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Causal Effects of Parents' Education on Children's Education

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NON TECHNICAL SUMMARY

Much research, in recent years, has focused on the link between parental education and children's education. More educated parents have, on average, better educated children. The policy implications of a link between parental education and children's education are huge. Increasing education today would lead to an increase in the schooling of the next generation and, in this way, to an improvement of later life outcomes such as health, productivity and wealth.

One simple way to measure how the family background is important in determining children's educational attainment - which we define as years of schooling - is to observe how much siblings are likely to study for a similar number of years compared to two unrelated people in the population. This comparison is informative of the importance of the family background.

How do parents influence their children's schooling attainment? Parents transmit some abilities genetically, they may influence children's development by stimulating them, and they may influence children's decisions. One important channel is parental education: do more educated parents influence their children's education "better"?

This paper shows that parents' education is an important determinant of children's education, but hardly an exclusive part of the common family background that influences the educational attainments of siblings from the same family. Our results based on Norwegian data indicate that an additional year of either mother's or father's education increases their children's education by as little as one-tenth of a year. From our analyses and from previous works, there is evidence that father's education is more important than that of mothers in influencing children's educational attainment. One possible explanation for a smaller maternal effect is that better educated mothers work more in paid employment and spend less time interacting with their children.

We test this hypothesis by comparing years of schooling of children of almost-identical mothers: mothers with the same age, same education, same number and age of children, and same husband's level of education but different years of working career when their children were young (4 and 7 years old). We do not find evidence of any detrimental effect of time spent in the labor market on children's years of schooling.

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Abstract: The paper shows that parents' education is an important, but hardly exclusive part of the common family background that generates positive correlation between siblings' educational attainments. Our estimates based on Norwegian twins indicate that an additional year of either mother's or father's education increases their children's education by as little as one-tenth of a year. There is evidence that father's education has a larger effect than that of mothers: one explanation is that better educated mothers work more in paid employment and spend less time interacting with their children. We test this hypothesis and find no evidence to support it.

Keywords: intergenerational transmission, education, mother's time, twin-estimator, sibling-estimator

JEL Classification: C23, I2

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1. Introduction

The association between parents' and their children's educational attainments has been one of the measures featured in the study of intergenerational mobility. It has either been the focus itself or has been part of the exploration of the reasons for earnings, income or social class persistence--the opposite of mobility (for example, see Blanden et al. 2010). Parental education is of course just one aspect of family background that influences children's subsequent achievements as adults, but an important one. For instance, parents' educational attainments have a large impact on their earnings; they may alter the 'productivity' of their time investments in children, such as reading to the child; and they may affect children's aspirations.

Another motivation for this study is the substantial rise in educational attainments across generations, with women's qualifications having increased more than men's in nearly all OECD countries (Buchman and DiPrete 2006). An important question is whether an increase in parents' education will increase the educational attainments of their children, with attendant impacts on their children's health, productivity, lifetime income and 'life chances' more generally. Because of the different trends by gender, we also would like to know whether mother's and father's education have different causal impacts on their children's education.

Table 1: Average Parent-Child Years of Education Correlation*

Country	Correlation
Italy	0.54
USA	0.46
Switzerland	0.46
Ireland	0.46
Poland	0.43
Belgium (Flanders)	0.40
Sweden	0.40
Czech Republic	0.37
Netherlands	0.36
Norway	0.35
New Zealand	0.33
Finland	0.33
Great Britain	0.31
Denmark	0.30

*Average of Mothers' and Fathers' Education, Ages 20-69, Surveyed 1994-2004
Source: Hertz et al. 2007.

In the current study we aim to estimate the causal impacts of parents' education. We focus on a comparison between the USA and Norway, although we compare Norway with some other countries to a more limited extent. Table 1, taken from a recent study (Hertz et al. 2007), puts the two countries in the context of other developed countries. It reports the average correlation (across 9-10 five-year birth cohorts) between the average of parents' years of education and those of their children.[1] With the Norwegian register data that we use in this paper (described further later in the chapter), the corresponding correlation is 0.38.[2] The correlation for the USA is clearly much higher.

Such a correlation, or a corresponding coefficient from a regression of children's education against that of their parents,[3] is unlikely to reflect solely a true causal effect of parent's education on that of their children. For instance, if people's 'abilities' affect their educational attainment and parents' and children's 'abilities' are correlated, then the regression coefficient will also reflect this correlation. Recent studies of the correlations in cognitive test results between parents and their children indicate substantial correlations, of the order of 0.4 (Anger and Heineck 2009, Black et al. 2009, Björklund et al. 2010). 'Ability' need not only reflect genes, but also skills acquired during childhood. Aspects of the family environment that promote acquisition of such skills may also be correlated with parents' educational attainments and their abilities,[4] further undermining a causal interpretation of the intergenerational correlation. The results of the twins' analyses reported later in the paper indicate that, at least for Norway, the USA and Sweden, the correlations reported in Table 1 overstate the causal impact of parents' education on children's education, and we suspect that this is also the case for other countries.

The theoretical framework provided in section 3 is used to structure empirical analyses that may allow us to identify the causal impact of mother's and father's education on that of their children. Before that it is helpful to put parents' education in the context of family background viewed more generally.

2. Sibling correlations

The correlation between siblings in some outcome such as educational attainment is a broader measure of family background and community effects on that outcome than the parent-child correlation (Björklund et al. 2008). The Norwegian register data described in detail in section 4 allow us to compute correlations in years of education between siblings born in the years 1973-78 (aged twenty-three to twenty-eight in 2001 when we observe their educational attainment). Table 2 shows these correlations for twins, combining monozygotic (MZ) and dizygotic (DZ) twins, non-twin siblings and siblings born close together (differences in age of between nine and thirteen months), distinguishing between brothers and sisters.

Table 2: Sibling Correlations in Years of Education

A.

Twins	Correlation	N
All	0.53	2807
Pair of brothers	0.59	932
Pair of sisters	0.62	1027
One brother, one sister	0.35	848

B.

