Does coresidence with grandparents reduce the negative association between sibship size and reading test scores? Evidence from 40 countries.

Abstract

This paper investigates the effect of coresidence with grandparents in three-generation households on the nature and size of the association between sibship size and reading test scores. It also explores whether this interaction changes with the level of socioeconomic development of a society. We argue that coresidence in traditional three-generation households has a protective effect against resource dilution and thus decreases the magnitude of the negative association between family size and test scores. We also suggest that coresidence in more modern contexts magnifies the degree of this negative association, since modern families form three-generation households only when severely destabilized. We apply 3-level regression models to the PISA 2000 data to examine our hypotheses and use the Human Development Index as a measure of development. We find that the negative association between family size and test scores increases at higher levels of development and does so more strongly when students coreside with grandparents. We, however, find no context, in which coresidence would erase the negative consequences of having many brothers and sisters on one's own school test scores. These findings hold even when controlling statistically for the effects of public expenditure on education, public social security expenditure, and crude divorce rate as well as for the interactions of these variables with sibship size.

Keywords: sibship size; school achievement; reading literacy; development; three-generation households; coresidence

1. Introduction: family size and educational achievement

The number of siblings (or family size, which is often used as a synonym for number of siblings), has traditionally been one of the exogenous variables in the status attainment model. While various aspects of the sibship configuration have attracted scholarly attention at least since the late 19th century (see examples provided by Steelman et al., 2002), family size was not standard part of research on social stratification and mobility until the field entered its 'second generation' (Ganzeboom, Treiman, & Ultee, 1991). Blau and Duncan's classic study *The American Occupational Structure* (1967) showed that men from smaller families attained, on average, more education than men from larger families, presumably due to the dilution of parental resources. A number of later studies (Featherman & Carter, 1976; Featherman & Hauser, 1978; Hauser & Featherman, 1977) were consistent in revealing a negative association between number of siblings and educational attainment and attributed this to resource dilution.

The reasons for the negative association between family size and educational achievement are, however, a frequently-debated issue in current sociological research (Guo & VanWey, 1999; Jaeger, 2008, 2009; Steelman et al., 2002). The literature offers four alternative explanations. First, the confluence model posits that each additional birth into a family changes the interpersonal dynamics and intellectual level of the family environment. Each child, then, is exposed to more or less advantageous environments for shorter or longer periods of his/her life, which cumulatively produces different cognitive as well as school outcomes (Guo & VanWey, 1999; Jaeger, 2009; Steelman, 1985; Zajonc & Marcus, 1975). Second, the resource dilution model assumes that the family has only a limited amount of economic and non-economic resources that can be used for the benefit of the children. Therefore, the more children there are in the family, the lower the share of available resources

each child can claim and the less education he/she obtains (Downey, 1995; Jaeger, 2008, 2009; van Eijck & de Graaf, 1995). Third, the economic literature postulates that both the number of children and the investment per child are chosen by parents and, as a consequence, there is a trade-off between the quality and quantity of children resulting in the observed negative association between sibship size and school outcomes (Angrist et al., 2010; Becker & Lewis, 1973; Becker &Tomes, 1976). Fourth, some authors propose that the association between family size and schooling is spurious and does not reflect a true causal link, since fertility and children's schooling may be jointly determined by some third variable(s) (Guo & VanWey, 1999). As summarized by Jaeger (2008, p. 217), "it might be that sibship size captures the influence of (…) socio-economic or other unmeasured family characteristics indirectly rather than having an independent causal effect on schooling outcomes". Although many different analytical strategies–including fixed-effect models (Guo & VanWey, 1999; Lindert, 1977; Olneck & Bills, 1979) and random-effect models (de Graaf & Huinink, 1992; Sandefur & Wells, 1999; Sieben et al., 2001) applied to sibling data and/or panel data as well as instrumental variable estimators applied to (quasi)-experimental data on twin-births (Black et al., 2005; Cáceras-Delpiano, 2006) or sibship sex composition (Angrist et al., 2010; Conley & Glauber, 2006)–have been employed to assess the validity of this last claim, the literature is still somewhat inconclusive with regards to whether there is indeed a causal effect of family size on school outcomes (Jaeger, 2008).

A further dispute is related to the role of socioeconomic context in shaping the nature and size of the association between number of siblings and socioeconomic outcomes. The existence of this negative association has been robustly and convincingly documented in many populations of Europe and North America (see also Booth & Kee, 2005; Heer, 1985, 1986; Jaeger, 2008; Hirschová & Kreidl, 2012; Kuo & Hauser, 1997; Olneck & Bills, 1979; Park, 2008; van Eijck & de Graaf, 1995; Steelman et al., 2002 offer a comprehensive review of this literature).

The empirical evidence is far less consistent and persuasive when we look beyond the advanced industrialized democracies or look at specific subpopulations. For instance Shavit and Pierce (1991) found that number of siblings has a negative effect on the educational attainment of Jews in Israel, but has no effect on education among the Arabs. The authors argued that, among other things, the Arabs can rely on the help of the extended family (the *hamula*) to share in the cost of child rearing and thus prevent undesirable resource dilution. Then, family size has no detrimental consequences for the child's education. Also Lu (2009) found a negative effect of the number of siblings among whites in South Africa, but no similar effect among the blacks. She offered differences in kin systems and family organization as an explanation. Similarly, Sudha (1997) reported a negative effect of sibship size among the Chinese and Indians in Malaysia, but no effect among the Malays, whose education, as the author pointed out, was subsidized by the state for several decades. Anh et al. (1998) found a negative association only in very large families (with at least 6 children) in Vietnam. Gomes (1984) found a positive effect of family size (particularly among the largest families with 7 or more kids) in Kenya, where parents maintain control over the earnings of the eldest child and can use it for the benefit of the younger siblings (see also Buchmann, 2000). Positive consequences of family size have been similarly reported in Botswana (Chernichovsky, 1985).

The effect of the number of siblings often varies across cohorts within a single society. Maralani (2008), for example, reported a strong positive association between family size and schooling in early urban cohorts in Indonesia, but negative associations in more recent urban cohorts. Moreover, her analysis revealed no association between family size and children's schooling for any cohort of rural children. Similarly, Lu and Treiman (2008) also identified variations in the association between family size and education across cohorts in China.

In this paper, we extend the literature on the varying association between sibship size and educational achievement by comparing 40 countries participating in the 2000 PISA survey of 15-year-old students. After reviewing arguments explaining this cross-country variation, we propose a specific measure: coresidence with a grandparent in a three-generation household that shall modify the relationship between sibship size and standardized test scores. We argue that the association between sibship size and test scores changes in a predictable way with level of socioeconomic development being more negative in the more advanced nations. Furthermore, we propose that there is a three-way interaction between sibship size, three-generation coresidence, and level of development. We suggest that coresidence with grandparents may serve as a buffer against resource dilution in more traditional societies, but does not have this protective effect in more socioeconomically advanced societies, where three-generation households are not formed out of tradition, but out of necessity in response to some serious problem such as teenage pregnancy, criminal activity, drug addiction, and poor health. In doing so, we link two important recent streams of population research–literature on sibship size effects (Steelman et al., 2002; Jaeger, 2008) and literature on social stratification across multiple generations (Mare, 2011), which has recently been attracting increasing attention (see e.g. Chan & Boliver, 2013; Hällsten, 2013; Hertel & Groh-Samberg, 2013; Jaeger, 2012; Mare, 2014; Pfeffer, 2014; Sharkey & Elwert, 2011; Zeng & Xie, 2011).

2. Explaining the variation in the association between family size and educational achievement

Many explanations have been proposed to account for the variability in the association between sibship size and stratification variables across contexts reaching from family organization, cultural roles, and intergenerational wealth flows, to the cost of education, demand for education, and mode of production in a given society/historical period (Maralani,

2008; Sudha, 1997). Generally, the list of explananda consists of factors that "influence both the availability of resources and their internal allocation within a family" (Lu & Treiman, 2008, p. 813).

Family organization and cultural roles that influence the amount and/or direction of wealth flows between the generations are particularly interesting to study, since they determine "whether the burden of child rearing is limited to the nuclear family or extended across broader kin networks, whether and how much school-aged children work inside and outside the home" (Maralani, 2008, p. 694). Maralani (2008, p. 695) concludes that "(i)n societies where parents bear most of the cost of schooling and where the costs are high, we might expect a negative relationship between family size and educational attainment. In societies with extended kinship networks and lower schooling costs, the relationship may be neutral or positive".

Sudha (1997) claims that resource-distribution and family-planning processes occur at higher levels of development as a consequence of the rising importance of schooling for socioeconomic achievement. Hence, a negative association between family size and schooling emerges in the course of socioeconomic development and strengthens with continuing modernization. Desai (1995) similarly proposed that variations in the negative correlation between parental resources (and their increasing dilution with growing family size) and child development (measured as height-for-age) are linked to level of development. She argued that this correlation is magnified as countries move from very low to moderate levels of socioeconomic development, since community resources and infrastructure (such as access to drinking water) matter much more than family resources at the lowest levels of development.

While there are many arguments operating with macro-level explanatory variables, there is surprisingly little empirical comparative research in this area. Most published papers are

single-country studies. These sometimes make comparisons across cohorts or historical periods (e.g., Lu & Treiman, 2008; Maralani, 2008), or across various segments of one society (Lu & Treiman, 2008; Maralani, 2008; Shavit & Pierce, 1991). Comparisons across societies are very uncommon, which is surprising since the persisting theoretical puzzles in this area call for more comprehensive comparative designs. Moreover, proposed explanatory macro-variables are seldom measured explicitly. Rather, speculative statements about the sources and nature of the differences between contexts are offered. These tentative interpretations, while often very enlightening and instructive, are not explicit empirical tests. More rigorous investigations would require finding measures of key explanatory variables, finding contexts with sufficient variation of these variables, and identifying interactions between sibship size and these other predictors. Given the enormous importance of family and family organization for social stratification, this lack of explicit tests and larger-scale quantitative comparisons is striking.

There are, nevertheless, a few exceptions to this rule. Wolter (2003) used PISA 2000 data from six countries (Belgium, Germany, Switzerland, Canada, Finland, and France) to explore the size of the effect of sibship size on reading literacy test scores. While this effect turned out to be negative in all countries, its size varied significantly: it was strongest and very pervasive in Belgium and weakest in Finland, where only children from very large families faced any disadvantages. In a post hoc interpretation, Wolter attributed cross-country differences to differing policies. Park (2008) took this issue a step further and included several country-level quantitative measures of public welfare provisions for families with children and public spending on family policies and education into his multi-level model of reading literacy test scores across 20 OECD countries selected from the PISA 2000 database. He found that the negative effect of sibship size was indeed lessened by strong and deepened by weak public (family-oriented) policies.

