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The Global Increase in the Socioeconomic Achievement Gap, 1964-2015

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ABSTRACT

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May 22, 2017

The existence of a "socioeconomic achievement gap"—a disparity in academic achievement between students from high- and low-socioeconomic status (SES) backgrounds—is well-known in educational research. The SES achievement gap has been documented across a wide range of countries. What is unknown in most countries is whether the SES achievement gap might be *changing* over time. This study combines 30 international large-scale assessments over 51 years, representing 100 countries and about 5.8 million students. Results indicate that on average globally, SES achievement gaps have increased for all three available measures of family SES: parents' education, parents' occupation, and the number of books in the home. These trends are partially explained by expanding school access and declining fertility rates.

The Global Increase in the Socioeconomic Achievement Gap, 1964-2015

The existence of a “socioeconomic achievement gap”—a disparity in scores on tests of academic achievement between students from high- and low-socioeconomic status (SES) backgrounds—is well-known in educational research. International assessments show that SES achievement gaps are present across a wide range of countries (Mullis et al. 2016; OECD 2016). This suggests that, in most societies, low-SES children do not receive the same learning experiences in and/or out of school as their high-SES counterparts. Across many countries, SES achievement gaps impede upward mobility (Jackson 2013). There is less evidence, however, on whether SES achievement gaps might be *changing* over time. Recent research shows that SES achievement gaps have increased in three individual countries: the US (Reardon 2011), South Korea (Byun and Kim 2010), and Malaysia (Saw 2016).

This paper asks whether these individual country findings could be part of a global trend. It uses evidence from 51 years of international large-scale assessments, dating from the First International Mathematics Study (FIMS) in 1964 to recent data from the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS), and the Progress in International Reading Literacy Study (PIRLS). It draws on 30 datasets across 100 countries representing some 5.8 million students, and seeks to describe the global trend in SES achievement gaps and identify its possible causes.

Evidence on Trends in the SES Achievement Gap

Each of the three recent domestic studies mentioned above uses different data sources and measures and identifies increasing SES achievement gaps over slightly different time periods. Using 19 nationally-representative US studies, Reardon (2011) shows that the gaps in reading and math achievement between students from families at the 90th and 10th income percentiles grew by about 40% between children born in the 1970s and the 1990s. However, the US gap appears to have narrowed slightly for children born in the subsequent decade (Reardon and Portilla 2016). In South Korean subsamples from three waves of TIMSS 8th grade (1999, 2003, and 2007), Byun and Kim (2010) find a strengthening association between math achievement and an index of SES (including parent education and household possessions). Using Malaysian subsamples from four waves of TIMSS 8th grade (1999, 2003, 2007, and 2011), Saw (2016) observes rapid growth in math and science achievement gaps between students whose parents attended post-secondary education and those who did not, gaps which have surpassed gender and ethnic achievement gaps in size.

Are these domestic trends in the SES achievement gap in the US, South Korea, and Malaysia part of a global trend? There is some early international evidence that SES achievement gaps may have increased in a number of countries between the 1970s and 1990s. The associations between science achievement and SES measures (parent education, parent occupation, and household books) increased between the First International Science Study (FISS) of 1970 and the Second International Science Study (SISS) of 1984 (Keeves 1992). The authors of the SISS report wrote that this increase might be partly attributable to increased validity of home background measures, but was likely also related to "increased polarization in society and in the benefits that flow from education" (p. 11). Baker, Goesling, and LeTendre (2002) show that in developing countries between the 1970s and 1995, the importance of family SES grew relative to school resources in predicting students' achievement, a change that they attribute to expanding school access and standardization of school quality. In contrast, more recently, the association between science achievement and an SES index (including parent education, parent occupation, and household possessions) has declined in a majority of countries participating in PISA 2006 and 2015 (OECD 2016). Thus, the evidence on a possible global increase in SES achievement gaps is mixed, and trends appear to differ between countries. What could explain cross-national differences in SES achievement gap trends? Could some drivers of inequality be global in scale?