Siblings, at most 5 years difference in age	Correlation	N
All	0.37	68,957
Pair of brothers	0.38	18,225
Pair of sisters	0.41	16,256
One brother, one sister	0.32	34,476

C.

Siblings, 9-13 month difference in age	Correlation	N
All	0.42	2798
Pair of brothers	0.46	714
Pair of Sisters	0.42	656
One brother, one sister	0.39	1428

Focussing on same-sex correlations, the correlations are about 0.6 for twins and 0.4 for non-twins, with the non-twin sibling correlation being slightly higher if the birth interval between siblings is small. The sibling correlation indicates what fraction of the total variance in years of education is attributable to shared family and community, and the relationship between the sibling correlation and the parent-child (intergenerational) correlation is as follows (Björklund et al. 2008): sibling correlation = (parent-child correlation)^2 + other shared factors that are uncorrelated with parents' education. In the samples in panel B of Table 2, the parent-child education correlation (using average parents' education) is 0.38, implying that only 0.14 (35 percent) of the 0.4 non-twin sibling correlation in education arises because of the educational attainment of their common parents. The rest is due to other common family and community factors.

A similar sibling correlation in years of education is obtained for a relatively small sample (229 families, 487 people) of British young people born between 1972 and 1984 (born in 1979 on average) observed when aged twenty-two or older (mean age=twenty-six) who can be matched to their brother or sister: the sibling correlation is 0.35.[5] The correlation between the average parental years of education and the child's years of education in this sample is 0.36, and so it accounts for 37 percent of the sibling correlation.[6]

In order to explore further how parents' education and other attributes reduce the variance attributed to 'family and community effects' and the correlation between siblings, we estimate the parameters of a family random effects model.[7] More specifically, years of education for individual i in family j (E_{ij}) is assumed to be given by $E_{ij} = \mathbf{X_{ij}\beta} + f_j + \varepsilon_{ij}$, where $\mathbf{X_{ij}}$ is a set of individual (for example, age, sex) and family variables (for example, parents' education); f_j is a family/community effect assumed to be uncorrelated with $\mathbf{X_{ij}}$ and the individual effect ε_{ij}. We estimate the parameters $\boldsymbol{\beta}$ and the variances of the family/community and individual effects, the so called 'between' and 'within' family variances, respectively. The sibling correlation net of covariates is the between-family variance divided by the sum of the between- and within-family variances. It indicates the importance of other shared family factors that are uncorrelated with the variables in $\mathbf{X_{ij}}$.

The first row of Table 3 shows the sibling correlation and the second row shows the between-family variance net of covariates (that is, the variance of f_j). In the first column we only control for the child's age (in $\mathbf{X_{ij}}$); in the second we also control for parents' education and in the third we control for a number of other parental attributes (measured in 1993) as well, including their incomes, work experience, family size and whether or not they were separated. The third row shows the percentage reduction of between-family variance that occurs when we control the family covariates. Controlling for parents' education reduces the between family variance by 40 percent and adding the other covariates reduces it by an additional 6-9 percent. The sibling correlation also falls from about 0.4 to about 0.25.

That is, about one-half of the between-family variance is attributable to factors that are common to the brothers and sisters but not correlated with the parental attributes we are able to measure from the Norwegian register data.

Table 3: Decomposition of Family Variance

A. Sisters

	Age only	Age and Parents' Education only	All covariates*
Sibling correlation	0.397	0.286	0.256
Between family variance	2.226	1.355	1.160
Percent reduction in family variance relative to first col.		39.1	47.9

*In addition to age, mother's and father's education, parental covariates are father's earnings, mother's earnings, mother's years of work, father's years of work, mother's transfer income, father's transfer income, number of children, whether separated or not, all measured as of 1993 (that is, 'history variables' are as of 1993).
N of families=27,736; N of children=13,655

B. Brothers

	Age only	Age and Parents' Education only	All covariates*
Sibling correlation	0.373	0.261	0.240
Between family variance	1.871	1.111	0.996
Percent reduction in variance relative to first column		40.6	46.7

*In addition to age, mother's and father's education, parental covariates are father's earnings, mother's earnings, mother's years of work, father's years of work, mother's transfer income, father's transfer income, number of children, whether separated or not, all measured as of 1993.
N of families=31,166; N of children=15, 349

A similar exercise can be performed with the small British sample of siblings described earlier, but we can only compare the equivalent of the first two columns in Table 3 (where we also control for gender in the first column). Adding parents' education to the regression reduces the sibling correlation from 0.36 to 0.24 and reduces the between family variance by 43 percent (from 1.547 to 0.881). The similarities with the Norwegian results are striking. Again parents' education is an important part of shared family background of siblings, but far from the only important aspect of the shared environment.

We wish, however, to go beyond description of family background influences on educational attainments and estimate the causal impacts of mother's and father's education on that of their children. The following theoretical framework is used to structure empirical analyses that may allow us to identify these causal impacts.

3. Theoretical Framework

Investments in children that affect their educational attainment require both parental time and money. Parents' time with their children transmits abilities, aspirations and values that affect how well they do in education, and there are many goods that parents buy, from early child care to home computers to direct tuition and private education that affect the level of education that children achieve. Parents' education affects the amount and productivity of these inputs. Our aim is to estimate the effect of a woman's (man's) education on her (his) children's education while controlling for her (his) partner's education. A reasonable interpretation of such an estimate is that the woman matches with a man with the same education despite her higher education, which would only occur if all women's education increased by the same amount. Thus, our analysis approximates the answer to the following thought experiment and policy question: what would happen to the mean educational attainment of children if the educational attainments of all women (men) were increased, for the same distribution of available partners? There are alternative questions, such as how does an increase in an individual's education affect her child's education, inclusive of the effects on who they marry? But in light of general increase in parents' education we focus on the former question.

