Children's cognitive ability and parents' education: distinguishing the impact of mothers and fathers

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January 2011

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Abstract

Discussion of transmission of socio-economic status from parents to children needs to consider gender differences in both generations. We consider each parent and their different links to outcomes for boys and girls using data for 30 countries. We relate children's cognitive ability recorded in tests of maths, science and reading at age 15 to the years of education of mothers and of fathers, concentrating on children with both natural parents present. The data come from the 2003 round of the Programme for International Student Assessment (PISA), co-ordinated by the Organisation for Economic Co-operation and Development (OECD). The results (focusing on maths) show (i) it is more common for father's education to have a greater association with children's achievement; (ii) this seems particularly true of sons; (iii) there is more variation across countries in the differences between fathers and mothers than between sons and daughters; (iv) there is some suggestion that mothers' education has somewhat more association with daughters' ability than with sons'; (v) the interaction of mother's and father's education typically has a positive association with the child's ability. However, there are substantial differences across countries in these patterns.

1. Introduction

Discussion of transmission of socio-economic status from parents to children needs to consider gender differences in both generations. Parents pass on a measure of their advantage or disadvantage to their children and it is clearly of interest whether fathers pass on more than mothers, and whether it is sons or daughters that gain or lose more from the transmission. A number of authors have produced important insights into the different strengths of the gender-specific parent-child links. These have been motivated in particular by the desire to distinguish the role of mothers. Notable examples include Jere Berhman (1997) from economics and Sylvia Korupp et al. (2002) from sociology. Our main value-added is to show how these links differ across a large pool of rich industrialised nations, using a data source that is specifically intended to allow cross-country comparison. We investigate whether there are common patterns across countries and whether there are countries that appear to be outliers to these patterns.

The child outcome that we consider is an educational one, reflecting the role accorded to education in explaining intergenerational mobility in income by economists and in social class by sociologists (Jo Blanden et al. 2007, Robert Erickson and John Goldthorpe 2002). We analyse children's cognitive ability as recorded in standardised tests of maths, science and reading at age 15. We relate this to years of education of mothers and of fathers. We use data for 30 countries from the 2003 round of the Programme for International Student Assessment (PISA), co-ordinated by the Organisation for Economic Co-operation and Development (OECD).

Section 2 motivates our analysis along the lines just described. We discuss the impact of parental education on children's learning, consider why the links might vary with gender in either generation and review some existing empirical evidence. Section 3 describes our data, focusing on the child test scores and the measures of mothers' and fathers' education. We discuss the collection of the latter – parental education is reported by the children – and the choice of a suitable sub-sample for analysis. Section 4 presents results from simple regression models of child test scores on each parent's education. We test six hypotheses concerning the associations across the generations, including one reflecting the possible complementarities between maternal and paternal input. These are intended as 'catch all' regressions, with the parental variables reflecting all direct and indirect influences of their education. The regressions do not show causal impacts because the education variables are correlated with parental abilities and other characteristics that we cannot control for. Section 5 summarises

and concludes.

2. Motivation and Literature

It is well known that children's educational outcomes vary sharply with their parents' socio-economic background. Differences in outcomes with parental background emerge early at the pre-school level and are re-enforced in childhood and the teenage years through to tertiary education. There is plenty of evidence for different countries and summaries can be found in OECD (2008) and Stephen Machin (2009).

Child outcomes can be usefully conceptualized within the simple framework proposed by Robert Haveman and Barbara Wolfe (1995), who drew on Arleen Leibowitz (1974). This has three outcome variables – ability, final schooling level, and adult income. These are linked in a recursive structure: ability helps determine final schooling level and both help determine income in adulthood. In this chapter we are concerned just with ability, as measured by test scores towards the end of compulsory schooling at age 15. Ability, within the Haveman and Wolfe framework, has two proximate determinants: home investments represented by the quantity and quality of time and goods inputs in the child, and heredity – see figure 1, which also shows the determinants of final schooling level. Home investments are in turn determined by parents' education and abilities, both directly and indirectly via family income. Parents' abilities are passed on in part via genetic inheritance.

Within this framework, the correlation of children's ability and parents' education reflects a number of factors. First, a direct effect through home investment, discussed later. Second, an indirect effect via family income. Third, and assuming parental education and ability are correlated, the impact of that ability coming through both home investments and genetic inheritance.[1]

The framework also serves as a reminder that the total correlation of parental education with the child's education will not be revealed in an analysis of children's ability alone. The child's final schooling level is a function of home investments and family income as well as his or her ability, and hence reflects additional impacts through those pathways from parental education. We illustrate this using data for the US drawn from the National Educational Longitudinal Survey (NELS) cohort. We regressed completed years of the child's education on years of father's and mother's education. We then added to the equation variables measuring child test scores for maths, science and reading at age 14. The estimated coefficients for parental education were reduced by only one third, illustrating that a

substantial part of the association of final schooling with parental education does not come through the child's ability in the early teenage years.[2]

How might the impact of mother's and father's education differ within this framework? Much of the interest to date in distinguishing the separate contributions of each parent to intergenerational transmission of socio-economic status has been motivated by a desire to give due recognition to the role of women, for example Behrman (1997), Aaron Johnston et al. (2005), Korupp et al. (2002), and Emily Beller (2009). More educated mothers, it is argued, are more likely than fathers with the same level of education to make higher investments into the production function of their children's cognitive achievement, in terms of quantity and quality of both time and goods. The more educated the mother, the more efficient her use of time spent with the child. Education may also increase women's bargaining power within the household, giving them more control over family income, again increasing home investments in the child. And the impact of each parent may differ for sons and daughters, it is reasoned, due to differences in aspirations and expectations. A well educated mother may act as a stronger role model for her daughters than for her sons, for example. The importance of each parent may vary over childhood. If mother's schooling has a greater association than father's schooling with the ability scores of high school children, this could reflect the particular advantage (if that is the case) of a more educated mother in early childhood, for example in time spent reading to the child, books in the home, and in use made of pre-schooling or choice of elementary school.[3]

The relative importance of fathers and mothers could be similar across countries. To continue with the example of early childhood, any special significance of educated mothers at this age may hold across different cultures and institutions. Or there may be differences, associated for example with variation across countries in the position of women in society. Part of any differences in the importance of each parent will be played out in outcome variables that are not the concern of this chapter – final schooling level and adult income in the Haveman and Wolfe framework, including in the case of income through occupational choice.

Most existing evidence relates to the child's final level of schooling, rather than ability during high school. The child's years of education are regressed on years of education of the mother and years of the father, and, typically, some variables chosen to control for other factors. Ideally, evidence would exhibit the following features, although this ideal is rarely found:

i.   results shown without as well as with any control variables

ii. allowance for the impact of unobserved parental ability

iii. recognition of the distinction between natural, step, and single parents

iv. education entered flexibly as levels achieved rather than just as years

v.   models estimated separately for boys and girls

vi. large sample size

Results with no controls (i) allow the full association of children's and parents' education to be revealed, including indirect as well as direct channels, for example via family income. This is the approach we take in Section 3. Moreover, comparing different studies there is often a 'distressingly small overlap in the explanatory variables included in the models' (Haveman and Wolfe 1995: 1855), making difficult comparisons of results that include controls (which also vary in definition). Results without controls will reflect the correlation of parental education with unobserved ability unless the latter is controlled for in some way (ii), which usually it is not. Many children do not live with both their natural parents (iii). The education of a 'parent figure' that is reported during high school may not correspond to the education of a parent present during early childhood. Inherited ability will only be proxied by parental education for natural parents. The specification of education, whether of parents or children, as a continuous variable measured in years risks hiding non-linearities (iv). Interest in gender differences sometimes only extends to the parents without allowing for differences in the children's generation (v). Large sample sizes (vi) increase the chance of identifying gender differences among both parents and children and differences between natural, step, and single parents.