Explanations for Trends in SES Achievement Gaps

Among the three single-country studies described in the previous section, there is substantial overlap in the potential explanations suggested for growing achievement gaps, including rising income inequality in the US and South Korea (Byun and Kim 2010; Reardon 2011); increasing school segregation, whether due to residential segregation in the US (Reardon 2011) or increasing school choice and curricular tracking in South Korea (Byun and Kim 2010); and growing inequality in parental investments in children, whether in private tutoring in South Korea and Malaysia (Byun and Kim 2010; Saw 2016) or other enrichment experiences in the US (Reardon 2011). The similarities between these three very geographically and culturally different countries raise the question of whether these economic, social, and educational trends may be global phenomena. Although there is ample international comparative research on which country characteristics are associated with larger SES achievement gaps, most of this research is cross-sectional—conducted at a single point in time. However, with such a design, it is difficult to isolate the causes of gaps, as differences between countries may be the result of a wide variety of cultural and historical factors. Thus, examining changes in gaps over time across a large number of countries may not only help to describe a global trend toward increasing inequality but also to identify the most important causes of SES achievement gaps.

Previous research suggests several candidates for global trends that could drive increasing SES achievement gaps in a large number of countries. First, the population of students enrolled in schools has become more diverse. Primary and lower secondary school enrollment has become virtually universal in developed countries and has increased dramatically in less developed countries (Baker, Goesling and LeTendre 2002). Since the target population of international assessments includes only students currently enrolled in school, countries with the most rapidly expanding school access may appear to have growing SES achievement gaps due to the inclusion of relatively disadvantaged populations. Additionally, increasing global migration has led to a larger share of immigrant students enrolled in schools in many countries, which could also lead to growing SES achievement gaps in these countries, to the extent that immigrant students are lower-achieving and lower-SES than native-born students (Andon, Thompson and Becker 2014).

Second, economic trends could be responsible for growing SES achievement gaps. The level of economic development is rising in most of the countries participating in international assessments, implying rising standards of living and capacity for public and private investment in education and child wellbeing. However, it is not clear that a higher level of development leads to smaller SES achievement gaps; in fact, the reverse may be true. Comparing countries cross-sectionally at a single point in time (the 1970s), Heyneman and Loxley (1983) found that family SES was a more important predictor of student achievement in more developed countries, a correlation that still appears weakly present in PISA 2015 results (OECD 2016). When looking at changes over time, Baker et al. (2002) suggested that the importance of SES grew more in developing countries. Another important economic trend, rising income inequality, was a suggested explanation for rising SES achievement gaps in both the US and South Korea (Byun and Kim 2010; Reardon 2011). Income inequality is increasing in many other countries as well, particularly in Europe and Asia (though income inequality appears to be decreasing in many Latin American and African countries) (OECD 2015; UNDP 2013). Although cross-sectional research shows that country income inequality is not strongly related to SES achievement gaps (Dupriez and Dumay 2006; Duru-Bellat and Suchaut 2005; Marks 2005), there is little published evidence on whether *changes* in income inequality within countries over time predict *changes* in SES achievement gaps. We may expect that countries with increasing income inequality experience increasing SES achievement gaps due to increasing disparities in the material resources of low- and high-SES families, as well as possible corresponding increases in neighborhood segregation by income (Reardon and Bischoff 2011).

Third, changing educational institutions could cause rising SES achievement gaps. A strong and consistent finding in cross-sectional comparative research is that countries with more rigid systems of curricular differentiation tend to have larger SES achievement gaps. In these studies, highly differentiated systems are those (primarily European) countries that select students at relatively young ages into academic and vocational tracks or schools (for a review, see Van de Werfhorst and Mijs 2010). Over time, however, it is not clear that changes in tracking systems could explain increasing SES achievement gaps. Although Byun and Kim (2010) identify increasing tracking as a potential explanation for increasing SES achievement gaps in South Korea, in most other countries participating in international assessments, reforms have been toward *de*-tracking, such as delaying the age when students are selected into tracks and/or enrolling a greater share of students in the academic track (Ariga et al. 2005; Benavot 1983;

Manning and Pischke 2006). Results from two over-time studies comparing SES achievement gaps within countries across cohorts that were subject to different tracking policies provide inconclusive evidence. Van de Werfhorst (2013) finds that, among eight countries participating in both FIMS in 1964 and the Second International Mathematics Study (SIMS) in 1980, the three countries that implemented de-tracking reforms experienced declines in SES achievement gaps. In contrast, Brunello and Checchi (2007) find that SES origin gaps in literacy measured in adulthood are *larger* in cohorts educated after de-tracking reforms.