Child's education equation

We follow Jere Behrman and Mark Rosenzweig (2002) and assume that a child's educational attainment depends linearly on the educational attainment of each of their parents (Ed_{mother} and Ed_{father}), plus some unobserved *pre-education* 'endowments'. While it is hard to be specific about the constituents of these 'endowments', thinking about them is important because they are likely to be correlated with parents' education. The first of these are *earnings* endowments of each parent ($Endow_{mother}$ and $Endow_{father}$) that affect their hourly earnings, which in turn have income, time allocation and bargaining effects on their children's education, as is described in the discussion of the effects of parents' education. As defined here, earnings endowments reflect genetic inheritance and pre-education environmental influences. We also assume that there is an endowment of the mother expressing her skill for child-rearing ($ParSk_{mother}$), and a child-specific attribute (e^c):

$$Ed_{child}=\delta_1 Ed_{mother} + \delta_2 Ed_{father}+ \Gamma_1 Endow_{mother}+ \Gamma_2 Endow_{father} +ParSk_{mother}+ e^c$$

Such a 'reduced form' equation is consistent with many models of family resource allocation in which human capital investments in the next generation (or the fruits of them) are valued by parents. While the father's skill in child-rearing could also appear in this equation, it is plausible that the mother's time is more important in child-rearing, and so we take that into account in this stark manner.

The coefficient on each parent's education measures the effect of their education net of the effects of their endowments, which are likely to be correlated with their educational attainments. In the context of economic models of the family, the parental education coefficients should reflect three separate effects of a parent's education on the education of their child (for example, Ermisch 2003; pp. 86-90). First, there is *an income effect*, which is positive because higher education increases the capacity to earn income in the market and more income is spent on everything that parents value. Second, there is *a substitution or time allocation effect*, which depends on the impact of a parent's education on the cost of human capital investment in their children. How costs vary with a parent's education depends on how much it increases the parent's earning capacity, how much of the parent's time is spent on child-education-enhancing activities and how much a parent's education increases the productivity of their time in such activities. The marginal cost of investment could, for example, decrease with higher parent's education because it enhances productivity sufficiently relative to their earning capacity ('market productivity'); or a there may be no effect on marginal cost of a parent's education because that parent contributes little time to human capital investment in children. Third, there may be *a bargaining effect*; for example, if mothers value children's education more than fathers and higher education increases her bargaining power, higher mother's education relative to the father's would increase children's education through this channel. In addition, analysis of American parents' time use (Guryan et al. 2008) suggests that time spent with children is valued more by better educated parents.[8] The coefficients associated with the parents' earnings endowments also reflect income, time allocation and bargaining effects, but in addition they reflect the association between parents' and their children's endowments—'heritability'.

Least squares estimation of the parameters of the child's education equation is unlikely to identify the effects of parents' education on children's because the parents' unobserved endowments are omitted from the regression. Their earnings endowments are likely to be correlated with their educational attainments, both because each parent's education is correlated with their own endowment and because each parent's endowment is correlated with that of the other parent and the other parent's education through matching in the marriage market.

Mother-twins

How might data on twin-mothers help address this problem? The assumption that we make to identify the effects of parents' education is that $ParSk_{mother}$ and $Endow_{mother}$ depend entirely on either genes or their common childhood environment, making them common to identical (MZ) twins. Then taking the difference between the offspring's education equations of identical twin sisters eliminates the sisters' endowments, leaving only differences in the twins' and their spouses' educational attainments and differences in their spouses' earning endowments on the right hand side of the equation. More formally, if Δ indicates a difference, the differenced children's (cousins') education equation is:

$$\Delta Ed_{child}=\delta_1\Delta Ed_{mother} + \delta_2\Delta Ed_{father} + \Gamma_2\Delta Endow_{father} +\Delta e^c$$

But why do twins who are supposed to have identical values of $ParSk_{mother}$ and $Endow_{mother}$ end up with different levels of education? There are clearly other aspects of their individual experiences that influence their educational attainments. In order for estimation of the differenced equation to identify the effects of parents' education these other aspects must not have a *direct* effect on the education of their children. That is another way of stating our identifying assumption.

Omission of the difference in the fathers' endowments ($\Delta Endow_{father}$) from the differenced equation could still cause a problem because it may be correlated with the difference in the twin-mothers' education and the difference in their spouses' education. For example, if fathers' endowments are positively correlated with their education, omission of the difference in fathers' endowments would tend to bias upwards the estimated impact of father's education (δ_2). We need a measure of the difference in the spouses' earnings endowments.

Earning-capacity equation

Assume that each person's observed earnings per hour (*Earnings*) depend on their educational attainment (*Ed*), their work experience (*Exper*), their *pre-education* earnings endowment (*Endow*) and 'luck', measurement error etc. (v):

$$Earnings=\beta Ed+ \beta_x Exper + Endow + v$$

From a sample of identical twins we can eliminate the earnings endowments by taking the difference between them, thereby obtaining estimates of the effects of education and work experience on earnings (β and β_x) that are not contaminated by correlation between a person's endowment and their education and work experience. With the estimates of β and β_x we can obtain an estimate of the person's endowment plus the 'luck' term, $Endow + v$. If v mainly reflects measurement error or 'earnings shocks', then we will have an error-ridden measure of endowments, thereby imparting errors-in-variables bias to our estimates if true endowments and education are correlated. Alternatively, if v mainly reflects post-education persistent factors and people sort themselves into couples partly on the basis of v, then it is appropriate to control for $Endow + v$. Given the uncertainty about the correct assumption, we present estimates of the parameters of the differenced children's (cousins') education equation with and without the measure of $\Delta Endow_{father}$. In our empirical application, most of the twins have nine years of data, which is averaged, to estimate β and β_x. This makes it more likely that v reflects persistent factors.