Haveman and Wolfe conclude from their survey of US evidence that 'the human capital of the mother is usually more closely related to the [educational] attainment of the child than is that of the father' (1995: 1855). Behrman (1997) takes a more detailed look at this question, focusing on studies from the US and a range of developing countries, where a priori the importance of mother's education is expected to be greater. He also finds that mother's education tends to be somewhat more important than father's education but emphasises that (a) the margin is not as large as suggested by what he sees as conventional wisdom, and (b) there is a considerable degree of variation across studies. Mother-daughter associations in general appear to be stronger than those for mother-son. Likewise, the father-son links appear stronger on average than the father-daughter links but Behrman concludes that the pattern here is less clear. He also notes that the evidence is more widespread for

children's schooling level than for cognitive ability, the focus of our chapter.

Recent contributions to the literature provide some evidence for rich industrialised countries other than the US, for example Jennifer Baxter (2002) for Australia, Guido Heineck and Regina Riphan (2007) for Germany, John Ermich and Marco Francesconi (2001) for the UK, and Anders Björkland et al. (2007) for Sweden.[4] All of these authors focus on the child's final schooling level, whether measured in years of education, categories, or proxied by qualifications obtained. They all include results that either have no controls or which control only for immigrant status (either by including indicators of this or by selecting natives only) and number of siblings (although this may already reflect some of the impact of parental education as more educated women tend to have fewer children). Data sets often combine cohorts from a wide range of years. Heinrich and Riphan conclude that 'maternal education has weaker effects for sons' than for daughters' outcomes' (p17). Baxter's results defy easy summary given the flexibility in the way both children's and parents' levels of education are entered in her models, but they appear to show father's education having a greater association with sons than does mother's education while the reverse is true for daughters. Ermisch and Francesconi cannot reject the hypothesis of no differences by gender within either generation in the UK (2001, Table A1), but, with a different UK dataset, Lorraine Dearden et al. (1997) find the same pattern as Baxter does for Australia: 'father's education is more important for sons, mother's education is more important for daughters' (1997: 57) although the differences are not strongly significant.

The analysis by Björkland et al. (2007) of Sweden is notable for satisfying most of the features of an ideal study listed earlier. A large sample of some 65,000 individuals provides a realistic opportunity to analyse separately different combinations of natural and step parent, for example natural mother and step father, step mother and natural father. It even yields over 1,000 children with adoptive parents. This in turn permits conclusions about the impact of unobserved parental ability transmitted through genetic inheritance as a striking feature of the data is that a child can be linked to a natural parent even when he or she is not the rearing parent. Among children raised by both natural parents, the results show father-son links to be some 30 percent larger than father-daughter links (t=6.9) but reveal no statistical difference in mother-son and mother-daughter links (t=0.84).[5]

The background for our own analysis is therefore one of rather mixed evidence, more abundant for the US than for other countries and focused on schooling levels rather than ability.

3. Data

The Programme for International Student Assessment (PISA) is a study of 15 year-olds' cognitive ability. Data are collected every three years. We use the 2003 data and analyse all OECD countries except Mexico and Japan.[6] In each country, a minimum of 150 schools were included in the sample, selected with probability proportional to size. Students were then randomly selected from within these schools. Average response rates of both schools and pupils were high (90 percent in both cases), although this varies moderately between countries.[7] The achieved sample size in 2003 across the countries we consider was 189,404 observations.

In 2003 PISA tested children's ability in one major (maths) and two 'minor' (reading and science) domains.[8] We focus in particular on the results for maths. However, mothers and fathers may have different roles in developing their children's cognitive ability in each of the three subjects. Recall the framework given in figure 2. For example, if mothers spend more time reading to their children than fathers, maternal education might be more important for the development of children's reading skills. Likewise, if fathers spend more time helping children with maths, paternal education may be particularly associated with scores in this subject. We therefore often provide results for all three domains.

Children's answers to the PISA test questions were summarized by the survey organizers into a score for each of the three domains, using an 'item-response model'. The intuition is that true ability in each subject is unobserved, and must be estimated from the answers to the test. The item response model is used to generate five 'plausible values' for ability in each subject for each individual, each value estimating the individual's true proficiency in the subject concerned and being equally plausible. These scores were scaled by the survey organizers to have a mean (across all participating PISA countries) of 500 points and standard deviation of 100. We follow the organisers' recommended use of the data by running our regression models for each plausible value and then averaging the estimated coefficients and standard errors. We also use the survey weights.

Children were asked two questions about their parents' education; what level they completed at school and what type of tertiary qualifications they hold. Responses were recorded into International Standard Classification of Education (ISCED) levels. Although these are designed to be internationally comparable, variation in definitions across countries may remain (Hilary Steedman and Steven McIntosh 2001). We convert ISCED levels into years of education, using country specific conversion coefficients provided by the PISA

organisers (OECD 2004: 308). We have already noted that parental education may have a non-linear influence on children's ability. However, we have chosen to use years of education for its simplicity in interpretation and ease in presentation of results across a number of countries.

We drop children who are first or second generation immigrants. Their parents' education cannot necessarily be interpreted in the same way as that of parents of native children. This reduces the sample size by over a fifth. The reduction is particularly prominent in New Zealand, Australia, Luxembourg and Switzerland, where over 40 percent of observations are dropped. We also exclude children not living with both their natural mother and natural father since in this case it is unclear to whom the information collected on parental education refers.[9] For children living with their natural parents we can be reasonably certain that the association of parental education and children's ability reflects all the various pathways described in figure 1 including genetic inheritance. Again, there is a large reduction in the sample size, especially in the USA and, perhaps surprisingly, in Turkey and where a further 40 percent of children are excluded from the analysis. A further 2 percent of observations are excluded where information is missing for both mother's and father's education. In 7 out of 30 countries, half the original sample has been excluded following these selection criteria (Australia, New Zealand, England, Scotland, USA, Luxembourg, and Switzerland). The overall sample size has been reduced by over 40 percent to 106,873 observations.

Table 1 shows a moderate association between mother's and father's years of education. The correlation coefficient is between 0.4 and 0.6 for most countries. Mother's and father's education is reported as the same for typically about half the sample in each country. This association is not surprising given the degree of assortative mating, where individuals select partners with similar characteristics. (The literature is surveyed by Hans-Peter Blossfeld 2009.) Yet although the correlation between mother's and father's education is strong, it is not so large as to prevent us from trying to identify their separate associations with children's cognitive ability.

Measurement error in the education variables, from children acting as proxy respondents, may be a concern. Wolfram Schulz (2006) investigates this problem using a convenience sample collected as part of the PISA 2006 field trial. Parents and children were asked separately to report the mother's and father's education level, with a choice of 5 categories. They gave the same category in 63 percent of cases for father's education and 66 percent for mother's. However, the figure varied substantially between education levels. For

example, when children reported 'university' as their father's education level, 86 percent of fathers also gave this answer. Yet when children reported 'non-university tertiary education' only 39 percent of fathers agreed. Comparisons can also be made using data for 10 countries in the actual 2006 PISA sweep.[10] Our investigation of these data shows results not dissimilar to those in the field trial, including much lower agreement between parental and child reports for non-university tertiary education. We also found some substantial variation across countries in these figures with, for example, notable differences in Italy in the numbers reporting secondary education to be the highest qualification obtained by mothers (18 percent of children but 44 percent of mothers).