At the same time that formal tracking policies are growing more equal globally, informal and private educational processes may be growing more unequal. School choice and privatization have increased in recent decades in many countries around the world (Bohlmark and Lindahl 2007; Eyles and Machin 2015; Valenzuela, Bellei and Ríos 2014) and privatization is increasing throughout the developing world (UNESCO 2015). Relatedly, private household expenditures on children appear to be growing dramatically and growing more unequal between income deciles in the US, Canada, and Australia (Kornrich, Gauthier and Furstenberg 2011). Another growing spending category across both developed and developing countries is out-of-school private tutoring or “shadow education” (Aurini, Davies and Dierkes 2013). As noted above, growing inequality in parental spending on private tutoring and enrichment activities was identified as a possible source for growing SES achievement gaps in the US, South Korea, and Malaysia (Byun and Kim 2010; Reardon 2011; Saw 2016).

Fourth and finally, increasing SES achievement gaps could be due to changing beliefs about parenting. As declining world fertility rates create smaller families (UN 2015), paradoxically, time-use surveys across a range of countries show that parents spend *more* time on caregiving (Gauthier, Smeeding and Furstenberg 2004). In the US, recent literature documents increasing parental time spent particularly on activities oriented toward children's cognitive development, a trend that appears more pronounced among college-educated parents and that is attributed to increasingly competitive college admissions (Alon 2009; Ramey and Ramey 2010; Schaub 2010). Lareau (2003) calls this parenting style of the American middle and upper class "concerted cultivation." But the phenomenon may be seen in other countries as well. Liu's (2016) intergenerational study of the rise of the "priceless" only child in urban China shows that the attention of parents and grandparents is largely focused around "deliberate cultivation and training" to ensure children's academic success. Another indicator of the global nature of this trend is the growth of the literature on "parentocracy," a term coined by Brown (1990) in reference to the UK, which has since been applied to rising parental involvement and private educational expenditures in Singapore (Ong 2014), Japan (Mochizuki 2011), Taiwan (Chang 2014), and Zimbabwe (Madzanire and Mashava 2012), among others.

Empirical Approach

No study has yet taken advantage of the full history of international assessments to study global changes in SES inequality, although a small number of economics studies have combined modern and historical international assessments to study changes in the *level* of achievement over time (e.g., Altinok, Diebolt and Demeulemeester 2014; Falch and Fischer 2012; Hanushek and Wößmann 2012); and one sociology study has used these data to compare changes in gender achievement gaps over time (Wiseman et al. 2009). The strength of an over-time design is twofold: It allows investigation of the understudied question of *changes* in SES achievement gaps, rather than the size of gaps at only a single point in time. Moreover, in predicting which national characteristics and policies are associated with SES achievement gaps, an over-time design allows each country to “be its own control,” ruling out many historical and cultural differences that often confound cross-sectional international comparisons. Such a design allows us to investigate, first, whether increasing SES achievement gaps are a global phenomenon, and second, how increasing SES achievement gaps are associated with changing educational and social policies and conditions.