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3. The effect of coresidence with grandparents on school outcomes

There has been little effort to systematically explore and describe the circumstances that lead to, and the consequences of, coresidence of grandparents and grandchildren for school outcomes in an international comparative perspective. There are two different approaches to the issue. Some studies explore three-generation households (grandparents, parents, grandchildren), whereas other emphasize skipped-generation households (grandparents plus grandchildren). The former coresidence pattern is more common in less developed societies today and typically becomes less prevalent as the society and economy modernize (Glazer et al., 2006; Pong & Chen, 2007; Popenoe, 1987; Ruggles & Heggeness, 2008; Shah et al., 2011; Japan is often pointed out as an exception with relatively high rates of three-generation coresidence, but even there three-generation households are declining, see Ruggles & Heggeness, 2008; Takagi et al., 2007). The latter type seems to be increasingly common in some mostly advanced industrialized societies due to the increasing incidence of specific problem behaviors such as drug addiction, teenage pregnancy, HIV infection, and divorce (Albuquerque, 2008; Bryson & Casper, 1999; Caputo, 2001; Hayslip & Kaminski, 2005; Kelch-Oliver, 2011; Minkler, 1999; Pong & Chen, 2007).

Studies of skipped-generation households are more common than investigations of three-generation coresidence, which have been almost completely absent in the field until recent years (Pong & Chen, 2007; but see Zeng & Xie, 2011). Three-generation households are more often researched in non-western societies, where they are more prevalent (Pong & Chen, 2007, 2010; Pong, Frick, & Moyi, 2004). In Europe, multigenerational households can be found in Southern European countries (such as Italy) and in Central European countries (such as Hungary). But even there the situation is more likely to develop as a reaction to the needs of the offspring (de Jong Gierveld, de Valk, & Blommesteijn, 1999; Pong et al., 2004).

Elsewhere in Europe three-generation households are very rare, perhaps because most Europeans value privacy and emphasize the nuclear family and independent living (Glaser et al., 2010; de Jong Gierveld et al., 1999; Pong et al., 2004).

Living with a grandparent (or several grandparents) can either be the result of tradition, or of necessity (Pilkauskas, 2012). While traditional coresidence may be beneficial for the kids, necessity often indicates trouble and social disorder. Necessity may result from the situation in either of the generations, but coresidence for the sake of the younger generation seems to be more common (Albuquerque, 2008; de Jong Gierveld et al., 1999; Park, 2005; Pilkauskas, 2012; Pong & Chen, 2007; Pong et al., 2004), since grandparents are typically rather reluctant to interfere with the lives of their children or grandchildren unless the intervention is absolutely unavoidable (Jendrek, 1994; Shore & Hayslip, 1994), and most grandparents strongly prefer independent households (de Jong Gierveld et al., 1999). Hence, grandparental coresidence is less and less common and typically indicates a highly destabilized and vulnerable family situation (Bengston, 2001; Cherlin & Furstenberg, 1992; Glaser et al., 2010; Park, 2005; Pebley & Rudkin, 1999).

Coresidence of three generations may have both positive and negative consequences for the grandchildren and its effects may be direct or indirect (Denham & Smith, 1989). Grandparents may directly contribute to the pool of the available financial resources, or their incomes may increase the diversity of available financial sources and thus partially shield the household from economic turbulence and labor market insecurities (Dunifon & Kowaleski-Jones, 2007; Mutchler & Baker, 2009; Pong et al., 2004). Grandparents can also function as role models, shaping the child's educational and occupational aspirations, and may "provide support for academic achievement in the form of help with homework, encouragement of intellectually oriented hobbies and activities" (Dunifon & Kowaleski-Jones, 2007, p. 467). Children can learn to plan their future, or can develop more effective relationships with adults through

regular interaction with grandparents (Denham & Smith, 1989; Hayslip & Kaminski, 2005). Similarly, grandchildren can benefit from the grandparent doing a part of the housework, so the parent is left with greater amount of time to spend with the offspring (Pong & Chen, 2010). Grandparents can supervise the child, and thus help prevent and detect problematic behavior that may require intervention (Pong & Chen, 2010; Pong et al., 2004). The presence of the grandparent can also alleviate parental stress (i.e. in singe-mother families), which in turn can improve parenting (Dunifon & Kowaleski-Jones, 2007), or lessen a child's stress from "overly critical or demanding parents" (Denham & Smith, 1989, p. 347).

However, three-generation coresidence may also be harmful to the child. The coresident grandparent can contribute to increased levels of stress. Since "grandparents, and especially grandmothers, often assume a substantial role in taking care of grandchildren" (Pebley & Rudkin, 1999, pp. 220-221), their high degree of involvement may result in disputes over the education or upbringing of the grandchild. Parenting practices and standards may be directly questioned or undermined. In general, grandparent's inability to maintain the right distance can create conflict (Attias-Donfut & Segalen, 2002). Such conflict-laden environment can then have a negative impact on the offspring, since the child does not know who the primary authority is, and/or suffers stress as a consequence (Dunifon & Kowaleski-Jones, 2007; Pong & Chen, 2010). Furthermore, grandchildren may be deprived of a certain proportion of family resources that are redirected to the grandparent–be these resources monetary (e.g. the cost of health care), material (such as own room to study and do homework in quiet), or other (parental time, attention etc.) (de Jong Gierveld et al., 2001; Pong & Chen, 2007, 2010).

The negative effect of coresidence identified in the regression-type model (a typical analytical tool for most studies) may result from non-random selection into coresidence: "it is hypothesised that the children's difficulties may be due to the family difficulties which led to the grandparent's involvement" (Glaser et al., 2010, p. 33; see also Cherlin &Furstenberg,

1992; McLanahan & Sandefur, 1994; Pong & Chen, 2007). Moreover, there seems to be selection into coresidence on socioeconomic status. More highly-educated grandparents prefer independent living and more highly-educated parents prefer non-familial care for their children (Pong & Chen, 2007; Pong et al., 2004). Hence coresidence may be more common among the lower classes and the negative effect of low SES may be confounded with the effect of coresidence. Indeed, the estimated effect of coresidence in these studies is frequently negative (see also Monserud & Elder, 2010).

A net positive effect of three-generation coresidence on behavioral or educational outcomes has been shown in single-mother families in the USA (Deleire & Kalil, 2002; Dunifon & Kowaleski-Jones, 2007). Aquilino (1996) reported a net positive effect of coresidence in households headed by child's parent on the chances of graduating from high school and getting into college. A positive effect of coresidence in intact families was documented by the Taiwanese data (Pong & Chen, 2007, 2010). Parker and Short (2009) found a positive effect of a coresident grandmother on school enrolment of children of absent (dead or non-coresident) mothers in Lesotho, South Africa.

An educational disadvantage for children in skipped-generation households was found by Monserud and Elder (2010). Bryson and Casper (1999) documented that children in skipped-generation households are more likely to be poor, receive public assistance, and have no health insurance. Mutcher and Baker (2009), however, pointed out that children from mother-only families with coresident grandparent are less likely to live below or at the poverty line compared to the same household type without the grandparent present, since they are more likely to receive wider array of financial aid (from the coresident grandparent, or from other sources). Working with international data, Pong, Frick, and Moyi (2004) found a negative effect of grandparental coresidence on the test scores of 3rd and 4th grade students. Yet they also found that this effect is weaker in countries where living with grandparents is more

common (the strongest negative effect was found in the USA and England). Moreover, they attributed some of the variation in this effect to family structure–with children from guardian families (but not from other family types) actually benefiting from having a grandparent in the household.

So, as summarized by Denham and Smith (1989, p. 348), "it is obvious that the influence of grandparents upon grandchildren depends upon a variety of individual, family, and cultural factors". In the next section of this paper we will develop hypotheses linking family size, coresidence with grandparents, and selected macro-level variables based on this assessment.

4. Hypotheses linking family size, coresidence, and level of development

Both sibship size effects and coresidence effects appear to be context-dependent. The contexts, in which they matter the most can be identified both at the family level and at the societal level. In this paper we link the literature on sibship size and coresidence with grandparents into one analytical context; we study how the association between sibship size and reading test scores may depend on coresidence, and how this correlation may change with socioeconomic development.

We argue that coresidence with grandparents can be used as an explicit indicator of how each family works and is organized. Grandparental coresidence in less developed societies is likely to have positive consequences for the child's school outcomes, and is likely to alleviate some potentially negative consequences of the lack of resources in the family (such as low socioeconomic status, or larger family size). Coresiding grandparents are more likely to serve as resource providers in more traditional societies. At higher levels of development, however, coresidence is more likely to indicate social dislocation and hence would be negatively associated with school outcomes. Furthermore, the negative impact of coresidence is likely to

be larger if combined with other disadvantages such as larger sibship or low SES. Coresiding grandparents are likely to be dependents/resource consumers in more modern societies. So overall, the (main) effect of coresidence is likely to turn from positive to negative with increasing development. Similarly, the protective effect of coresidence (against the dilution of resources) is likely to change to detrimental with continuing development.

5. Data, variables, and method

We use data from the first wave of OECD "Programme for International Student Assessment" (PISA 2000) combined with macro-level indicators of the level of development, public spending on welfare and education, and family destabilization. PISA "is a collaborative effort among OECD Member countries to measure how well 15-year-old young adults (...) are prepared to meet the challenges of today's knowledge societies" (Adams & Wu, 2002, p. 15). PISA assesses reading, mathematical, and scientific literacy, while also collecting additional school- and student-level information. We elected to use the 2000 wave of the survey, since it contains richer information on the composition of the student's household (namely information about siblings and coresidence with grandparents) than more recent waves.

PISA 2000 was primarily aimed at the reading literacy (Adams & Wu, 2002) of randomly chosen students born between 1983 and 1987. Reading literacy was defined as an individual's ability to retrieve, understand, use, interpret, and evaluate information in order to achieve one's goals and to develop one's knowledge (OECD 2001). We are working with data from the *student questionnaire*, which (apart from the reading literacy variables) collects information about siblings, structure of a student's family, and about education and occupation of a student's parents.

The PISA 2000 dataset contains information collected in 43 countries (data were collected in 32 countries–28 OECD and 4 non-OECD–in the year 2000; the rest was collected in 2002). The data collection was organized to maximize its international comparability (Adams & Wu, 2002). Our analysis excludes three of the original countries (Japan, Netherlands, and Lichtenstein) due to various problems with the data (missing information about parental education in the Japanese data, very low school participation rate in the Netherlands, and very small sample size in Lichtenstein; see Adams & Wu, 2002, p. 186 for additional details). Further reductions in the sample size reflect our decision not to study skipped-generation households (since somewhat different mechanisms lead to the establishment of three-generation and skipped-generation households, and we want to focus our analysis on the former type) and elimination of data with missing values on one or more covariates (we deleted observations with missing values on any explanatory variable). Thus we base our investigation on 151377 cases from 40 countries.

Our analysis employs the reading literacy scale in the position of the dependent variable. PISA reports five plausible values of reading literacy for each student. "The plausible values represent a set of random values for each student selected at random from an estimated ability distribution of students with similar item response patterns and background. They are intended to provide good estimates of parameters of student populations (for example, country mean scores), rather than estimates of individual student proficiency" (OECD, 2002, p. 22). We used STATA's `mi` package (STATA Corp., 2011b) to work with plausible values, since plausible values and imputed values (or latent variables and missing data) are conceptually and computationally synonymous and require, as stated by Lee and Cai (2012, p. 1), "the same analytical tools". The overall mean on the reading test is 485 in our analytical sample (see Table 1); reading test scores by country are reported in Table A.1 in the Appendix.