One way to test the influence of measurement error in parents' education is to estimate two sets of regressions with the 2006 data, one using the parents' responses, the other using the children's, and then to compare the results.[11] We exclude immigrants and cases with incomplete information on mothers and fathers education in either the parental or child questionnaire. We cannot exclude children not living with their natural parents since the 2006 data contain no information on family structure. We estimate the regressions separately for the 10 countries and then take the unweighted average of the parameter estimates. Using children's reports of education, a child whose father is university educated scores 41 points higher on average in the PISA reading test than if the father had less than secondary schooling. (The standard deviation of scores is about 100 points.) When using fathers' reports of education, the same regression yields a 45 points difference. The corresponding estimates for maternal university education are 38 points with the child's reports and 49 points with the mother's reports. This indicates some notable attenuation in estimates when using the children's reports. Attenuation, at least for university education, is the general pattern in individual countries but there is some substantial variation from country to country. We do not feel we have enough evidence on which to base any adjustment of our estimates using the child reports for the full set of 30 countries. But the need for further research on the quality of the parental education measures in PISA is clear.

We can illustrate the variation across countries in the links between the generations shown in our sub-sample of 2003 PISA data when we do not distinguish fathers from mothers. We regress the child's maths score on years of parental schooling, taking whichever is the higher, father's or mother's, although in about a half of cases there is no difference as already seen in table 1. In presenting the results in figure 2, we multiply the estimated regression coefficient by four, the number of years a university degree course takes in many countries, and then divide by the standard deviation of children's test scores in the pooled (all

country, all children) sample, which is equal to 100. This produces a standardised coefficient.[12] One can interpret this coefficient as the number of 'international' standard deviations of test score associated on average with a 4 year increase in parental education. We also adopt this practice in the next section.

The variation across countries is marked, the standardised estimate varying from less than 0.2 of a test score standard deviation to about 0.8. Note the particularly strong relationship between parental schooling and children's ability in the USA and England and in the four Central European countries, where the Czech Republic and Hungary stand out.[13] It is also interesting to make pairwise comparisons between certain countries. The figure for the USA is twice that for Canada (0.56 compared to 0.27). Likewise, parental education has greater association with children's maths ability in England compared to Scotland, and in Denmark compared to Sweden.[14]

4. Results

We now test the association between each parent's education and their child's cognitive skills at age 15 using regression models in which each parent's years of education enters separately. To be clear, although we will use the terms 'effect' and 'impact' at times for convenience, we are not presuming a causal relationship in any of the models we estimate.

Fathers' versus Mothers' Education

In the first model, we allow for gender differences in the parents' generation only, restricting the effect of each parent's education to be the same for boys and girls (individuals are denoted by the subscript *i*). Missing value dummies for each parent's education are included in this and all subsequent regressions.

$A_i = \alpha + \gamma.BOY_i + \lambda_1.PA_i + \lambda_2.MA_i + \xi_i$, where

      A = the child's test score

      BOY = 1 if the child is a boy and 0 otherwise

      PA = father's years of schooling

      MA = mother's years of schooling

      ξ = error term

We test the following hypothesis for each country:

H1: mothers and fathers have the same effect on children's ability ($\lambda_1 = \lambda_2$)

(In the terminology of Korupp et al. (2002), $\lambda_2 = 0$ implies what they refer to as the 'Conventional' model that only fathers 'matter'; our H1 reflects their 'Joint' model, and rejection of H1, together with non-zero λ_2, is analogous to their 'Individual' model. Note however that our outcome variable differs)

Figure 3 plots the estimated values of the regression coefficients, λ_1 and λ_2, having scaled them in the way described in the previous section – by multiplying by four and dividing by 100. As before, we see the estimated impact of four additional years of a parent's education, measured in 'international' standard deviations of test scores. So a figure of 0.5 means that a rise in mother's or father's education of four years is associated on average with a rise in test score equal to one half of an international standard deviation.

Countries that sit in the top right of the diagram have the greatest association between parental education and child ability, that is the least educational mobility. The further the country lies away from the 45 degree line, the greater the difference between the effect of mother's and father's education. A circle around the country name shows that the difference is significant, that is we reject H1, at the 5 percent level. A square shows that it is significant at the 10 percent level.

Out of the 30 countries, 14 have circles or squares. These are somewhat more frequently found above the line, implying a greater effect of fathers. In several, the differences are big in percentage terms – in the Netherlands, Switzerland, Germany and Australia, the father's effect is at least twice the mother's. In the USA it is some 50 percent larger.[15] Differences of a similar magnitude are found in the countries that are significantly below the line. It is difficult to detect clear general patterns, whether in terms of groups of countries or in terms of the overall level of parental effect. It does not appear to be the case that where family background is especially important, this is associated with one parent in particular. All the Nordic countries are below the line, but none significantly so. The same is true of the poorer countries Greece, Portugal and Turkey, in line with the view of Behrman (1997) that mother's education may be especially important lower down the development scale. There is no common pattern for the Central European countries. In several Northern European countries, such as Sweden, Belgium, England and Denmark, the difference between

the effect of mothers' and fathers' education is small.

This variation about the 45 degree line shows there are substantial cross-country differences in the relative importance of mothers and fathers. But at the same time, half the countries are without circles or square: we cannot reject the null hypothesis of no difference in father's and mother's impact in half of the countries, even at the 10 percent level. Table 2 reports results from the regression model when we combine the data for all countries so as to increase vastly sample size (we include country dummies). Of course, this has disadvantage of restricting the impact for fathers and mothers to be the same in each country – in effect we are averaging across both the vertical and horizontal dimensions in the graph. The p-values reported in Table 2 show that we reject the null of no difference in this pooled sample at the 5 percent level (but never at the 1 percent level) for all three subjects, maths, science and reading. And, in this pooled sample, fathers on average have more effect (not shown). For example, for maths, the standardised coefficient estimates are 0.238 for fathers and 0.208 for mothers.

Distinguishing between sons and daughters

Our review of the literature suggested that parents may be more effective at transferring their human capital to children of the same gender. The next model takes this into account by introducing interactions between each parent's education and the child's gender:

$$A_i = \alpha + \gamma.BOY_i + \beta_1.PA_i + \beta_2.MA_i + \beta_3.BOY_i.PA_i + \beta_4.BOY_i.MA_i + \xi_i$$

We begin by comparing the effect of mothers and fathers separately for sons and daughter, hence testing two hypotheses.

H2: mothers and fathers have the same effect on daughters ($\beta_1 = \beta_2$)
H3: mothers and fathers have the same effect on sons ($\beta_1 + \beta_3 = \beta_2 + \beta_4$)

(Rejection of H2 and H3 is in line with the 'sex-role' model of Korupp et al. (2002))

Figures 4 and 5 show the results of testing these hypotheses for each country for maths and tables 2 and 3 give the results for each subject for the pooled sample of all countries. The pooled sample results show a clear difference between sons and daughters. For daughters, we always fail to reject the null hypothesis, while for sons we always reject it. Fathers' education is more important than mothers' for sons. For example, Table 3 shows that four additional

years of mothers' education is estimated to increase their sons' maths score by 0.163 (= 0.202 – 0.039) of an international standard deviation. The same addition in fathers' education leads to an increase of 0.232 (= 0.198 + 0.034), about 40 percent more.

The picture for individual countries in part reflects these results – there are 14 countries above the 45 degree line in figure 4 for daughters, signifying fathers more important, but 20 in figure 5 for sons. (The Nordic countries are all below the line in figure 4 but not in figure 5.) But in most countries the null cannot be rejected, whether for sons or for daughters. Germany and Australia are the only countries significantly above the line for both sons and daughters.

We now test two further hypotheses based on the same model:

H4: fathers have the same effect on sons as on daughters ($\beta_3 = 0$)
H5: mothers have the same effect on sons as on daughters ($\beta_4 = 0$)

Note the difference between H2 and H3, and H4 and H5. The first pair of hypotheses focuses on the differences in effects of mothers and fathers for children of a specified gender. Now we consider one parent at a time but compare their effect on sons and daughters.