Father-twins

What can we learn from twin-fathers? If $Endow_{father}$ is the same for each twin,

$$\Delta Ed_{child}=\delta_1\Delta Ed_{mother} + \delta_2\Delta Ed_{father} + \Gamma_1\Delta Endow_{mother} + \Delta ParSk_{mother} +\Delta e^c$$

While we can use the same method to measure the difference in the mothers' earnings endowments as used for fathers, using differences between father-twins does not remove the impact of parenting skills of the mother from the picture, and if these are correlated with the mother's earnings endowment or the father's education, estimates of the effects of parents' education would be biased. Of course, the implication of a larger chance of omitted variable bias with father-twins is a consequence of our assumption that parenting skills of the mother are what is mainly important. If parenting skills of the father also played an important role in shaping the child's educational attainments, then the estimates based on mother-twins would suffer from a similar problem.

In general, if it is the case that child-rearing skills of the mother are more important than those of the father, then the omission of the parenting skills' endowment from the twin-difference education equations would have more of an impact on the estimates of the effects of parents' education based on father-twins than those based on mother-twins. If the mother's parenting skills endowment is positively correlated with the education of the father through matching in the marriage market, then we expect that estimates of the effect of the father's education obtained from father-twins will be larger than those obtained from mother-twins. Similarly, the estimated effect of the mother's education obtained from father-twins would also be larger than those obtained from mother-twins if the mother's parenting skills endowment is correlated positively with her education. We do in fact find this pattern in section 5.

4. Norwegian data

The foundation of the samples used in our empirical analysis is a register-based panel data set covering the entire resident population of Norway for the years 1993-2001. Information on household size and composition as well as individual information such as place of residence, date of birth, educational attainment and work status is obtained from these data. Here twins are defined as people of the same sex, born in the same calendar year and month from the same parents. About one-half are likely to be MZ twins while the other one-half are DZ, who are the same in terms of inheritance of genes as other siblings, and differ from other siblings in being born on the same day. Both twin parents and their children need to be alive in 1993 to be observed in our data, and to be in our analytical samples both twins must have at least one child aged over twenty-two in 2001. Education levels are measured in 1993 for twins (parents) and in 2001 for their children. The levels of education are transformed into years of education according to the maximum level of education attained. The sample of twin-mothers consists of 2,914 children (aged over 22) from 787 families, and the twin-father sample consists of 3,020 children from 790 families. Appendix Table 1 provides descriptive statistics comparing our twins' samples with the general population.

5. Baseline Results: Norway and USA

All specifications of the twins' regressions include, in addition to the other parent's education, the gender and age of the child and whether or not parents were living together in 1993.[9] Female children remain in education for about one-half year longer and parental separation tends to reduce the child's years of education in all estimated models. In each case, we compare two specifications: without and with an estimate of the other parent's earnings' endowment estimated in the way described in section 3.[10] The results for Norway in panel A of Table 4 indicate similar effects of each parent's education using either twins' sample: the estimated effect of mother's education is never statistically different from father's education, either between the mothers' and fathers' twins estimators or within each twin-type estimator. The corresponding ordinary least squares estimates for mother's and father's education effects are 0.249 and 0.213, respectively, from the mother-twins' sample and 0.220 and 0.218 from the father-twins' sample, neither being statistically different from one another. Using father-twins produces larger estimated effects for both parent's education than estimates based on mother-twins, and with these estimates mother and father effects are nearly identical. The coefficient of the earnings endowment (not shown) is positive (and larger in the father-twins' estimate), but has only a small effect on the estimates of the effects of parents' education. We also tested whether effects of parental education differ by the sex of the child, and found no evidence of significant differences using the twins' samples.[11]

Table 4: Twins-estimates of Parents' Education on Child's Education

A. Norwegian data (standard error in parentheses)

Method:	Mother-Twins		Father-Twins	
	No endowment control	Endowment control	No endowment control	Endowment control
Mother's education	0.104 (0.040)	0.101 (0.040)	0.157 (0.030)	0.156 (0.030)
Father's education	0.118 (0.025)	0.119 (0.025)	0.159 (0.033)	0.157 (0.033)

Source: Pronzato (2010). All specifications include the gender and age of the child and an indicator of parents' not living together in 1993; N=1,575 mother-twins, 1,582 father-twins.

B. United States' data (standard error in parentheses)

Method:	Mother-Twins		Father-Twins	
	No endowment control	Endowment control	No endowment control	Endowment control
Mother's education	-0.274 (0.145)	-0.263 (0.145)	0.043 (0.139)	0.016 (0.145)
Father's education	0.133 (0.071)	0.141 (0.072)	0.344 (0.162)	0.350 (0.162)

Source: Behrman and Rosenzweig (2002) Tables 4 and 5; N=424 mother-twins, 244 father-twins.

Panel B of Table 4 shows analogous estimates for US twins from Behrman and Rosenzweig (2002) using a sample of MZ twins from the Minnesota Twin Register, with information obtained from a mail survey. Children of twins from both country's samples were born around the same time—the early 1970s. The estimated effect of father's education from the US sample is significantly larger than that of mother's education.[12] The effect of mother's education is estimated to be small, if not negative. These results are strikingly different from the Norwegian estimates, although the small US samples, particularly for father-twins, produce fairly imprecise estimates of the effects, even when the estimates differ significantly from zero.

For both countries the larger estimated impacts of both parents' education found with the father-twins sample are consistent with the unobserved mother's parenting skills endowment being correlated positively with her and her partner's education, as predicted at the end of section 3. This is because the father-twins' estimates do not difference-out her parenting skills' endowment.

An issue that has not, to our knowledge, been raised with a twins-(or sibling-) difference strategy to identify effects arises from the fact that the cousin offspring are part of the same extended family.[13] To the extent that this generates similarities between cousins because of social influence within the extended family, offspring differences in education may be compressed , which may reduce the estimated impacts of parents' education relative to those in the general population.[14] Furthermore, sisters may interact more within the extended family than brothers, thereby reducing estimated parental education effects from the twin-mothers' sample relative to those using the twin-fathers' sample. If so, that may also account for the larger effects estimated from twin-fathers' samples.