Data

The data for this study are derived from 30 international large-scale assessments of math, science and/or reading: FIMS 1964, SIMS 1980, FISS 1970, SISS 1984, the first international reading comprehension study (FIRCS 1970), the Reading Literacy Study (RLS 1991), and multiple years of TIMSS (1995-2015), PIRLS (2001-2011) and PISA (2000-2015). All studies are conducted by the International Association for the Evaluation of Educational Achievement (IEA) except PISA, which is conducted by the Organization for Economic Cooperation and Development (OECD). Together, the studies represent 109 countries and about 5.8 million students. Students are either in fourth grade/age 10 (FISS, FIRCS, SISS, RLS, TIMSS, and PIRLS), eighth grade/age 14 (FIMS, FISS, FIRCS, SIMS, SISS, RLS, and TIMSS), or age 15 (PISA).[1] SES achievement gaps are calculated for each country in each subject for each study. Limiting the sample to countries that have participated in at least two different assessments in different years reduces the sample to 100 countries and a total of 2228 observations (country-subject-years). The countries participating in international assessments tend to be high- or middle-income; the mean GDP per capita in 2015 for countries in the analytic sample was

[1] Assessments of twelfth grade students are omitted, as only a small proportion of the age cohort remains in upper secondary school in many countries, particularly in early cohorts.

$30,366.69, compared to the world GDP per capita of $15,546.30.[2] A full list of included countries appears in Appendix A.

Variables

Achievement. Full descriptions of the math, science, and reading skills assessed in each study are available from the IEA's and OECD's official published reports. Although there are similarities among the different tests of the same subject, only the scores from multiple years of the TIMSS, PIRLS, and PISA studies are strictly comparable. Since each test is on a different scale, in the main models that combine different studies, all scores are standardized to a mean of 0 and standard deviation of 1 within each country-study-year before calculating each SES achievement gap. The validity of the resulting gap estimates then depends on the assumptions that all tests are interval scaled and that different tests rank students similarly. The main models pool math, science, and reading gaps and include dummy variables to control for subject.[3]

SES. In each dataset, at least one of the following three measures of family socioeconomic status is available: parents' education, parents' occupation, and the number of books in the household. For parents' education and occupation, the higher of the two parents was used.[4] All SES variables are reported in ordered categories; the number of categories varies somewhat by study and by country. Parent education was generally 6-8 categories, such as (1) None, (2) Primary, (3) Lower secondary, (4) Vocational upper secondary, (5) Academic upper secondary, (6) Postsecondary vocational certificate, (7) Associate's degree, (8) Bachelor's

[2] Gross domestic product per capita converted to current (2016) international dollars using purchasing power parity (PPP), obtained from the World Bank.
[3] Supplemental analyses check the robustness of results by running models separately by subject (Appendix K) and separately for TIMSS, PIRLS, and PISA (Appendix B); results are similar.
[4] Additional detail on the treatment of mothers' and fathers' SES characteristics is reported in Appendix F.

degree or more. Parent occupation was generally 9-10 categories corresponding to one-digit ISCO codes, reordered by average occupational status (Ganzeboom and Treiman 1996). In order of lowest to highest status, they are: (1) Laborers, (2) Agricultural, (3) Plant Operators, (4) Craft/Trade, (5) Service, (6) Clerk, (7) Business, (8) Technician, (9) Managerial, (10) Professional. Books in the household were usually reported in 5-6 categories, such as: (1) 0-10 books, (2) 11-25 books, (3) 26-100 books, (4) 101-200 books, (5) 201-500 books, (6) More than 500 books. The percentile method used to calculate SES achievement gaps (described in the Methods section below) requires only that categories be ordered, not an equal number of categories with consistent meanings or distributions across years or countries, so the maximum possible categories were retained in each year.[5] All SES variables are student-reported except for eight recent studies where they are parent-reported: PIRLS 2001, 2006, and 2011; TIMSS 2011 and 2015 fourth grade; and PISA 2006, 2009, and 2012 (in participating countries; otherwise student-reported).

Cohort birth year. The mean birth year for each country-year, derived from student reports either of birth year and month or of age in years and months, relative to the known year and month of testing in each country. Survey weights were used when calculating means. Birth year ranges from 1949.86 in the UK FIMS 1964 sample to 2005.78 in the New Zealand TIMSS 2015 4th grade sample. In models, birth year is set to 0 in 1989, producing a range from -39.14 to 16.78.[6]

[5] Models were also run with categories harmonized across datasets and results were very similar (see Appendix B).
[6] Student birth year and month were not publicly available in TIMSS 2015 and thus are estimated as the mean country birth year in TIMSS 2011 plus four.

