Educational Inequality, Women Empowerment and Assortative Matching*

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Abstract

Inequality largely depends upon educational inequality. Using PISA data from all waves and for all countries I show that family variables count more than school variables in explaining math, reading and science scores and that women education, which can proxy empowerment, counts more than father education. Those results remain robust when the regressions control for assortative mating by including interaction dummies on parents' education or using propensity score matching estimators. I show, numerically and analytically, that a model with collective bargaining for households' decisions, warm glow preferences and human capital accumulation can rationalize both of the above facts. The relative higher impact of mothers' education primarily depends on the relative higher time that they devote to children education and can increase when women' bargaining power endogenously depend upon their human capital. This second channel captures an empowerment externality.

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1 Introduction

Increasing inequality is surely one of the major recent events. Income and wealth inequality on the one side and educational inequality on the other are largely interconnected phenomena[1]. Thereby understanding the main determinants of educational inequality has important implications for inequality in general. Several paper using country level data and reviewed in the next section show alternatively that income, wealth or other family background variables are important in determining the educational attainment of children. Furthermore, some policy documents report a positive correlation between mothers' educational attainment and children's one[2]. No academic work however discusses causality for the latter relation, something which requires also controlling for assortative mating within the couple.

The availability of household level and cross-country data such as the PISA studies allows researchers to respond those questions. PISA provides comparable scores in math, reading and science for adolescents jointly with surveys conducted at children, family and school level. The surveys provide numerous variables that allow to disentangle the role of family versus the school or the education system in general and the role of mothers versus fathers. I conduct an empirical analysis using PISA data to assess the determinants of educational attainments. Results show that family financial and cultural background count much more than schools characteristics, with the exceptions of teachers' quality. Noteworthy is that cultural background seems to count more than the inter-generational transmission channelled through financial resources. The controls used in the regressions are selected through principal component analysis to minimize jointly omitted variable bias and multi-collinearity. Results remain robust to the inclusion of either family income or wealth. Further, I find robust evidence that mothers' education, which can proxy mothers' empowerment, counts more than fathers' one. To account for possible non linear effects educational

[1] A recent report from the OECD[45] discusses the link between educational and income inequality. The links between education and inequality are discussed early in Becker and Chiswick[8], Galor and Tsiddon[31] or Barro[5] among others.

[2] See OECD[46]. Also field experiments such as Decker et. al. [22] confirm the link between parents and mothers' education specifically and children's one.

levels are categorized in six different levels. The impact of mothers seems to be particularly strong at intermediate level of educations, a fact suggesting that traditional channels such as time devoted t child rearing might play a significant role. Indeed very highly educated mothers might have higher incentives to substitute time spent in child rearing with labour hours, due to the higher wage premium. Despite the significance of the effects it is possible to imagine that the impact of mothers' educational attainments might partly stem from spillovers related to assortative mating. The fact that highly educated mothers tend to couple with highly educated fathers can increase the probability that offsprings perform well in school. To control for this effect and to compute the exact marginal effect of the mother alone, I also estimate two alternative econometric specifications, one which includes interaction dummies for the joint mother and father education levels and another which uses propensity score matching techniques. Results are confirmed in those specifications.

Those results have important policy implications. If family variables, cultural capital and income, matter more than school systems positive inter-generational transmission of inequality might be stronger than previously thought[3].

To rationalize the above results construct a dynamic model where households' decisions are collectively bargained and in which parents also hold warm glow preferences, thereby internalizing the value function of the future generation. Households decide consumption for both spouses and spend in education for their children. Both spouses in the model supply labour services in the labour market. Wages in the labour market positively depend on the human capital and this is equally true for both spouses. Human capital evolves across generations following a law of motion that links future human capital to current one (of both spouses) and to investment in education. I solve the model numerically and analytically, the latter under a knife-edge specification, and show two results which are compatible with the empirical evidence. First, higher parents' education grants higher income and higher investment in children education. Second, mothers' human capital

[3]It would be interesting in this respect to examine if some education systems like the Reggio-Emilia, whose goals are of equipping children with most equal educational devises, reduce the extent to which parents' human capital drives future generations' one.

counts relatively more than fathers' human capital in transmitting education to future generations. In the benchmark specification of the model this effect is due primarily to the realistic assumption that mothers devote relatively more time in children rearing and education than fathers. As the quality of the child rearing time increases with mothers' education, their human capital transmits more strongly to their children. Furthermore, I examine whether other factors can change this transmission effect. The assumption that women bargaining power endogenously increases with their level of human capital, relatively to that of the father, marginally increases the transmission from mothers' human capital. As women bargaining power raises with their level of education, mothers have higher ability to influence households' decisions, including investment in education. As the value functions of different genders in future generations are weighted according to the bargaining weights, mothers' would internalize the effects of the educational choices on female offsprings. This might marginally increase investment in daughters' education, it has however little effects on the overall educational attainments of future generations. Next, I examine how results change with a reduction of the gender wage gap in favour of women. In this case as one might expect mothers substitute child rearing time with working time. This in turn reduces future generations' educations level and human capital. This results shall obviously not be taken as a suggestion to maintain the current gender wage gap, rather the opposite. Women provide a social externality at the cost of their wage and this calls for sharing the burden of the externality. At last, the model can rationalize the empirical results showing that mothers' transmission of human capital tends to prevail mainly at intermediate levels of education, while the effects reverse again at the highest level of education. Through the model I simulate the case in which female wage premium experiences a jump at the highest quantile of education. When it is so the contribution of mothers' education remains higher than that of fathers, but only up to the highest quantile and it declines afterwards. This is due again to the fact that highly educated mothers tend to substitute child rearing time with labour hours. Hence despite they higher quality of the time spent in child care, the fall in the quantity reduces the transmission of mothers' education.

The rest of the paper is structured as follows. Section 2 reviews various papers to which the paper links. Section 3 presents the data and the empirical analysis and results. Section 4 presents the model and its results. Section 5 concludes.

2 Literature Review

This paper is linked to two main strands of the literature, one empirical and one theoretical.

Empirically the paper is linked to a host of papers addressing the determinants of educational attainments and inequality. A number of papers has assessed the role of family background. Most often the inter-generational persistence of educational attainments has been explained with socioeconomic variables such as parental education, income or wealth. In many cases authors exploit exogenous changes in regulations or other quasi-natural experiments. Black, Devereux, and Salvanes[12] using Norwegian data study inter-generational link on educational attainments using the reform of the education system that was implemented in different municipalities at different times in the 1960s as an instrument for parental education. They find little role for parents' education, except for the case of mothers' education, and suggest that other family characteristics, inherited characteristics or education spillovers might play a larger role. The role of parental income for children education is studied in Dahl and Lochner[21], while that of parental wealth is studied in Bleakley and Ferrie[13]. Both papers find little role for family income and wealth[4], again pointing at other factors. All of those studies are based on single country data, while my paper uses a comparable cross-country survey which has been conducted for several years. Also contrary to the above papers, results in my paper do assign some role to family economic background (mostly wealth). Finally, the availability of a larger dataset, both in terms of observations and variables, allows me to control for country differences and to better isolate the role of mothers' education, relatively to other family characteristics.

Other authors have examined empirically the role of alternative factors, such as school and or

[4]Other studies along a similar vein include Chevalier, Denny, and McMahon[16], Hertz et al[36] and Rothstein and Wozny[52].

local cultural factors. Ellison and Swanson[30] examine the role of high quality schools and show that the distribution of unexplained school effects includes a thick tail of schools that produce many more high-achieving students than is typical. Krapohl et. al.[44] examined the role of inherited traits. While Currie and Moretti[20] show that local social networks can have an important role in children development. Recently Giuliano et al.[33], using both data on educational attainment of immigrants and locals from schools in Florida, have shown the culture of origins matters for attitudes toward long term orientation and ultimately for educational attainments. Contrary to those the extensive number of questions, conducted both at family and school level, in the PISA surveys allows me to compare family and school background.

At last, some empirical evidence exist on the positive correlation between mothers' education and children's ones. Most is summarized into the OECD[46] report. Also field experiments such as Decker et. al. [22] confirm the link between mothers' and children's culture. Finally, Dohmen et. al.[25] presents evidence that mothers' traits tend to be transmitted across generations. At last, the paper by Jones, Schoonbroodt, Tertilt[37] examine and compare the role of fathers and mothers education for the endogenous fertility rate and the quantity-quality trade-off.

The analysis of this paper focuses on the full set of PISA surveys and examines progressively the role of family cultural traits relatively to school characteristics and the role of women empowerment also controlling for couples' assortative matching. Using PISA data has several advantages. It provides comparable cross-country observations, thereby allowing the researchers to exploit cross-sectional variations. By now the survey has been repeated for a number of years and this allows me to exploit the temporal dimension. At last, if one focuses on the last surveys (mostly 2012 and 2015) PISA provides a very detailed survey questionnaire which covers numerous family, school and individual characteristics, thereby ensuring that unobserved heterogeneity is minimal.

Theoretically this paper is related to works that extend and apply the altruistic parents models from Becker and Barro[7] and the Barro and Becker[6] to study the role of intra-households decisions for future generations. I focus in particular on the role of intra-households decisions for

children educational attainments. Importantly intra-households decisions are conducted within a non-unitary model[5] (see Chiappori [17], [18]), whereby the bargaining weight of each member of the couple matters. The basic framework is an overlapping generation infinite horizon model in which married couples face a trade-off between the quantity and the quality of their children. For intra-households decisions I focus onto cooperative bargaining models[6]. This is the most suitable model environment given the research question at hand since it accounts for the separate role of spouses' bargaining power, but also retains the possibility of joint family decisions, such as those related to children education. The solution concept follows the proportional method[7], in which optimization implies maximizing the product of the gains from marriage. To dissect the role of mothers' education for children human capital, the model embeds two channels. The first is the traditional direct channel of inter-generational human capital accumulation, which is driven by parents' human capital and households' investment in education. Second, in a variant of the model, where female bargaining power endogenously depends on human capital, mothers' education also plays an indirect role through the intra-households decision on educational investment. Higher female education, increases mothers' bargaining power, hence her ability to influence intra-households decisions.

Other authors have pointed out at the role of women bargaining power for children investment in education. Doepke and Tertilt[23] examines the men's incentives to support women empowered regimes. Edlund and Lagerlöf[29] show through a model that women empowerment can facilitate human capital accumulation. Miller[42] argues along the same lines. The closer model to the one presented in this paper is De LaCroix and Donckt[26], who also endogenize women bargaining power with respect to their human capital.

[5]It is well established that the unitary model is not well suited to study that various family choices including women labour supply or investment in children education (see Knowles[40] among others).

[6]As Pollack[49] notes those models have become the benchmark in studying family decisions.

[7]See Kalai[39].

3 Empirical Analysis

The goal of the empirical analysis is to assess the main determinants of children educational attainments along two dimensions. At first, the paper re-examines the role of the family background, both in terms of economic as well as cultural determinants, vis-a-vis the role of school characteristics. This question has important policy implications since it informs about extent to which the education system can correct inherited inequalities. Within the family context I am also interested in examining the relative contribution of each parent separately relative to their joint contribution, stemming from assortative mating. There are several reasons for doing so. First, all the PISA reports show that the correlation between mothers' education and children PISA scores is higher than the corresponding one for fathers. Causality still remains an open question, but there are several reasons to believe that mothers' role might go on top and beyond that of fathers'. First, according to most recent surveys on time use parents[8], and especially highly educated mothers[9], devote more time to child care. Beyond that there are at least two other channels through which mothers can affect children education and they are both linked to mothers' education levels themselves. First, there is extensive evidence that women education affects their empowerment, intended as the ability to influence decisions at home and outside of the house. Women education can however affect children educational attainments also through marital selection or assortative mating, particularly with regard to educational homogamy. This effect is particularly strong at the top of the earning distribution. One challenge of the empirical analysis will be to quantify the marginal role of women education by controlling for assortative mating.