Estimates for MZ twins from the Norwegian data can be obtained by using information on siblings, who are comparable in terms of shared genes to DZ twins. The average effect of the twin-parents' education for the mixture of MZ and DZ twins is approximately $\delta_A = 0.5\delta_{MZ} + 0.5\delta_{DZ}$, because about one-half of the twins are identical ones. In order to make the sibling estimates as comparable as possible to DZ twins we focus on same sex siblings born between 9 and 13 months of one another—this sample provides our estimate of δ_{DZ}.[15] To illustrate, in the case of endowment controls, the shared-mother sibling estimate of the effect of mother's education is 0.136 and the shared-father sibling estimate of the effect of father's education is 0.124.[16] In conjunction with the corresponding twins-estimates in Table 4-A these estimates imply that for Norwegian MZ twins the estimated effect of mother's education is 0.066 (std. error=0.089) and the effect of father's education is 0.190 (std. error=0.072). At first sight, these estimates for MZ twins appear to be more comparable to the US estimates in the sense that the estimated effect of father's education is larger than that of mother's education and the latter is not statistically significantly different from zero. But the point estimate of the effect of father's education is smaller in Norway than in the USA and the estimated effect of mother's education is larger than in the USA, and indeed, owing to their imprecision, the Norwegian estimated effects do not differ statistically between fathers and mothers.

To summarise, from Table 4 it appears that in Norway each parent's education has a similar effect on their children's educational attainments, while in the USA it is only father's education that has an impact on the education of his offspring. The relatively low precision of the US estimates makes it difficult, however, to come to strong conclusions—for instance, the father-twins' estimates of the effect of father's education for MZ twins do not differ significantly between the two countries despite a difference in the point estimate of 0.16 (the standard error of the difference is 0.18). There is, however, some indication from the MZ twins' point estimates that the effect of mothers' education may be smaller than that of father's, both in Norway and the USA. Furthermore, MZ-twins-estimates for Sweden (Holmlund et al. 2008, p.32) indicate a marginally significant positive effect of father's education (0.111; std. error=0.063) using a father-twins' sample, but a virtually zero effect of mother's education (-0.014; std. error=0.055) using a mother-twins sample.[17] Because of the imprecision of the estimates, the difference in parental effects is not statistically significant.

Behrman and Rosenzweig (2002) argue that the smaller effect of mother's education may have occurred because mother's time in the home is critical to the development of children's skills that payoff in terms of educational attainments, and better educated mothers work more in paid employment and as a consequence spend less time at home with their children during childhood. We investigate this issue for Norway in the next section.

6. Impact of mother's employment history on children's education

First, using Norwegian mother-twins, we find that an additional year of the mother's education indeed increases her work experience (as measured by her years of pension contributions as of 1993; mean=14.6 years) by about 6 months (std. error=1.4 months). The father's education has an insignificant negative effect on her work experience.

To investigate whether or not the educational attainments of Norwegian children are sensitive to the time that the mothers spent at home we use a different method, which compares similar women rather than twins. We select a sample of mothers who have at least one child aged over twenty-two in 2001, who have had their children with only one partner, and for whom we have data on 'pension points' (related to the level of their earnings) in 1993. We form clusters of mothers, all of whom have the same level of education and age, the same number of children, the same age of oldest child and the same level of education for the father. Thus each cluster is homogenous with respect to these variables. There are 34,365 of such clusters with an average of 13.2 women per cluster (454,943 observations in total). We then estimate a fixed effects' regression in which the average years of education of a woman's children (aged over twenty-two) is the dependent variable, the cluster to which she belongs is a 'fixed effect' and the years the mother spent in employment (as measured by her pension contributions), her average 'pension points', father's years in employment and his average pension points, whether the parents are separated and the percentage of a woman's children who are daughters are the explanatory variables. Thus, we only use *within cluster variation* to estimate the effect of the explanatory variables; by construction, variation within a cluster in the mother's experience in paid employment is not correlated with the variables that define the cluster. Data from 1997 on hours and wages indicates that 'pension points' are significantly correlated with wages and hours, and so represent a proxy for them.

Theoretically, an additional year in employment has potentially opposing impacts on the child's education: it reduces time spent at home with children but it increases family income (that is, less time inputs to children but more goods inputs). The results in Table 5 indicate that more employment experience increases children's years of education, contrary to the hypothesis put forward by Behrman and Rosenzweig (2002) to explain the small effect of mother's education estimated with their data. It appears that the income effect dominates and/or the actual reduction in time with children is small, with other non-market time being reduced in response to more employment time (as suggested by Guryan et al. 2008).

Table 5: Fixed Effect (by Cluster) Estimates of Impacts of Parents' Employment Experience on the Average Years of Education of their Children

	Parameter estimate	Standard Error
Per cent daughters	0.349	0.007
Parents separated	-0.537	0.008
Mother's pension years	**0.014**	**0.001**
Mother' Ave. Pension Pt.	0.043	0.004
Father's pension years	0.011	0.001
Father' Ave. Pension Pt.	0.143	0.003
Constant	11.812	0.023

N observations=454, 943; N of clusters=34,365. Cluster is defined so that all mothers in the cluster have the same level of education and age, the same number of children, the same age of oldest child and the same level of education for the father.

One way that children of mothers who spent more time in paid employment achieve higher educational attainments is by doing better in school, which increases their chances of pursuing higher education. We have data on grades obtained by children at the end of lower secondary school for the 1986 cohort of children, who finished lower secondary school in 2002. For this group of children we form clusters based on the same criteria as earlier, and perform a fixed effect regression that exploits within cluster variation to estimate the impact of parents' years of employment on the child's grades. We focus on grades in three subjects: Norwegian, Maths and English.