Most of the following time-varying country covariates are drawn from UNESCO indicators, unless otherwise noted. Country-level indicators not collected annually were linearly interpolated for missing years.

Level of School Enrollment. Net proportion of the age cohort enrolled in school in the year of testing. For fourth grade testing cohorts, the proportion enrolled in primary school in the testing year is used; for eighth grade and 15-year-old cohorts, the proportion enrolled in secondary school is used.

Proportion Immigrant Background. Proportion of students reporting first- or second-generation immigrant status, computed from the microdata.

GDP per capita. Gross domestic product per capita converted to 2012 international dollars using purchasing power parity (PPP) rates was obtained from the World Bank and was averaged over the lifetime of each testing cohort from birth to test year.

Income Inequality. Gini coefficient ranging from 0 (perfect equality) to 1 (perfect inequality) was obtained from the World Bank for less-developed countries and from the Luxembourg Income Study for wealthier countries and was averaged over the lifetime of each testing cohort from birth to test year.[7]

Age When Tracking Begins. Consistent with prior international comparative research, "tracking" is defined as selection into overarching programs with academically- or vocationally-oriented curricula. The age when this selection occurred in a given country in each testing year was used. Historical tracking policies were taken from Brunello and Checchi (2007), supplemented by

[7] World Bank and Luxembourg Income Study data on income inequality (Gini coefficient) are not perfectly comparable. The Luxembourg Income Study uses income post-tax and transfer, equivalized by number of household members, while the World Bank uses official government income statistics that are not adjusted in these ways. World Bank Gini figures are generally higher than LIS Gini figures. Since this study is interested in comparing changes in time-varying covariates within countries over time, only one data source is used for each country. The validity of results, then, relies on the assumption that a one-unit change in each Gini measure is approximately equivalent, but not that the absolute levels of each measure are comparable.

information from UNESCO/International Bureau of Education (IBE) National Reports, the OECD's PISA reports, and the *International Encyclopedia of National Systems of Education* (Postlethwaite 1995). Age of track selection ranges from 10 to 16. Countries such as the US that did not practice this type of tracking between 1964 and 2015 are coded as age 16 in all years.

Proportion in Private Schooling. Students enrolled in privately-managed institutions (regardless of funding source) as a proportion of total enrollment in the year of testing. For fourth grade testing cohorts, the proportion enrolled in primary school in the testing year is used; for eighth grade and 15-year-old cohorts, the proportion enrolled in secondary school is used.

Fertility Rate. Total births per woman in the birth year of each testing cohort, obtained from the United Nations Population Division.

Higher Education Excess Demand. The proportion of students expecting to attend higher education in the test year (estimated from the microdata), minus the gross proportion of actual enrollment in higher education in the test year. Higher education refers to any tertiary program (short or long cycle, i.e. ISCED 5B or 5A) or more.[8]

Methods

Missing data for all student-level variables except achievement are imputed using multiple imputation by iterative chained equations and creating five imputed datasets for each country-year. Each gap is estimated five times and averaged, and standard errors are calculated to reflect uncertainty due to imputation.[9] The plausible values of achievement included in some

[8] Expected higher education attendance is either student- or parent-reported, depending on the dataset; student- and parent-reported expectations do not appear to differ in magnitude.
[9] Models were also run using listwise deletion rather than multiple imputation of missing data, and results were similar (see Appendix L).

datasets (PISA, TIMSS, and PIRLS) can also be understood in a multiple imputation framework, and therefore are included in this procedure.[10]

For each country in each study, SES disparities in achievement are measured as the gap in standardized achievement between the 90th and 10th percentiles of each country's distribution of each SES variable, following Reardon's (2011) method for income achievement gaps. First, achievement is standardized within each country, year, and subject; mean achievement (and standard error) is calculated for each SES category for each country; category means are plotted at their percentile ranks for each country and year; cubic models are fit through the points using weighted least squares[11]; and finally achievement at each country's 90th and 10th SES percentiles is interpolated from the model. All gaps are calculated using student sample weights. Gaps will tend to be attenuated in country-years where SES is less reliably measured (e.g., students typically report SES with more error than parents). Due to the standardization of achievement described above, gaps will also be attenuated in country-years where achievement is less reliably measured. Therefore, gaps are adjusted according to each country's test reliability for each study, as published in the corresponding technical reports, as well as according to the estimated reliability of each SES report. For studies where both students and parents reported the same SES variable, reliability can be calculated from the microdata. These reliabilities are then applied to all other years.[12]