3.1 Data and Econometric Specification

The data for the analysis is collected from the PISA surveys - the Program for International Student Assessment[10]- which has been conducting surveys of students, families and schools since

[8]See Aguiar and Hurst[3].
[9]See Bianchi et. al.[10] and McLanahan[41].
[10]See https://www.oecd.org/pisa/pisaproducts/.

2003. These dataset has several advantages. It is the only comparable cross-country dataset on educational attainments, thereby it allows researchers to exploit well the cross-sectional dimension. The survey has now been conducted for several years, thereby the dataset also offers temporal variation. At last, mostly in the last wave, the questionnaire contains many more questions related to children and family background and to school characteristics. This allows the researcher to reduce at minimum the unobserved heterogeneity. As we will see later on, many variables contain duplicate information. To avoid multi-collinearity, while minimizing the omitted variables' bias, the regressors are pre-selected based on a principal component analysis[11]. The extracted factors explain more than half of the variation in the group.

The general econometric specification, which is detailed below, regresses scores for math, reading and science onto a set of family variables, parents' education and school characteristics controlling for country fixed effects and for children gender. For robustness checks four different specifications of the econometric model are run. Those specifications include a benchmark specification, two additional ones augmented with interaction dummies on parents' education levels and one two-stage procedure based on propensity score matching analysis. The last two in particular serve the purpose of disentangling the role of mother's education relatively to educational mating. More details on those specifications are given below. Also for robustness regressions are run on two different data samples. The first pools observations from all the surveys from 2003 to 2013 and runs the regressions based on a common set of controls. The advantage of this specification is that it allows to include 72 countries[12] and it covers data over several years, hence it features extensive variation both at the cross-sectional level and at the temporal level. The second data sample considered takes the responses from the 2015 survey. In this case there is no temporal variation, however in this year the survey includes many more questions, hence the set of regressors

[11]Combinations of related characteristics are subjected to factor analysis with varimax rotation, which produces orthogonal factors. This means that the factors eventually chosen and included in the regressions are not correlated to each other.

[12]Note that some of the "economies" are territories of the larger countries, like in the case of the US (for example Puerto Rico).

and controls is much larger than in the pooled regression.

3.1.1 PISA Survey

The target groups of the PISA tests and surveys are school students aged between 15.3 and 16.2, who have completed at least 6 years of education. Students are assessed in science, mathematics, reading, collaborative problem solving and financial literacy. I focus on the first three scores. Specifically the PISA dataset[13] makes available metrics for students proficiency, namely math, reading and analytical abilities. The core of the study is the two-hour computer- or paper-based test. Note that different groups of students answer different yet overlapping sets of items. This serves the purpose of adapting questions to different countries and institutional contexts. Despite this comparability might not perfect. For this reason the data are often adjusted by computing multiple imputations, the so called plausible values. Details about this procedure are in Appendix A. Regressions have been re-estimated in all cases by checking using both imputed and non-imputed values. The comparison shows no significant difference between the two. This is consistent also with finding in Dustmann et. al.[28].

Besides the test results, the PISA assessment also consists of a student, school, and parents' background questionnaire and another questionnaire on educational background and career interests. Overall, the surveys contain information about household resources and learning practices, such as parent's support of student's learning, as well as education and occupation of the parents and income of the household. Data about school resources and infrastructure is also collected. In the benchmark econometric specification family financial background is measured through wealth. We choose wealth as benchmark control as the alternative, namely income is reported only for some countries. To check robustness however each regression is repeated by including income, in place of wealth among the controls. In this case however the country sample is limited to the reporting ones (detailed in Table **??** in Appendix A). The next section presents the benchmark empirical specification.

[13] Available at https://www.oecd.org/pisa/pisaproducts/.

3.2 Benchmark Empirical Specification and Selection of Explanatory Variables

The benchmark econometric specification reads as follows[14]:

$$y_i = \mu_i + \beta_0 + \beta_1 MED_i + \beta_2 FED_i + \Pi_1 X_i + \Pi_2 Home_i + \Pi_3 School_i + \varepsilon_i \quad (1)$$

where the index i indicates the household, y_i is PISA score of the student i, where y_i is alternatively the math, the science and the reading score. The regressors include the variables MED_i and FED_i which are dummies for mother's education and father's education respectively. To allow for non-linear effects six different education levels for each parent are considered. The above benchmark regression is estimated on the pooled sample 2003-2013 (results shown in Table 2), but also separately using the data from the 2015 survey (results shown in Table 5). As explained above the second includes many more variables than previous surveys.

The group of regressors labelled as $Home_i$ contains variables related to domestic resources and family educational choices. The set of regressors is selected by computing the factors for each et of variables (see Appendix A). Factors for this group, namely $Home_i$, include for the pooled surveys 2003 to 2013: cultural possessions at home, home educational resources, ICT resources, home possessions. For the 2015 survey questions provide further factors, mostly related to parents' educational choices. Those include parents communication, parents support in science, parents choice of school based on performance, parents choice of school based on costs, parents' school choice based on religion or teaching/pedagogical approaches. Whereby available the $Home_i$ variables also include alternatively households' wealth or income or family possessions. Note that not all countries report the income level, hence when this is used the regressions are done on a restricted set of countries (they are listed in Appendix A).

In both surveys, the variables' group $School_i$ includes the following orthogonal factors: teacher/student ratio, percent of certified teachers, percent of teachers with graduate degree, inadequate administrative stuff, inadequate teaching stuff. The 2015 survey also includes questions which relate to

[14]The data are re-scaled and adjusted using REPEST STATA package as discussed in Appendix A.

the following factors: school infrastructure, percentage of teachers with master or bachelor, total number of all teachers at school, class size, whether the school is public or not and the percentage of school funds coming from government.

Controls, X_i, include student gender, student age, whether he/she is native or not. Additionally, country fixed effects[15] are included. In this and the following specifications robust standard errors are clustered at school level.

3.2.1 Results Benchmark Specification

The results for the benchmark specification on the pooled waves 2003-2013 and for the 2015 survey alone are reported in Table 2 and Table 5. Results are shown for regression on each type of score, namely math, science and reading. For each score regression Table 2 shows additional columns for which the econometric specification includes alternatively wealth, income or home resources.

Results can be summarized as follows. First, family characteristics, especially income, wealth, cultural possessions and educational resources have a bigger impact on children educational attainments than school characteristics. The coefficients on school characteristics are very small and in many cases insignificant especially if one includes in the regression controls like family income or resources. Few observations are noteworthy. For the 2003-2013 pooled regression only the teacher/student ratio seems to be occasionally significant. For the 2015 survey based regression total number of teachers, whether they possess a graduate degree and the class size seem to play a role. At last the 2015 regression shows that if the school is public, this has a negative and significant coefficient. In the pooled regressions among the family variables both cultural possessions and home possessions seem to be important, while the second is insignificant in the 2015 wave. This is a noteworthy feature since it indicates that family cultural transmission is stronger than the one channelled through financial resources. It is also interesting to note that ICT resources have either low significance or even a negative impact on educational attainments and this is true in both data

[15]Note that PISA scores have been made comparable across different education system. Hence, country fixed effects capture the residual variation mainly associated with local networks (see Currie and Moretti[20]).

samples. Finally, wealth and income have mostly positive and significant coefficients in the pooled regression. In the 2015 regression wealth becomes insignificant[16]. This is why Table 5 only reports the results when including income.

We shall now examine the results related to the role of each parent education separately. In the pooled regressions both parents' education levels have generally positive and significant signs, the more so for higher levels of education. For the pooled regression the mothers' effect prevails in most of the columns. Interestingly the fathers' effect also falls mildly when income or resources are included in the regression, thereby hinting at the possibility that part of the fathers' contribution might be related to the spending capacity[17]. In the 2015 wave regression the impact of fathers' education becomes insignificant. Importantly for the 2015 regression it is possible to control for the variable "time spent in child rearing" (communication, parents' support in sciences, etc.), which is not available for past surveys. This control might contribute to explain the limited role of fathers. Overall, results from this benchmark specification suggest a different role for mothers and fathers, but the question needs further investigation. Indeed as explained above the role of mothers' education might be biased by other channels, one of which, and perhaps the most relevant, is assortative mating. Hence the regressions shall control for this. This is done in the next two sessions using two different methodologies.

Before closing this section, it is worth mentioning few other interesting results, although they are beyond the focus of the paper. First, native and higher age students do better in all PISA scores. Female students tend to do better in reading, while male do better in math. This is a common result in the empirical literature on education and it is usually explained with cultural biases[18]. Another interesting observation is that the time that parents spend in general communication with children produces positive results, while helping with science studies has a negative effect. Learning science

[16]The reason for this is that in this case the regression include many more variables which absorb most of the effects which would otherwise be channeled through wealth.

[17]When the regression includes income instead than wealth the results are generally less significant, but this is mostly due to the small country sample for which this variable is observed.

[18]See Guiso, Monte, Sapienza and Zingales[34] among others.

might indeed require that children develop abilities through independent thinking. Home resources related to classics tend to be more beneficial on school performance than ICT resources. For the 2015 regressions variables related to parents' school choice show that a choice based on academic performance has more beneficial effects that choices based on economic reasons or religious beliefs. This confirms again the importance of cultural values relatively to financial resources.

3.3 Propensity Score Matching Estimator

It is possible that mothers' education matters for children school performance only to the extent that highly educated mothers tend to assort with highly educated and highly earning fathers. One way to disentangle the casual effect of mothers' education on children educational attainment controlling for other confounding factors is to use the propensity score matching technique. The technique allows to control for several potential confounding factors, including the one we are interested in, namely assortative matching.

The technique used here can be briefly summarized as follows. First, one shall identify the treatment group which in this case consists of mothers with high education. The propensity score matching consists in dividing the control and the treatment group in bins which share certain characteristics. The bins from the treatment and the control group, in this case identified by fathers' education levels, shall be linked according to the similarity of the characteristics. The estimator of the treatment effect for every bin is then simply the difference between the outcome variable for that bin and the outcome variables for its matched counter-part. The global estimator for the average treatment effect (ATE) is the sample average of the treatment effect, hence in this case all couples whereby the mother has high education. The estimator exists and is consistent under certain assumptions (see Abadie and Imbens[1][19]).

With potentially many confounding factors, the curse of dimensionality typically complicates and introduces arbitrary judgment in the construction of the bins, which is based on the choice of

[19]Some conditions are normally defined for the propensity score matching estimator to exist and be consistent (Abadie and Imbens[1]). Those are:. Ignorability assumption, Overlap assumption, Random sampling.

the covariates. Optimally one shall obtain a single distance function capturing the main covariates, assortative mating in our case. This is done in the method suggested by Rosenbaum and Rubin [53], which controls for the covariates using a unified distance function, namely the propensity score. The propensity score is defined as a conditional probability of receiving a treatment, in this case mother having a better education, given a set of explanatory variables. A two-stage procedure emerges (see Cameron and Triverdi[14]). In the first step, a logit model for the treatment, mother's education, as outcome variable is estimated with confounders which include father's education, wealth as well as country fixed effects. This parsimonious specification allows me to control for assortative mating and possibly other major confounding factors, while at the same time limiting the bias due to arbitrary choices of the covariates. The fitted values from the first stage characterize the propensity score, which summarizes the pre-treatment controls. Subsequently the following econometric specification is estimated with OLS[20]:

$$y_i = \mu_i + \beta_0 + \beta_1 MED_i + \beta_2 PSCORE_i + \Pi_1 X_i + \Pi_2 Home_i + \Pi_3 School_i + \varepsilon_i \tag{2}$$

The second stage regression includes mothers' education, school variables and other controls, while the rest of the family variables contributions is captured by the propensity score. Table 4 and 7 show results of the second stage regression, for the pooled regression and for the 2015 respectively. As before the 2015 survey allows us to include many more home and school variables into the regression. Both the pooled regression and the one based on the 2015 unequivocally exhibit a higher coefficient for mothers' education for the math and science scores, the only exception being the coefficient on the reading score for the pooled regression.