The explanatory variables are the same as in Table 5 with two exceptions: (1) as the unit of observation is the child, not the mother, per cent daughters is replaced by a dummy variable for being female; (2) we split parents' work experience and average pension points into two segments of childhood: up to the child's fourth birthday and the next three years of childhood (from the child's fourth to seventh birthday). While the latter variable refers precisely to a moment in the development of the child whose outcome is observed, the first variable summarizes the whole parent's career, from its beginning to the fourth birthday of the child. Therefore, the effects of pension years and pension points may not seem easy to interpret since they depend on how mothers distribute the time of work between the years prior to the childbirth and the four years following it. However, by clustering for the age of the oldest child and the number of older children, the comparison is amongst women with – probably - the first career-interruption at the same time (given by the same age of the oldest child) and the same number of interruptions due to maternity (given by the same number of older children). These two variables, used for the clustering, should help to compare women with a similar career.

Table 6: Fixed Effect (by Cluster) Estimates of Impacts of Parents' Employment Experience on the Maths' Grade of their Children when aged 16

	Parameter estimate	Standard Error
Female	0.138	0.011
Parents separated	-0.255	0.016
Mother's pension years, up to age 4 of child	**0.003**	**0.002**
Mother' Ave. Pension Pt., up to age 4 of child	0.044	0.008
Father's pension years up to age 4 of child	-0.001	0.002
Father' Ave. Pension Pt. up to age 4 of child	0.021	0.006
Mother's pension years ages 4-7 of child	**0.018**	**0.007**
Mother' Ave. Pension Pt. ages 4-7 of child	-0.007	0.006
Father's pension years, ages 4-7 of child	0.000	0.012
Father' Ave. Pension Pt. ages 4-7 of child	0.023	0.005
Constant	3.151	0.035

N observations=41, 057; N of clusters=5,886. Cluster is defined so that all children in the cluster have the same mother's level of education and age, the same number of siblings, the same age of oldest sibling and the same level of education for the father.

The results indicate that mother's employment experience up to age four of the child is not statistically significant, with the exception of English grades, for which it has a positive effect. Mother's work experience between the ages of four and seven of the child has a significant positive effect on grades in all three subjects. Table 6 shows the results for grades in math, for which the pattern of coefficients is representative of the two other subjects.

These exercises strongly suggest that, at least in Norway, even if the effect of mother's education is smaller than that of the father, this is not because her greater employment experience reduces her child's performance in school nor her child's years of completed education. Indeed it appears to be an advantage to spend time in contexts other than that of the home. Of course, the conclusion may be different for the USA because of, for example, differences in child care arrangements for working mothers, which are likely to be more accessible, cheaper and of better quality in Norway than their USA counterparts for a large section of the population.

The analyses in Tables 5 and 6 are also relevant to a policy change in Norway in August 1998. A cash-benefit was offered to families with a child between one and three years old (maternity leave is one year) who make no or very limited use of state-subsidized day-care facilities. The amount of the benefit is up to 400€ euros a month, not taxable, and not tested against parents' income or labour market participation. Naz (2004) finds that women, particularly highly educated women, did less paid work after the reform while husbands' working hours did not change. Our results suggest that children are unlikely to benefit from the reform in terms of better educational outcomes, although there may of course be other benefits.

7. Heterogeneous effects

Do the effects of parents' education differ according to their level of education? In addition to the intrinsic interest of this question, splitting the sample by parents' education level approximates two alternative ways of identifying causal effects of parents' education: studying adopted children and the consequences of a reform in the education system. The former exploits the lack of a genetic link between parents and adopted children, while the latter generates an exogenous change in educational attainment for some cohorts or regions, a common example being an increase in compulsory schooling age. Usually the parents who adopt are not representative of the population—they are on average older and better educated.[18] In contrast, reforms of compulsory schooling only affect education at the bottom of the distribution because that is where the reform produces the exogenous change in parents' education (for example, raising the minimum school-leaving aged from fifteen to sixteen). A common finding in the adoption studies (for example, Plug 2004. Björklund et al. 2006) is that the effect of father's education is positive and statistically significant while mother's education does not have a significant causal impact. In contrast, studies of reforms of compulsory schooling (for example, Black et al. 2005) find a significant positive effect of mother's education, but a negligible effect of father's education.[19] This pattern is replicated in a study using both of these ways of identifying causal effects with the same source of Swedish register data (Holmlund et al. 2008). The larger effect of father's education for those with higher levels of education may reflect more father-child interaction among higher educated fathers, in both intact and separated-parent families. Here we exploit the data on Norwegian twins to estimate the effects of parents' education for two groups: one in which both parents have 11 or fewer years of education and one in which both have more than 11 years. The results are shown in Table 7.

From the father-twins' samples, the pattern from previous studies is replicated in the following sense: in the low education sample, mother's education has a relatively large and statistically significant effect, in contrast to father's education, while in the high education sample the effect of father's education is larger than that of mother's, although both are statistically significant. The patterns are less consistent with previous studies when using the mother-twins' samples, from which it appears that each parent's education has similar effects, if any. From this evidence it is difficult to come to clear conclusions about the part of the parental education distribution in which effects of parents' education are larger.

Table 7: Twins-estimates of Parents' Education on Child's Education, Norwegian data by Parents' Education Level (standard error in parentheses)

Method:	Mother-Twins		Father-Twins	
	11 or fewer years of education	More than 11 years of education	11 or fewer years of education	More than 11 years of education
Mother's education	0.121 (0.083)	0.102 (0.118)	0.192 (0.048)	0.180 (0.056)
Father's education	0.124 (0.031)	0.064 (0.076)	0.096 (0.099)	0.287 (0.079)
N children	2187	270	1529	602
N families	573	79	389	173

Source: Pronzato (2010). All specifications include the gender and age of the child and an indicator of parents' not living together in 1993.

Another aspect of heterogeneity is different effects of parental education for daughters and sons. Buchman and DiPrete's (2006) analysis suggests that this could be important, and gender-specific effects may differ according to the level of the parent's education. Because of relatively small sample sizes it is difficult to investigate this issue with samples of twins. In order to explore the issue further we use large samples of parent-siblings born 13-60 months apart. We opt to trade some bias for much better precision. Compared to the twins' estimates in Table 4-A, the estimated impacts of mother's education are slightly larger. For example, for the specifications with endowment control, the effects of mothers' and father's education from the sister-mothers' estimates are 0.126 and 0.162, respectively (cf. 0.096 and

0.124 from the mother-twins' estimates); from the brother-fathers' estimates the corresponding estimates are 0.192 and 0.132, respectively (cf. 0.161 and 0.158 in Table 4-A). The likely direction of bias from using siblings rather than twins is less clear for the impact of father's education because the brother-fathers' estimate for the effect of father's education is actually smaller than the corresponding twins' estimate.

