + \theta_k(x_{ki'f'} * 1 - x_{kif} * 0)] \\
&\quad + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if}) \\
&= \beta_0 + \sum_{k=1}^{m}[\beta_k(x_{ki'f'} - x_{kif}) + \theta_k(x_{ki'f'})] + \sum_{j=1}^{n}\delta_j(c_{ki'f'} - c_{kif}) \\
&\quad + (\eta_{f'} - \eta_f) + (\mu_{i'f'} - \mu_{if})
\end{aligned}
$$

Comparison identifies β_0; β_k;θ_k, k=1, … , m; δ_j, j = 1, … , n; and $(\eta_{f'} - \eta_f)$

Since we assume the error in the general model has mean 0 and a constant variance, in each of the comparisons, the difference of such error terms, $\mu_{i'f'} - \mu_{if}$, will also have the mean of 0 and a constant variance. Out of these comparisons, we are especially interested in the fourth comparison and the sixth comparison. Details of the empirical specification on these two cases and interpretations will be provided in Section VI, after I describe the data in the following section.

Section IV. Data on Holt Adoptees and their Siblings

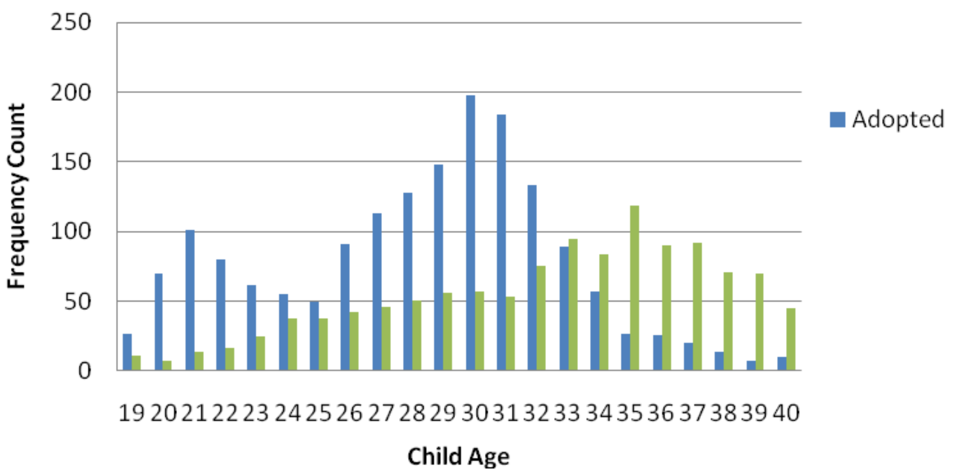
The data used in this paper are taken from the Survey of Holt Adoptees and Their Families, 2005, which is available through Inter-University Consortium for Political and Social Research. Bruce Sacerdote, Professor at Dartmouth College, collected the survey between January 2004 and June 2006 to assess the health status, educational attainment, and income of Korean-American adoptees and their adoptive families. A mail-in survey was sent to a random sample of families who had adopted a child through Holt International's Korea program between 1970 and 1980; thus, the adoptees' ages ranged from 24-34 when the survey was administered in 2004. Their recorded age in the year of 2004 is used in my analyses, since educational attainment and income level is significantly related to the age level.

Unlike many other adoption agencies, which allow parents to directly interact with children in orphanages and choose children based on the recommendation of adoption agents and personal inclination, Holt International bases its adoption process on randomized matches of parents and children. Once qualifications to adopt are met, parents are then assigned a child on a first come, first serve basis, regardless of the background of the parents or adoptees. Parents are not allowed to specify gender or anything else about their future adoptees. Children who are older, have siblings also up for adoption, or have disabilities are adopted through a separate process, which does not pertain to our data. One exception to the rule is that families with all boys are permitted to request a child of the opposite gender (Holt International).

The overall response rate was 27 percent; a total of 1,114 families were observed, with 2,886 cases each representing an adopted or a non-adopted child in the family. To deal with the low response rate, Sacerdote also surveyed a small sample of adopted children and showed that the decision to respond was not correlated with adoptee outcomes. Details about the evidence of the quasi-random assignment can be found in Appendix A.

In addition to information on the children's health, education, and income, the survey also collected basic demographic outcomes on the siblings of the adoptees. The family background (parental input) variables that are of my interest include parental income at the time of adoption, parental education, parents' drinking and smoking behaviors, as well as height and weight. Since the survey relied on parent reports of their adult children's outcomes, surveys were also sent to a small subset of adoptees. Their surveys included the same questions asked of their adoptive parents, as well as the adoptee's value of assets, religion, and frequency of religious attendance.

Figure 1. Age of Children



The sample consists of 1,690 adopted children and 1,196 biological children. Out of 1,690 adopted children, 29.3% of them are male and 70.2% of them are female. Out of 1,196 biological children, 61.5% of them are male, and 37.2% of them are female. The imbalance between gender in adopted children is not due to the preference of the parents, but the greater availability of Korean female babies for adoption. Figure 1 shows frequency histograms of children's age for adopted children and biological children. For both groups, the youngest child is 19 years old, and the oldest is 40. The average age of adopted children is 28, while the average age for biological children is 32.

Table 2. Number of Children in Families

Number of Children in the Family	Frequency Count
1	68
2	349
3	316
4	208
5	99
6	40
7	32
Total	1,112

Table 1 shows a frequency tabulation of family sizes in the sample. Out of 1,114 families, only 64 have a single child (a Hold adoptee); 349 have two children, 316 have three children, and 208 have four children. 99 families have five children, and 72 have six or seven children. However, the data includes information on only five of the children in those large families. The average age of fathers is 62, with the youngest father being 47 and the oldest one being 83. The average age of mothers is 59, with the youngest mother being 39 and the oldest being 83.

More details on the historical context of the Korean adoptions in the US, and Holt International's adoption process can be found in Appendix B and C. The following table shows descriptive statistics of the variables pertinent to my analyses.