<Table 1 about here>

The student questionnaire asked, "How many brothers and sisters do you have?" Students reported the number of younger, older, and same-age siblings by ticking the relevant box ranging from "none" to "four or more" in each category. The final number of siblings was then obtained by adding responses to each item. The scale ranges from 0 to 12 in our analytical sample. The questionnaire did not differentiate among biological, half-, or step-siblings. Respondents in the analytical sample have on average 1.9 brothers and sisters (see Table 1). Several country means fall significantly below the overall mean, with the lowest values recorded in Bulgaria (1.0), Italy (1.3), and Korea (1.3). The highest means are found in Peru (3.0), Indonesia (2.9), Israel (2.9), and Mexico (2.9; see Table A.1 in the Appendix).

Students were further asked, "Who usually lives at home with you?" They were offered eight possible yes/no questions. One of these questions related to grandparent(s). Based on the data we are able to ascertain whether the student coresided with a grandparent (grandparents), but we can neither determine the number of coresiding grandparents, nor their characteristics. Hence, coresidence is measured by a dichotomous variable, with category 1 denoting coresidence with a grandparent (or several grandparents) and 0 meaning no coresidence. Overall, about 20 % of students in the analytical sample coreside with a grandparent (see Table 1). About 2 % of students coreside in Finland, 4 % in Iceland and Sweden. At the other extreme, we find 50 % coresiding students in Bulgaria, and 48 % in Indonesia and Thailand (see Table A.2 in the Appendix).

<Table 2 about here>

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We also used student questionnaire data on household composition to differentiate among 3 types of parental constellations: the student lives with either (1) two biological parents, or (2) one biological (single) parent, or (3) one biological parent and his/her opposite sex partner who is not biologically related to the child (note that our classification differs from the family structure variable provided in the PISA database). In our sample, about 80 % of students lived with two biological parents, 13 % with a single parent, and about 7 % with a biological parent and a step-parent (see Table 1). The share of students living in intact families ranges from a low of 65 % in the USA and 69 % in Latvia, to a high of 94 % in Macedonia, 93 % in Korea and Indonesia (see Table A.2 in the Appendix). The lowest percentage living with a single parent is recorded in Indonesia (4 %), Macedonia (5 %), and Korea and Greece (6 %). The highest share of students from single-parent families is found in Latvia (20 %), Chile and New Zealand (19 %), and in the USA, Peru, Russia and Brazil (18 %; see Table A.2 in the Appendix). Coresidence is somewhat less common in families with one biological parent and one step-parent (about 14 % students in step-families coreside with grandparents), while about 20 % of students in two-biological parent and single-parent families coreside with their grandparents (see Table 2; coresidence by family structure within individual countries is shown in Table A.3 in the Appendix).

Parental education is measured using ISCED categories (we combine categories 1 and 2, since the former has only few cases in many countries). We use the higher of the mother's and father's education and dichotomize the resulting variable into four contrast variables in the analysis. Parental occupation was measured with an open-ended question about the characteristics of the parents' main job. The answer was coded using ISCO codes and then transformed into ISEI (Ganzeboom & Treiman, 1996). Again, we use the higher of both parents' ISEI (variable "HISEI" provided in the original PISA 2000 dataset). The average

ISEI in the analytical sample is 47.9 (see Table 1); we center ISEI on its grand mean to render the intercept in the model equation more interpretable (Hox, 2002, pp. 54-58). A dichotomous variable indicating that student's mother was employed around the time of the interview was also utilized (66 % of mothers were employed, see Table 1; the variable was dichotomized from students' reports on their mothers' employment situation – the original question differentiated full-time employed, part-employed, and unemployed mothers looking for a job as well as other non-employed mothers). We also control for respondents' gender in the analysis (coded 1-male, 0-female). There are 51 % girls in the analytical sample (see Table 1).

We use several macro-level variables in our analysis. We employ a single composite macro-level indicator of the level of development/modernization of each individual country, the so-called Human Development Index (HDI). We understand modernization as movement towards democracy, a national and welfare state, and higher levels of education, equality, industrialization, social mobility, wealth, general social tolerance, individualism, secularism (Divale & Seda, 2000; Ciftci, 2010; Marks, 2009), and towards the nuclear family (Popenoe, 1987).

Gross Domestic Product (GDP) has often been used as an indicator of modernization. This practice, however, has been criticized at least since the 1970s, as GDP was not designed to measure development/progress and does not measure it adequately (Eurostat, 2010; Afsa et al., 2008; Boarini et al., 2006; United Nations Development Programme, 1990). As summarized by Afsa et al. (2008, p. 1), GDP "is essentially a measure of economic activity, and more specifically of economic activities leading to monetary transactions. As a result, GDP suffers from two major weaknesses: (a) being a monetary aggregate, it pays little or no attention to distributional issues and to elements of human activity or well-being for which no direct or indirect market valuation is available; (b) it is measuring productive flows and, as such, ignores the impact of productive activities on stock, including stock of natural

resources." The advocates of alternative measures of development put it succinctly in stating that "income is not the sum total of human life" (United Nations Development Programme, 1990, p. 9). Human development is then defined as a general (beneficial) movement towards better-quality life, linked to forming and using capabilities. It is a way of enlarging people's choices (be it in the matters of education, health, living standard, or politics) and enhancing well-being. Income, measured by the GDP, is only partially a proxy for such choices. It may be necessary, but not sufficient for human development: "there is no automatic link between income growth and human progress" (United Nations Development Programme, 1990, p. 10). It is argued that using GDP as a proxy for development has shifted attention away from the ends (benefits for people) toward means.

Some authors have advocated using alternative measures, be they adjusted or extended versions of GDP itself, sets of indicators (which reflect multidimensionality of progress), or composite indexes (which acknowledge multidimensionality of progress while answering the need for a single, easily used measure; Afsa et al., 2008; Boarini et al., 2006). So far no single preferred alternative has emerged. UNDP's Human Development Index (HDI) is one of the well-known composite indexes. Presented in the 1990 *Human Development Report*, it was set to replace GDP as a measure of human development, capturing what are claimed to be three main elements of human life – longevity, knowledge, and standard of living (United Nations Development Programme, 1990). Despite still being rather imperfect (it has been criticized for not working with enough dimensions of human development and for being arbitrary, even redundant, see McGillivray & White, 1993; Cahill, 2005; Ranis et al., 2006; Afsa et al., 2008), it "remains one of the few indexes that are regularly compiled and widely disseminated by international organizations to allow systematic cross-country comparisons" (Afsa et al., 2008, p. 1). We use the HDI as a way of addressing the issue of GDP inadequacy when it comes to measuring development/modernization/progress.

HDI consists of three dimensions: health, education, and living standards. HDI utilizes a set of four variables to cover these three dimensions: health is measured by life expectancy at birth; education by combining mean years of schooling of adults above 25 and expected years of schooling of children of school entering age; and Gross National Income (GNI) per capita measures living standard (income is adjusted for variations in purchasing power across countries). The inclusion of health and educational achievement into HDI along with an indicator of economic performance was guided by the idea that both education and health are "regarded as two major ingredients of development and progress" (Afsa et al., 2008, p. 13). The HDI is measured on a scale ranging from 0 to 1; higher values reflect higher level of development (Cahill, 2005).

Our analysis employs HDI values taken from the 2011 *Human Development Report* (United Nations Development Programme, 2011, pp. 131-134). We use values for the year 2000, which–within selected PISA countries–range from 0.543 in Indonesia to 0.913 in Norway. For the purposes of our analysis we categorized the HDI into four categories using the values of 25th, 50th, and 75th percentile (0.7405; 0.8275; 0.8635, respectively). We categorized HDI in order for its interactions with sibship size (a continuous variable) to be more readily interpretable. There were, then, ten countries in each category (1st quartile consists of Albania, Brazil, Bulgaria, Indonesia, Latvia, Mexico, Peru, Romania, Russia, Thailand, 2nd quartile Argentina, Chile, Czech Republic, Greece, Hong Kong, Hungary, Italy, Macedonia, Poland, Portugal, 3rd quartile Austria, Denmark, Finland, France, Iceland, Israel, Korea, Luxemburg, Spain, United Kingdom, and finally the 4th quartile Australia, Belgium, Canada, Germany, Ireland, New Zealand, Norway, Sweden, Switzerland, and the United States). Values of HDI and assignment of countries into quartiles are presented in Table A.1 in the Appendix).

We employ three macro-level variables as controls in our analyses: total public expenditure on education, total public social expenditure, and crude divorce rate. The first two variables

follow the logic of Park's analysis (Park, 2008), which postulated that public financial support for education and/or families may reduce resource dilution and protect children against the negative consequences of having many brothers and sisters. We do not, however, use the same context-level variables, mostly for practical reasons: our analysis covers countries not included in Park's models. Park's macro-level measures of public investment into education and public transfers towards families were not available for all countries in our sample. Instead we use public expenditure on education and total public social security spending, which are clearly related both conceptually and empirically. Total public expenditure on education is defined as "the total public expenditure (current and capital) on education expressed as a percentage of the Gross Domestic Product (GDP) in a given year … includ[ing] government spending on educational institutions (both public and private), education administration, and transfers/subsidies for private entities" (World Bank, 2013). Similarly to Park (2008) we are using a 10-year average for years 1991-2000. The data on public expenditure on education come from World Bank's World Development Indicators database (World Bank, 2013). We also use total public social security expenditure as a percentage of GDP, which is defined as "the sum of expenditure (including benefit expenditure and administration costs) of all existing public social security/social protection schemes or programmes in the country" (International Labour Office, 2010, p. 261) including spending on health in the year 2000. The data came from ILO's *World Social Security Report* (International Labour Office, 2010, pp. 258-261). The missing data point for Peru was taken from the *Restoring Fiscal Discipline for Poverty Reduction in Peru* publication (World Bank, 2003, p. 33).

<Table 3 about here>

We further expand the list of macro-level indicators to include crude divorce rate (CDR) in 2000 as a rough indicator of the destabilization of the family system at the time of the PISA survey. Crude divorce rate refers to the annual number of divorces per thousand individuals in the population. The information was taken from UN *2003 Demographic Yearbook* (United Nations, 2006). CDR was missing for Chile in the source database, since divorce was not made legally possible in Chile until 2004. Zero was substituted for this missing data point. The correlations and descriptive statistics (computed in the sample of 40 countries) of all macro-level variables are presented in Table 3. We see that the country-level variables are relatively highly correlated with Pearson's correlation coefficients ranging from 0.30 to 0.66.