It can be argued that the outcome of the propensity score procedure depends largely on the confounding factors included in the first stage. For this reason and to test robustness of the results, a third specification is estimated, in which the assortative matching channel is isolated by means of interaction dummies between mothers' and fathers' education levels.

[20]Estimators are carried on a random choice of the imputed values.

3.4 Interaction Dummies for Assortative Matching

The propensity score matching is a an appropriate way to control for confounding factors, but delivers best results when there are many of them. For the second question pursued in this paper, namely the role of mothers' education, there is one main confounding factor, namely assortative mating. The latter can be controlled for through an alternative and possibly more efficient specification, namely the inclusion in the benchmark specification of interaction dummies constructed by computing all combinations of the six education levels for mothers and fathers. The omitted category in this setting is both parents having low education. This alternative econometric specification is then estimated through OLS. Table 3 and 6 show results for the marginal effects of mothers' education, for the pooled regression and for the 2015 respectively. The pooled regression, which is also the more robust given the large data sample, show an additional interesting fact, namely that mothers' education matters more at all intermediate levels of education. On the contrary at the highest level of education fathers' coefficients tend to prevail for all PISA scores. This might by due to two reasons. First, there might be a composition effect as females' presence in the highest levels of education, namely graduate or doctoral studies, is often scant. Second, as argued below through the lenses of the theoretical model, an important effect of mothers' human capital is channeled through the additional time that they devote to children care and education. Females at the highest level of education are likely to see a non-linear jump in their wage premium that induces them to spend more of their time working. For those females the trade-off emerges between child rearing time and working time steeper. This might reduce female marginal contribution to children education.

3.5 Summary of Empirical Results

All together the above results show two main consistent patterns. First, family variables tend to matter more than school variables. This has very important consequences. To the extent that income and wealth inequality is driven by educational inequality, the prevalence of family influence

over societal choices on educational outcomes impairs the possibility of absorbing differences of opportunities over time. Second, even upon controlling for assortative mating, there seems to be a significant larger role of mothers' education.

The above results can be rationalized with an OLG model a' la Becker and Barro[7] and the Barro and Becker[6] with non-unitary structure of households' decisions and in which one can disentangle the role of mothers' bargaining power. This is done next.

4 An OLG Model with Empowered Women and Children Educational Investment

This section lays down and examines the quantitative implications of a model that can rationalize the above evidence. The model envisaged below provides a link between parents and future generations human capital. The model also contains additional channels between mothers' and future generations human capital.

The model is an overlapping generation model, where parents' value function depends upon future generations' one. Parents' warm glow preferences are needed to model the intra-households decisions about children education. Both fertility and education decisions are endogenous in a way that embeds the typical quantity-quality trade-off a' la Becker and Barro[7] and the Barro and Becker[6]. Moreover households' decisions are done via a collective bargaining , rather than through the unitary model[21].

In the model parents devote hours to child care. This choice embeds a trade-off. More hours spend in child care increase children educational attainments, hence their future wages and consumption. Parents value that since they assign a weight to future generations value function. On the other side, child care reduce the time that parents' working hours. In the model the first effect tends to prevail for higher income families, a fact already observed in past literature (see Donckt and De la Croix[26]). The empirical evidence presented above also shows that kids from

[21]The non-unitary model is much better suited to model family choices such as investment in children education (see Knowles[40] among others).

wealthier families achieve higher educational attainments.

The model also allows to discuss separately the role of women education. The latter affects children human capital directly and indirectly. First, future generations human capital accumulates through both parents' human capital in an assortative fashion. Second, future generations human capital also depends upon family investment in education. Following Doepke and Tertilt[23], as well as other past studies, it is assumed that mothers spend relative more time than fathers in children education. This naturally increases the transmission of education between mothers and children. In an extension of the model women bargaining power is endogenized with respect to their human capital, relatively to that of men[22]. This adds an indirect channel of inter-generational transmission between mothers and daughters. As women bargaining power raises with their level of education, mothers have higher ability to influence households' decisions, including children education. Since the value function of future generations of different gender is weighted according to their relative bargaining power, highly educated mothers tend to internalize relatively more daughters value functions. Because of this they might marginally increase daughters educational investment. As we show later however the impact on the overall human capital of future generations is quantitatively unchanged when the bargaining weights are endogenized.

4.1 OLG Model with Collective Bargaining

The model has an OLG structure. Households are composed by males and females who are equal except for the fact that women biologically tend to devote more time to child rearing. Additionally the model allows me to differentiate males and females bargaining power. As in Becker and Barro[7] and the Barro and Becker[6] parents have warm glow preferences and care about children value function. In each period t the household makes family decisions by maximizing the recursive formulation of the household value function. The latter is constructed from the individual value function. Each individual lives for two periods, whereby in the first they only accumulate human capital, while in the second men and women are randomly matched and form married couples

[22] I follow the formulation indicated in Donckt and De la Croix[26].

that jointly choose the family consumption, the number of children and the off-springs educational investment subject to the household resource constraints. During adulthood individuals work and have children, hence they have to allocate their time endowment between child rearing and the labour market. Wage are set in a competitive labour market that rewards higher human capital with a premium.

Intra-households decisions are made within a collective bargaining structure (see Chiappori [17], [18]). Within this framework households pool resources, hence face a single budget constraint, but they have separate individual value functions at each time t:

$$V_t^i = u(c_t^i) + \beta b(n_t) n_t \mathbb{E}_t \left\{ \frac{(1-\eta_{t+1}^m)V_{t+1}^f + \eta_{t+1}^m V_{t+1}^m}{2} \right\} \tag{3}$$

where i is the index for the individual, hence $i = f, m$ indicated male and females and β represents a general time discount factor. The variable c_t^i is individual consumption. The variable n_t is the family number of children. Fertility is endogenous here. Parents derive utility also from the off-spring value function and this increases with the number of the off-springs. Like in Becker and Barro[7] the term $b(n_t)$ indicates the the degree of altruism toward future generations. The future value function is constructed by assuming that the population is divided in half female and half males and the weights on daughters and sons are given by the respective female, $(1-\eta_{t+1}^m)$, and male bargaining weights, η_{t+1}^m. Importantly no form of disparity is introduced between the weights that mothers and fathers attach to future generations and/or to different sexes. Hence none of the following results is driven by exogenously imposed asymmetries in utility valuations. At last, note that the assumption that the population shares are constant over time and that gender bargaining power weights also future value functions[23] implies that the value function is recursive, hence that households' decisions are time-consistent. As for η_{t+1}^m we can generally assume that it is partly determined by social norms and partly by gender human capital and age skills premia, with the last two being linked to each other in a competitive market. In the benchmark version of the model

[23]Inter-generational preferences for intra-family bargaining power can be solidly justified on the basis of sociocultural transmission of norms. See Bisin and Verdier[11] for an extensive review of the literature on cultural transmission of norms across generations.

η^m_{t+1} is a primitive exogenous parameter. In an extended version of the model a positive relation between η^m_{t+1} and women human capital is introduced (see Donckt and De la Croix[26]).

4.1.1 Time allocation decision and labour market

Following Doepke and Tertilt[23] and Donckt e De la Croix[26] I assume that men inelastically supply all their time in the labour market, namely $t^m = 1$, while women bear the child rearing. Assuming a fixed time cost per child, ϕ, women time allocation at any time t can be detailed as follows:

$$t^f_t + \phi n_t + \phi(e^f_t + e^m_t) \leq 1 \tag{4}$$

where ϕn is the time cost needed for the child rearing and $\phi(e^f_t + e^m_t)$ is the time cost for educating daughters and sons and where e^f_t and e^m_t represent the choice of educational investment[24]. The remaining time is devoted to labour[25].

Labour earnings of each individual depend on the time supplied in the labour market and on their individual level of education. At any time t they are given by $w^m_t t^m_t h^m_t$ and $w^f_t t^f_t h^f_t$. The labour market is competitive. Firms hire both male and females and merge their labour supply into a Cobb-Douglas production function, $Y_t = A(t^m_t h^m_t)^\alpha (t^f_t h^f_t)^\alpha$. Production homogeneity of degree one and full competition imply that:

$$w^f_t = \alpha A_t (t^m_t h^m_t)^{1-\alpha} (t^f_t h^f_t)^{\alpha-1}; w^m_t = (1-\alpha) A_t (t^m_t h^m_t)^{-\alpha} (t^f_t h^f_t)^\alpha \tag{5}$$

Note that the above wages embed a skill premium component, as the wage increases with human capital. The skill-premium has two effects. On the one side, it contributes to incentivize human capital accumulation. On the other side it creates a trade-off, relevant only for women, between time spent in child rearing and time spent working.

[24] An alternative to this specification is to assume that $\phi(e^f_t + e^m_t)$ represents a financial cost in a formal education market and this would enter the households' budget constraint. The two specifications are equivalent as they do not affect the quantity-quality trade-off and the link between women human capital through their bargaining power.

[25] The extension to the case in which both parents devote time to child rearing is straightforward. In this case both members of the couple choose labour supply. Such addition however would not alter the quantity-quality trade-off and the role of women human capital.

4.1.2 Value Functions, Budget Constraints and Human Capital Accumulation

Households decide about consumption and children educational investment to maximize the aggregate households' value function at every period t:

$$V^h(h_t^f, h_t^m) = \eta_t^m V^m(h_t^f, h_t^m) + (1 - \eta_t^m) V^f(h_t^f, h_t^m) \tag{6}$$

Given the collective bargaining agreement households pool resources. This delivers the following budget constraint:

$$c_t^m + c_t^f \leq w_t^m t_t^m h_t^m + w_t^f h_t^f (1 - \phi n_t - \phi(e_t^f + e_t^m)) \tag{7}$$

where t_t^f has been substituted from 4 and where w_t^m and w_t^f are given by 5. Households also take into account the human capital accumulation for male and female:

$$h_{t+1}^f = (Be_t^f)^\delta (h_t^f)^\gamma (h_t^m)^{1-\gamma} \tag{8}$$

$$h_{t+1}^m = (Be_t^m)^\delta (h_t^f)^\gamma (h_t^m)^{1-\gamma} \tag{9}$$

Future generations human capital is affected by both parents' human capital and by investment in education in a multiplicative way[26]. Homoteticity is assumed so that $0 < \gamma < 1$. The parameter δ, namely the elasticity of human capital to educational investment, is above 0. The parameters B and δ measure the returns to education, $\frac{\partial h_{t+1}^f}{\partial e_t^f} = \delta B (Be_t^f)^{\delta-1} (h_t^f)^\gamma (h_t^m)^{1-\gamma}$ and $\frac{\partial h_{t+1}^f}{\partial e_t^f} = \delta B (Be_t^f)^{\delta-1} (h_t^f)^\gamma (h_t^m)^{1-\gamma}$. When returns to education are lower than the cost (this happens for values of B and δ which are low enough), investment in education becomes zero. Equivalently the absence of women from the labour market, namely a time constraint such that the entire time endowment is devoted to child care, produces a corner solution for the women education level, e_t^f. This is so since in this case labour market returns from women education are nil, while costs remain positive. At last, note that the technology for human capital accumulation is positively

[26]Starting from the Ben-Porath [9] it is assumed that investment (education) and human capital enter in a multiplicative way into the production function of human capital (see also Heckman [35] and Rosen [51]). See recent discussion from Garcia and Heckman [32] on the Ben-Porath assumptions.

assortative in that $\frac{\partial^2 h_{t+1}^f}{\partial h_t^f \partial h_t^m} = (Be_t^f)^\delta \gamma(1-\gamma)(h_t^f)^{\gamma-1}(h_t^m)^{-\gamma} > 0$, implying that parents' education is complementary in the production of human capital. This feature can well capture the assortative matching channel that we discussed in the empirical part. In the model the parameter δ also captures the degree of complementarity, hence the impact of assortative mating. The higher the δ, the higher is the impact of the joint parents' human capital.