Table 3. Summary Statistics for Important Variables

	Adoptees			Non-Adoptees				
Variables	Obs.	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Min.	Max.
Child is male	1663	0.292	0.455	1173	0.624	0.485	0	1
Child's current age	1667	28.212	4.567	1188	32.331	5.065	19	40
Child's years of education	1642	14.880	2.070	1159	15.799	2.260	9	21
Child's Income (in thousands of $)	1509	43.058	34.720	1110	61.531	43.040	10	200
Mother's years of education	1650	15.122	2.456	1180	15.285	2.437	9	20
Father's years of education	1635	15.908	2.879	1171	16.272	2.770	9	20
Family income at adoption (in thousands of $)	1624	32.472	23.646	1166	33.649	24.776	10	200
log family income at adoption	1216	9.591	0.534	935	9.581	.555	5.572	11.350
Mother's BMI	1574	25.727	5.073	1132	25.417	4.620	16.444	49.223
Father's BMI	1547	27.513	4.311	1132	27.347	4.128	16.690	43.758
Mother Drinks	1624	0.526	0.499	1161	0.571	0.495	0	1
Father Drinks	1562	0.606	0.489	1140	.6429825	.4793303	0	1

Section V. Empirical Specification

A. Comparing the Outcomes of Adoptees in Different Family Environments

In the first part of my analyses, I analyze how children's environment affects their educational outcomes. Since adoptees are assigned to their families in a quasi-random matter, I can estimate the treatment effect of being assigned to a family with a certain characteristic using my general model. Since I compare adoptees who are assigned to different family environments, this is the fourth comparison case specified in Section IV.

(5) $$y_{i'f'} - y_{if} = \sum_{k=1}^{m} [\beta_k (x_{ki'f'} - x_{kif})] + \sum_{j=1}^{n} \delta_j (c_{ki'f'} - c_{kif}) + (\eta_{f'} - \eta_f)$$

This comparison identifies the set of $\beta_k.x_{kif}$ as family specific characteristics. The variables to be used in the regression are listed in the following table.b

Table 4. Variables in the Treatment Effect Regression

	Parents related Variable	Sibling Related Variables
x_{kif}, family specific characteristic	Mother's years of education	Dummies indicating the number of siblings
	Father's years of education	Family has a biological child
	log family income at time of adoption	Any female sibling
	Mother's BMI	Any male sibling
	Father's BMI	
	Mother Drinks	
	Father Drinks	
c_{kif}, individual specific characteristic	Child's gender, child's age, year child entered Holt system, and child's age at adoption	

In my analysis, I am limiting the sample to include only the last adoptee in each family for the following reasons. First, the interpretation about parental ability does not necessarily apply to those parents who had a biological child after already adopting a child. It may well be that the parents did not plan to have a biological child but decided to do so after pregnancy. Secondly, the age gap between the oldest child and the youngest child naturally implies that the oldest child would have been treated like the only child before the appearances of other siblings, and similarly, the treatment effect of being in a family with many children will be different for the child of an earlier birth order and the last child. Lastly, this method allows me to skip the process of assigning a dummy variable to each family, since each child will represent a unique family environment.

The number of siblings and adoptee outcome

Previous literature has well documented the influence of sibling size on children's outcomes. A model based on quantity vs. quality was formalized in Becker and Tomes [1976], where they defined the child quality as their educational attainment or income level, and theorized that a trade-off existed between having more children and having more "quality" children. Blake [1981] terms it the dilution model, where the parents face certain constraints on their resources. As the number of siblings increases, they must divide the resources among those children, thereby decreasing the amount of resources each child can claim. This is the detrimental effect that researchers found in investigating the dilution model (Blake [1981], [1992]; Olneck and Bills [1979]). Other researchers though have found that compared to an only child, a child's educational attainment increases with the addition of a second child, but decreases from the addition of more siblings (Kessler [1991]).

However, as discussed previously, such an approach requires an extended interpretation based on Lindert's idea [1977]. According to Lindert, it could well be that parents with greater tastes or abilities for grooming achievers than other parents with the same observed attributes may prefer to have fewer children. If so, then studies showing that greater family size depresses achievement may really be showing only the relevance of unobserved parental tastes and abilities for grooming achievers. This suggests that the effect of having many siblings may actually derive from the parental preference regarding how many children they are willing to raise and how to rear their children.

Hanushek [1992] claims that the analysis of "value added," or achievement growth, over a restricted period of time can be used to circumvent such difficulties regarding individual parenting style and also account for individual fixed effects such as innate ability, motivation, etc. From his investigation of trade-offs between number of children and their scholastic performance, Hanushek also found that family size directly affects children's achievement. Though parents show no favoritism to first-born children, being early in the birth order implies a distinct advantage solely because of the higher probability of being in a small family (Hanushek [1992]).

An ideal experimental setting to investigate the impact of sibling size would be where each family is required to raise a certain number of non-genetically related children, with the number determined at random. Although such an experiment would be difficult to implement, some researchers have observed samples of families with twin children, with the birth of a twin as an exogenous shock to the family size. Many researchers who worked with twin data found no evidence of such child quantity-quality tradeoff in their studies (Angrist, Lavy and Schlosser [2005]; Black, Devereux and Salvanes [2005]). In light of Lindert's idea, this finding seems to suggest that what has been viewed as the effect of sibling size largely captures the parental preference or ability toward grooming achievers. Thus, if the parents who are disposed toward raising few children were forced to raise more, the additional sharing of parental resources would not in itself have an adverse effect on children's achievement.

My study with adoptees adds to this literature, since such parental characteristics reflected in sibling size can be broken down into two factors—environmental and hereditary. The parents who are less oriented toward grooming high achievers may pass on certain genetic characteristics that make their children less inclined toward attaining greater education level or higher income. Using an adoption study, where children are assigned to parents at random, I can eliminate the genetic effect in the discussion and regard the observed effect of sibling size as entirely dependent on the environment. Of course in this case, the sibling size is determined by a parents' deliberate and well-considered decision to introduce another child to the family, reflecting their preference and beliefs on grooming achievers. Finding that larger sibling size depresses achievement in this case, combined with the findings from twins studies, would suggest that there exists an adverse environmental effect of having parents who are more inclined toward having many children in the family. Hence, from the equation (5), I estimate the effect of being placed in the family f' with a certain number of children, namely j number of children. Then the coefficient β_k on the sibling size dummy estimates the effect of being assigned to a family with j number of children; it does not only consider the effect of growing up with (j-1) siblings, but also accounts for the effect of being assigned to parents who are willing to raise j number of children.