Since the dependent variable is a test score, i.e. a numeric variable, regression analysis seems to be an appropriate analytical tool. Yet, one has to deal with a nested data structure that includes schools nested within countries and students nested within schools. Therefore, we decided to use a multi-level version of regression analysis to take this clustering structure into account. We decided to use three-level hierarchical linear models, in which students (level-1, N = 151377) are nested within schools (level-2, N = 8218**)** and schools are nested within countries (level-3, N = 40) with explanatory variables measured at level-1 and level-3.[1] We estimated all models using `xtmixed` procedure in STATA 13 MP (STATA Corp., 2011a).

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[1] Our model specification may inspire the conclusion that the second level (schools) is redundant in our analysis, since there are no explanatory variables measured at the school level. The reason why the second level is nevertheless kept in the model relates to the use of schools as sampling units in the complex sample designs that were implemented in all countries. If the complexities of the sampling design were ignored, we would face the risk of obtaining biased point estimates of model parameters as well as underestimated standard errors (Kreuter & Valliant, 2007). While PISA is distributed with a set of replicate weights that reflect the sampling structure

We estimated and present five multi-level models. The first model uses only two level-1 predictors (family size and coresidence), one level-3 predictor (HDI), and their three-way interaction (along with all lower-order interaction effects required by the marginality principle). The second model adds individual-level controls (respondent's gender, parental education, family structure, mother's employment status, parental ISEI). We decided to present these two sets of results because the structure of the relationships between explanatory variables is very complex and endogeneity is not easily determined. We believe that comparing the two sets of results would both capture the overall picture of the interrelatedness of family size, coresidence, and level of development, and would also depict the degree to which these patterns may be due to correlations with other variables such as family structure, socioeconomic status, mother's employment and so on. Furthermore, we expand Model 2 by adding other macro-level controls (total public social security expenditure, total public expenditure on education, crude divorce rate). We add these additional control variables one by one to form Model 3 (controlling for total public social security expenditure on top of variables contained in Model 2), Model 4 (similarly controlling for total public expenditure on education), and Model 5 (controlling for crude divorce rate). Each of Models 3, 4, and 5 also interacts the newly added country-level variable with sibship size.

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and many PISA users seem to prefer the use of replicate weights in their own work, replication is not generally considered to outperform direct incorporation of design information into the analysis (Kreuter & Valliant, 2007). Indeed some scholars recommend that incorporating elements of multi-stage sampling directly into a multi-level analysis design is the obvious choice as it adequately reflects the uncertainty due to sampling in the analysis and has also other favorable properties (see e.g. Treiman 2009: ch. 9).

6. Results

We present results of the first two estimated models of determinants of reading test scores in Table 4 and begin our interpretation with the simpler one. We see that there is a negative association between family size and reading test scores in countries with the lowest HDI (the first quartile). This is equally so with and without coresidence with grandparents. Among students not coresiding with grandparents, the estimated coefficient for sibship size is -3.555, while it is -3.305 (= -3.555+0.250) among coresiding students. The difference between these two slopes is not statistically significant at the 0.05 level (s.e. = 0.250, t = 0.48, p = 0.630). It seems that the disadvantage in reading test scores associated with larger sibship size is unrelated to coresidence status in the least developed countries in our sample (i.e. in countries with HDI between 0.543 and 0.732).

<Table 4 about here>

Table 4 shows that the negative association between sibship size and reading test scores increases at higher levels of development. For instance, among students who do not coreside with their grandparents, the estimated associations are -3.555, -3.499, -4.289, and -4.684 in the 1st, 2nd, 3rd, and 4th quartiles of the distribution of HDI values, respectively. An even stronger trend also applies to students in three-generation households, where the associations are -3.305, -6.111, -7.883, and -8.468 going from the first to the fourth HDI quartile (see Model 1 in Table 4).

Even more interesting is the changing difference between the sibship size slopes estimated for coresiding and non-coresiding students. We have observed already that these slopes do not

differ in the least developed countries in our sample. Yet, the situation changes as we move toward more developed societal contexts. For instance, in the second quarter of the distribution of HDI values the two slopes differ by -2.862, which turns out to be statistically significant at the conventional 0.05 level (t-statistic testing the equality of the slopes is -2.92, which implies p = 0.004). The two slopes further diverge in the third and fourth quartiles of HDI distribution, the differences being -3.844 and -4.034, respectively (see Table 4, Model 1).

Clearly, the estimated association between sibship size and reading test scores depends both on three-generation coresidence and level of development: the association becomes more negative as we move from moderate to high levels of development. The interaction is best portrayed in a graph (see Figure 1), which depicts the growing difference in the slopes of the sibship size across levels of development as well as the divergence of the two slopes with increasing development.

<Figure 1 about here>

Model 2 adds statistical controls measured at level-1 (individual students) into Model 1. These controls do not change the overall picture to any significant degree, yet the estimated effects are somewhat weaker. For instance, the main estimated effect of the number of siblings is -2.622 (among students who do not coreside) in Model 2, i.e. it is reduced by approximately 25 % in comparison to its size in Model 1 (see Table 4). The estimated negative effect of the number of siblings (among students who are not coresiding) tends to increase with development. In the second quartile of HDI it is -2.795 (= -2.622-0.173), in the third quartile it is -3.559 (= -2.662-0.937), and in the highest quartile it grows to -4.077 (= -2.622-1.455; see Table 4 for the respective interaction terms that produce these point

estimates). Similarly, the estimated association between sibship size and reading test scores increases with development among students who do coreside with their grandparents. While it is -2.910 (= -2.622-0.288) in the 1st quartile of HDI (see Model 2 in Table 4), it grows to -5.415 (= -2.622-0.288-0.173-2.332), -6.934 (= -2.662-0.288-0.937-3.087), and -7.510 (= -2.662-0.288-1.455-3.145) in the 2nd, 3rd, and 4th quartiles, respectively.

<Figure 2 about here>

The difference between the two sibship size slopes (defined by coresidence status) increases from the negligible value of -0.288 (HDI in the 1st quartile) to the more substantial -3.145 (HDI in the 4th quartile). Evidently, Models 1 and 2 support the same story: the absolute value of the estimated sibship size slope tends to increase with development and this growth is more pronounced if the student lives in a three-generation household with at least one of his/her grandparents. These tendencies in the net associations are displayed graphically in Figure 2.

The main effect of coresidence is -14.824 in Model 1 indicating that coresidence is associated with poorer test scores at lower levels of HDI and no siblings present in the same household. The effect of coresidence on test scores seems to change with HDI in a non-linear fashion (see Table 4). While it always stays negative, we only find a significantly more negative effect of coresidence at the highest HDI level, i.e. in the most advanced societies. Hence, we can conclude that coresidence is, net of other factors, always associated with lower reading test scores in our sample of countries.

Now we pause briefly to comment on the estimated effects of other explanatory variables. We see that boys score almost 25 points lower on the reading test scale than girls. Students from

intact families perform better than students from single-parent or step-parent family environments. The mean net difference between a student from a two-parent and a single-parent family is -2.652, and between two-parent and a step-parent family it is -4.836 (all these effects are highly statistically significant (the respective p-values are lower than 0.0005).

Model 2 also indicates strong positive and significant net effects of parental education on test scores. For instance, a student whose parents have tertiary education is expected to score 21 points higher on the reading test than a student whose parents have only primary education, disregarding other variables in the model. Similarly, parental occupational status has a strong positive effect on reading literacy. Net of other factors, each additional point on the ISEI scale increases expected test score by 0.817 points. Hence, the expected net difference between the child of a secondary school teacher (ISEI = 71) and a farm worker (ISEI = 16) in the reading literacy test is approximately 45 points (0.817*(71-16) = 44.935). Moreover, the mother's employment tends to be associated with poorer performance on the reading test (net of other factors in the model)–the difference is 1.074 points, which seems to be of relatively little substantive importance.

<Table 5 about here>

Models 3, 4, and 5 represent essential theory-motivated extensions of Model 2 presented above. Each of these models includes one additional country-level control variable – namely total public social security expenditure (TPSE), total public expenditure on education (TPEE), and crude divorce rate (CDR) – and its interaction with sibship size. The inclusion of TPSE and TPEE into the model follows the logic of Park's paper (Park 2008) to see if public resources directed towards schooling and/or welfare transfers reduce the disadvantage

stemming from larger sibships and if this happens differently by three-generation coresidence. The third of these additional macro-level variables (CDR) then reacts to our assumption that it might be growing family instability (and not socioeconomic development per se) that is responsible for increasing negative effects of coresidence and increasing negative effects of sibship size in more advanced societies.

Estimated parameters of these models are presented in Table 5. Clearly, only some additional level-3 controls have a significant net effect on reading literacy. More specifically, TPSE and TPEE have little net effect on reading literacy. Furthermore, their interactions seem to be of negligible substantive importance. For instance, the interaction between TPSE and sibship size is statistically significant (t=-4.78, p<0.0005), but it is substantively uninteresting (the point estimate is -0.155 with the TPSE scale ranging from 2.32 to 28.5). CDR, on the other hand, has a positive net effect on reading literacy (see Table 5). This positive association may reflect declining average levels of pre-divorce conflict at higher divorce rates (see e.g. Amato & Hohmann-Marriott, 2007).

Furthermore, once we add these level-3 controls (and their interactions) into our models, we see little change in the effects of other variables. One of the more salient modifications is found in Model 3. It suggests that the effect of sibship size (among not-coresiding students) does not change with development – it is between -3.984 and -3.706 in the lowest and highest categories of HDI (with somewhat lower values in the middle two categories, see Table 6). The effect of sibship size does, however, change with HDI among students who coreside with their grandparents and it becomes more negative at higher development levels (see Table 6): for instance the effect of sibship size is -4.405, -5.273, -6.446, and -7.164 in the 1st, 2nd, 3rd, and 4th HDI quartiles, respectively (see Table 6, Model 3). Hence, sibship size effect increases with HDI when we look at students living in three-generation households and its slope is significantly steeper than among students not living in three-generation households.

Also Models 4 and 5 document that the effect of sibship size changes more dramatically (i.e. becomes more negative) with HDI levels in three-generation households than in two-generation households. For instance, Model 4, which controls for TPEE and its interaction with sibship size, gives the following point estimates of the sibship size effect in three-generation households: -2.867, -5.399, -6.945, and -7.537 in the 1st, 2nd, 3dr, and 4th quartiles of development (see Table 6). The sibship size effect grows only relatively moderately with HDI in two-generation households, from -2.585 in the lowest HDI quartile to -4.103 n the highest HDI quartile (see Table 6). Model 5 (which controls for CDR at level-3) confirms the same story. The sibship size effect among coresiding students grows from -2.955 at the lowest HDI level to -7.455 at the highest HDI level, while it increases from -2.668 to -4.023 only, when we look at students who are not coresiding with their grandparents (see Table 6). Hence, even Models 3, 4, and 5 confirm that the effect of sibship size changes to a significant degree with HDI levels when we look at three-generation households, whereas it changes comparatively little (or not at all) when we investigate two-generation households only.[2]

<Table 6 about here>

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[2] Countries at the lower two levels of development (as measured by HDI) appear to be particularly diverse with respect to culture and history; most notably post-communist societies stand out as a distinct group. Therefore, we also experimented with other control variables to capture this apparent diversity and included a dichotomous indicator of post-communism into our models. This additional covariate does not change other effects in Models 1-5 to any significant degree (practically not at all).