Figure 6 suggests little evidence against H4 and not much variation from country to country. Countries sit quite tightly round the 45 degree line. The null hypothesis is rejected nowhere, although it is just rejected for maths at the 5 percent level in the pooled sample (Tables 2 and 3) with fathers having somewhat more effect for sons. Figure 7 for girls also shows less scatter than the earlier graphs but the obvious change from figure 6 for boys is that most countries are now to the right of the 45 degree line (23 out of 30). Mothers appear to have more influence on girls' ability in maths than on boys' ability, although only in France and Denmark is the effect statistically significant. The broad pattern in figure 7 is reflected in the results for maths in Tables 2 and 3. An increase of mother's education of four years is associated with an increase in a daughter's maths score of 0.202 of a standard deviation, compared to a 0.163 increase for sons (= 0.202 – 0.039), a modest difference. However for reading and science we cannot reject the null of no difference in effect.

Complementarities between parents

The preceding models have constrained mother's and father's education to have independent effects on children's cognitive ability. However, the influence of one may depend on the other. There could be substitution possibilities between mother's and father's

schooling, as described by Behrman (1997). This would mean the effect of having a highly educated mother is smaller if the father is also highly educated. On the other hand, mother's and father's education could be complementary. In this case better educated mothers are more effective at passing on their human capital to children if the father is also better educated. There seems only a scant existing literature on this issue.[16]

We test for these effects by including an interaction between mother's and father's education in our first model (which restricts the parental effects to be the same for boys and daughters). (As before, by 'effect' we mean 'association.') The model is now specified:

$$A_i = \alpha + \gamma.BOY_i + \psi_1.PA_i + \psi_2.MA_i + \psi_3.PA_i.MA_i + \xi_i$$

We test the hypothesis:

H6: Mothers' and fathers' influences do not interact with each other ($\psi_3 = 0$)

Results for the pooled sample show a positive coefficient on the interaction term for all three subjects, implying complementarity, and one that is well determined ($t = 5.9$ for maths, for example).[17] When estimating the model for each individual country, we find the interaction to be positive in 22 countries and significant at the 5 percent level in 9. The latter group includes three of the four Central European countries, and all three countries from the UK present in the data, England, Scotland and Northern Ireland. A statistically significant negative impact at the 5 percent level is found in three countries: Italy, Portugal and Switzerland.

The typical pattern of complementarity suggests that assortative mating may strengthen the intergenerational transmission of human capital, at least as far as the outcome we have considered in this chapter, children's cognitive ability in their early/mid-teens. Educational 'homogamy', that is marriage to a person of the same educational level, leads to 'advantageous (and disadvantageous) economic and sociocultural resources of two individuals [being]... pooled and cumulated' (Blossfeld 2009). Complementarity implies that the impact of this pooling and cumulation on children's learning is not additive. However, our results here are best seen as suggestive, requiring further elaboration in the light of possible measurement error and better theoretical underpinning.

5. Conclusions

To our knowledge, existing studies have not considered the separate associations of mothers' and fathers' education with their sons' and daughters' cognitive ability for a large number of countries using data designed with cross-national comparison in mind. We therefore make a contribution to the literature on how educational advantage and disadvantage are transferred between generations by exploring these gender differences for 30 rich industrialised nations, restricting attention to children living with both natural parents. This complements a small body of work that has investigated the links usually for a single country, focusing in the main on the children's final level of schooling rather than cognitive ability.

It is not easy to make broad generalisations from our results. The picture often differs substantially across countries; mothers are more important in some, fathers in others. This cross-national variation supports the mixed evidence in our review of the literature. It also serves as a reminder that one should be cautious about making general statements on the basis of evidence drawn from a single country, for example the US for which the earlier evidence seems more abundant than elsewhere.

That said, we attempt a summary of the general picture, focusing on the results for ability in maths. First, it is more common for father's education to have a greater effect than mother's education. Remember we use 'effect' without implying causality. Second, this appears to be particularly true of sons, although there are plenty of countries that are counter examples. Third, there seems to be more variation across countries in the gender differences in the parents' generation than the children's. Fourth, there is some suggestion that mothers' education has more effect on their daughters' ability than their sons, yet the difference is often small. Fifth, it seems we should not only consider the relative importance of each parent's education, but also how they combine. Our results suggest that they may typically combine positively; mother's and father's education appear complementary in their association with the child's ability.

This last observation leads to the first avenue for further work. We have not distinguished between couples where the father is more educated than the mother and those where the opposite is the case. The type of combination of father's and mother's education may matter for the child's learning, although selection bias can be expected – women who 'marry up' (hypergamy) may differ from those who 'marry down' (hypogamy) in unobserved ways that influence their child's learning.

A second avenue is to enrich the measurement of each parent's socio-economic status, moving beyond education alone. An obvious possibility is occupation, following the lead of,

for example, Korupp et al. (2002). Each parent's occupation is recorded in PISA, although again is reported by the child. Our preliminary exploration of these data, adding measures of father's and mother's occupation to our regressions, tended to produce a clearer pattern that mothers 'matter' more for girls, while fathers are more important for boys. Inter alia, further work in this direction would require a conceptual framework to complement that in figure 1 for parental education.

The third avenue is to try to relate the cross-national patterns we have found to country-specific policies or institutions. This is a challenge. There seems no easy explanation as to why fathers have more influence than mothers in countries like Australia and Germany, for the opposite to be true in Hungary and Turkey, and for no significant differences in, for example, England and Belgium. One possibility that we cannot yet entirely rule out is that the differences we observe across countries in the PISA data are often due to variations in data quality; our measure of family background is reliant upon 15 year old children knowing and accurately reporting their mother's and father's levels of education and we have drawn attention to evidence that questions whether this is the case.

Despite the limitations and the avenues still to explore, we have at least highlighted the role that gender may play in the transfer of human capital between generations. In this respect, the spirit of the chapter contrasts with a reasonable amount of existing work on economic and social mobility. We advocate investigation of gender differences in other aspects of intergenerational mobility, accompanying further work on the role that these differences play in children's cognitive abilities.

Acknowledgements

Endnotes

1. There is no explicit role for schools in the model. One can think of parents' choice of

schools, subject to various constraints, also being determined by their education and abilities. If schools have a positive impact, the simple correlation of parental education and child ability will in part reflect this pathway.

2. The NELS cohort were first interviewed in 1988 at age 14. We imputed completed years of education for both cohort members and parents from variables for highest qualification achieved.

3. On the channels by which educated mothers influence early childhood learning and the evidence for this, see for example Katja Coneus and Maresa Sprietsma (2009).

4. For further evidence on the US, see for example Behrman and Mark Rosenzweig (2002) and Lídia Farré et al. (2009). Korupp et al. (2002) compare the US with (West) Germany and the Netherlands, but they include parental occupation as well as education in their models.

5. The father-son link is stronger than the mother-son link (t=3.5) and the mother-daughter link stronger than the father-daughter link although the difference in this case is not well determined (t=2.05). T-statistics calculated by us from the reported standard errors for each regression coefficient (Björkland et al. 2007, table 2, column 1); we have thus ignored covariances when estimating the standard error of the difference in coefficients.

6. Japan is excluded because data are missing for all observations on some key variables, including whether the child lives with their biological or step parents.

7. Questions marks over response patterns in England are analysed in John Micklewright et al. (2010).

8. The PISA assessment focuses on children's functional skills; whether they can apply what they have learned to real life situations. It is argued that this assists the cross-national validity of the study, allowing measurement of achievement against a standard in a culture free way.

9. Children are told 'Some of the following questions are about your mother and father or those person(s) who are like a mother or father to you, for example, guardians, step-parents, foster parents, etc. If you share your time with more than one set of parents or guardians, please answer the following questions for those parents/guardians you spend the most time with.'

10. Among OECD countries, parents were questioned as well as children in Germany, Denmark, Iceland, Italy, Korea, Luxemburg, New Zealand, Poland, Portugal and Turkey.

11. We assume that any measurement error lies only in the child's reports, although this may

not be the case. See also Nanna Lien et al. (2001).