Table 8 shows that using the full sample of sister-mothers, an additional year of mother's education raises their son's education by 0.096 years, but it raises a daughter's education by 0.159 years. An additional year of father's education raises their offspring's education by 0.162 years irrespective of the gender of the child. Estimates using brother-fathers show a similar pattern by gender of the child, with the effects of mother's education being generally higher and that of father's being lower than estimated from sisters.

Table 8: Siblings-estimates of Parents' Education on Child's Education, Norwegian data (standard error in parentheses)

A. Sisters born 13-60 months apart

	Overall	11 or fewer years of education	More than 11 years of education
Mother's education	0.096	0.113	0.046
	(0.007)	(0.015)	(0.025)
Mother's ed. *	**0.063**	**0.115**	**0.045**
daughter	**(0.008)**	**(0.017)**	**(0.030)**
Father's education	0.162	0.162	0.170
	(0.006)	(0.007)	(0.016)
Father's ed. *	**-0.005**	**0.016**	**-0.055**
daughter	**(0.007)**	**(0.009)**	**(0.019)**
N families	29,029	18,679	2,677
N children	101,396	72,753	8,922

All specifications include the gender and age of the child, an indicator of parents' not living together in 1993, and the earnings endowment of partner.

B. Brothers born 13-60 months apart

	Overall	11 or fewer years of education	More than 11 years of education
Mother's education	0.162	0.173	0.157
	(0.006)	(0.009)	(0.012)
Mother's ed. *	**0.064**	**0.094**	**0.030**
daughter	**(0.007)**	**(0.012)**	**(0.015)**
Father's education	0.133	0.159	0.121
	(0.006)	(0.016)	(0.014)
Father's ed. *	**-0.007**	**0.029**	**-0.025**
daughter	**(0.006)**	**(0.018)**	**(0.016)**
N families	30,491,	14,566	5,840
N children	121,413	62,025	20,728

All specifications include the gender and age of the child, an indicator of parents' not living together in 1993and the earnings endowment of partner.

The gender pattern is repeated when focusing on samples in which both parents have eleven years of education or less. A Danish study (Bingley et al. 2009, Table 2), which uses a schooling reform that mainly affected less educated parents, comes to different conclusions: the effect on the son's education is larger than for daughters irrespective of the gender of the parent. Also, a Norwegian study (Black et al. 2005) which uses a reform in compulsory schooling only finds a significant positive effect of mother's education on their sons' education (in the 'low education' (less than ten years) sample). For better educated parents in our study, the gender pattern is less clear because the results differ between the sisters' and brothers' samples. For the former, father's education has a much larger effect than that of the mother, and the father's education has larger effect for sons than daughters. With sample of brother-fathers, the effect of mother's education is larger than that of father's education, and the mother's effect is even larger if the offspring is a daughter.

It appears then that the differential effect of mother's education always favours daughters, while the gender interaction with father's education is less clear in direction and it is often statistically insignificant, even with our large samples. If we discount the possibility that mothers act to favour girls over boys in their child investments, the larger effect of their education on daughters suggests that a mechanism behind the effect may be through the effect of the mothers on their daughters' aspirations and motivation—a 'role model effect' for short.

8. Conclusions

We have shown that parents' education is an important, but hardly exclusive part of the common family background that generates positive correlation between the educational attainments of siblings from the same family. But the correlation between the educational attainments of parents and those of their children overstates considerably the causal effect of parents' education on the education of their children. Our estimates based on Norwegian twin-mothers indicate that an additional year of either mother's or father's education increases their children's education by as little as about one-tenth of a year (the twins' estimates may be downward-biased compared to the general population because of social influence effects within the extended family). While estimates of the effects based on father-twins are about fifty percent higher for both parents, we have reason to believe that these estimates are biased upwards. There is some evidence that the mother's effect is larger among less educated parents, while the father's effect is larger among better educated parents. We also find that the effect of mother's education is larger for daughters than sons.

Comparing indirect estimates for monozygotic twins for Norway and Sweden with identical twins' estimates from the USA, it appears that father's education has a larger effect than that of mothers in all three countries, but the parental effects only differ significantly in the USA analysis. One explanation for a smaller maternal effect is that better educated mothers work more in paid employment and spend less time interacting with their children. We test this hypothesis for Norway using a 'matching estimator' and find no evidence to support it; indeed children of otherwise identical mothers (on a number of criteria, including both parents education) who worked more in paid employment complete *more* years of education. Of course, the relationship may differ in the USA, say because of better and cheaper child care arrangements in Norway. Also, in light of the imprecision of the point estimates that we have for the USA it may be the case that the difference in parental effects is not really much larger in the USA than in Norway or Sweden.

Comparison of the twins' estimates with conventional regression estimates for Norway suggests that about one-half of the correlation between parent and child education appears to reflect the correlation of activities and attitudes of parents that improve their children's educational achievements with the parents' own education rather than a causal impact. Recent research by one of the authors (Ermisch 2008) tries to quantify the impact of educational activities and parenting style on a child's pre-school development. It suggests that even though these parental 'inputs' to child development have significant effects on child development and are strongly correlated with parents' education, a large part of the differences in early cognitive and behavioural development by parents' education or income group remain unaccounted for by these inputs. Thus, there still remains much to discover about the aspects of 'what parents do' that enhances their children's educational attainments and how these aspects are correlated with parents' education.