4.1.3 Recursive Formulation of the Value Function

The recursive formulation for the households' value function reads as follows:

$$V^h(h_t^f, h_t^m) \tag{10}$$
$$= \max_{\left\{c_t^m, c_t^f, n_t, e_t^m, e_t^f\right\}} \left\{ \eta_t^m u(c_t^m) + (1-\eta_t^m) u(c_t^f) + \frac{1}{2}\beta n_t \mathbb{E}_t \left[\eta_{t+1}^m V^m(h_{t+1}^m, \bar{h_{t+1}^f}) + (1-\eta_{t+1}^m) V^f(h_{t+1}^f, \bar{h_{t+1}^m}) \right] \right\}$$

the above is maximized subject to 7, 8 and 8. Note that $\bar{h_t^f}$ and $\bar{h_t^m}$denote the average human capital in the population. As sons and daughters randomly marry children from other families, the average level of the human capital for spouses enter the future value function. The latter are taken as given since they results from the educational choices of other parents. In this context the intra-households educational choices configure a Nash game, in which parents educational choices are the best response to others' families educational choices in a context of random meeting of spouses. See also Doepke and Tertilt[23] on this point. This strategic interaction also delivers a positive externality as parents' internalize the effects that their educational choices have on their off-springs' spouses.

4.1.4 Bargaining Representation

In the benchmark model bargaining weights are set exogenously. In an extended version of the model bargaining power is set as function of human capital. I adopt the functional form proposed by Donckt and De la Croix[26], which reads as follows:

$$\eta_t^m = (1-\zeta)\bar{\eta_t^m} + \zeta \frac{(h_t^m)^\mu}{(h_t^m)^\mu + (h_t^f)^\mu} \tag{11}$$

The component $(1-\zeta)\bar{\eta_t^m}$ captures the component assigned by the society to men. The second term in [**?**] captures the dependence of the women bargaining power upon education. Underlying this formulation is the idea that women with higher education, by possessing higher critical understanding and psychological self esteem, also possess higher ability to negotiate (see Kabeer[38] and more recently Murphy-Graham[43]). Through this channel the ability of mothers to influence households' decisions is amplified by their human capital.

4.2 Optimality and Equilibrium Conditions with Exogenous Bargaining

This section presents the first order condition and the equilibrium conditions of the model for the case with exogenous bargaining. The next section presents an analytical solution of this model under one specific functional form for the utility. A numerical solution will follow for the model with a general utility function and for the case with endogenous bargaining. Under both solutions the link between parents' education and wealth on the one side and children human capital is discussed, by also dissecting the special role of mothers' human capital.

Utility is modelled according to a CES specification with an elasticity σ. The optimality condition for consumption sharing reads as follows:

$$\eta_t^m (c_t^f)^\sigma = (1-\eta_t^m)(c_t^m)^\sigma \tag{12}$$

Under equal bargaining, each spouse gets the same share of consumption. This is rather intuitive since income is pooled under the collective bargaining model. By merging 12 with the budget constraint, 7, one can obtain an expression for consumption of females and males[27]:

$$c_t^f = \left[1 - \frac{(\eta_t^m)^{\frac{1}{\sigma}}}{(\eta_t^m)^{\frac{1}{\sigma}} + (1-\eta_t^m)^{\frac{1}{\sigma}}}\right] \left[A_t (h_t^m)^{-\alpha} (h_t^f)^\alpha (1 - \phi n_t - n_t(e_t^f + e_t^m))^\alpha\right] \tag{13}$$

$$c_t^m = \left[\frac{(\eta_t^m)^{\frac{1}{\sigma}}}{(\eta_t^m)^{\frac{1}{\sigma}} + (1-\eta_t^m)^{\frac{1}{\sigma}}}\right] \left[A_t (h_t^m)^{-\alpha} (h_t^f)^\alpha (1 - \phi n_t - n_t(e_t^f + e_t^m))^\alpha\right] \tag{14}$$

[27] Note that given homoteticiy of degree one of the production function and compatitive markets a linear allocation implies that $w_t^m t_t^m h_t^m + w_t^f t_t^f h_t^f =$
$= w_t^m h_t^m + w_t^f h_t^f (1 - \phi n_t - \phi(e_t^f + e_t^m)) =$
$= A_t (h_t^m)^{-\alpha} (t_t^f h_t^f)^\alpha = A_t (h_t^m)^{-\alpha} (h_t^f)^\alpha (1 - \phi n_t - \phi(e_t^f + e_t^m))^\alpha$.

Noteworthy the elasticity of substitution in consumption, σ, renders the balance of consumption between males and females very sensitive to the bargaining power.

Next we derive the fertility choice and children education. Let's define with λ_t the lagrange multiplier on 7. This, as usual, is equal to the marginal utility, hence $\lambda_t = \frac{\eta_t^m}{(c_t^m)^\sigma} = \frac{1-\eta_t^m}{(c_t^f)^\sigma}$. The first order conditions with respect to the two education levels read as follows:

$$\frac{\eta_t^m}{(c_t^m)^\sigma}\left[\frac{Y_t}{t_t^f}\alpha n_t\right] + \frac{\beta}{2} n_t \eta_t^m \mathbb{E}_t\left[\frac{\partial V^m(h_{t+1}^m, \bar{h_{t+1}^f})}{\partial e_t^m}\right] = 0 \tag{15}$$

$$\frac{\eta_t^m}{(c_t^m)^\sigma}\left[\frac{Y_t}{t_t^f}\alpha n_t\right] + \frac{\beta}{2} n_t (1-\eta_t^m) \mathbb{E}_t\left[\frac{\partial V^f(h_{t+1}^f, \bar{h_{t+1}^m})}{\partial e_t^f}\right] = 0 \tag{16}$$

By the envelope theorem:

$$\mathbb{E}_t\left[\frac{\partial V^m(h_{t+1}^m, \bar{h_{t+1}^f})}{\partial e_t^m}\right] = \mathbb{E}_t\left[\frac{\eta_{t+1}^m}{(c_{t+1}^m)^\sigma} w_{t+1}^m \frac{\partial h_{t+1}^m}{\partial e_t^m}\right] \tag{17}$$

$$\mathbb{E}_t\left[\frac{\partial V^f(h_{t+1}^f, \bar{h_{t+1}^m})}{\partial e_t^f}\right] = \mathbb{E}_t\left[\frac{\eta_t^m}{(c_t^m)^\sigma} w_{t+1}^f \frac{\partial h_{t+1}^f}{\partial e_t^f}\right] \tag{18}$$

The above first order conditions can be expressed in terms of the endogenous states, namely the parents' levels of human capital, after substituting for w_{t+1}^m from 5 and noting that $\frac{\partial h_{t+1}^m}{\partial e_{t+1}^m} = \delta(Be_{t+1}^m)^{\delta-1}(h_t^f)^\gamma(h_t^m)^{1-\gamma}$ and $\frac{\partial h_{t+1}^m}{\partial e_{t+1}^m} = \delta(Be_{t+1}^m)^{\delta-1}(h_t^f)^\gamma(h_t^m)^{1-\gamma}$.

At last, we shall derive the first order condition with respect to the fertility choice. This reads as follows:

$$\begin{aligned}&\frac{\eta_t^m}{(c_t^m)^\sigma}\left[A_t(h_t^m)^{1-\alpha}(h_t^f)^\alpha\alpha(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}(\phi+e_t^f+e_t^m)\right] \\ &= \frac{\beta}{2}\mathbb{E}_t\left\{V^h(h_{t+1}^f, h_{t+1}^m)\right\}\end{aligned} \tag{19}$$

where $\mathbb{E}_t\left\{V^h(h_{t+1}^f, h_{t+1}^m)\right\} = \mathbb{E}_t\left\{\eta_{t+1}^m V^m(h_{t+1}^m, \bar{h_{t+1}^f}) + (1-\eta_{t+1}^m)V^f(h_{t+1}^f, \bar{h_{t+1}^m})\right\}$. The full list of first order conditions can be found in appendix B.

4.3 An Analytically Tractable Version of the Model

To gain some intuition it is useful to lay down a tractable version of the model which can be solved analytically. This can be done under the utility functional form employed in Doepke and Tertilt[23], whereby consumption utility is logarithmic and separable. Also the number of off-springs enters the utility separably. Contrary to them I simplify terms by setting to zero the intra-couples altruistic motive, whereby each spouse assigns a utility weight to the other spouse. Note that I assume that parents weight children utility equally, independently from their gender. Also no asymmetry is assumed on how parents weight daughters' and sons' utility. This assumption is done to avoid that the mothers' effect is biased by asymmetric weights on off-springs' genders.

The utility specification for each individual member of the household is then set as follows:

$$V^i(h_t^i, \bar{h_t^j}) = \ln(c_t^m) + \kappa \ln((n_t) + \frac{1}{2}\beta \mathbb{E}_t \left[\eta^m V^m(h_t^m, \bar{h_t^f}) + (1-\eta^m) V^f(h_t^f, \bar{h_t^m}) \right] \tag{20}$$

The full solution of the model, which is detailed in Appendix C, allows me to draw the following proposition.

Proposition 1. *Investment in children education, raises with the fraction of time that mothers devote to child rearing captured by the cost, ϕ. Higher education levels and higher human capital of parents both increase human capital for future generations through the accumulation equation.*

Proof. The proof hinges on the full model solution which is detailed in a separate Appendix available upon request. By examining the policy functions 47 and 47 one can see that the cost ϕ increases education levels for both daughters and sons for any level of the other parameters.

The results outlined in the proposition 1 are well in line with the evidence presented in section 3. Likewise in the empirical analysis, an increase in parents' education, namely in their cultural capital, increases children human capital. This happens through two channels. First, parents' human capital directly enters the accumulation of future generations human capital. Note that this channel also embeds an assortative mating component, as parents' human capital enters multiplicative, hence in a complementary way, the accumulation. Second, parents with higher human capital earn

higher wage premia, hence also invest more in education. Indeed the education levels in 47 and 47 increase with the parameter δ, that determines the returns to education, hence the incentives to spend in education (relative to consumption). This second channel is consistent with the link uncovered in the data between family wealth and/or income and children educational attainments.

Next, in the empirical analysis mothers' education has a stronger impact. In the model this effect is driven primarily from the time that mothers invest in child rearing. This suggests an important trade-off in the model, as higher time devoted to child rearing increases human capital of future generations, thereby creating a social externality, but at the cost of foregone wages for women.

In the next section I simulate a version of the model with more general preferences. Numerically I confirm the above results, namely that human capital of future generations increases with that of the parents and that mothers' human capital counts relatively more.

4.4 Quantitative Results

Session 4.3 showed the link between parents' education levels and in particular the relative role of the mother under an analytically tractable version of the model. In this section I aim to draw results which are valid for more general utility functions and also quantify the effects. To this purpose I calibrate the model and simulate it. The graphs below show how the policy function, describing the evolution of children human capital, changes with respect to both parents' human capital (shown separately). The policy functions is plotted for different parameter scenario to appreciate the role of the various effects operating in the model. The next sub-section describes the calibration used.

4.4.1 Calibration

The parameters are partly drawn form macro studies and partly calibrated to match main facts about education ratios. Most of the parameters are in line with OLG models such as de La Croix and Doepke[27] or de La Croix and Donckt[26].

Like in most OLG models one period is taken to be 30 years.

Technology and human capital accumulation. Here the technological frontier is determined by the human capital accumulation, and the related returns, and by the production function, and the related labour marginal productivity. I set jointly the parameters governing the returns to education, B, and the parameter governing the marginal productivity of labour in the production function, α, respectively to 23.38 and 0.345. The two jointly determine, for given values of δ and γ, the gender wage gap, which according to data from Bureau of Labor Statistics implies $w_t^f = 0.8w_t^m$, and the ratio of education expenditure to GDP, which in most countries is at round 0.06. The parameter γ in the human capital accumulation is set equally for both spouses to make sure that their innate abilities to transmit human capital are the same. The parameter δ is set like in de la Croix and Doepke [27]. Finally, the time cost parameter ϕ associated with child care is set according to de la Croix and Doepke [27].