7. Conclusions and discussion

We have documented that the estimated associations between number of siblings and reading test scores among 15-year-old students vary systematically with grandparental coresidence and with the level of development as measured by the Human Development Index in a sample of 40 countries. The negative association between sibship size and reading scores was relatively modest, and did not differ by coresidence, in the least developed nations in our sample. Yet, these associations tend to be more negative at higher levels of HDI. Furthermore, the increase is greater among students who coreside with grandparents and relatively smaller (but still significantly different from zero) among students who live separately from their grandparents. Hence, three-generation coresidence magnifies the disadvantage stemming from large sibships and does so more strongly in the most advanced societies. The main findings are rather robust vis-à-vis partial model re-specifications including adding new macro-level covariates (and their interactions with sibship size) such as public spending on education, public spending on social security, and crude divorce rate.

Our findings do not fully confirm our initial hypotheses that grandparental coresidence would protect students from the negative effects of resource scarcity resulting from a larger sibship at lower levels of social development. It is possible that coresidence with grandparents has this protective effect, but it might only be detectible at much lower levels of development. Our analysis was based on a sample of 40 relatively advanced societies that included OECD countries and a handful of other, comparatively advanced nations. The lowest value of the Human Development Index in our sample was 0.543 (in Indonesia), with the average value being 0.80; i.e. it is possible that our data did not represent social contexts where the anticipated protective effect would play out fully. We therefore believe that our hypothesis

should also be examined in other, less advanced societies in order to be subjected to a more complete test.

The results do, however, provide evidence that coresidence of three generations is associated– on average–with a significant socio-economic disadvantage at higher levels of development. Indeed, this disadvantage increases at higher levels of modernization. We interpret this as an indication that grandparents tend to coreside as dependents (rather than as providers) more often in more advanced socio-economic contexts. While three-generation households are less and less common, they are associated with growing socio-economic disadvantage. To the extent that cross-sectional data may hint at future developments, one would anticipate that the harmful effects of three-generational coresidence would magnify in the coming decades if the modernization process continues. If this development takes place, it would further highlight the need to include multiple generations in status attainment models (see e.g. Chan & Boliver, 2013; Hällsten, 2013; Hertel & Groh-Samberg, 2013; Jaeger, 2012; Mare, 2011, 2014; Pfeffer, 2014).

Furthermore, our results suggest that a larger sibship and three-generation coresidence represent two particular dimensions of disadvantage. When they are combined, children's tests scores are particularly strongly impacted; more so than one would expect on the basis of each of these circumstances alone. This interaction also suggests that the disadvantages associated with coresidence and sibship size do not reflect one underlying scale (e.g. household density), because this argument would imply that – in the context of a multivariate statistical model – both coresidence and sibship size should affect test scores additively.

This paper illustrates further the heterogeneity of sibship size effects. Other authors have shown that the sibship size effect may vary according to help coming from outside of the nuclear family, e.g. from the extended family (Shavit & Pierce, 1991), religious communities

(Blake, 1989), or the state (Park, 2008). We have shown that the sibship size effect also varies by level of overall socioeconomic development, being relatively weak in less advanced societies and quite stronger in more advanced societal contexts. Furthermore, we have shown that the sibship size effect interacts with three-generation coresidence: the sibship size effect is significantly stronger in three-generation households than in two generation households. This finding, however, is only limited to the more advanced societies in our sample.

The purpose of this text was not to adjudicate the three competing interpretations of the repeatedly reported associations between sibship size and educational achievement (Booth & Kee, 2005; Jaeger, 2008; Kuo & Hauser, 1997; Park, 2008; van Eijck & de Graaf, 1995). On the contrary, our data make such adjudication unfeasible and we interpreted our results as purely descriptive, making no assertions regarding the nature of causality. We believe that our results are in principle consistent with all three explanations of sibship size effects: resource dilution, the dynamics of intellectual environment in the family, as well as the possibility of a joint determination of both parental fertility and children's schooling are all likely to change with socioeconomic development. Similarly, these processes are equally likely to interact with three-generation coresidence.

8.   References

Adams, R., & Wu, M. (Eds.). (2002). *PISA 2000 Technical report*. Paris, France: OECD.

Afsa, C., Blanchet, D., Marcus, V., Pionnier, P.-A., Rioux, L., d'Ercole, M. M., Ranuzzi, G., & Schreyer, P. (2008). Survey of existing approaches to measuring socio-economic progress. *Commission of Measurement of Economic Performance and Social Progress*. Retrieved July 24, 2012, from http://www.stiglitz-sen-fitoussi.fr/documents/Survey_of_Existing_Approaches_to_Measuring_Socio-Economic_Progress.pdf

Albuquerque, P. (2008). *Grandparents living in multigenerational households* (Working Paper WP 46/2008/DE/CISEP). Retrieved February 20, 2012, from http://www.repository.utl.pt/bitstream/10400.5/2479/1/wp462008.pdf

Amato, P. R., & Hohmann-Marriott, B. (2007). Comparison of high- and low-distress marriages that end in divorce. *Journal of Marriage and Family, 69*(3), 621–638.

Angrist, J., Lavy, V. & Schlosser, A. (2010). Multiple Experiments for the Causal Link between the Quantity and Quality of Children. *Journal of Labor Economics 28*(4), 773–824.

Anh, T. S., Knodel, J., Lam, D., & Friedman, J. (1998). Family size and children's education in Vietnam. *Demography*, *35*(1), 57–70.

Aquilino, W. S. (1996). The life course of children born to unmarried mothers: Childhood living arrangements and young adult outcomes. *Journal of Marriage and the Family*, *58*(2), 293–310.

Attias-Donfut, C., & Segalen, M. (2002). The construction of grandparenthood. *Current Sociology, 50*(2), 281–294.

Becker, G. & Lewis, H. G. (1973). On the Interaction between the Quantity and Quality of Children. *Journal of Political Economy, 81*(2) part 2, S279-S288.

Becker, G. & Tomes, N. (1976). Child Endowments and the Quantity and Quality of
Children. *Journal of Political Economy 84*(4) part 2, S143-S162.

Bengston, V. L. (2001). Beyond the nuclear family: The increasing importance of
multigenerational bonds. *Journal of Marriage and Family, 63*(1), 1–16.

Black, S. E., Devereaux, P. G., & Salvanes, K. G. (2005). The more the merrier? The effect
of family composition on children's education. *Quarterly Journal of Economics,
120*(2), 669–700.

Blake, J. (1989). *Family size and Achievement.* Berkeley, CA: University of California
Press.

Blau, P. M., & Duncan, O. D. (1967). *The American occupational structure*. New York,
NY: John Wiley and Sons, Inc.

Boarini, R., Johansson, A., & d'Ercole, M. M. (2006). *Alternative measures of well-being*.
OECD Social, Employment and Migration Working Papers No. 33. Retrieved
February 6, 2013, from http://www.oecd.org/dataoecd/13/38/36165332.pdf

Booth, A. L., & Kee, H. J. (2005). *Birth order matters: The effect of family size and birth
order on educational attainment* (IZA Discussion Paper No. 1713). Bonn, Germany:
Institute for the Study of Labor. Retrieved November 1, 2012, from
http://ftp.iza.org/dp1713.pdf

Bryson, K, & Casper, L. M. (1999). Coresident grandparents and grandchildren. *U.S. Census
Bureau, Current Population Reports*. Retrieved January 16, 2012, from
http://www.census.gov/prod/99pubs/p23-198.pdf

Buchmann, C. (2000). Family structure, parental perceptions and child labor in Kenya: What
factors determine who is enrolled in school? *Social Forces*, *78*(4), 1349–1379.

Cáceras-Delpiano, J. (2006). The impacts of family size on investment in child quality.
Journal of Human Resources, 41(4), 738–754.

Cahill, M. B. (2005). Is the Human development index redundant? *Eastern Economics Journal*, *31*(1), 1–5.

Caputo, R. K. (2001). Grandparents and coresident grandchildren in a youth cohort. *Journal of Family Issue*s, *22*(5), 541–556.

Chan, T. W., & Boliver, V. (2013). Social mobility over three generations in Britain. *American Sociological Review*, forthcoming.

Cherlin, A. J., & Furstenberg Jr., F. F. [1986] (1992). *The new American grandparent: A place in the family, a life apart*. Cambridge, MA: Harvard University Press.

Chernichovsky, D. (1985). Socioeconomic and demographic aspects of school enrollment and attendance in rural Botswana. *Economic Development and Cultural Change*, *33*(2), 319–332.

Ciftci, S. (2010). Modernization, Islam, or social capital: What explains attitudes toward democracy in the Muslim world? *Comparative Political Studies, 43*(11), 1442–1470.

Conley, D., & Glauber, R. (2006). Parental educational investment and children's academic risk: Estimates of the impact of sibship size and birth order from exogenous variations in fertility. *Journal of Human Resources, 41*(4), 722–737.

De Graaf, P. M., & Huinink, J. J. (1992). Trends in measured and unmeasured effects of family background on educational attainment and occupational status in the Federal Republic of Germany. *Social Science Research, 21*(1), 84–112.

De Jong Gierveld, J., de Valk, H., & Blommesteijn, M. (1999). *Living arrangements of older persons and family support in more developed countries* (UN/POP/AGE/2000/5). Retrieved February 28, 2012, from http://www.un.org/esa/population/pubsarchive/untech/pdf/untech5b.pdf

De Jong Gierveld, J., de Valk, H., & Blommesteijn, M. (2001). Living arrangements of older persons and family support in more developed countries. *Population Bulletin of the*

United Nations, special issue, living arrangements of older persons: Critical Issues and Policy Responses, *42/43*, 193–217.

Deleire, T., & Kalil, A. (2002). Good things come in threes: Single-parent multigenerational family structure and adolescent adjustment. *Demography, 39*(2), 393–413.

Denham, T. E., & Smith, C. W. (1989). The influence of grandparents on grandchildren: A review of the literature and resources. *Family Relations, 38*(3), 345–350.

Desai, S. (1995). When are children from large families disadvantaged? Evidence from cross-national analyses. *Population Studies, 49*(2), 195–210.

Divale, W., & Seda, A. (2000). Cross-cultural codes of modernization. *World Cultures, 11*(2), 152–170.

Downey, D. B. (1995). When bigger is not better: Family size, parental resources, and children's educational performance. *American Sociological Review, 60*(5), 746–761.

Dunifon, R., & Kowaleski-Jones, L. (2007). The influence of grandparents in single-mother families. *Journal of Marriage and Family, 62*(2), 465–481.