Sibling composition and parental allocation of resources

I also add the following variables into the equation, [Any Female Sibling] and [Any Male Sibling], and estimate the effect of sibling gender composition on children's outcomes. Furthermore, by adding [Biological Children in the family], I test whether a new reference group is created for adoptees when there is a biological child present in the family.

The researchers who worked with data on twins and found no evidence of child quantity-quality tradeoff in their studies would reject the dilution model; their findings suggest that parental resources cannot be thought of as limited physical quantities divided among children, with each child becoming entitled to fewer resources as more siblings are introduced. However, even without the quantifiably divisible property, it is still possible to consider how different parents choose to allocate differently among their children.

Economists believe that the way parents thin out their resources among their children is dependent on the parents' preference toward the equity of success outcomes of their children (Becker [1981]). Equity-concerned parents will prefer all children attaining a similar level of achievement, while parents who prefer to maximize the sum of their children's achievements will devote more resources into children who are likely to attain higher levels of achievement given the same resources (Behrman, Pollak, and Taubman [1982]).

Some economists have considered the parental resources allocation behavior by looking at children's achievement in relation to the sex composition of siblings. Since a male has traditionally achieved a higher income level than a female of comparable background, those parents who want to maximize the total earnings of their children may devote more resources to male children's education. Interactions among siblings may also change depending on the sex composition of siblings (Butcher and Case [1994]). By observing the achievement of girls when a boy sibling is introduced to the family in Taiwan, Parish and Willis [1992] have found that girls who have brothers attain lower levels of education than those from families with only female siblings. Butcher and Case [1994], on the other hand, found that women raised only with male siblings have received more education on average than women raised with any sisters. They suggested a model based on the "reference group" theory, where parents with only one daughter measure their daughter's achievement on the same scale as their son's. A presence of another daughter, though, may set a separate standard that diminishes the achievement goal for the daughters.

Doing a similar study with a sample of adoptees has its limitations since parents may set a very different goal for the achievement of the adoptees as compared to the biological children. However, if I find the same results as that of Butcher and Case [1994], it would be very interesting, as it would indicate that parents set their goals for their daughters in a similar way for both biological and adopted children. Additionally, applying the "reference theory" to the case of adoptees may yield an important observation. For instance, if the adoptees with only biological siblings had higher achievements on average than the adoptees with other adoptive siblings, then this may indicate that the presence of another adoptee in the family would lead the parents to set a different goal for the adoptees.

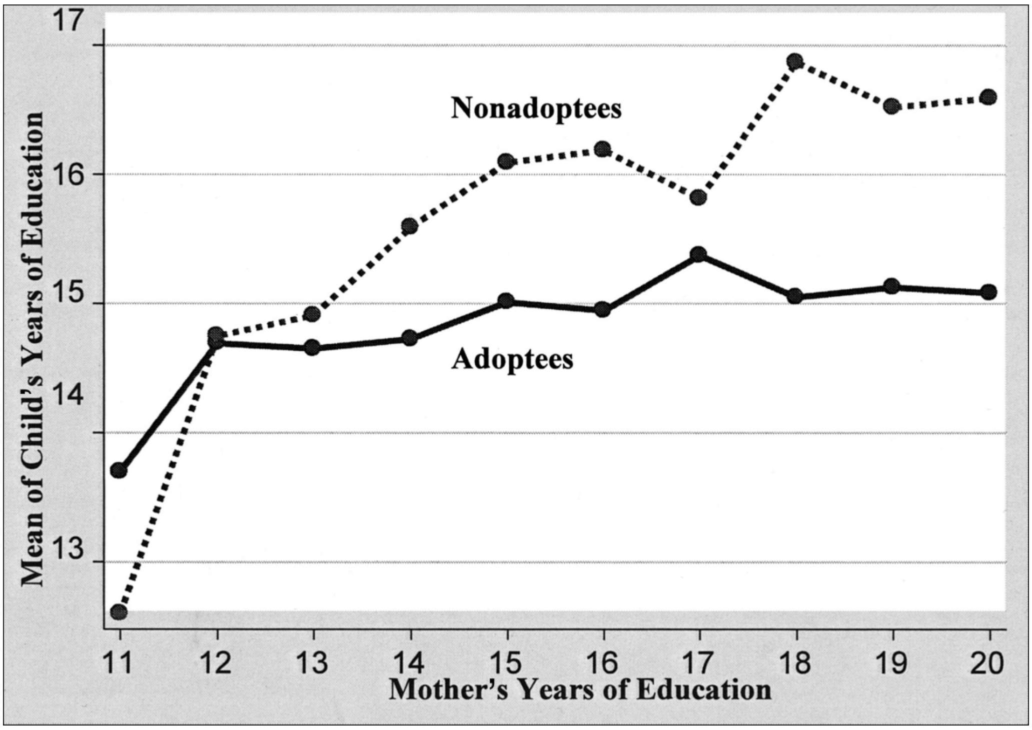
Transmission of Parental Education

As discussed in detail in section II, I am interested in finding out the hereditary influence of parents' education on children's education. The coefficients on the variables [Mother's years of education] and [father's years of education] can be interpreted as transmission coefficients, with the rest of the family-related and individual specific variables as control variables. The transmission takes place purely through nurture, since there is no genetic relationship between parents and adoptees. I can compare my results with the findings by other researchers.

B. Comparing the Transmission Coefficient for Adoptees and Biological Children

From comparing the educational outcomes of the children in the sample, I find that biological children on average attained more years of education than the adoptees. The following graph from Sacerdote's paper [2007] shows the mean of child's years of education for adoptees and biological children for each level of mother's education.

Figure 1.Mean Child's Years of Education vs. Mother's Years of Education



Source: Adapted from Sacerdote 2007, Figure 2, p. 20

Note: Dashed line is for non-adoptees (biological children). Solid line is for adoptees.