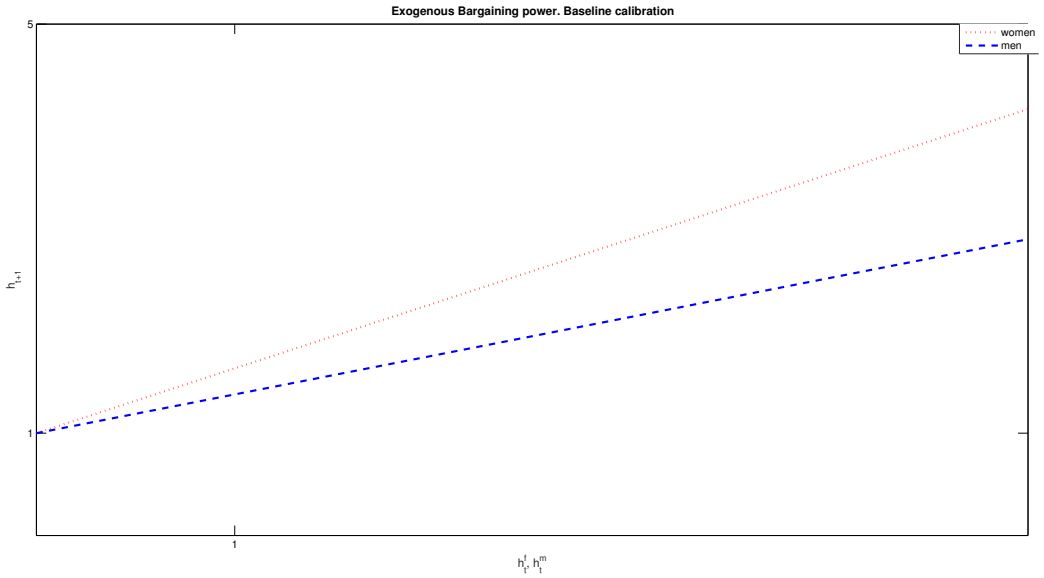
Preferences. The consumption elasticity of substitution, σ, is set to $\frac{1}{4}$. Indeed consistently with Becker and Barro[7] and Barro and Becker[6], to have a positive number of children one shall have a parameter on consumption, $1-\sigma$, larger than the parameter on the number of children, which is one. To make sure that our results are not driven by any ad hoc assumption on how parents weights children according to their gender it is assumed that $\eta_t^m = 0.5$.

Endogenous bargaining. For this case the bargaining parameter follows the functional form in 11 with $\mu = 2$ (see de La Croix and Donckt[26]).

Aggregate exogenous productivity. Aggregate productivity, A_t, follows an AR(1) process with persistence of 0.95. This is well in line with RBC literature.

4.4.2 Policy Function and the Link of Human Capital across Generations

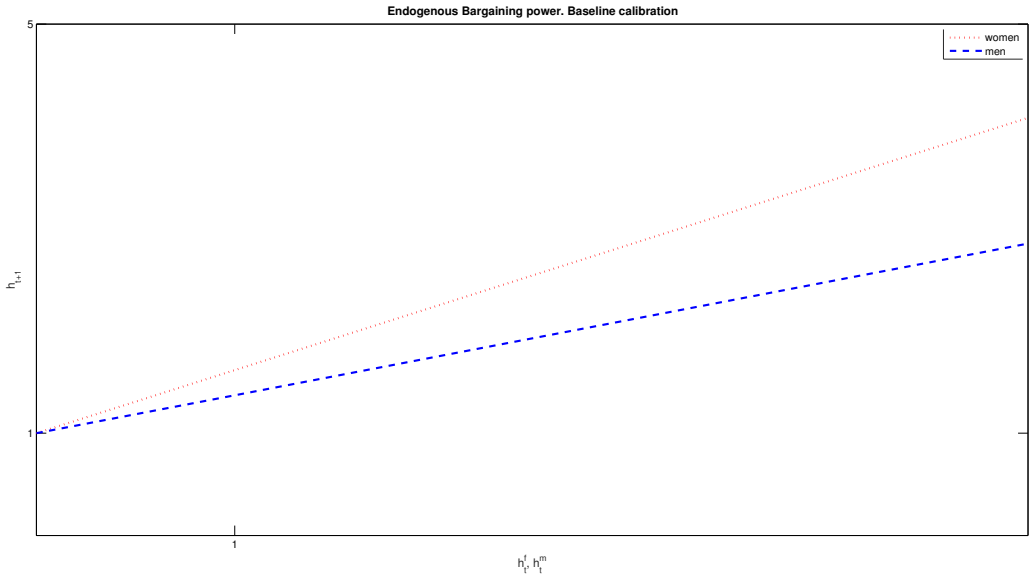
Figure 4.4.2 below shows the policy function of future generations human capital plotted against the two endogenous state variables, namely the human capital of both parents separately. The figure clearly shows that future generations' human capital raises with both parents human capital. Second, the figure also shows that the contribution of the mother's human capital to the children



education is higher than that of the father. Since the calibration does not impose any specific asymmetries in preferences between the mother and the father, nor any other differences in the spouses abilities to produce education, the channel that explains the larger contribution of the mother can be linked to the time that they spend in child rearing.

Next, I examine whether other channels can explain the relative higher contribution of mothers. First, I assume that bargaining power endogenously depend upon the relative degree of human capital of the two spouses following the specification outlined in 11. Figure 4.4.2 shows results. As before human capital of future generations depends positively upon parents' levels. And once more mothers' human capital counts more. Marginally, and compared to the previous case, the steepness of the mothers' human capital contribution is slightly larger. The marginal effect is however small. More highly educated women tend to weight more daughters' value functions. This may increase marginally investment in daughters' education. However, the overall effect on future generations human capital is small.

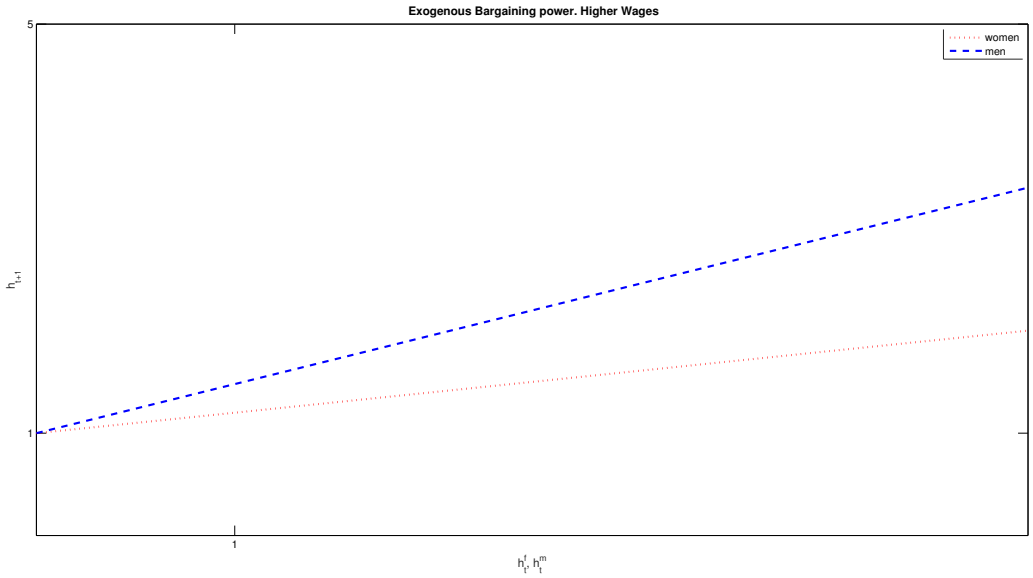
Finally, I examine whether reducing the gender wage gap, by increasing the share of women



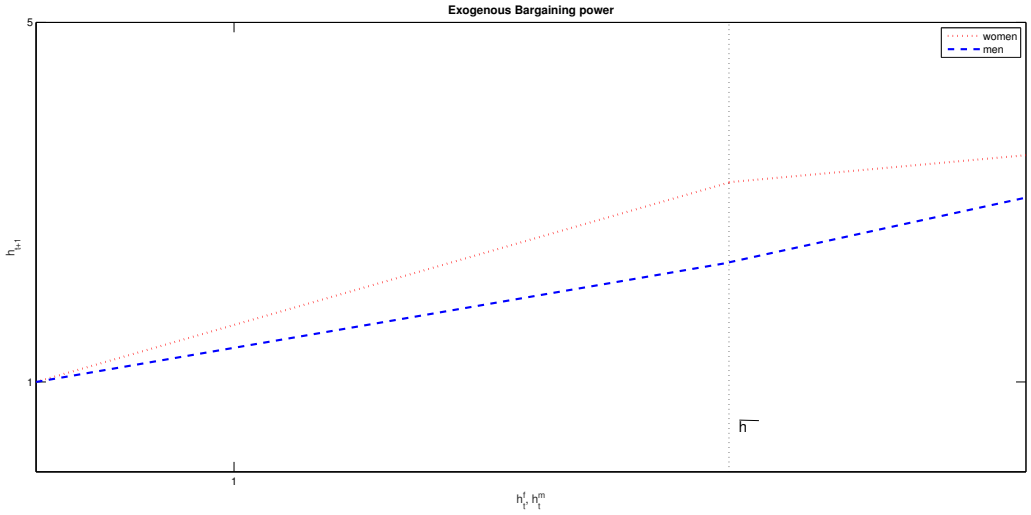
labour hours, α, can change results. Increasing women wages steepens the trade-off between the cost of child rearing and the wage premium. This could in turn potentially increase women incentives to devote time to children education. Such an effect would also be compatible with the facts, observed in the ATUS survey examined by Agiar and Hurst[3], that in recent years highly educated fathers have increased the time that they devote to child rearing. Figure 4.4.2 shows the model results. The traditional substitution effect seems to be operative in this case, as mothers' substitute time for child rearing with working time thereby reducing children education attainments.

4.5 Non-Linear Effects of Human Capital

The regression presented in Table 3, whose specification includes interaction dummies between fathers and mothers education, shows that the effect of the latter tends to prevails mostly for the intermediate level of education. On the contrary for the highest level of education the ranking of the effects is reversed. As suggested before this might be due to a composition effect, as the presence of mothers at the highest level of education is lower. But it might also be due to a subtle



interaction of the quantity-quality trade-off. The model presented above shows that the time that mothers spend with children is an important driver of the relative higher transmission of education. For more educated mothers the quality of time spent in child care and education raises. This in turn raises children performance in school or their human capital. However, for mothers at the highest quantile of the distribution there might be a non-linear jump in the wage premium. The latter steepens the trade-off that they face between time spent in child care and time spent working. The model presented can rationalize well this channel. To see this the following simulation is run. Under the assumption of exogenous and equal bargaining (hence under the pareto solution), Figure 4 plots the policy function of children human capital against fathers' and mothers' human capital respectively as before. However, now it is assumed that above a certain threshold of education the wage premium for mothers' jumps (from 0.345 to 0.45). As the figure shows the effects of mothers' human capital still tends to prevails for all level of human capital. However, and contrary to before, for levels of human capital above the threshold the impact of mothers tends to decline. When female wage premium raises, mothers tend to substitute the time spent in child care with



the time spent working. The reduction in the quantity of time devoted to child care reduces the transmission of human capital despite the increase in the quality of child care.