12. Four years is also roughly the international standard deviation of both mother's and father's years of education. The international standard deviations for both test scores and years of education tend to be higher than most national standard deviations, as they reflect both within- and between-country differences.

13. The position of the Central European countries is consistent with large differences in education attainment by family background during the communist period as well as any differences that have emerged subsequently (Yossi Shavit and Hans-Peter Blossfeld 1993, UNICEF 1998).

14. Comparison with results in Gabriela Schütz et al. (2008, table 3), drawn on by Machin (2009), is a reminder that the detailed cross-country picture of intergenerational mobility may depend on the measure of socio-economic status that is selected and the data set that is used: these authors use data from the Trends in Maths and Science Study and books in the home to proxy family background. We find a correlation of only 0.43 for our family background associations in figure 2 with theirs for the same countries. See Giorgina Brown et al. (2007) on the comparability of surveys.

15. A similar pattern is found in the NELS data for the US when we regress age 14 scores on parental education (see note 2).

16. For example, Behrman cites Ricardo Barros and David Lam (1996), who find evidence of a positive interaction suggesting complementarity.
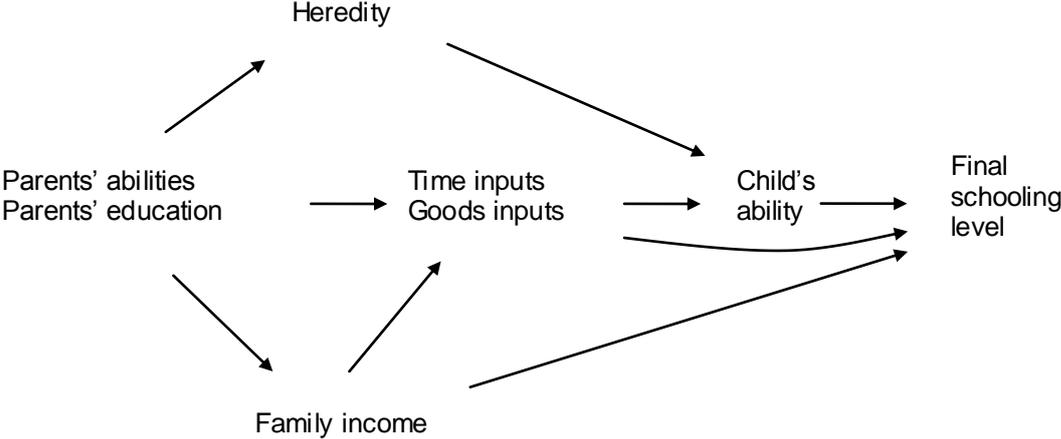
17. Not surprisingly, the inclusion of the interaction term reduces the precision of the estimated main effects of each parent's education. They remain strongly significant individually but for example in the maths equation the effect of mother's education is not statistically different from the effect of father's education.

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**Figure 1. The determination of children's ability and final schooling levels**

Heredity

Parents' abilities
Parents' education

Time inputs
Goods inputs

Child's
ability

Final
schooling
level

Family income

Source: adapted from Haveman and Wolfe (1995, figure 1).

Figure 2. Children's maths score and highest parental education (PISA 2003)

Standard deviations change in children's maths score with a 4 year increase in highest parental education
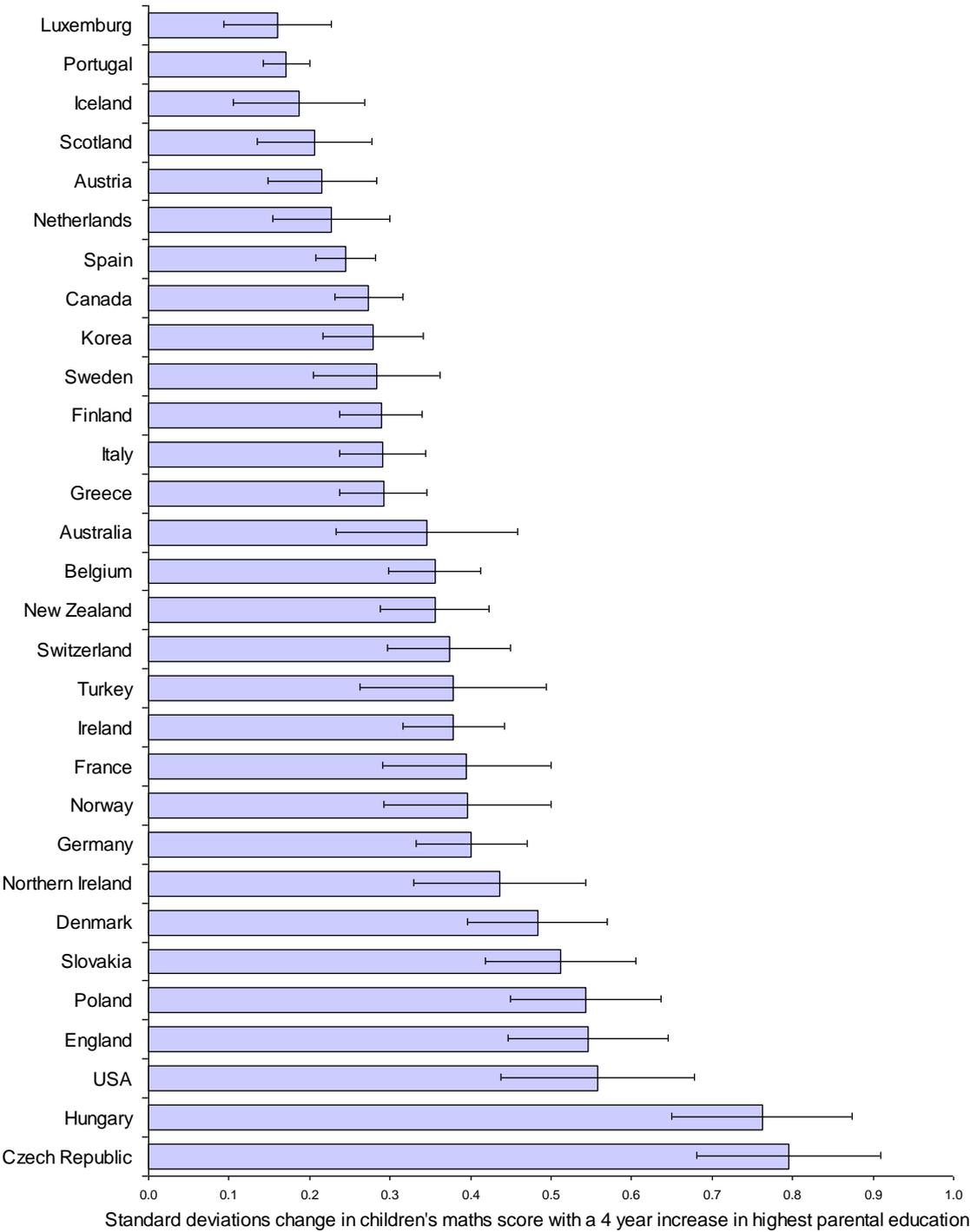
Note: See the text for the description of the regression behind these results. The horizontal lines at the end of each bar represent 95 percent confidence intervals around the estimates.