The difference in the levels of education for adoptees and biological children is apparent from the above figure. This difference may result from reasons other than the absence of genetic relation between parents and adoptees. However, many of the factors that could depress adoptees' educational achievement are common to all adoptees; they are all Korean babies orphaned in similar time periods and adopted into American households as babies. Therefore, the factors that may have negatively depressed academic achievement of adoptees collectively are controlled for by the dummy that indicates the child is an adoptee. Hence, I am interested in finding out to what extent this difference is attributable to the genetic transfer of intelligence between parents and their biological children. Furthermore, I wish to compare the outcomes of adoptees and biological children in the same family. In order to best approach this problem, I use the general model, which accounts for the family fixed effect as well as the difference in the parental influence on adoptees and biological children. The equation of interest is reproduced below:

(6)
$$y_{if} = \alpha + \beta_0 B_{if} + \sum_{k=1}^{m} [\beta_k x_{kif} + \theta_k x_{kif} * B_{if}] + \sum_{j=1}^{n} \delta_j c_{jif} + \eta_f F_{if} + \mu_{if}$$

When I compare the outcomes of two children i' and i, the equation becomes

(7)
$$y_{i'f} - y_{if} =$$

$$\beta_0(B_{i'f} - B_{if}) + \sum_{k=1}^{m} [\beta_k(x_{ki'f} - x_{kif}) + \theta_k(x_{ki'f} * B_{i'f} - x_{kif} * B_{if})] + \sum_{j=1}^{n} \delta_j(c_{ki'f} - c_{kif}) + (\eta_{f'} - \eta_f) + (\mu_{i'f} - \mu_{if})$$

When we perform a fixed effect regression that assigns dummies to each family, the family-related variables, $x_{ki'f}$, become differentiated away. Hence we are left with $x_{ki'f} * B_{i'f}$, which are family specific characteristics interacted with the dummy for whether the child is a biological child. In the first part of my analysis which used equation (5), β_k signified the environmental effect related to x_{kif} on the adoptee's outcome. In the present analysis that includes both adoptees and biological children, β_k is assumed to be the same environmental effect for both adoptees and biological children in a family, while θ_k signifies the extra effect of the given parental characteristic on biological children. The variables to be used in the regression are listed in the following table.

Table 5. Variables in the genetic transfer analysis

	Mother's years of education*Bio
	Father's years of education*Bio
	log family income at time of adoption*Bio
$x_{ki'f} * B_{i'f}$, family specific characteristics interacted with the indicator $B_{i'f}$	Mother's BMI*Bio
	Father's BMI*Bio
	Mother Drinks*Bio
	Father Drinks*Bio
	Child's gender
c_{kif}, individual specific characteristic	Child's age
	Biological Child

Hence, I can find out the additional correlation between the biological child's education and parental characteristic in comparison to that involving an adoptee. Having more information about the adoptee's birth parents' characteristics could be helpful to my analysis, but since the birth parents' characteristics are not correlated with adoptive parental characteristics, the error would be random.

Section V. Important Results and Interpretation

A. Comparing the Outcomes of Adoptees in Different Family Environments

Table 6 shows the impact of family environment on children's educational outcomes. Each of the columns display adopted children's educational attainment regressed on key family characteristics, corresponding to the equation (5) and its specifications. As stated before, the sample is limited to the last child of each family, and all regressions are controlled for child's age, the year child entered Holt system, and child's age at adoption, which are not displayed in the table. The regression in column [1] only includes the dummies that correspond to the specific number of children in the family, while [2] also includes variables for parent's education and income. [3] includes additional dummies that signify different sibling compositions in the family, such as the presence of a biological child or a male sibling in the family. [4] and [5] are the same regressions as [3], but the sample is separated into male adoptees and female adoptees. [6] includes additional variables that relate to parent's BMI and smoking status. [7] and [8] are the same regressions as [6], but the sample is again separated into male adoptees and female adoptees.

Table 6. Educational Attainment of Youngest Adoptees

	[1] pooled	[2] pooled	[3] pooled	[4] female	[5] male	[6] pooled	[7] female	[8] male
2 Children	-0.423	-0.669	-0.714	-0.376	-2.519	-0.678	-0.373	-2.334
	(0.378)	(0.393)**	(0.489)	(0.561)	(1.576)	(0.592)	(0.672)	(0.186)
3 Children	-0.080	-0.287	-0.412	0.049	-2.072	-0.430	-0.073	-1.302
	(0.386)	(0.400)	(0.547)	(0.639)	(1.884)	(0.725)	(0.834)	(0.549)
4 Children	-0.462	-0.615	-0.781	-0.253	-2.924	-0.625	-0.056	-2.319
	(0.417)	(0.433)	(0.601)	(0.709)	(1.887)	(0.799)	(0.928)	(0.287)
5 Children or more	-0.853	-1.160	-1.433	-1.312	-2.061	-1.328	-1.251	-1.964
	(0.504)*	(0.521)**	(0.729)*	(0.838)	(1.981)	(0.953)	(1.080)	(0.424)
Mother's years of education		0.081	0.082	0.097	0.128	0.099	0.097	0.128
		(0.049)	(0.050)*	(0.059)	(0.119)	(0.054)*	(0.066)	(0.316)
Father's years of education		0.011	0.011	-0.007	0.082	0.008	-0.003	0.126
		(0.043)	(0.043)	(0.051)	(0.106)	(0.047)	(0.055)	(0.313)
log family income at time of adoption		-0.251	-0.246	-0.278	-0.214	-0.279	-0.347	-0.127
		(0.175)	(0.177)	(0.204)	(0.440)	(0.191)	(0.224)	(0.793)
Family has a biological child			0.352	0.507	-0.698	0.008	-0.018	-0.339
			(0.377)	(0.434)	(0.957)	(0.342)	(0.410)	(0.671)
Any female sibling			0.032	0.052	0.380	0.227	0.099	0.056
			(0.366)*	(0.409)	(1.327)	(0.428)	(0.483)	(0.969)
Any male sibling			0.089	-0.241	0.633	0.177	-0.186	0.615
			(0.376)	(0.447)	(0.897)	(0.424)	(0.499)	(0.575)
Mother's BMI						-0.010	-0.030	0.107
						(0.026)	(0.030)	(0.112)
Father's BMI						0.011	-0.002	-0.015
						(0.030)	(0.037)	(0.814)
Mother Drinks						-0.066	-0.396	0.968
						(0.305)	(0.356)	(0.200)
Father Drinks						0.051	0.383	-0.828
						(0.309)	(0.361)	(0.330)
last adoptee is male	-0.592	-0.509	-0.475			-0.646		
	(0.250)**	(0.257)**	(0.317)			(0.345)*		
Constant	21.714	22.122	21.954	15.8385	15.868	15.909	23.332	18.637
	(3.988)**	(4.220)**	(4.261)**	(2.417)**	(3.020)**	(2.636)**	(3.886)**	(6.448)**
Number of Observations	450	430	430	328	102	388	295	93
R-squared	0.1274	0.1347	0.137	0.1611	0.3186	0.1436	0.1634	0.4018

- Controlled for child's age, the year child entered Holt system and child's age at adoption.
- One star (*) indicates significance at 10% level, two stars (**) indicates significance at 5% level. Number in grey indicates standard deviation.