5 Conclusions

Inequality in wealth and income is growing and educational inequality is one of their major determinants. In this paper the determinants of educational attainments are assessed. Empirically using the PISA for all 72 countries and all past waves, it is established that family cultural and financial background matters more than school characteristics. This has important policy implications, as it implies that current school systems are not able to reabsorb households' inequality. Second, on the margin mothers' human capital or education level is found to matter more than fathers' ones, particularly so for the intermediate levels of educations. This is true even when controlling for assortative mating. The empirical results are rationalized through an OLG model in which parents hold warm glow preferences, households' decisions are made based on collective bargaining, parents earn wage premia according to their level of human capital and future generations human capital accumulates based on parents' human capital and households' investment in education. The

model captures well the link between parents' human capital, both directly through the accumulation equation, and indirectly through the wage premium, which fosters investment in children education. The role of mothers' human capital happens to prevail. In the model this is primarily due to the relative more time that mothers devote to child rearing and education. Endogenizing women bargaining power slightly increases the transmissions of education from mothers. As women bargaining power raises with their level of education, mothers have higher ability to influence households' decisions, including children education. Moreover in this case mothers internalize the spillovers onto daughters bargaining and spending capacity.

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6 Appendix A. PISA Data Structure, Sampling and Scaling

This section provides details about the dataset and its transformations made within the PISA project to check for accuracy and comparability.

6.0.1 Sampling

The PISA study has a 2-step sampling procedure. First, schools are chosen from a comprehensive national list of all PISA-eligible schools with probabilities which are proportional to an estimated number of 15-year-old students enrolled in the school. At the second stage, the students within each schools are sampled, typically 42 students for computer-based tests or 35 students for paper-based tests[28]. Therefore, the sample of the students can not be considered random. Survey weights, available at the PISA website, must therefore be incorporated into the analysis to ensure that each sampled student represents the appropriate number of students in the full PISA population.

6.0.2 Cross-Country Comparability

The selection of questions in the PISA tests is based on a variant of matrix sampling (using different sets of items and different assessment modes), in which each students receives a sub-set of questions from a pool of items. Comparability across tests is guaranteed by using item response theory (IRT) scaling. Specifically, it is noted that some items requires similar skills to be addressed. Results are then described in terms of distributions of skill performances in the population.

It is possible to further improve comparability by using the multiple imputation procedure or plausible values[29]. Plausible values are drawn from a posteriori distribution by combining the scaled test items (IRT) with a latent regression model using information from the student context questionnaire[30]. The average estimator across plausible values is reported and the imputation error is added to the variance estimator, which allows to retrieve the unbiased estimations. This

[28]For countries participating in the International Option of Financial Literacy (FL), the students are a sub-sample of the students who are chosen for the regular PISA test.

[29]See information provided in the PISA Technical Report[48].

[30]Stata procedure REPEST is specifically designed to be used with the PISA dataset.

Table 1: **List of countries included in the estimations.**

3-character	Freq.	Percent	Cum.
CHL	7,053	8.18	8.18
DEU	6,504	7.54	15.72
DOM	4,740	5.50	21.22
ESP	6,736	7.81	29.03
FRA	6,108	7.08	36.12
GBR	14,157	16.42	52.54
GEO	5,316	6.17	58.70
HKG	5,359	6.22	64.92
KOR	5,581	6.47	71.39
LUX	5,299	6.15	77.54
MAC	4,476	5.19	82.73
MEX	7,568	8.78	91.50
PRT	7,325	8.50	100.00

procedure allows the researcher to control for additional differences in performance which might be due to different schools methodologies or other local institutional/cultural differences.

Each of the above regressions is run using scores values with and without imputations. This is done to make sure that results are not biased by outliers emerging from imperfect comparability. Importantly results for our experiments seem to be unaffected by the use of imputed values. This finding is consistent with Dustmann et. al.[28].

6.0.3 List of Countries for Income-based Regressions

As discussed in the text when the econometric specification includes income as opposed to wealth a restricted set of countries shall be used, since only those report this variable. Table **??** below contains the list of countries for this case. All together the dataset for this case contains still 42,691 students.

7 Appendix B. Full List of Model Equations

The models features one exogenous state, namely the productivity shock A_t, and two predetermined states, namely human capital of both parents, h_t^m and h_t^f. Let us assume that t_t^m and $t_t^f = (1 - \phi n_t - \phi(e_t^f + e_t^m))$.

7.1 Model with Exogenous Bargaining

Budget and technology constraints:

$$c_t^m + c_t^f \leq w_t^m t_t^m h_t^m + w_t^f h_t^f (1 - \phi n_t - \phi(e_t^f + e_t^m)) \tag{21}$$

$$h_{t+1}^f = (Be_t^f)^\delta (h_t^f)^\gamma (h_t^m)^{1-\gamma} \tag{22}$$

$$h_{t+1}^m = (Be_t^m)^\delta (h_t^f)^\gamma (h_t^m)^{1-\gamma} \tag{23}$$

Competitive prices:

$$w_t^f = \alpha A_t (t_t^m h_t^m)^{1-\alpha} (t_t^f h_t^f)^{\alpha-1}; w_t^m = (1-\alpha) A_t (t_t^m h_t^m)^{-\alpha} (t_t^f h_t^f)^\alpha \tag{24}$$

Value functions:

$$V^h(h_t^f, h_t^m) = \eta_t^m V^m(h_t^f, h_t^m) + (1 - \eta_t^m) V^m(h_t^f, h_t^m) \tag{25}$$

$$V_t^m = \frac{(c_t^m)^{1-\sigma}}{1-\sigma} + \beta b(n_t) n_t \frac{(1-\eta_{t+1}^m) V_{t+1}^f + \eta_{t+1}^m V_{t+1}^m}{2} \tag{26}$$

$$V_t^f = \frac{(c_t^f)^{1-\sigma}}{1-\sigma} + \beta b(n_t) n_t \frac{(1-\eta_{t+1}^m) V_{t+1}^f + \eta_{t+1}^m V_{t+1}^m}{2} \tag{27}$$

Above one can assume $b(n_t) = 1$ or $b(n_t) = n_t^{1-\varepsilon}$.

Consumption functions:

$$c_t^f = \left[1 - \frac{(\eta_t^m)^{\frac{1}{\sigma}}}{(\eta_t^m)^{\frac{1}{\sigma}} + (1-\eta_t^m)^{\frac{1}{\sigma}}}\right] \left[A_t (h_t^m)^{-\alpha} (h_t^f)^\alpha (1 - \phi n_t - n_t(e_t^f + e_t^m))^\alpha\right] \tag{28}$$

$$c_t^m = \left[\frac{(\eta_t^m)^{\frac{1}{\sigma}}}{(\eta_t^m)^{\frac{1}{\sigma}} + (1-\eta_t^m)^{\frac{1}{\sigma}}}\right]\left[A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f + e_t^m))^{\alpha}\right] \tag{29}$$

Fertility choice:

$$\begin{aligned}&\frac{\eta_t^m}{(c_t^m)^{\sigma}}\left[A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}\alpha(\phi + e_t^f + e_t^m)\right] \\ &= \frac{\beta}{2}\mathbb{E}_t\left\{V^h(h_{t+1}^f, h_{t+1}^m)\right\}\end{aligned} \tag{30}$$

Education choices:

$$\begin{aligned}0 = &\frac{\eta_t^m}{(c_t^m)^{\sigma}}\left[-A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}\alpha n_t\right] + \\ &+\frac{1}{2}\beta\mathbb{E}_t\left\{\left[(1-\alpha)A_{t+1}(h_{t+1}^m)^{-\alpha}(t_{t+1}^f h_{t+1}^f)^{\alpha}\right]\left[\delta(Be_{t+1}^m)^{\delta-1}(h_t^f)^{\gamma}(h_t^m)^{1-\gamma}\right]\right\}\end{aligned} \tag{31}$$

$$\begin{aligned}0 = &\frac{\eta_t^m}{(c_t^m)^{\sigma}}\left[-A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}\alpha n_t\right] + \\ &+\frac{1}{2}\beta\mathbb{E}_t\left\{\left[\alpha A_t(h_{t+1}^m)^{1-\alpha}(t_{t+1}^f h_{t+1}^f)^{\alpha}\right]\left[\delta(Be_{t+1}^f)^{\delta-1}(h_t^f)^{\gamma}(h_t^m)^{1-\gamma}\right]\right\}\end{aligned} \tag{32}$$

7.2 Model with Endogenous Bargaining

The functional form for endogenous bargaining is in equation 11 in the main text.

The set of equations is the same as above, except for the first order conditions on the education levels, which now read as follows:

$$\begin{aligned}0 = &\frac{\eta_t^m}{(c_t^m)^{\sigma}}\frac{\eta_t^m}{(c_t^m)^{\sigma}}\left[-A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}\alpha n_t\right] + \\ &+\frac{1}{2}\beta\left\{\frac{\partial\eta_{t+1}^m(h_{t+1}^m, h_{t+1}^f)}{\partial h_{t+1}^m} + \left[(1-\alpha)A_{t+1}(h_{t+1}^m)^{-\alpha}(t_{t+1}^f h_{t+1}^f)^{\alpha}\right]\right\}\left[\delta(Be_{t+1}^m)^{\delta-1}(h_t^f)^{\gamma}(h_t^m)^{1-\gamma}\right]\end{aligned} \tag{33}$$

$$\begin{aligned}0 = &\frac{\eta_t^m}{(c_t^m)^{\sigma}}\left[-A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1-\phi n_t - n_t(e_t^f+e_t^m))^{\alpha-1}\alpha n_t\right] + \\ &+\frac{1}{2}\beta\left[-\frac{\partial\eta_{t+1}^m(h_{t+1}^m, h_{t+1}^f)}{\partial h_{t+1}^f} + \left[\alpha A_t(h_{t+1}^m)^{1-\alpha}(t_{t+1}^f h_{t+1}^f)^{\alpha}\right]\right]\left[\delta(Be_{t+1}^f)^{\delta-1}(h_t^f)^{\gamma}(h_t^m)^{1-\gamma}\right]\end{aligned} \tag{34}$$

7.3 General Utility Specification

We shall solve the model under the utility specification in 20. For this case we assume exogenous bargaining. Let us first re-write the budget contestant by substituting wages with their marginal productivity. This delivers:

$$c_t^m + c_t^f \leq (1-\alpha)A_t(h_t^m)^{-\alpha}(t_t^f h_t^f)^{\alpha} + \alpha A_t(h_t^m)^{1-\alpha}(t_t^f h_t^f)^{\alpha-1}h_t^f t_t^f \tag{35}$$

Summing up and substituting $t_t^f = (1 - \phi n_t - n_t(e_t^f + e_t^m))$, the above delivers:

$$c_t^m + c_t^f \leq A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1 - \phi n_t - n_t(e_t^f + e_t^m))^{\alpha} \tag{36}$$

Next, we shall write down the Lagrangian problem, which reads as follows:

$$\mathcal{L} = \eta \ln(c_t^m) + (1-\eta)\ln(c_t^f) + \kappa \ln((n_t) + \frac{1}{2}\beta \mathbb{E}_t \left[\eta^m V^m(h_t^m, \bar{h_t^f}) + (1-\eta^m)V^f(h_t^f, \bar{h_t^m})\right] + \tag{37}$$
$$+ \lambda_t \left[c_t^m + c_t^f \leq A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1 - \phi n_t - n_t(e_t^f + e_t^m))^{\alpha-1}\right]$$

The first order conditions on consumption of male and female deliver the following marginal condition:

$$\frac{\eta^m}{1-\eta^m} = \frac{c_t^m}{c_t^f} \tag{38}$$

The latter merged with the budget constraint, 36, delivers the following consumption functions for males and females:

$$c_t^f = \frac{\eta^m}{1-\eta^m}\left[A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1 - \phi n_t - n_t(e_t^f + e_t^m))^{\alpha}\right] \tag{39}$$

$$c_t^m = \frac{1-\eta^m}{\eta^m}\left[A_t(h_t^m)^{-\alpha}(h_t^f)^{\alpha}(1 - \phi n_t - n_t(e_t^f + e_t^m))^{\alpha}\right] \tag{40}$$

Whereby males and females hold the same bargaining power consumption would be equalized.