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Appendix Table 1: Descriptive Statistics on Norwegian Parents and Children (Twins and Overall Population)

	Mothers		Fathers	
	Twins	**Population**	**Twins**	**Population**
Parent's level				
Age (1993)	44.3	47.1	47.5	50.8
	(6.1)	(8.6)	(6.9)	(9.4)
Number of siblings (1993)	3.45	3.72	3.42	3.89
	(3.42)	(4.99)	(3.87)	(5.37)
Years of schooling (1993)	10.9	11.2	11.5	11.6
	(2.1)	(2.2)	(2.6)	(2.6)
Earnings (€ - 1993)	13,342	12,382	23,216	20,423
	(10,287)	(10,312)	(17,750)	(19,381)
Transfers (€ - 1993)	3,067	3,210	2,281	3,437
	(4,329)	(4,275)	(4,900)	(6,025)
Self employed (1993)	0.103	0.097	0.224	0.260
Number of children (1993)	2.45	2.42	2.44	2.51
	(0.94)	(1.02)	(0.94)	(1.07)
Parents - observations	1,575	278,390	1,582	303,703
Child's level				
Age (2001)	27.0	29.4	27.8	29.7
	(7.0)	(8.8)	(7.2)	(9.3)
Years of schooling (2001)	12.9	12.9	12.9	12.9
	(2.4)	(2.4)	(2.4)	(2.4)
Other parent’s schooling (1993)	11.6	11.5	11.1	11.0
	(2.6)	(2.6)	(2.2)	(2.2)
Divorce (1993)	0.205	0.176	0.187	0.159
Earnings (€ - 2001)	25,111	25,540	25,488	25,740
	(17,999)	(19,289)	(17,571)	(19,360)
Transfers (€ - 2001)	3,235	3,393	3,177	3,365
	(5,520)	(5,673)	(5,339)	(5,655)
Self employed (2001)	0.076	0.097	0.083	0.105
Children - observations	3,857	674,507	3,853	764,256
Children over 22-observations	2,914	545,523	3,020	618,550

Notes: average values with standard deviations in brackets; “self-employed” is a dummy variable indicating whether part of the income is from self-employment work; “number of children” comprises children of any age; “age” at the child’s level is measured for all children while the other variables at the child’s level are only summarized for children over 22.
Source: Pronzato (2010)

[1] On average, their study finds no trend in these correlations over the birth cohorts of 1930-1985, although for the USA and Great Britain there is evidence of a modest upward trend for more recent cohorts. In broad terms, the average should, however, be comparable to the birth cohorts represented in the current study.

[2] It is calculated from a sample of people born in the years 1973-78 with at least one sibling corresponding to that used in panel B of Table 2 and in Table 3. The parents' education was measured in 1993. The correlations with the mother's and father's education are virtually the same.

[3] Recall that the correlation coefficient is the product of the regression coefficient and the ratio of the standard deviation in parents' years to the standard deviation in children's years of education.

[4] For instance, Ermisch (2009) shows that better educated mothers tend to 'score higher' on educational activities and better child-mother interactions with their young children. Such behaviour is associated with better cognitive development during the pre-school years. Supportive behaviour toward older children is also more evident among better educated mothers, and this behaviour is associated with better educational attainments for their children.

[5] These are members of the British Household Panel Survey who can be matched to their parents because we observed them living together at least once during the survey from 1991-2006.

[6] The parent-child correlation is lower when we do not confine the sample to matched siblings—0.26 for children aged twenty-two and older.

[7] This exercise is inspired by the one undertaken by Björklund et al. (2008) to account for the sibling correlation in income.

[8] Positive education gradients in time spent with children contrast with negative ones for typical leisure and home production activities, thereby suggesting this 'different preferences' interpretation.

[9] The regressions take the form $E_{ij} = \mathbf{X_{ij}\beta} + f_j + \varepsilon_{ij}$ where f_j is now a fixed effect that may be correlated with the variables in $\mathbf{X_{ij}}$. The usual 'fixed effect' estimation procedure is used, which eliminates f_j by subtracting the within-family mean of each variable from that variable.

[10] Ideally the earnings variable in the twins' earning capacity regressions should be hourly earnings, but the register data do not contain hours; the estimate of the endowment is based on average annual earnings, using nine years to compute the averages in most cases.

[11] In a much larger sample of all same-sex siblings, section 8 reports that the mother's education has a larger effect on daughters than sons, but the effect of the father's education is the same irrespective of the child's sex.

[12] The corresponding ordinary least squares estimates for mother's and father's education effects are 0.137 and 0.286, respectively, from the mother-twins' sample and 0.254 and 0.325 from the father-twins' sample, the difference in parental effects being statistically different in the mother-twins' sample.

[13] We are grateful to Tom DiPrete for pointing out this possibility.

[14] As is well known, measurement errors in parents' education also operate to reduce the estimated impact, particularly in fixed effects estimation.

[15] In fact, the effects of mother's and father's education estimated from samples of siblings change very little when the birth interval between siblings is widened; see Pronzato (2010).

[16] Neither of these estimates is significantly different from the estimate from the corresponding twins-estimator. In the mother-sibling estimates, the estimated effect of the father's education (standard error in parentheses) is 0.136 (0.027) and the estimated effect of the mother's education from the father-sibling estimator is 0.187 (0.031).

[17] These estimates are based on samples of 5886 children of twin-mothers and 4061 children of twin-fathers selected from Swedish register data from among parents being born between 1945 and 1955. The estimates control for but the paper does not present estimates of the other parents' education in each sample. These Swedish estimates of parents' education effects based on pooled MZ and DZ twins are not significantly different from the corresponding estimates in Table 4-A for Norway.

[18] Also, children are not randomly assigned—adoption authorities may try to match children to adoptive couples who are similar to their natural parents.

[19] But Bingley (2009) finds positive and nearly equal effects of mother's and father's education on children's education (0.114 and 0.123, respectively, and not significantly different from one another) using a 1958 reform in Denmark that affects children in the 8^{th} and 9^{th} grades. Thus, his estimated effects of parents' education are very similar to our overall Norwegian estimates based on twins (Table 4-A), both in their size and the absence of a significant difference between parents.