I perform an F-test to see if accounting for different gender significantly improves the fit of the regression. My null hypothesis is that separated regressions do not provide a significantly better fit than the pooled one. Comparing [3] with the separated regressions [4] and [5], I find the F-value of 33.12 with (1,384) degrees of freedom. The 0.01 critical value for the F-test is smaller than 6.85. The null hypothesis is rejected since the F calculated from the data is greater than the 0.01 critical value of the F distribution. Similarly, comparing [6] with the separated regressions [7] and [8], I find an F-value of 36.43 with (1, 339) degrees of freedom. I reject the null, since this is smaller than the 0.01 critical value.

From [1], I see that the coefficient for each of the dummies that indicate the number of children in the family is negative. This indicates that the years of total education of an adoptee who has one or more siblings is lower than that of an adoptee who has no siblings. Adoptees with one more sibling receive -0.423 less years of education than adoptees who are only children in the families. Adoptees who have 2 other siblings receive -0.080 less years of education than only-child adoptees. Furthermore, the educational attainment of adoptees with 3 other siblings is lower than the adoptees with just one other sibling, and the negative effect is even greater for adoptees with more than 3 siblings. Adoptees with 3 other siblings receive -0.462 less years of education, while adoptees with more than 4 or more siblings will receive -0.853 less years of education. This last coefficient is significant at a 10% level.

Similar observations are made regarding the number of siblings when other variables are added to the regression. With other family characteristics controlled in [2], [3], and [6], I still observe that having a sibling lowers the adoptee’s educational attainment, and having more than 3 siblings has a greater negative impact on an adoptee’s education than having just one other sibling. When the family characteristics such as parental income and education, the existence of a biological child in the family as well as sibling gender are controlled, having one other sibling decreases an adoptee’s educational attainment by -0.678 years. Having two other siblings decreases an adoptee’s education by -0.430 years, and having three other siblings has a negative impact of -0.625 years on the adoptee’s education. Having 4 or more siblings would decrease the adoptee’s educational attainment by -1.328 years, as opposed to when the adoptee is an only child. While the numbers slightly vary depending on the number of control variables, the coefficients on the number of sibling dummies remain negative.

In light of the previous literature, this coincides with the findings that raising a greater number of children is associated with lower levels of educational attainment of children. From twin studies, researchers have suggested that this may be due to the fact that parents who are more apt to groom achievers may choose to have fewer children. In my study, the family size for the each of the last adoptees has been determined solely by the adoptive parents' decision to introduce one more child in the family. I still find that an increase in sibling size indeed has negative effect on adoptees' education even when parental income and education level are controlled for, and there is no genetic relationship between parents and children; this suggests that parents who make the choices to have fewer children may indeed create a certain kind of home environment that encourages children to attain more education.

Considering the effect of sibling composition on adoptees' educational outcomes, I find that the presence of a female sibling in the family unequivocally has a positive effect on the adoptee's education, while the presence of a male sibling in the family depresses female adoptee's educational attainment. In column [6], I see that having a female sibling increases the adoptee's education by 0.227 years, given that the sibling size, parental characteristics are controlled for in the regression. On the other hand, the presence of a male child in the family depresses the female adoptee's education by -0.186 years, while the effect is positive for male adoptees at 0.615 years. This is much like the result found by Parish and Willis (1992), who observed that Taiwanese girls who have brothers attain lower levels of education than those from families with only female siblings.

Results in column [3] and [6] indicate that the effect of having a biological sibling is positive on the adoptee's education level. However, when the regression is run on the sample of male adoptees, the presence of a biological child in the family depresses the male adoptee's educational attainment. In [5], having a biological child in the family decreases the male adoptee's education by -0.698 years. When more control variables regarding parents' BMI and drinking status are added to the regression in [8], the presence of a biological child still decreases the male adoptee's education by -0.339 years. This negative effect is not existent or not as severe in the cases of female adoptees. In [7], the presence of a biological child depresses the female adoptee's education by -0.018 years, which is one thirds in magnitude compared to the coefficient for male adoptees.

I also look at the transmission coefficients between parental education and adoptees' education. As expected, higher level of mother's education has a positive correlation with adoptee's education. In all columns, the coefficient for mother's education turned out positive. In column [6], it is shown that the transmission coefficient between mother's years of education and adoptee's years of educational is 0.099, meaning a one year increase in mother's years of education is associated with a 0.099 year increase in child's education. Father's educational attainment similarly has a positive transmission coefficient, but had mixed results when the regression was run separately for female and male adoptees. In pooled cases of [3], the transmission coefficient is positive at 0.011. Even when more variables are controlled for in [6], the result is similar and the coefficient is 0.008. However, when the regression was limited to the sample of female adoptees, father's education no longer has a positive transmission coefficient. In [4], the coefficient for father's years of education is -0.007, and it is -0.003 when sibling composition is controlled for in [7]. For male adoptees, on the other hand, increasing father's education by a year has a stronger positive effect. It is associated with an increase in adoptee's education by 0.126 years, as shown in [8].

Interestingly, the family's income at adoption appears to have a negative effect on adoptee's education. This is observed in every single regression, as shown by the negative slopes for the variable in all columns. This may be due to the measurement error associated with the variable. The survey respondents' answers regarding their income decades ago may not be very accurate; furthermore, they reported their income in a broad range, which may have distorted the results. The results in column 6 show that the coefficient on the log of family income at the time of adoption is -0.279.