Eurostat. (2010). Measuring more than 'just' economic development. Retrieved July 24, 2012, from http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Measuring_more_than_'just'_economic_development

Featherman, D. L., & Carter, T. M. (1976). Discontinuities in schooling and the socioeconomic life cycle. In W. H. Sewell, R. M. Hauser, & D. L. Featherman (Eds.), *Schooling and Achievement in American Society* (pp. 133–160). New York, NY: Academic Press.

Featherman, D. L., & Hauser, R. M. (1978). *Opportunity and change*. New York, NY: Academic Press.

Ganzeboom, H. B. G, Treiman, D. J, & Ultee, W. (1991). Comparative intergenerational
stratification research: Three generations and beyond. *Annual Review of Sociology,
17*(1), 277–302.

Ganzeboom, H. B. G., & Treiman, D. J. (1996). Internationally comparable measures of
occupational status for the 1988 International standard classification of occupations.
Social Science Research, *25*(3), 201–239.

Glaser, K., Montserrat, E. R., Waginger, U., Price, D., Stuchbury, R., & Tinker, A. (2010).
Grandparenting in Europe. Report June 2010. London: Grandparents Plus. Retrieved
February 28, 2012, from http://www.grandparentsplus.org.uk/wp-
content/uploads/2011/03/Grandparenting-in-Europe-Report.pdf

Glazer, K., Agree, E. M., Costenbader, E., Camargo, A., Trench, B., Natividad, J., &
Chuang, Y.-L. (2006). Fertility decline, family structure, and support for older persons
in Latin America and Asia. *Journal of Aging and Health, 18*(2), 259–291.

Gomes, M. (1984). Family size and educational attainment in Kenya. *Population and
Development Review, 10*(4), 647–660.

Guo, G., & VanWey, L. K. (1999). Sibship size and intellectual development: Is the
relationship causal? *American Sociological Review, 64*(2), 169–187.

Hällsten, M. (2013). Inequality across three and four generations in Egalitarian Sweden: 1st
and 2nd cousin correlations in socio-economic outcomes. *Research in Social
Stratification and Mobility*, http://dx.doi.org/10.1016/j.rssm.2013.09.002

Hauser, R. M., & Featherman, D. L. (1977). *The process of stratification. Trends and
analyses*. New York, NY: Academic Press.

Hayslip Jr., B., & Kaminski, P. L. (2005). Grandparents raising their grandchildren: A
review of the literature and suggestions for practice. *The Gerontologist, 45*(2), 262–
269.

Heer, D. M. (1985). Effects of sibling number on child outcome. *Annual Review of Sociology, 11*, 27–47.

Heer, D. M. (1986). Effect of number, order, and spacing on child and adult outcomes: An overview of current research. *Biodemography and Social Biology, 33*(1–2), 1–4.

Hertel, F. R., & Groh-Samberg, O. (2013). Class mobility across three generations in the U.S. and Germany. *Research in Social Stratification and Mobility* (2013), http://dx.doi.org/10.1016/j.rssm.2013.09.007

Hirschová, M., Kreidl, M. (2012). Vliv počtu sourozenců na matematickou, čtenářskou a přírodovědnou gramotnost v ČR. [The Effect of Sibship Size on School Achievement in Mathematics, Reading, and Science in the Czech Republic] *Sociologický časopis/Czech Sociological Review, 48*(4), 697–735.

Hox, J. (2002). *Multilevel analysis. Techniques and applications*. Mahwah, NJ: Lawrence Erlbaum.

International Labour Office. (2010). *World social security report 2010/11. Providing coverage in times of crisis and beyond*. Geneva, Switzerland: ILO. Retrieved March 14, 2013, from

http://www.ilo.org/public/english/protection/secsoc/downloads/policy/wssr.pdf

Jaeger, M. M. (2008). Do large sibships really lead to lower educational attainment? New evidence from quasi-experimental variation in couples' reproductive capacity. *Acta Sociologica, 51*(3), 217–235.

Jaeger, M. M. (2009). Sibship size and educational attainment. A joint test of the confluence model and the resource dilution hypothesis. *Research in Social Stratification and Mobility, 27*(1), 1–12.

Jaeger, M. M. (2012). The Extended Family and Children's Educational Success. *American Sociological Review 77*(6), 903–922.

Jendrek, M. P. (1994). Grandparents who parent their grandchildren: Circumstances and decisions. *The Gerontologist, 34*(2), 206–216.

Kelch-Oliver, K. (2011). African American grandchildren raised in grandparent-headed families: An exploratory study. *The Family Journal, 19*(4), 396–406.

Kreuter, F., & Valliant, R. (2007). A Survey on Survey Statistics: What is done and can be done in STATA. *The Stata Journal, 7*(1), 1–21.

Kuo, H.-H. D., &, Hauser, R. M. (1997). How does size of sibship matter? Family configuration and family effects on educational attainment. *Social Science Research, 26*(1)*, 69–94.

Lee, T., & Cai, L. (2012). Alternative multiple imputation inference for mean and covariance structure modeling. *Journal of Educational and Behavioral Statistics* OnlineFirst Oct. 8, 2012. DOI: 10.3102/1076998612458320

Lindert, P. H. (1977). Sibling position and achievement. *Journal of Human Resources, 12*(2), 198–219.

Lu, Y., & Treiman, D. J. (2008). The effect of sibship size on educational attainment in China: Period variations. *American Sociological Review, 73*(5), 813–834.

Lu, Y. (2009). Sibship size and education in South Africa: Black–White variations. *Research in Social Stratification and Mobility, 27*(2), 110–125.

Maralani, V. (2008). The changing relationship between family size and educational attainment over the course of socioeconomic development: Evidence from Indonesia. *Demography, 45*(3), 693–717.

Mare, R. D. (2011). A multigenerational view of inequality. *Demography, 48*(1), 1–23.

Mare, R.D. (2014). Multigenerational aspects of social stratification: Issues for further research. *Research in Social Stratification and Mobility*, http://dx.doi.org/10.1016/j.rssm.2014.01.004

Marks, G. (2009). Modernization theory and changes over time in reproduction of socioeconomic inequalities in Australia. *Social Forces, 88*(2), 917–944.

McGillivray, M. & White, H. (1993). Measuring development? The UNDP's Human development index. *Journal of International Development*, *5*(2), 183–192.

McLanahan, S., & Sandefur, G. D. (1994). *Growing up with a single parent: What hurts, what helps*. Cambridge, MA: Harvard University Press.

Minkler, M. (1999). Intergenerational households headed by grandparents: Contexts, realities, and implications for policy. *Journal of Aging Studies, 13*(2), 199–218.

Monserud, M. A., & Elder, G. H., Jr. (2010). *Household structure and children's educational attainment: A perspective on co-resident grandparents* (Paper presented at the annual meeting of the American Sociological Association, Hilton Atlanta and Atlanta Marriott Marquis, Atlanta, GA). Retrieved February 20, 2012, from http://www.allacademic.com/meta/p411276_index.html

Mutchler, J. E., & Baker, L. A. (2009). The implications of grandparent coresidence for economic hardship among children in mother-only families. *Journal of Family Issues, 30*(11), 1576–1597.

OECD. (2001). *Knowledge and skills for life. First results from PISA 2000*. Paris, France: OECD Publishing.

OECD. (2002). *Manual for the PISA 2000 database*. Paris, France: OECD Publishing. Retrieved July 31, 2012, from http://www.oecd.org/edu/preschoolandschool/programmeforinternationalstudentassessmentpisa/33688135.pdf

Olneck, M. R., & Bills, D. B. (1979). Family configuration and achievement: Effects of birth order and family size in a sample of brothers. *Social Psychology Quarterly, 42*(2), 135–148.

Park, H. (2008). Public policy and the effect of sibship on educational achievement: A

    comparative study of 20 countries. *Social Science Research, 37*(3), 874–887.

Park, H.-O. (2005). Grandmothers raising grandchildren: Family well-being and economic

    assistance. *Focus, 24*(1), 19–27. Retrieved February 28, 2012, from

    http://www.irp.wisc.edu/publications/focus/pdfs/foc241d.pdf

Parker, E. M., & Short, S. E. (2009). Grandmother coresidence, maternal orphans, and

    school enrollment in Sub-Saharan Africa. *Journal of Family Issues, 30*(6), 813–836.

Pebley, A. R., & Rudkin, L. L. (1999). Grandparents caring for grandchildren: What do we

    know? *Journal of Family Issues, 20*(2), 218–242.

Pfeffer, F.T. (2014). Multigenerational approaches to social mobility. A multifaceted

    research agenda. *Research in Social Stratification and Mobility*,

    http://dx.doi.org/10.1016/j.rssm.2014.01.001

Pilkauskas, N. V. (2012). Three-generation family households: Differences by family

    structure at birth. *Journal of Marriage and Family, 74*(5), 931–943.

Pong, S.-L., & Chen, V. W. (2007). Living with grandparents, family relations, and

    grandchildren's school achievement in Taiwan. Retrieved February 1, 2012, from

    http://paa2007.princeton.edu/download.aspx?submissionId=72063

Pong, S.-L., & Chen, V. W. (2010). Co-resident grandparents and grandchildren's academic

    performance in Taiwan. *Journal of Comparative Family Studies, 41*(1), 111–130.

Pong, S.-L., Frick, W, & Moyi, P. (2004). Coresident grandparents and grandchildren's

    academic performance. Retrieved February 27, 2012, from

    http://citation.allacademic.com/meta/p_mla_apa_research_citation/1/0/9/1/8/pages109

    182/p109182-1.php

Popenoe, D. (1987). Beyond the nuclear family: A statistical portrait of the changing family

    in Sweden. *Journal of Marriage and the Family, 49*(1), 173–183.

Ranis, G., Stewart, F., & Samman, E. 2006. Human development: Beyond the Human development index. *Journal of Human Development*, *7*(3), 323–358.

Ruggles, S., & Heggeness, M. (2008). Intergenerational coresidence in developing countries. *Population Development Review, 34*(2), 253–281.

Sandefur, G. D., & Wells, T. (1999). Does family structure really influence educational attainment? *Social Science Research, 28*(4), 331–357.

Shah, N. M., Badr, H. E., Yount, K., & Shah, M. A. (2011). Decline in co-residence of parents and children among older Kuwaiti men and women: What are the significant correlates? *Journal of Cross-Cultural Gerontology, 26*(2), 157–174.

Sharkey, P., & Elwert, F. (2011). The legacy of disadvantage. Multigenerational neighborhood effects on cognitive ability. *American Journal of Sociology 116*(6), 1934–1981.

Shavit, Y., & Pierce, J. (1991). Sibship size and educational attainment in nuclear and extended families: Arabs and Jews in Israel. *American Sociological Review, 56*(3), 321–330.

Shore, R., & Hayslip, B. (1994). Custodial grandparenting: Implications for children's development. In A. E. Gottfried & A. W. Gottfried (Eds.), *Redefining families: Implications for children's development* (pp. 171–218). New York, NY: Plenum Press.

Sieben, I., Huinink, J., & de Graaf, P. M. (2001). Family background and sibling resemblance in educational attainment. Trends in the former FRG, the former GDR, and the Netherlands. *European Sociological Review, 17*(4), 401–430.