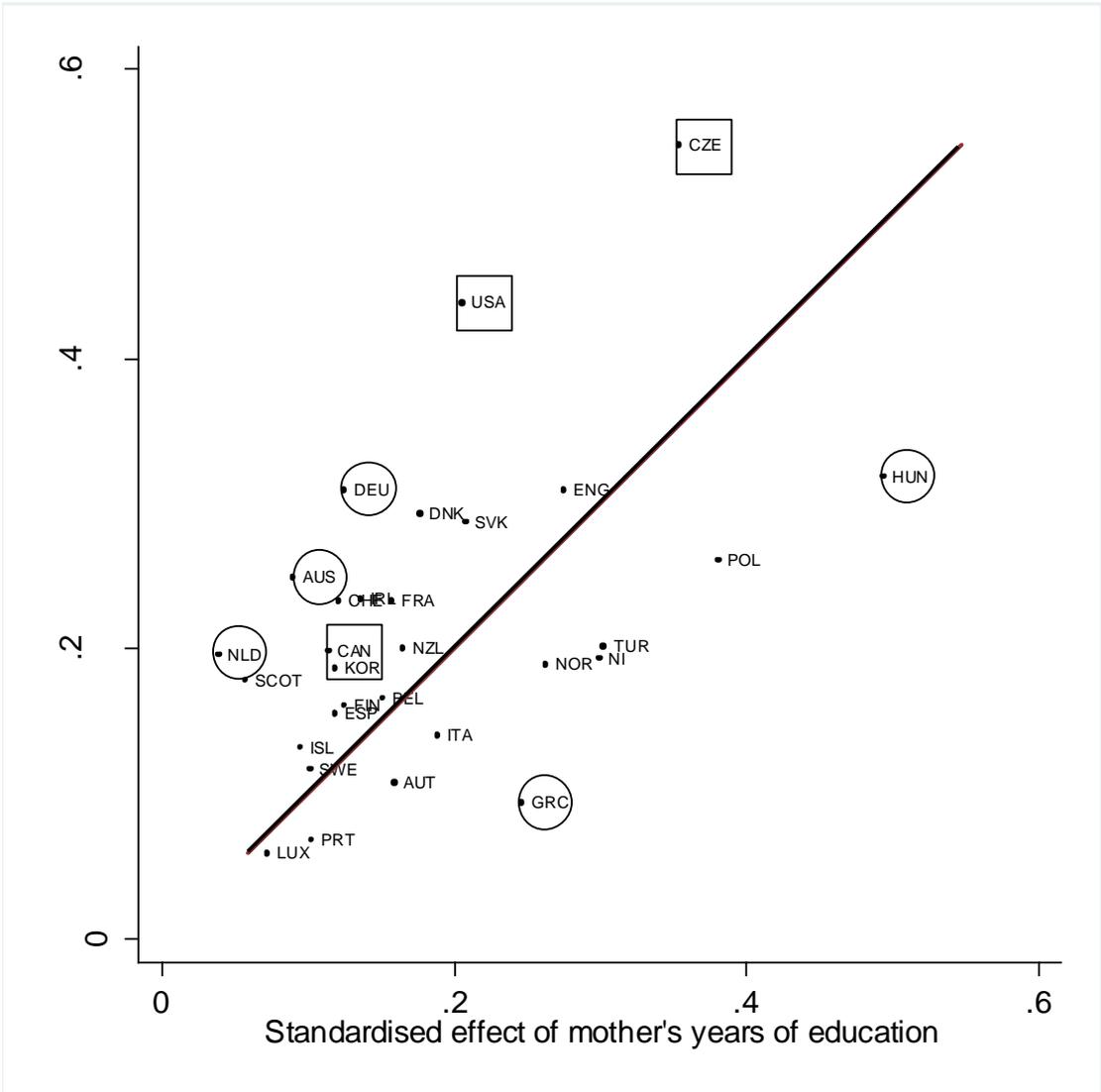**Figure 3. Mother's and father's education and child's maths score (H1)**
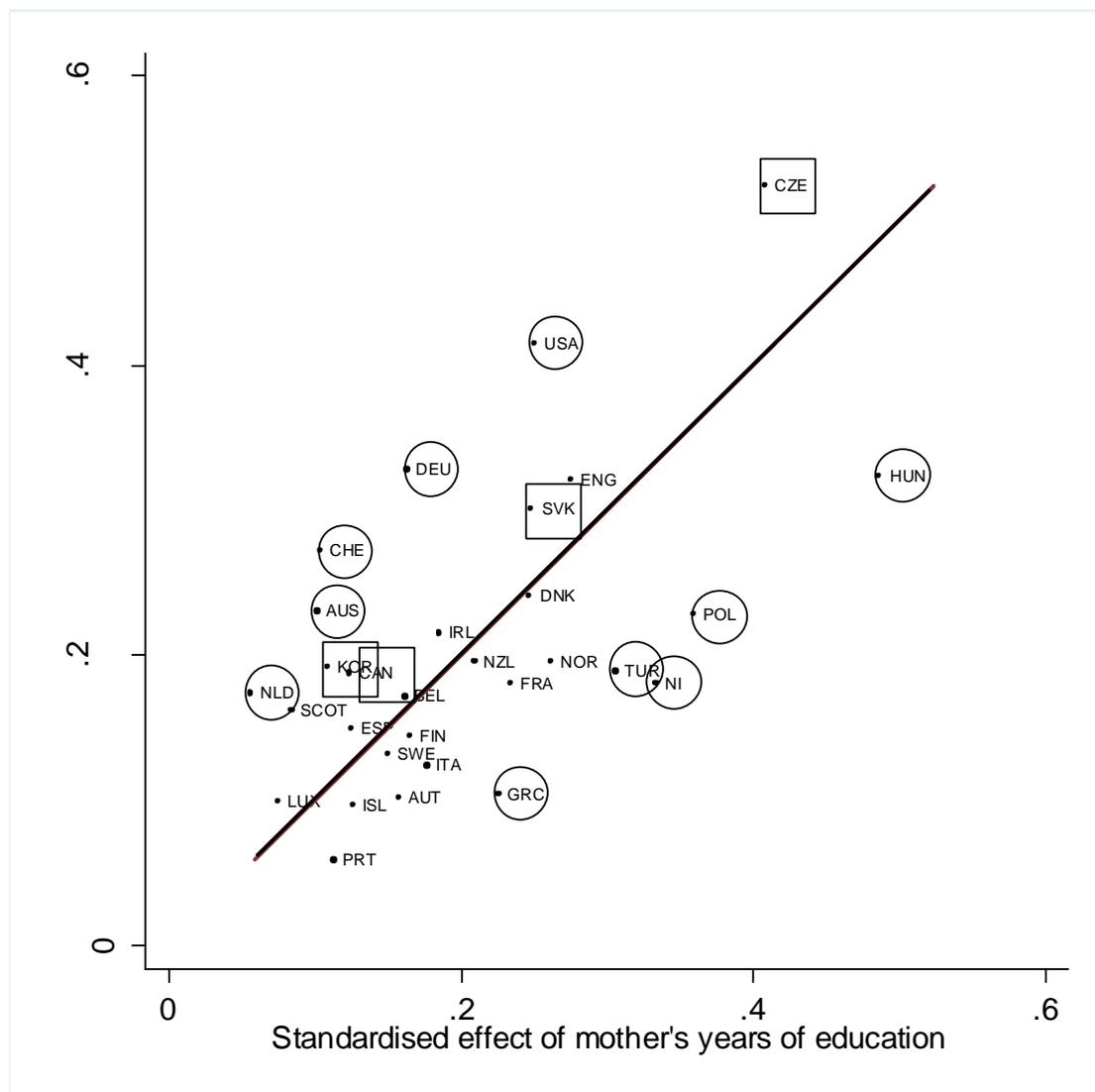
Notes: The 45 degree line represents where mother's and father's education have equal influence on their children's maths score. Circles (squares) indicate countries where the effect of mother's and father's education is statistically different at the 5% (10%) significance level. The x and y axis show the standardised effect of mother's and father's education: by how many (international) standard deviations does a child's test score change with a 4 year increase in the parent's education.