To derive the education levels in closed form and following Doepke and Tertilt[23] I assume the following functional forms for the value functions:

$$V^m(h_t^m, h_t^f, \bar{h_t^m}, \bar{h_t^f}) = a_1 + a_2 \ln(h_t^m) + a_3 \ln(h_t^f) + a_4 \ln(\bar{h_t^m}) + a_5 \ln(\bar{h_t^f}) \tag{41}$$

$$V^f(h_t^m, h_t^f, \bar{h_t^m}, \bar{h_t^f}) = b_1 + b_2 \ln(h_t^m) + b_3 \ln(h_t^f) + b_4 \ln(\bar{h_t^m}) + b_5 \ln(\bar{h_t^f}) \tag{42}$$

Given the above first order conditions on education imply the following margin:

$$e_t^m = e_t^f \frac{a_2}{b_3} \frac{\eta^m}{1-\eta^m} \tag{43}$$

Finally the first order condition with respect to fertility reads as follows:

$$\frac{\delta}{n_t} = \eta^m \frac{1}{c_t^m} \left[A_t (h_t^m)^{-\alpha} (h_t^f)^{\alpha} \alpha (1 - \phi n_t - n_t(e_t^f + e_t^m))^{\alpha - 1} (\phi + e_t^f + e_t^m) \right] \tag{44}$$

By rearranging the above delivers the following level of fertility:

$$n_t = \frac{\kappa - \frac{\beta}{2}\delta(a_2\eta^m + b_3(1-\eta^m))}{\phi(\kappa + \alpha)} \tag{45}$$

Merging the fertility condition above with the education margin delivers the following education levels:

$$e_t^f = \frac{\frac{\beta}{2}\delta(1-\eta^m)b_3\phi}{\kappa - \frac{\beta}{2}\delta(a_2\eta^m + b_3(1-\eta^m))} \tag{46}$$

$$e_t^m = \frac{\frac{\beta}{2}\delta\eta^m a_2\phi}{\kappa - \frac{\beta}{2}\delta(a_2\eta^m + b_3(1-\eta^m))} \tag{47}$$

The optimal time allocation for women is given by:

$$t_t^f = \frac{\alpha}{\kappa + \alpha} \tag{48}$$

Plugging this into consumption delivers the following expressions:

$$c_t^m = \eta^m \left[A_t (h_t^m)^{-\alpha} (h_t^f)^{\alpha} (\frac{\alpha}{\kappa + \alpha})^{\alpha} \right] \tag{49}$$

$$c_t^f = (1-\eta^m) \left[A_t (h_t^m)^{-\alpha} (h_t^f)^{\alpha} (\frac{\alpha}{\kappa + \alpha})^{\alpha} \right] \tag{50}$$

Table 2
Academic Performance of Children given Parental Education, Home and School Resources, Waves 2003-2012

	Math			Science			Read		
	wealth	income	resources	wealth	income	resources	wealth	income	resources
mother's education - group 1	12.84***	8.485**	8.858	8.899**	11.46***	9.143	10.70***	7.309	6.055
	(3.372)	(3.592)	(6.761)	(3.536)	(3.979)	(6.685)	(3.875)	(5.009)	(6.093)
mother's education - group 2	11.97***	2.164	4.323	8.780**	1.999	0.0403	9.561**	5.349	1.435
	(3.206)	(4.134)	(6.157)	(3.598)	(4.145)	(6.380)	(3.891)	(4.989)	(5.982)
mother's education - group 3	21.08***	16.25***	15.64***	19.19***	17.10***	14.64**	18.62***	16.95***	12.25**
	(3.080)	(4.109)	(6.066)	(3.510)	(4.217)	(6.189)	(3.878)	(5.066)	(5.846)
mother's education - group 4	27.12***	25.00***	20.88***	25.46***	26.39***	22.67***	24.81***	25.32***	18.05***
	(2.855)	(3.873)	(6.117)	(3.150)	(3.973)	(6.185)	(3.887)	(4.887)	(5.950)
mother's education - group 5	26.53***	24.28***	23.16***	26.11***	26.44***	24.47***	25.86***	30.71***	23.19***
	(3.227)	(4.122)	(6.564)	(3.732)	(4.052)	(6.475)	(3.711)	(5.298)	(6.452)
mother's education - group 6	36.48***	37.68***	28.00***	36.07***	36.57***	26.06***	32.49***	37.60***	25.67***
	(3.221)	(4.066)	(6.299)	(3.657)	(3.945)	(6.398)	(3.944)	(4.899)	(6.055)
father's education - group 1	12.41***	9.517**	5.381	13.41***	8.309**	12.26*	16.27***	18.69***	17.45***
	(3.018)	(4.226)	(8.027)	(3.416)	(3.630)	(7.220)	(3.479)	(4.847)	(6.707)
father's education - group 2	9.158***	6.295	−2.851	8.221**	2.012	−1.455	10.35***	6.181	5.137
	(2.961)	(4.019)	(7.913)	(3.489)	(3.874)	(7.399)	(3.586)	(4.519)	(6.892)
father's education - group 3	18.74***	17.19***	8.192	19.50***	16.87***	13.94*	22.69***	24.58***	19.14***
	(2.967)	(4.183)	(7.484)	(3.829)	(3.501)	(7.356)	(3.490)	(4.134)	(7.006)
father's education - group 4	23.63***	23.84***	13.26*	22.54***	20.75***	14.02**	25.68***	29.87***	22.60***
	(2.882)	(4.213)	(7.320)	(3.455)	(3.448)	(7.107)	(3.598)	(4.144)	(6.623)
father's education - group 5	19.64***	22.80***	9.651	19.41***	21.20***	12.57*	22.30***	26.16***	17.24**
	(3.498)	(4.628)	(8.229)	(4.242)	(3.703)	(7.396)	(3.945)	(4.333)	(7.105)
father's education - group 6	43.19***	39.53***	30.16***	42.41***	38.73***	35.04***	42.55***	42.28***	35.73***
	(3.047)	(4.679)	(7.877)	(3.461)	(3.763)	(7.511)	(3.861)	(4.436)	(6.937)
wealth, std	22.21***			21.75***			22.26***		
	(0.732)			(0.702)			(0.718)		
student's gender: 1 - female, 0 - male	−10.35***	−11.00***	−10.15***	−3.828***	−2.188	−3.127	34.20***	36.01***	35.49***
	(1.005)	(1.666)	(2.404)	(0.969)	(1.548)	(2.082)	(0.944)	(1.656)	(1.948)
age of student	16.17***	22.30***	19.91***	15.89***	21.81***	18.40***	16.49***	19.87***	15.90***
	(1.464)	(2.027)	(2.872)	(1.536)	(2.144)	(2.876)	(1.596)	(2.000)	(2.600)
native	25.17***	17.25***	11.13***	32.53***	26.12***	21.80***	28.05***	16.49***	9.459**
	(1.974)	(2.959)	(4.044)	(2.083)	(3.313)	(4.036)	(2.234)	(3.497)	(4.100)
teacher/student ratio	−0.247	1.107***	1.906***	−0.0998	0.935***	1.895***	−0.0538	0.950***	2.000***
	(0.228)	(0.318)	(0.584)	(0.220)	(0.255)	(0.515)	(0.242)	(0.305)	(0.429)
proportion of certified teachers	13.95**	7.729	−0.122	13.10**	8.966	13.15	14.18**	3.186	1.251
	(6.755)	(6.691)	(11.84)	(6.048)	(7.251)	(10.77)	(6.169)	(7.468)	(11.14)
proportion of teachers with grad degree	8.366**	8.394*	4.035	8.017**	6.441*	−5.930	7.418**	8.546*	−0.989
	(3.585)	(4.605)	(10.94)	(3.580)	(3.656)	(9.487)	(3.342)	(4.594)	(8.842)

	wealth	income	resources	wealth	income	resources	wealth	income	resources
inadequate admin staff, std	−2.768**	−4.919***	−2.455	−2.645**	−4.417***	−2.932	−2.775**	−5.880***	−3.316*
	(1.327)	(1.828)	(2.450)	(1.249)	(1.614)	(2.121)	(1.208)	(1.931)	(1.835)
inadequate teaching staff, std	5.913***	1.702	−0.234	5.533***	1.822	0.295	4.753***	1.223	−0.575
	(1.019)	(1.824)	(2.559)	(1.029)	(1.608)	(2.255)	(1.065)	(1.668)	(1.931)
household income - group 2		12.39***	10.45***		12.07***	9.009***		11.51***	7.741***
		(1.851)	(2.905)		(1.694)	(2.781)		(2.096)	(2.637)
household income - group 3		26.20***	21.06***		24.09***	18.82***		23.11***	15.93***
		(1.859)	(2.782)		(1.646)	(2.665)		(1.841)	(2.410)
household income - group 4		33.97***	24.51***		30.74***	22.13***		30.43***	20.39***
		(1.871)	(3.227)		(1.664)	(3.158)		(1.920)	(3.050)
household income - group 5		42.92***	32.50***		38.01***	29.07***		37.38***	26.37***
		(2.190)	(3.710)		(2.028)	(3.388)		(2.199)	(3.239)
household income - group 6		54.72***	42.29***		47.77***	36.55***		46.22***	32.14***
		(2.620)	(3.812)		(1.992)	(3.199)		(2.318)	(3.012)
cultural possessions, std			8.959***			12.60***			11.49***
			(1.286)			(1.206)			(1.196)
home educational resources, std			11.42***			12.44***			10.68***
			(1.441)			(1.335)			(1.239)
ict resourses, std			6.318***			6.033***			6.944***
			(1.214)			(1.232)			(1.238)
home possessions, std.			−2.147			−8.831***			−5.898***
			(1.955)			(2.070)			(1.859)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
No. of Obs.	265929	81736	27793	265929	81736	27793	265929	81736	27793
R^2	0.370	0.372	0.284	0.292	0.311	0.245	0.305	0.336	0.276

Each column represents OLS regression coefficient. Estimations are done using multiple imputation and weighting according to the PISA survey structure. Standard errors are clustered at the school level. Significance levels are * p≤0.10, ** p≤0.05, ***p≤0.01.

Table 3
Marginal Effects of Mother's and Father's Education, Wave 2003-2012

	Math	Science	Read
mother's education - group 1	13.53***	14.41***	16.24***
	(4.407)	(4.212)	(5.119)
mother's education - group 2	17.70***	18.28***	19.83***
	(4.033)	(3.626)	(4.433)
mother's education - group 3	31.39***	33.09***	31.16***
	(3.738)	(3.733)	(4.402)
mother's education - group 4	33.38***	35.69***	34.88***
	(3.660)	(3.600)	(4.280)
mother's education - group 5	32.56***	37.39***	34.69***
	(3.916)	(3.939)	(4.384)
mother's education - group 6	42.32***	46.80***	41.85***
	(3.920)	(3.891)	(4.336)
father's education - group 1	13.66***	16.68***	17.54***
	(3.889)	(3.877)	(4.698)
father's education - group 2	12.42***	12.90***	13.96***
	(3.636)	(3.805)	(3.883)
father's education - group 3	25.98***	28.32***	29.96***
	(3.602)	(3.563)	(3.701)
father's education - group 4	28.84***	29.34***	30.49***
	(3.387)	(3.448)	(3.604)
father's education - group 5	26.86***	28.80***	30.54***
	(3.783)	(3.658)	(3.972)
father's education - group 6	45.84***	47.45***	45.79***
	(3.802)	(3.577)	(3.680)
No. of Obs.	265929	265929	265929

Marginal effects after weighted OLS with interactions. Standard errors are clustered at school level. Significance levels are * p≤0.10, ** p≤0.05, ***p≤0.01.