STATA Corp. (2011a). *STATA longitudinal data/panel data reference manual. Release 12*. College Station, TX: STATA Press.

STATA Corp. (2011b). *STATA multiple imputation reference manual. Release 12*. College Station, TX: STATA Press.

Steelman, L. C. (1985). A tale of two variables: A review of the intellectual consequences of sibship size and birth order. *Review of Educational Research, 55*(3), 353–386.

Steelman, L. Carr, Powell, B., Werum, R., & Carter, S. (2002). Reconsidering the effects of sibling configuration: Recent advances and challenges. *Annual Review of Sociology, 28*(1), 243–269.

Sudha, S. (1997). Family size, sex composition and children's education: Ethnic differentials over development in Peninsular Malaysia. *Population Studies, 51*(2), 139–151.

Takagi, E., Silverstein, M., & Crimmins, E. (2007). Intergenerational coresidence of older adults in Japan: Conditions for cultural plasticity. *Journal of Gerontology, 62B*(5), S330–S339.

Treiman, D. J. (2009). *Quantitative Data Analysis: Doing Research to Test Ideas*. San Francisco, CA: Jossey-Bass.

United Nations Development Programme. (1990). *Human development report 1990*. Oxford, United Kingdom: Oxford University Press.

United Nations Development Programme. (2011). *Human development report 2011. Sustainability and equity: A better future for all*. Basingstoke, United Kingdom: Palgrave Macmillan. Retrieved October 29, 2012, from http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf

United Nations. (2006). *2003 Demographic yearbook*. New York, NY: United Nations. Retrieved March 14, 2013, from http://unstats.un.org/unsd/demographic/products/dyb/dybsets/2003%20DYB.pdf

Van Eijck, K., & de Graaf, P. M. (1995). The effects of family structure on the educational attainment of siblings in Hungary. *European Sociological Review, 11*(3), 273–292.

Wolter, S. C. (2003). *Sibling rivalry: A six country comparison* (Discussion Paper No. 734). Bonn, Germany: Institute for the Study of Labor. Retrieved May 21, 2012, from ftp://repec.iza.org/dps/dp734.pdf

World Bank. (2003). *Restoring fiscal discipline for poverty reduction in Peru. A public expenditure review*. Washington, DC: The World Bank.

World Bank. (2013). World development indicators: Public spending on education, total (% of GDP). Retrieved March 14, 2013, from http://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?page=2

Zajonc, R. B., & Markus, G. B. (1975). Birth order and intellectual development. *Psychological Review, 82*(1), 74–88.

Zeng, Z., & Xie, Y. (2011). *The effects of grandparents on children's schooling: Evidence from rural China*. Demography and Ecology Center Working Paper No. 2011-11, University of Wisconsin-Madison. Retrieved April 14, 2013, from http://www.ssc.wisc.edu/cde/cdewp/2011-11.pdf

9.   Appendix

<Table A.1 about here>

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Tables and Figures

Table 1: Descriptive statistics of level-1 variables used in the analysis. 15-year-old students in selected countries in 2000. Number of level-1 observations (students) = 151377.

Reading literacy score (mean)	485
Female	50.7 %
Parental HISEI (mean, before centering)	47.9
Education of the better educated parent (ISCED)	
Level 1 or less (primary education or less)	9.9 %
Level 2 (lower secondary)	12.3 %
Level 3B or 3C (upper secondary)	13.0 %
Level 3A (upper secondary)	26.3 %
Level 5A, 5B, or 6 (tertiary)	38.5 %
Number of siblings (mean)	1.9
Mother is employed (proportion)	66.3 %
Family structure (proportion):	
Two biological parents	80.3 %
Single biological parent	13.0 %
One biological parent and their partner	6.8 %
Co-resident grandparent(s) (proportion)	19.8 %

Table 2: Per cent co-residing with grandparents by family type. 15-year-old students in selected countries in 2000. Number of level-1 observations (students) = 151377.

Family type	% co-residing
Intact family (two biological parents)	20.3 %
Single parent	19.7 %
Biological parent and a step-parent	13.6 %

Table 3: Correlations and descriptive statistics of macro-level variables used in the analysis. Number of level-3 observations (countries) = 40.

	HDI	TPEE	TPSE	CDR
HDI	1.00			
Total public expenditure on education (TPEE)	0.66	1.00		
Total public social expenditure (TPSE)	0.64	0.63	1.00	
Crude divorce rate (CDR)	0.44	0.37	0.30	1.00
Mean	0.80	4.69	16.87	1.84
s.d.	0.09	1.39	7.03	0.98
Minimum	0.543	1.1	2.32	0.00
Maximum	0.913	7.7	28.5	4.31

Table 4: Estimated parameters and standard errors (in parentheses) of three-level hierarchical linear models of reading literacy. Number of level-1 observations (students) = 151377, number of level-2 observations (schools) = 8218, number of level-3 observations (countries) = 40.

	Model 1	Model 2
Co-residence with grandparent(s)	-14.824 (1.400)	-12.483 (1.365)
Sibship size	-3.555 (0.350)	-2.622 (0.344)
HDI quartile (1st quartile is ref. category)		
HDI 2nd quartile	48.935 (14.894)	47.775 (14.749)
HDI 3rd quartile	94.656 (14.918)	89.684 (14.768)
HDI 4th quartile	111.794 (14.877)	103.301 (14.736)
Male		-24.568 (0.425)
Family structure (intact family is ref. category)		
Single parent		-2.652 (0.602)
Parent and step-parent		-4.836 (0.808)
Education (ISCED level 1 or lower is ref. category)		
ISCED 2		3.783 (0.898)
ISCED 3B, or 3C		15.748 (0.956)
ISCED 3A		19.324 (0.895)
ISCED 5A, or 5B, or 6		21.270 (0.981)
Socioeconomic status of parental occupation (ISEI)		0.817 (0.017)
Mother employed		-1.074 (0.466)

Table 4: continued

Interactions		
Sibship size*co-residence	0.250 (0.519)	-0.288 (0.507)
HDI 2nd quartile*co-residence	8.248 (2.271)	7.157 (2.221)
HDI 3rd quartile*co-residence	3.664 (2.57)	3.024 (2.508)
HDI 4th quartile*co-residence	-13.217 (2.582)	-12.739 (2.519)
HDI 2nd quartile*sibship size	0.056 (0.562)	-0.173 (0.549)
HDI 3rd quartile*sibship size	-0.734 (0.549)	-0.937 (0.536)
HDI 4th quarter*sibship size	-1.129 (0.485)	-1.455 (0.472)
HDI 2nd quartile*sibship size*co-residence	-2.862 (0.982)	-2.332 (0.96)
HDI 3rd quartile*sibship size*co-residence	-3.844 (1.109)	-3.087 (1.083)
HDI 4th quartile*sibship size*co-residence	-4.034 (1.018)	-3.145 (0.993)
Intercept	420.256 (10.521)	421.662 (10.45)

Table 5: Estimated parameters and standard errors (in parentheses) of three-level hierarchical linear models of reading literacy. Number of level-1 observations (students) = 151377, number of level-2 observations (schools) = 8218, number of level-3 observations (countries) = 40.

	Model 3	Model 4	Model 5
Co-residence with grandparent(s)	-12.189 (1.364)	-12.493 (1.365)	-12.476 (1.364)
Sibship size	-3.984 (0.427)	-2.585 (0.390)	-2.668 (0.351)
HDI quartile (1st quartile is ref. category)			
HDI 2nd quartile	50.236 (16.375)	45.735 (14.907)	46.148 (13.114)
HDI 3rd quartile	92.759 (17.641)	82.862 (17.312)	75.668 (13.808)
HDI 4th quartile	106.834 (17.604)	96.097 (17.574)	86.739 (14.029)
Male	-24.555 (0.425)	-24.568 (0.425)	-24.566 (0.425)
Family structure (intact family is ref. category)			
Single parent	-2.648 (0.602)	-2.653 (0.602)	-2.652 (0.602)
Parent and step-parent	-4.806 (0.808)	-4.841 (0.807)	-4.828 (0.809)
Education (ISCED level 1 or lower is ref. category)			
ISCED 2	3.829 (0.898)	3.778 (0.897)	3.788 (0.897)
ISCED 3B or 3C	15.815 (0.955)	15.742 (0.956)	15.749 (0.956)
ISCED 3A	19.370 (0.895)	19.318 (0.895)	19.318 (0.895)
ISCED 5A, 5B, 6	21.343 (0.981)	21.264 (0.981)	21.266 (0.981)
Socioeconomic status of parental occupation (ISEI)	0.816 (0.017)	0.817 (0.017)	0.817 (0.017)
Mother employed	-1.139 (0.466)	-1.076 (0.466)	-1.079 (0.466)
Total public social security expenditure	-0.348 (0.942)		
Total public social security expenditure*sibship size	-0.155 (0.032)		
Total public expenditure on education (10-year average)		3.590 (4.832)	
Total public expenditure on education*sibship size (10-year average)		0.026 (0.157)	
Crude divorce rate			17.491 (5.318)
Crude divorce rate*sibship size			-0.111 (0.178)

Table 5: continued

Interactions

Sibship size*co-residence	-0.421 (0.508)	-0.282 (0.508)	-0.287 (0.507)
HDI 2nd quartile*co-residence	6.660 (2.233)	7.167 (2.230)	7.190 (2.220)
HDI 3rd quartile*co-residence	3.024 (2.508)	3.017 (2.504)	3.057 (2.507)
HDI 4th quartile*co-residence	-12.986 (2.520)	-12.732 (2.522)	-12.749 (2.518)
HDI 2nd quartile*sibship size	1.189 (0.600)	-0.194 (0.553)	-0.172 (0.549)
HDI 3rd quartile*sibship size	1.096 (0.653)	-0.999 (0.623)	-0.853 (0.548)
HDI 4th quarter*sibship size	0.278 (0.591)	-1.518 (0.590)	-1.355 (0.515)
HDI 2nd quartile*sibship size*co-residence	-2.057 (0.967)	-2.338 (0.965)	-2.357 (0.958)
HDI 3rd quartile*sibship size*co-residence	-3.137 (1.083)	-3.079 (1.081)	-3.103 (1.084)
HDI 4th quartile*sibship size*co-residence	-3.037 (0.994)	-3.149 (0.994)	-3.145 (0.992)
Intercept	419.431 (12.322)	426.043 (11.939)	430.791 (9.700)

Table 6: Estimated net effects of sibship size from selected three-level hierarchical linear models of reading literacy. Number of level-1 observations (students) = 151377, number of level-2 observations (schools) = 8218, number of level-3 observations (countries) = 40.