Figure 4. Mother's and father's education and daughter's maths score (H2)
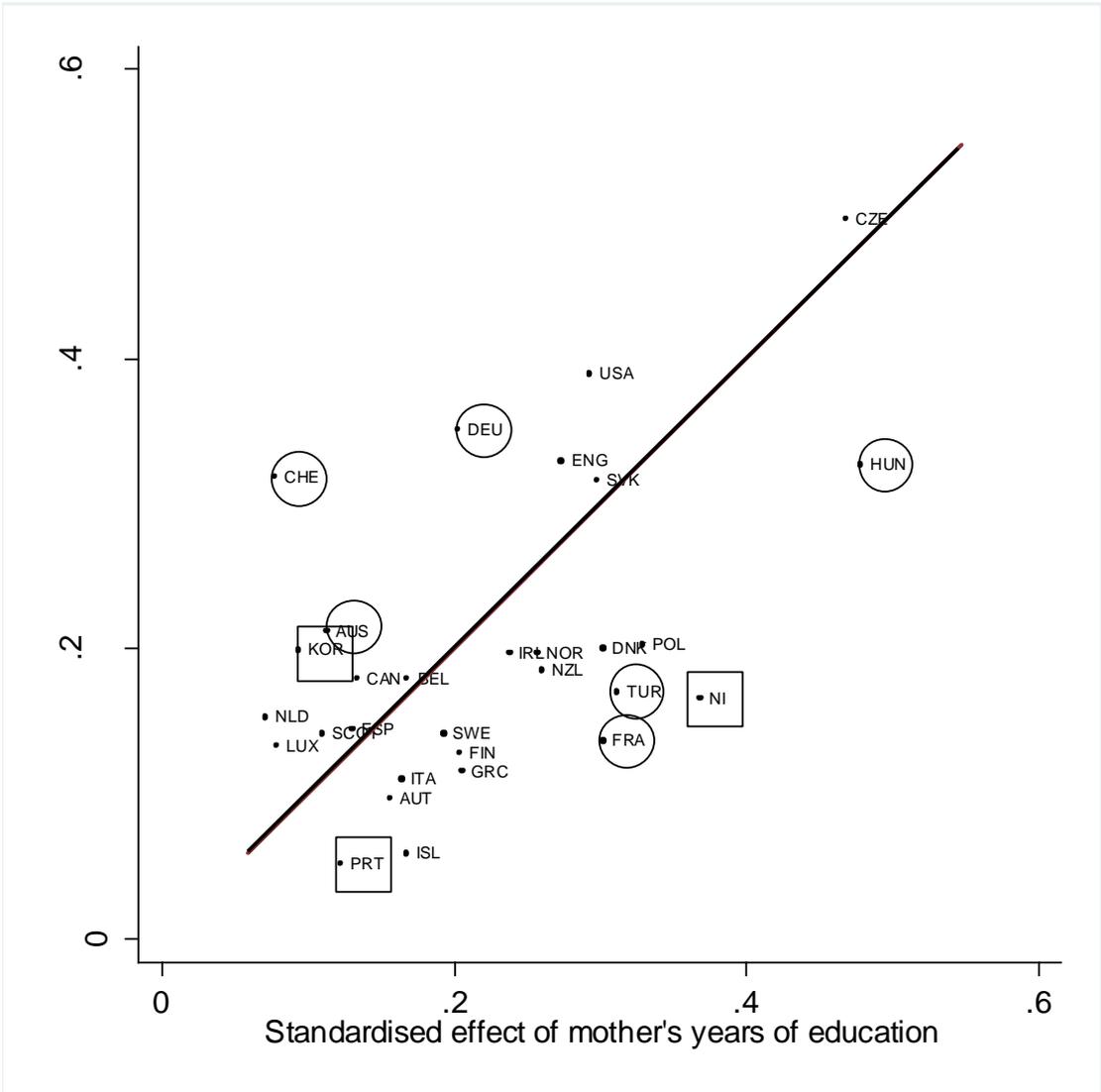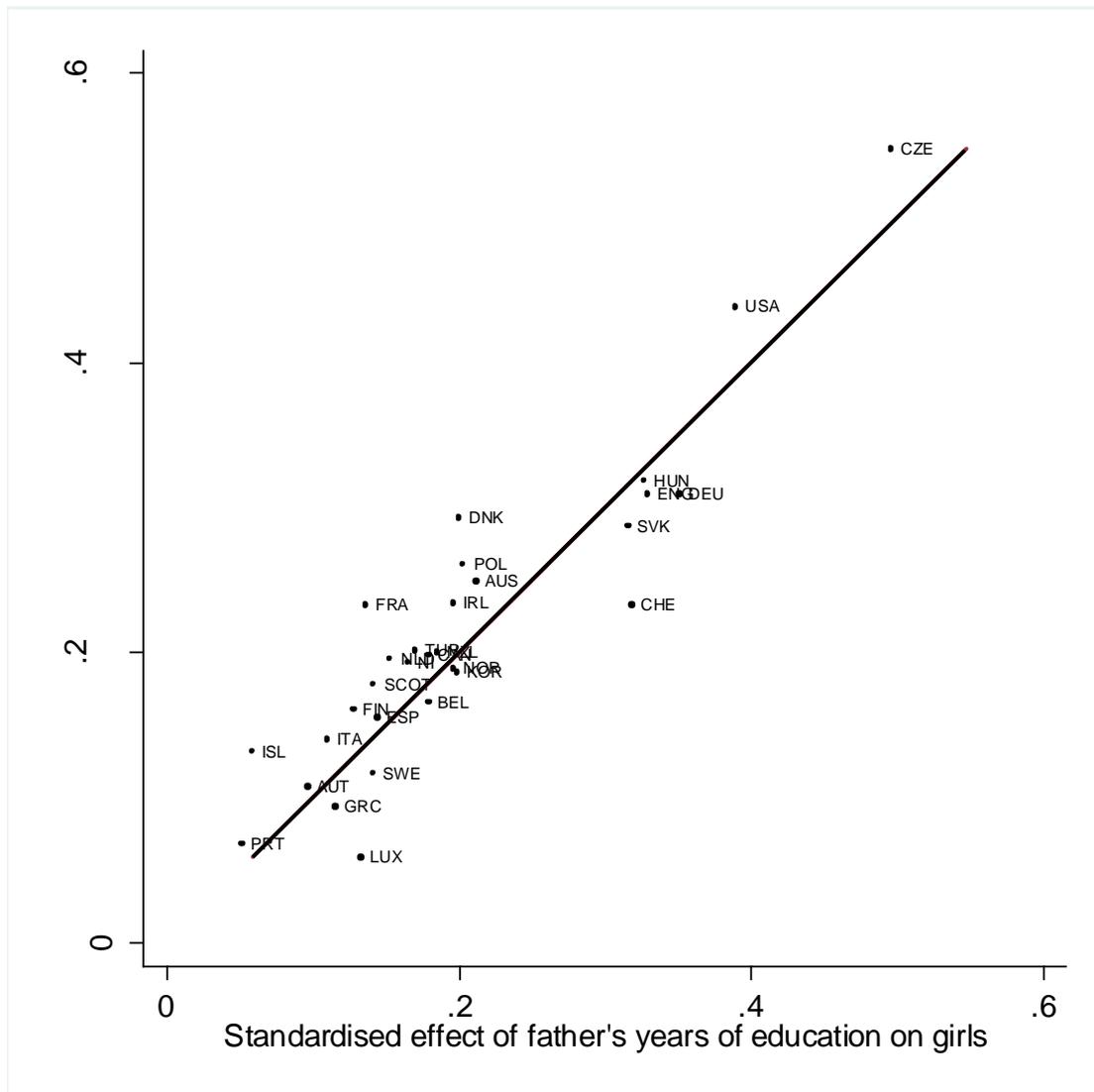

Notes: see figure 3.