From the regression results shown in Table 6, I found that the transmission coefficient between parents' and adoptees' years of education is positive. Especially, I found that the transmission coefficient between mother's and adoptee's education to be 0.082 in column [3], where the regression is controlled for sibling size, parental education and income, and sibling composition. The coefficient was 0.099 in column [6], where variables related to parental drinking status and BMI were added to the regression. To verify the validity of my transmission coefficients, I compare such numbers with the transmission coefficients found by Sacerdote [2007]. Sacerdote's transmission coefficients were found by regressing child's education on mother's education, with only individual specific variables such as child gender, age, year entered into the Holt system. I also attempt to reproduce his results to show that I understand his regression methods correctly.

Table 7. Reproduction of Sacerdote's Transmission Coefficients

	Sacerdote's Results		My Results	
	Adoptee	Biological	Adoptee	Biological
Years of education	0.089	0.315	0.081	0.298
(mother to child)	(0.029)**	(0.038)**	(0.027)**	(0.028)**
Height inches	-0.004	0.491	-0.021	0.499
(mother to child)	(0.034)	(0.049)**	(0.035)	(0.036)**
Is obese	0.003	0.108	0.007	0.105
(mother to child)	(0.020)	(0.034)**	(0.020)	(0.020)**
Is overweight	-0.026	0.174	-0.027	0.170
(mother to child)	(0.029)	(0.037)**	(0.028)	(0.030)**
BMI	0.002	0.221	0.003	0.239
(mother to child)	(0.025)	(0.045)**	(0.025)	(0.027)**

Source: Part of the table is adapted from Sacerdote 2007, Table 8, p. 30
Note: One star (*) indicates significance at 10% level, two stars (**) indicates significance at 5% level. Number in grey indicates standard deviation.

Table 7 lists some of the transmission coefficients Sacerdote found as well as my replication results. The coefficient for years of education between mother and adoptee is 0.089 in Sacerdote's results, and I find it to be 0.081. Despite the slight difference which could result from individuals omitted during data organizing process, these numbers are very similar to my transmission coefficients in table 6.

Sacerdote also observed that the transmission coefficient is significantly higher for the biological children, for all of the above listed characteristics. I am especially interested in analyzing the education transmission coefficient for adoptees and biological children. This leads to the second part of my analysis.

B. Comparing the Transmission Coefficient for Adoptees and Biological Children

Before I perform a fixed effect regressions based on the models in equations (6) and (7), I perform a general multi-variable regression. As Sacerdote [2007] explains, many "unobservables covary with income, parental education, neighborhood quality, etc, so it is impossible to definitively separate out root causes"; however, multi-regressions are still widely used in related literature, and I can see which of my variables have the largest influence on children's levels of education.

Table 8 shows the multi-variable OLS regression on children's educational outcomes. Since the sample of the survey includes also biological children of the adoptive parents, I can compare the differences in the slope of the adopted children and biological children. The regression in column [1] is a simple OLS regression on the listed family related and individual specific variables. Column [2] includes additional control variables such as parental BMI and parents' drinking status. [3] and [4] are same regressions as [2] performed on the samples divided into adoptees and biological children. From the table, it is apparent that the correlation between children's education and mother's education is the largest and is significant at a 5% level. It is notable that the slope for biological children is greater than that of adopted children. The slope for father's education is also positive, except for when the sample is limited to adoptees. It is also interesting that parental BMI shows negative correlation with the children's educational attainment while parents' drinking status has a positive correlation.

Comparing the slope on [Mother's years of education] for adoptees and biological children, I find that the slope is 0.092 for adoptees, much like the transmission coefficient shown in Table 7 column [6]. On the other hand, the slope is 0.156 for biological children, which is 0.064 greater than the coefficient for the adoptees. Looking at [Father's years of education], I find that the coefficient is negative for adoptees at -0.019, but positive at 0.204 for biological children. These results indicate that the correlation between parents' and children's education is greater on biological children.

Table 8. Multi-variable regression on Children's educational outcomes

	[1] pooled	[2] pooled	[3] adoptee	[4] bio
Child is a biological child	1.038	1.055		
	(.124)**			
Mother's years of education	0.113	0.118	0.092	0.156
	(.022)**	(.023)**	(.031)**	(.033)**
Father's years of education	0.095	0.083	-0.019	0.204
	(.019)**	(.02)**	(.027)	(.029)**
log family income at time of adoption	0.083	0.032	-0.030	0.001
	(.068)	(.073)	(.102)	(.101)
Mother's BMI		-0.028	-0.035	-0.022
		(.011)**	(.014)**	(.016)
Mother Drinks		0.133	0.016	0.251
		(.123)	(.167)	(.174)
Father BMI		-0.017	0.005	-0.047
		(.012)	(.016)	(.018)**
Father Drinks		0.098	0.107	0.156
		(.126)	(.173)	(.176)
Number of Children in the family	-0.080	-0.085	-0.141	0.046
	(.041)*	(.043)**	(.062)**	(.061)
Family has a biological child	-0.176	-0.185	-0.010	
	(.134)	(.141)	(.15)	
Any female sibling	-0.216	-0.131	-0.091	-0.255
	(.131)*	(.137)	(.178)	(.223)
Any male sibling	-0.053	0.016	-0.040	-0.166
	(.117)	(.122)	(.176)	(.174)
Child is Male	-0.230	-0.275	-0.636	0.110
	(.115)**	(.12)**	(.169)**	(.174)
Constant	12.032	12.995	14.473	11.344
	(.474)	(.659)	(1.112)**	(.945)**
Number of Observations	2227	2031	1088	943
R-squared	0.091	0.111	0.069	0.203

*controlled for children's age, which is not displayed.
* One star (*) indicates significance at 10% level, two stars (**) indicates significance at 5% level. Number in grey indicates standard deviation.
* I test the null hypothesis that separated regressions [3] and [4] do not provide a significantly better fit than the pooled regression in [2]. My F is 119.69 with (1, 2006) degrees of freedom, which is greater than the 0.01 critical value. Hence I reject the null.

However, this multi-variable regression compares the educational attainments of adoptees and biological children from similar family environments. Since the first part of my analysis shows that parents may possess unobserved parenting skills that greatly influence the rearing environment, I perform a fixed effect regression to include additional dummies that control for having the same parents. In this fixed effect regression, all the terms that are common to each family are differentiated away and we are only left with the italicized variables, which are obtained by multiplying the dummy for biological children with family specific control variables, such as mother's education, family income, parents' BMI and smoking status. The results are shown in Table 9.