	Net effect of sibship size	
Model 3	No co-residence	Co-residence
1st HDI quartile	-3.984	-4.405
2nd HDI quartile	-2.795	-5.273
3rd HDI quartile	-2.888	-6.446
4th HDI quartile	-3.706	-7.164
Model 4	No co-residence	Co-residence
1st HDI quartile	-2.585	-2.867
2nd HDI quartile	-2.779	-5.399
3rd HDI quartile	-3.584	-6.945
4th HDI quartile	-4.103	-7.534
Model 5	No co-residence	Co-residence
1st HDI quartile	-2.668	-2.955
2nd HDI quartile	-2.840	-5.484
3rd HDI quartile	-3.521	-6.911
4th HDI quartile	-4.023	-7.455

Table A.1: Descriptive statistics of selected variables used in the analysis by country. 15-year-old students in 2000. Number of level-1 observations (students) = 151377.

Country	Reading literacy score (mean)	Number of siblings (mean)	HDI	HDI quartile	Number of level-1 cases
Albania	366.6	2.0	0.691	1st	3967
Argentina	432.4	2.6	0.749	2nd	2546
Australia	534.9	2.0	0.906	4th	4650
Austria	507.1	1.6	0.839	3rd	3406
Belgium	528.4	1.7	0.876	4th	4943
Brazil	389.3	2.4	0.665	1st	3446
Bulgaria	432.4	1.0	0.715	1st	3056
Canada	528.3	1.9	0.879	4th	18811
Chile	422.0	2.2	0.749	2nd	3500
Czech Republic	502.7	1.5	0.816	2nd	4539
Denmark	509.4	1.9	0.861	3rd	3099
Finland	552.0	2.0	0.837	3rd	4355
France	512.4	1.8	0.846	3rd	2986
Germany	509.3	1.5	0.864	4th	4232
Greece	480.7	1.4	0.802	2nd	2749
Hong Kong	533.2	1.5	0.824	2nd	3331
Hungary	490.3	1.4	0.775	2nd	3944
Iceland	512.1	2.5	0.863	3rd	2482
Indonesia	369.8	2.9	0.543	1st	4664
Ireland	540.5	2.6	0.869	4th	1796
Israel	482.3	2.9	0.856	3rd	2712
Italy	496.2	1.3	0.825	2nd	3720
Korea	524.7	1.3	0.830	3rd	2840
Latvia	469.4	1.6	0.732	1st	3086
Luxembourg	460.0	1.6	0.854	3rd	2358
Macedonia	383.7	1.4	0.772	2nd	3089
Mexico	434.9	2.9	0.718	1st	3231
New Zealand	544.7	2.2	0.878	4th	2299
Norway	520.8	2.0	0.913	4th	2404
Peru	342.8	3.0	0.674	1st	3634
Poland	479.6	1.8	0.770	2nd	2959
Portugal	484.6	1.4	0.778	2nd	2638
Romania	453.9	1.4	0.704	1st	3357
Russia	468.7	1.7	0.691	1st	4441
Spain	499.7	1.4	0.839	3rd	4220
Sweden	524.2	2.2	0.894	4th	2629
Switzerland	504.3	1.6	0.873	4th	4389
Thailand	443.3	2.1	0.626	1st	3801
UK	545.5	2.0	0.833	3rd	4682
USA	519.2	2.4	0.897	4th	2386

Table A.2: Per cent co-residing with grandparents and per cent living in various family types by country. 15-year-old students in 2000. Number of level-1 observations (students) = 151377.

Country	% co-residing with grandparents	Family type		
		% in intact families	% in single parent families	% in step-parent families
Albania	32.2	91.7	7.4	0.9
Argentina	29.0	76.7	17.5	5.8
Australia	5.3	74.5	16.0	9.5
Austria	25.0	80.1	12.9	7.1
Belgium	6.7	79.9	11.5	8.7
Brazil	26.2	73.3	18.1	8.6
Bulgaria	50.3	85.5	12.1	2.3
Canada	9.5	76.3	13.7	10.0
Chile	22.0	71.4	19.2	9.4
Czech Republic	19.1	79.8	10.6	9.6
Denmark	4.5	75.5	13.9	10.6
Finland	2.4	76.4	16.6	7.1
France	7.4	76.6	14.4	9.1
Germany	19.7	77.8	14.6	7.7
Greece	24.4	92.1	6.3	1.5
Hong Kong	12.6	89.7	8.9	1.4
Hungary	13.4	76.5	15.6	7.9
Iceland	3.8	73.2	13.3	13.5
Indonesia	48.2	92.8	4.3	2.9
Ireland	10.9	87.4	10.1	2.5
Israel	14.3	89.9	8.0	2.0
Italy	32.0	84.0	14.0	2.0
Korea	27.9	92.8	5.9	1.3
Latvia	30.8	68.5	20.0	11.6
Luxembourg	16.2	83.0	9.2	7.9
Macedonia	46.6	93.8	5.4	0.8
Mexico	28.6	82.6	13.8	3.6
New Zealand	6.4	70.9	18.8	10.4
Norway	9.3	77.0	12.9	10.1
Peru	21.8	79.1	17.6	3.4
Poland	18.9	89.2	8.1	2.7
Portugal	25.3	84.3	10.6	5.1
Romania	31.4	86.2	10.1	3.7
Russia	32.7	73.8	18.2	8.1
Spain	26.2	86.7	11.6	1.7
Sweden	3.7	72.2	17.3	10.5
Switzerland	11.7	80.5	13.1	6.4
Thailand	48.0	85.7	10.4	4.0
UK	6.9	76.1	14.3	9.7
USA	16.2	64.8	18.3	16.9

Table A.3: Per cent co-residing with grandparents by family type and by country. 15-year-old students in 2000. Number of level-1 observations (students) = 151377.

Country	Two biological parents	Single parent	One biological parent, one step-parent
Albania	32.5	29.0	30.6
Argentina	28.4	33.7	22.3
Australia	5.3	5.9	4.3
Austria	26.8	17.6	17.1
Belgium	6.5	7.8	7.0
Brazil	25.4	30.1	24.6
Bulgaria	50.0	53.8	41.4
Canada	9.5	10.1	8.3
Chile	17.9	37.0	22.8
Czech Republic	20.1	17.0	12.4
Denmark	4.8	3.9	3.4
Finland	2.7	1.7	0.7
France	6.8	10.5	7.4
Germany	21.4	15.6	10.8
Greece	23.7	35.1	23.8
Hong Kong	12.1	15.8	28.9
Hungary	13.2	16.6	9.0
Iceland	3.4	6.1	3.3
Indonesia	48.1	45.0	56.6
Ireland	10.9	11.5	9.1
Israel	14.1	18.4	9.1
Italy	33.3	26.3	19.2
Korea	27.8	30.5	21.1
Latvia	29.8	34.6	29.7
Luxembourg	16.8	13.4	14.1
Macedonia	46.6	47.6	34.6
Mexico	27.5	34.7	31.9
New Zealand	6.3	7.2	5.4
Norway	9.3	10.0	8.3
Peru	20.6	25.2	32.0
Poland	18.8	21.8	13.6
Portugal	24.8	30.7	22.2
Romania	31.1	32.9	33.9
Russia	31.7	39.4	27.1
Spain	26.5	25.4	20.6
Sweden	3.6	4.0	4.0
Switzerland	12.7	7.0	8.5
Thailand	48.0	46.5	52.7
UK	7.1	6.9	4.9
USA	17.2	15.4	13.2

Figure 1: Estimated total effects (from Model 1) of the number of siblings on reading test scores by quartiles of the Human Development Index and co-residence with grandparents from a three-level linear regression model. PISA 2000, number of level-1 observations (students) = 151377, number of level-2 observations (schools) = 8218, number of level-3 observations (countries) = 40.
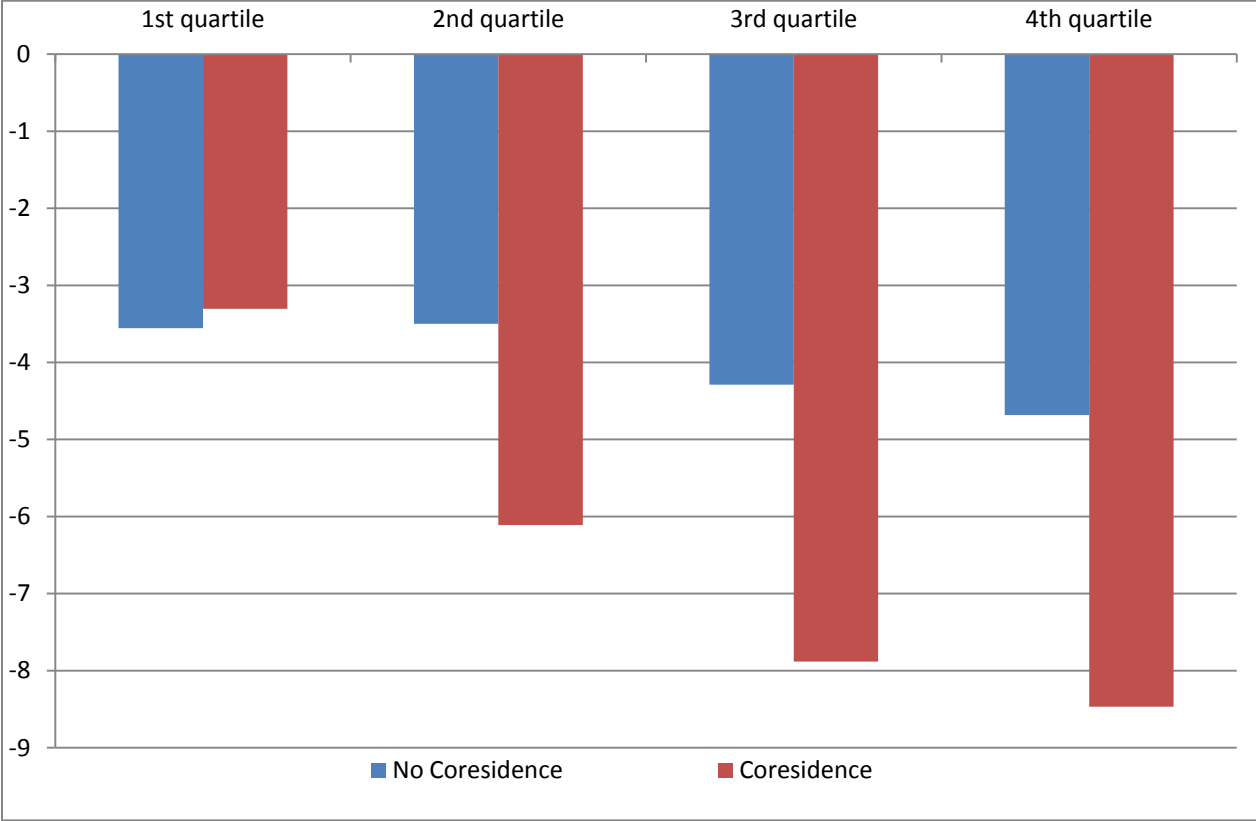
Figure 2: Estimated net effects (from Model 2) of the number of siblings on reading test scores by quartiles of the Human Development Index and co-residence with grandparents from a three-level linear regression model. PISA 2000, number of level-1 observations (students) = 151377, number of level-2 observations (schools) = 8218, number of level-3 observations (countries) = 40.