Table 4
Matching Technique, Wave 2003-2012

	Math	Science	Read
mother' educ: university	19.53***	19.90***	16.30***
	(4.841)	(5.043)	(4.869)
father' educ: university	14.78***	16.47***	19.64***
	(4.914)	(5.337)	(4.530)
wealth, std	20.17***	18.00***	16.35***
	(2.430)	(2.951)	(2.567)
student's gender: 1 - female, 0 - male	−12.39**	−1.670	34.85***
	(4.953)	(5.307)	(4.836)
age of student	11.60	21.41**	8.812
	(7.833)	(8.580)	(7.821)
native	10.40*	14.66**	10.84*
	(6.309)	(6.419)	(6.054)
teacher/student ratio	1.247**	1.765***	1.778***
	(0.518)	(0.477)	(0.470)
proportion of certified teachers	13.47	10.45	7.686
	(10.39)	(9.653)	(12.25)
proportion of teachers with grad degree	13.00	13.99	14.33
	(9.250)	(11.27)	(8.947)
inadequate admin staff, std	−10.42***	−12.10***	−8.774***
	(3.195)	(2.934)	(2.956)
inadequate teaching staff, std	0.618	0.315	3.216
	(2.969)	(2.925)	(3.031)
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
No. of Obs.	155061	155061	155061
R^2	0.299	0.264	0.302

Each column represents OLS coefficients weighted for matching. The first-stage matching regression (performed with psmatch2 Stata function) includes education and wealth. Estimations are carried out on a random choice of an imputed value. Standard errors are clustered at school level. Significance levels are * p≤0.10, ** p≤0.05, ***p≤0.01.

Table 5
Academic Performance of Children
given Parental Education, Home and School Resources, Wave 2015

	Math	Science	Read
	5.440	2.338	5.235
mother's education - group 1			
	(5.360)	(4.327)	(4.465)
mother's education - group 2	4.638	3.803	7.011
	(4.351)	(4.283)	(4.436)
mother's education - group 3	15.75***	19.00***	23.53***
	(5.592)	(5.271)	(5.185)
mother's education - group 4	13.65***	15.18***	17.18***
	(4.952)	(4.387)	(4.499)
mother's education - group 5	15.88***	15.20***	17.40***
	(4.994)	(4.431)	(5.016)
mother's education - group 6	13.63**	13.92***	16.03***
	(5.588)	(5.164)	(5.290)
father's education - group 1	−6.033	−4.657	−7.069
	(5.796)	(4.749)	(5.532)
father's education - group 2	−0.310	2.523	3.200
	(5.414)	(4.096)	(4.657)
father's education - group 3	−3.731	4.630	2.924
	(5.973)	(4.938)	(5.153)
father's education - group 4	0.193	6.325	5.787
	(5.393)	(4.682)	(4.599)
father's education - group 5	4.737	8.236*	4.985
	(5.443)	(4.816)	(4.880)
father's education - group 6	7.478	11.28**	8.521*
	(5.432)	(4.624)	(4.913)
student's gender: 1 - female, 0 - male	−8.337***	−7.368***	20.73***
	(2.176)	(2.018)	(1.884)
Age	12.01***	13.30***	13.71***
	(3.387)	(2.929)	(3.748)
native	24.63***	34.03***	25.61***
	(5.587)	(6.220)	(6.968)
cultural posessions, std	8.562***	10.46***	8.740***
	(1.156)	(1.069)	(1.130)
home educ.resources, std	5.385***	6.286***	7.281***
	(1.157)	(0.939)	(1.137)
ict resourses, std	4.917**	4.354**	3.928
	(2.148)	(2.199)	(2.460)
home possessions, std.	−3.348	−5.763*	−2.550
	(2.652)	(2.959)	(3.191)
parent communication, std.	1.946**	1.693**	3.221***
	(0.899)	(0.765)	(0.839)
parent support science, std.	−3.399***	−3.028***	−5.065***
	(0.910)	(0.841)	(1.048)
parent_choose_sch_educperf, std.	6.022***	6.200***	6.981***
	(0.997)	(0.818)	(0.928)
parent_choose_sch_econom, std.	−5.884***	−5.475***	−5.876***
	(0.994)	(0.946)	(0.921)
parent_choose_sch_approach, std.	−4.749***	−5.674***	−4.560***
	(1.081)	(1.008)	(1.120)
household income, group 2	8.056***	9.278***	9.393***
	(2.639)	(2.827)	(2.837)
household income, group 3	16.74***	15.53***	19.02***
	(3.122)	(3.068)	(3.288)
household income, group 4	16.28***	15.29***	17.16***
	(3.958)	(3.465)	(3.337)

household income, group 5	28.39***	25.41***	22.75***
	(4.380)	(3.313)	(4.689)
household income, group 6	45.35***	40.05***	38.51***
	(3.572)	(3.486)	(3.726)
school infrastructure, std.	3.756	5.876	6.382
	(5.449)	(4.548)	(5.289)
Student-Teacher ratio	0.401*	0.263	0.340
	(0.242)	(0.202)	(0.207)
Total number of all teachers at school	0.205***	0.209***	0.225***
	(0.0400)	(0.0367)	(0.0376)
proportion of certified teachers	1.281	−1.501	−1.892
	(4.683)	(4.232)	(4.848)
proportion of teachers with grad degree	102.9***	93.89***	94.14***
	(28.03)	(27.18)	(30.03)
proportion of all teachers Masters	7.941	10.17	12.64*
	(6.524)	(6.543)	(6.749)
proportion of all teachers Bachelor	−1.317	−2.439	−1.433
	(5.469)	(4.641)	(5.234)
inadequate admin staff, std	−0.893	−1.487	−0.456
	(2.021)	(1.919)	(2.159)
inadequate teaching staff, std	−7.218	−9.113**	−10.26*
	(5.566)	(4.475)	(5.472)
Class size	0.587***	0.650***	0.766***
	(0.218)	(0.201)	(0.218)
Percent government funding	−0.0896*	−0.0977**	−0.122***
	(0.0476)	(0.0413)	(0.0435)
public school = 1, private school =0	−7.952*	−11.43***	−15.23***
	(4.466)	(4.414)	(4.464)
Country Fixed Effects	*Yes*	*Yes*	*Yes*
No. of Obs.	21710	21710	21710
R^2	0.400	0.381	0.367

Each column represents OLS regression coefficients. Estimations are done using multiple imputation and weighting according to the PISA survey structure. Standard errors are clustered at the school level. Significance levels are * p≤0.10, ** p≤0.05, ***p≤0.01.

Table 6
Marginal Effects of Mother's and Father's Education, Wave 2015

	Math	Science	Read
mother's education - group 1	−2.751	−4.997	−4.236
	(6.403)	(7.496)	(7.246)
mother's education - group 2	4.197	−1.426	1.941
	(5.474)	(6.490)	(6.273)
mother's education - group 3	12.86**	13.60*	18.51***
	(6.532)	(7.231)	(7.040)
mother's education - group 4	12.56**	12.69*	14.46**
	(5.533)	(6.680)	(6.440)
mother's education - group 5	13.22**	11.10*	10.77*
	(5.723)	(6.684)	(6.491)
mother's education - group 6	12.50**	9.314	12.13*
	(5.544)	(6.883)	(6.671)
father's education - group 1	2.154	−2.253	−4.680
	(6.972)	(6.649)	(7.950)
father's education - group 2	9.204*	8.684	10.54
	(4.902)	(5.439)	(6.518)
father's education - group 3	2.816	8.468	8.793
	(5.693)	(6.466)	(7.383)
father's education - group 4	13.55***	14.94***	15.68**
	(5.134)	(5.685)	(6.595)
father's education - group 5	13.16**	15.42***	14.05**
	(5.229)	(5.889)	(6.872)
father's education - group 6	18.32***	14.95**	13.12*
	(5.269)	(5.929)	(7.009)
No. of Obs.	21710	21710	21710

Marginal effects after weighted OLS with interactions. Standard errors are clustered at school level. Significance levels are * p≤0.10, ** p≤0.05, ***p≤0.01.

Table 7
Matching Technique, Wave 2015

	Math	Science	Read
mother' educ: university	10.16***	8.854***	9.721***
	(1.255)	(1.248)	(1.253)
father' educ: university	5.666***	4.729***	0.845
	(1.426)	(1.430)	(1.476)
cultural posessions, std.	5.996***	8.362***	10.13***
	(0.848)	(0.834)	(0.839)
home educ.resources, std.	−1.556*	0.0271	1.870**
	(0.889)	(0.889)	(0.899)
ict resourses, std.	−5.879***	−7.280***	−7.366***
	(1.529)	(1.515)	(1.522)
home possessions, std.	19.30***	13.65***	10.19***
	(2.165)	(2.121)	(2.111)
parent communication, std.	4.581***	4.286***	2.988***
	(0.745)	(0.722)	(0.725)
parent support science , std.	−5.178***	−2.363***	−3.769***
	(0.704)	(0.692)	(0.696)
parent_choose_sch_educperform, std.	4.401***	4.394***	5.247***
	(0.666)	(0.660)	(0.680)
parent_choose_sch_econom, std.	−8.844***	−8.529***	−8.011***
	(0.683)	(0.684)	(0.672)
parent_choose_sch_approach, std.	−4.844***	−6.175***	−5.339***
	(0.635)	(0.631)	(0.642)
household income, group 2	6.167***	7.572***	4.670*
	(2.307)	(2.308)	(2.387)
household income, group 3	22.33***	19.06***	26.45***
	(2.460)	(2.416)	(2.536)
household income, group 4	21.93***	19.45***	22.70***
	(2.629)	(2.604)	(2.676)
household income, group 5	34.51***	30.98***	31.07***
	(2.739)	(2.720)	(2.755)
household income, group 6	46.37***	43.04***	45.91***
	(2.464)	(2.461)	(2.506)
student's gender: 1 - female, 0 - male	−13.74***	−11.85***	17.88***
	(1.188)	(1.183)	(1.194)
Age	8.396***	9.827***	11.39***
	(2.058)	(2.052)	(2.061)
native	14.26***	17.91***	13.26***
	(3.116)	(3.028)	(3.221)
school infrastructure, std.	5.595**	8.184***	6.620***
	(2.241)	(2.143)	(2.176)
Student-Teacher ratio	0.470***	0.283***	0.519***
	(0.0928)	(0.0909)	(0.0989)
Total number of all teachers at school	0.121***	0.118***	0.131***
	(0.0147)	(0.0151)	(0.0155)
proportion of certified teachers	2.777	1.719	−4.970**
	(1.959)	(1.973)	(2.121)
proportion of teachers with grad degree	57.13***	41.73***	20.61
	(12.32)	(13.14)	(13.35)
proportion of all teachers Master	−1.102	−1.536	4.250
	(2.869)	(2.934)	(2.904)
proportion of all teachers Bachelor	−10.78***	−7.496***	−2.468
	(2.087)	(2.083)	(2.209)
inadequate admin staff, std.	−1.886**	−1.616*	−0.238
	(0.864)	(0.876)	(0.850)
inadequate teaching staff, std.	−8.966***	−10.41***	−8.940***
	(2.411)	(2.275)	(2.317)
Class size	0.389***	0.468***	0.532***
	(0.0885)	(0.0887)	(0.0937)
Percent government funding	−0.150***	−0.150***	−0.151***
	(0.0218)	(0.0217)	(0.0216)
public school = 1, private school =0	−3.206*	−7.281***	−8.092***
	(1.767)	(1.766)	(1.787)
Country Fixed Effects	Yes	Yes	Yes
No. of Obs.	18244	18244	18244
R^2	0.321	0.281	0.267

Each column represents OLS coefficients weighted for matching. The first-stage matching regression (performed with psmatch2 Stata function) includes education and wealth. Estimations are carried out on a random choice of an imputed value. Standard errors are clustered at school level. Significance levels are * p≤0.10, ** p≤0.05, *** p≤0.01.