The results from Table 9 show that the average educational attainment of adopted female children in the sample is 14.647 years, as indicated by the constant. The signs of the coefficients on the interacted variables are mostly as expected. Given the same parents and home environment, a year of increase in [Mother's years of education] is shown to have an additional effect of 0.150 years of increase in education for biological children, in comparison to adoptees. The coefficient for [Father's years of education] is also positive and even greater at 0.206. Family income at adoption has a negative coefficient, which is understandable since this variable consistently had negative coefficients in previous regressions, seemingly having negative effects on children's education. [Mother's BMI] and [Father's BMI] both have negative coefficients, indicating that high levels of parental BMI have a greater negative effect on biological children's educational attainment. It makes intuitive sense that a highly inheritable trait like BMI has a more significant impact on biological children's education. Interestingly, having parents who are drinkers seems to have additional positive effect on biological children's education.

Table 9. Child's educational attainment; fixed effect regression

	[1]
Child is a biological child	-2.999
	(0.889)**
*Mother's years of education*Bio*	0.150
	(0.034)**
*Father's years of education*Bio*	0.206
	(0.029)**
*log family income at time of adoption*Bio*	-0.006
	(0.104)
*Mother's BMI*Bio*	-0.023
	(0.017)
*Father BMI*Bio*	-0.048
	(0.018)**
*Mother Drinks*Bio*	0.278
	(0.179)
*Father Drinks*Bio*	0.159
	(0.182)
*Number of Children*Bio*	-0.002
	(0.056)
Child is Male	-0.184
	(0.117)
Constant	14.647
	(0.336)
Number of Observations	1554
R-squared	0.152

* sample in the regression is limited to the children who are in families that include at least one biological child.
* all the italicized variables that has *Bio in its name are multiplied with a dummy indicating whether the child is a biological child.
* controlled for children's age, which is not displayed.
* One star (*) indicates significance at 10% level, two stars (**) indicates significance at 5% level. Number in grey indicates standard deviation.

This result shows that a significant part of the gap between educational attainment of biological children and adoptees can indeed be attributed to the genetic relationship between parents and biological children. From the first part of my analysis, I found that a one year increase in mother's years of education increases the adoptees' by 0.099 years. The result in Table 9 suggests that given a biological child in the same family, a one year increase in mother's years of education will have an effect greater than 0.099 years, due to the genetic influences. Although it is not possible to simply add the two coefficients together to get the effect of such increase on biological children, the positive coefficients on parental education variables nonetheless have an interesting implication; the more educated the parents are, the greater the gap between biological children and adopted children would be. This coincides with the general trend displayed in Figure 1, where the distance between the education level of adoptees and biological children diverges as mother's years of education increases. Hence while having highly educated parents has a positive effect on adoptee's educational attainment, it appears to have an additional positive effect on biological children due to the genetic heritability of intelligence, which causes a significant difference in such children's educational attainment.

Section VI. Conclusions and Future Work

In this research, I introduced a comprehensive model that can be used to analyze parental influences on children's outcomes. By applying the model to the data on Korean American adoptees, I attempted to quantify the treatment effect of growing up in different family environments as well as identify the effect genetic inheritability of intelligence. I found that the transmission coefficient between mother's years of education and adoptee's years of education is 0.099, indicating that a one year increase in mother's education is associated with 0.099 year increase in child's education. Similarly, I found father's educational attainment has a positive transmission coefficient, but has mixed results when the regression was run separately for female and male adoptees.

I also found that an increase in the number of siblings has a negative effect on adoptee's educational attainment, even when parental income and education level are controlled for. Such findings suggest that parents who make the choices to have fewer children may indeed create a better kind of home environment for the adoptees to attain more education. Regarding sibling composition, I found that the presence of a female sibling in the family unequivocally has a positive effect on the adoptee's education, while the presence of a male sibling in the family depresses female adoptee's educational attainment. Furthermore, the presence of a biological child in the family depresses the male adoptee's educational attainment.

In the second part of my analysis, I found that the gap between the educational attainment of adoptees and biological children are significantly attributable to the genetic transfer of education (or intelligence) from highly educated parents to their biological children. In a regression that controls for the same parents and home environment, a year of increase in [Mother's years of education] is linked to 0.150 years of additional increase in biological children's education, in comparison to adoptees. The coefficient for [Father's years of education] is also positive and even greater at 0.206. Due to this significant, positive additional effect on biological children from the parents, an increase in parent's education leads to a greater difference in the educational attainment of adoptees and non-adoptees.

The data set has the following constraints, without which my analysis may be improved. Firstly, the survey sent out by Holt International only asked the parents to fill in the information up to five children they have. Because 6% of the families in the sample have more than 5 children, the incompleteness of data can influence the results, especially since the information is not omitted at random but is specifically missing for those children in large families. Secondly, the income measure appears noisy, which may account for the parental income measures appearing insignificant to children's educational attainment and having negative coefficients. Also, having more information on the biological parents of the adoptees can improve my analysis. Having such information allows a comparison between the educational attainment of the adoptees who have less educated biological parents and highly educated adoptive parents, with those in the opposite situation—with highly educated birth parents and less educated adoptive parents. Such a comparison may add further insight to the relative importance of genetic and environmental influences on children's outcomes.

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Appendix A. Evidence of Random-Assignment and Non-selective Response to the Survey

As explained in the data description section, adoptees were assigned to the eligible families on a first-come, first-serve basis, making the process effectively randomized. Sacerdote [2007] offers some statistical evidence to show that the assignment process is indeed random. By regressing pre-treatment (before adoption) characteristics of adoptees on pre-treatment characteristics of the adoptive parents, Sacerdote [2007] shows that these characteristics are uncorrelated. Here is a brief summary of the results from his regressions. None of the family background characteristics, such as the log of family income, parental education, and median income in adoptive family's zipcode area are statistically significant predictors of adoptee age at arrival, height, weight or gender.