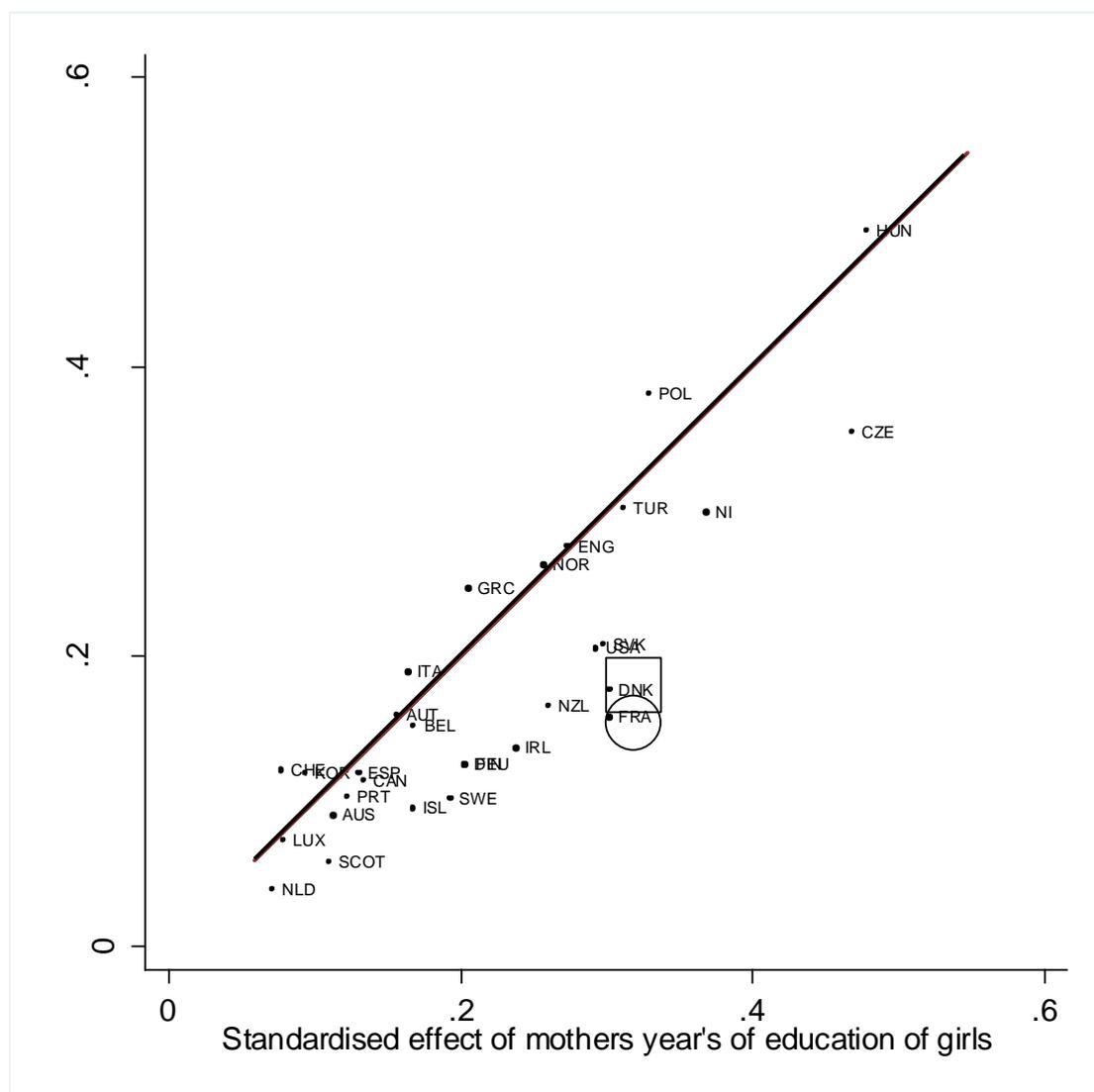**Figure 5. Mother's and father's education and son's maths score (H3)**

Notes: see figure 3.

Figure 6. Father's education and son's and daughter's maths score (H4)

Notes: The 45 degree line represents where father's education has equal influence on boy's and girl's maths scores. See also figure 3.

Figure 7. Mother's education and son's and daughter's maths score (H5)

Notes: The 45 degree line represents where mother's education has equal influence on boy's and girl's maths scores. See also figure 3. There is a statistically significant difference at the 10% level in Finland, though this is not clearly illustrated in the graph due to the overlapping country labels.

Table 1. Mother's and father's years of education

Country	Label	Sample size	Correlation between mother's and father's values	Mother's education = father's education (%)	One parent's education is missing (%)
Iceland	ISL	2,108	0.36	42	1
England	ENG	1,891	0.40	43	5
Australia	AUS	4,745	0.41	46	2
Norway	NOR	2,116	0.41	51	2
New Zealand	NZL	1,540	0.41	43	7
Northern Ireland	NI	1,745	0.41	42	4
Finland	FIN	3,789	0.42	52	1
France	FRA	2,086	0.42	51	3
Sweden	SWE	2,345	0.43	53	2
Belgium	BEL	4,656	0.44	53	3
USA	USA	2,158	0.44	64	0
Canada	CAN	14,418	0.45	51	1
Scotland	SCOT	1,219	0.45	42	4
Austria	AUT	2,801	0.46	50	1
Germany	DEU	2,365	0.46	51	3
Netherlands	NLD	2,484	0.47	52	3
Denmark	DNK	2,276	0.48	46	2
Ireland	IRL	2,522	0.48	46	1
Switzerland	CHE	3,612	0.50	54	2
Luxembourg	LUX	1,226	0.51	54	9
Czech Republic	CZE	4,243	0.53	54	1
Greece	GRC	2,506	0.53	48	0
Italy	ITA	8,329	0.53	49	1
Slovakia	SVK	5,473	0.54	78	1
Spain	ESP	7,885	0.57	51	3
Poland	POL	3,682	0.58	59	0
Turkey	TUR	2,752	0.58	43	1
Hungary	HUN	3,135	0.62	53	2
Korea	KOR	3,861	0.68	61	1
Portugal	PRT	2,905	0.76	60	1
Total		106,873	0.61	54	2

Notes: based on data after sample selection rules have been applied (no migrants, children living with natural parents only, at least one parent's education coded).

Table 2. Tests of hypotheses for the three PISA domains, pooled sample of 30 countries (p-values)

Hypothesis		Maths	Reading	Science
H1	Mother → Child = Father → Child	0.04	0.03	0.02
H2	Mother → Daughter = Father → Daughter	0.24	0.42	0.31
H3	Mother → Son = Father → Son	0.00	0.02	0.02
H4	Father → Son = Father → Daughter	0.04	0.13	0.21
H5	Mother → Son = Mother → Daughter	0.03	0.31	0.25
H6	Mother ↔ Father interaction = 0	0.00	0.00	0.00

Notes: Figures in the table refer to p-values; estimation of standard errors allows for clustering of children within schools.

Table 3. Standardised regression coefficients for the three PISA domains, pooled sample of 30 countries

	Maths	Reading	Science
Boy (γ)	0.114 (0.046)	-0.372 (0.046)	0.039 (0.048)
Father's Years of Education (β_1)	0.198 (0.011)	0.186 (0.011)	0.218 (0.012)
Boy × Father's Years of Education (β_3)	0.034 (0.016)	0.025 (0.017)	0.022 (0.018)
Mother's Years of Education (β_2)	0.202 (0.013)	0.173 (0.012)	0.198 (0.014)
Boy × Mother's Years of Education (β_4)	-0.039 (0.016)	-0.015 (0.016)	-0.018 (0.017)

Notes: Standard errors in parentheses. Their estimation allows for clustering of children within schools. The models include a dummy variable for each country although the coefficients are not reported. The β coefficients represent the standardised effect of that variable; by how many (international) standard deviations does a child's test score change with a four year increase in mother's or father's education. The γ coefficient shows the difference between boys and girls using the same metric; for example, boys are estimated to have reading scores that on average are 0.372 of an international standard deviation lower than those of girls, holding other factors constant.