For a very small number of cases, the data includes information on the birth mother's marital status, age at adoptee's birth, and years of education. Doing similar regressions, Sacerdote [2007] also finds no statistically significant relationship between birth mother characteristics and adoptive family characteristics. Also the initial survey had a low response rate of 34%. To find out if only the parents who had adoptees with more successful outcomes responded to the survey, Sacerdote sent out the surveys again to a portion of the non-respondents. Using the resurvey data and the complete data in Holt records, Sacerdote showed that adoptee outcomes are not statistically significant predictors of the parents' decision to respond to the original survey. The details of the regression results can be found in "How Large Are the Effects from Changes in Family Environment? A Study of Korean American Adoptees" [2007].

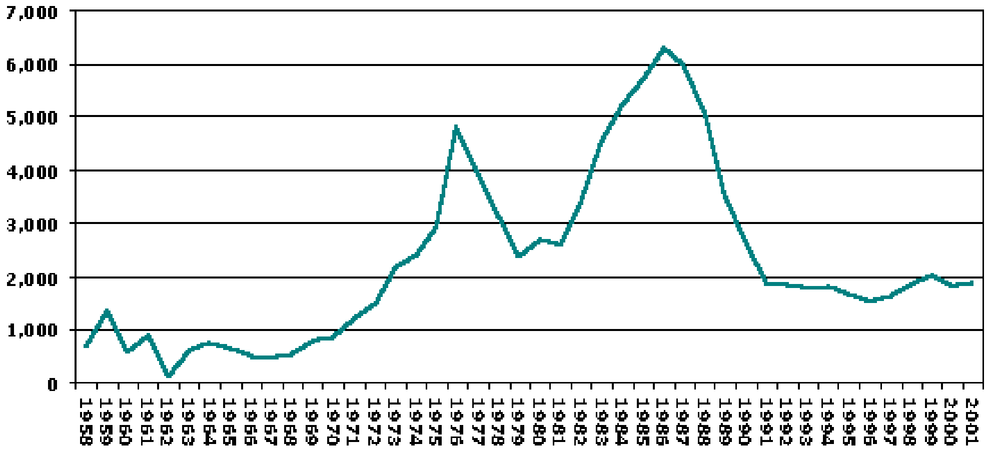
Appendix B. History of Korean American Adoption

According to Nelson [2009], sustained large-scale transracial adoption in the US, including transnational adoptions, began in the 1950s. The first recorded instance of Korean adoptee being placed in an American home occurred in 1953, just five years after the first domestic transracial adoption of an African American child to a white family (Nelson). The first generation of Korean adoptees consisted mainly of war orphans from the aftermath of the Korean War. Many were fathered by U.S. military personnel and were ostracized in South Korea for their biracial heritage. In the ensuing years, out-of-wedlock births and a small social welfare budget have been the prime reasons for international adoptive placement (Chun [2000]).

Although the initial numbers of Korean adoptions were small, Korean adoptions became an icon of a transracial and transnational adoption. A lot of media attention was given to the small group of Korean adoptees who arrived in the US, since all other Asian nationals were strictly barred from legal immigration to the US. Moreover, the story of Bertha and Harry Holt adopting eight Korean children in 1955 became a media sensation, establishing the narrative of a war orphan rescued and placed into benevolent while families. Many families became interested in adopting Korean babies, and from helping those families via correspondences, the Holts went on to create Holt Adoption Agency, which since became responsible for over 30,000 Korean-American adoptions until today (Nelson).

There was a great increase in transracial and transnational adoptions in the 1960s and 1970s, a significant part of which were Korean adoptions. Scholars attribute the general increase to a number of factors, including the followings. First, there was a decrease in the number of adoptable white infants, due to better family planning and improved standards of living for households. Also, as baby boom generation reached the age of parenthood, the number of parents wishing to adopt increased. The civil rights movement and the related effort to desegregate the American society may have also promoted the idea of transracial adoption (Nelson).

Figure 2. Number of Adoptions of Korean Children by American Families



Source: Adapted from *International Adoption Facts*, the Evan B. Donaldson Adoption Institute

The number of Korean adoptions fell sharply in the 1990s. Having hosted Seoul Olympics in 1988, a sense of national shame emerged about still sending away a large number of children to other countries. As South Korean economy continued to expand, becoming one of the 20 largest economies in the world, the number of South Korean children put away for adoption decreased (Nelson). In 1990, South Korea was the primary country from which U.S. citizens adopted, representing over 30 percent of U.S. international adoptions. In 2001, South Korean adoptions dropped to 10% of the total. Today, China, Russia, and Ukraine are now among the top adoptee-sending countries (US State Department). Given the South Korean government's present effort to further decrease the number of adoption, it is likely that South Korea will cease to be among the countries that send the most number of children to the US.

Appendix C. Holt International and Their Adoption Process

Since its establishment in1955, Holt Adoption Agency grew into what is now called Holt's International Children's Services, which has been involved in 30 to 40 percent of the total adoptions of Korean children by the US families. About 300 Korean adoptees every year are placed by Holt and hundreds more from China and from programs in Bulgaria, Guatemala, Ukraine, U.S., India, Ethiopia, Nepal, Philippines, Mongolia, Haiti, Uganda, Thailand and Vietnam (Sacerdote [2007]).

The process of adopting through Holt's Korea program takes about 24 months from the time of application. The important steps include application filing, home study assessment participation, adoption education class attendance, criminal background check clearance, matching with an adoptee, adoptee flying to the U.S., and legal adoption of child in family court. Due to U.S, and South Korean law, adoptive parents must have income over 125 percent of the poverty level, be between ages of 25 and 45, and been married for three years of longer. Also, they cannot have more than four children in the current family. Holt's Children's Services in Korea, which functions independently from Holt International Children's Services, is responsible for connecting children with qualified adoptive parents and conducts this in a manner that randomly assigns children into families (Sacerdote [2007]).

Unlike many other adoption agencies, which allow parents to directly interact with children in orphanages and choose children based on the recommendation of adoption agents and personal inclination, Holt International bases its adoption process on randomized matches of parents and children. Once qualified to adopt within this program, children are assigned to families on a first come, first served basis, regardless of the background of parents. Parents are not allowed to specify gender or anything else about their future adoptees. Children who are older, have siblings also up for adoption, or have disabilities are adopted through a separate process, which does not pertain to our data. One exception to the rule is that families with all boys are permitted to ask for a child of the opposite gender (Holt International).