[10] PISA 2015 used 10 rather than five plausible values of achievement. Thus, 10 imputed datasets were generated and combined with the 10 plausible values of achievement.
[11] Cubic functions were chosen for consistency with Reardon (2011). Quadratic or linear functions are used in country-years where there are insufficient SES categories. Linear functions are also used for country-years when more than 20 percent of students fall into the top or bottom SES category, as linear functions can be estimated more reliably than cubic functions in these cases. Models were also run with all linear gaps, and results are similar (see Appendix L).
[12] See Appendices D and H for more information on the reliability adjustment. Models were also run without adjusting for reliability, and results were similar (see Appendix D).

The 90/10 percentile method compares students at the same relative position within the SES distribution of their respective country birth cohorts, even as shifting SES distributions cause the absolute meanings of these positions to change. Thus, the analyses here assume that family SES is a positional rather than an absolute good in terms of the advantages it confers to children.[13] The procedure described above is repeated for each of the three SES variables, for each country and each study. Gaps are estimated separately for each SES variable rather than constructing an SES index to avoid loss of information because not all SES variables are available in every dataset. Although each variable represents a slightly different dimension of SES, it is not possible to adjudicate between substantive versus sample selection explanations for differences in results. Thus, results are compared across the three SES variables as a robustness check, with parent education achievement gaps presented as the main results, as parent education has the widest coverage of countries and years.[14]

Because each observation in the data is a country-study-year, nested within countries, a hierarchical growth model is appropriate. The model is estimated as follows:

$$\hat{G}_{ij} = \gamma_{00} + \gamma_{10} Y_{ij} + (\boldsymbol{X}_{ij} - \overline{\boldsymbol{X}}_j)\mathbf{B} + \overline{\boldsymbol{X}}_j \mathbf{\Gamma} + \boldsymbol{\Lambda}_{ij} + v_j + r_j Y_{ij} + u_{ij} + \epsilon_{ij},$$

$$v_j \sim N(0, \tau_{00}); r_j \sim N(0, \tau_{11});\ u_{ij} \sim N(0, \sigma^2);\ \ \epsilon_{ij} \sim N(0, \omega_{ij}),$$

where $\hat{G}_{ij}$ is the estimated gap in country j in country-study-year i, γ_{10} is the coefficient for cohort birth year Y_{ij}, $\boldsymbol{X}_{ij}$ is a vector of time-varying country covariates in country-year i, $\overline{\boldsymbol{X}}_j$ is the average of vector $\boldsymbol{X}_{ij}$ within country j, $\boldsymbol{\Lambda}_{ij}$ is a vector of dummy variables indicating age at testing and test subject, $\boldsymbol{B}$ is a vector of coefficients for the time-varying country covariates, $\mathbf{\Gamma}$ is a vector of coefficients for country-average covariates, τ_{00} is the between-country variance of

[13] This issue is discussed in more detail in Appendix E.
[14] Additional analyses of gaps computed from models including all three SES variables are reported in Appendix G.

the true gaps, τ_{11} is the between-country variance of true slopes of cohort birth year, σ^2 is the true within-country variance of the gaps, and $\omega_{ij} = \left[s.e.\left(\hat{G}_{ij}\right)\right]^2$ is the sampling variance of $\hat{G}_{ij}$. ω_{ij} is estimated using a variance-known model in HLM 7, which uses the standard errors estimated for each gap to give greater weight to more precisely-estimated gaps.[15] Note that cohort birth year and age at testing are not collinear because observations come from a wide range of years. Model estimates are reported with robust Huber-White standard errors.

The coefficient for cohort birth year represents the average trend in SES gaps over time across countries; if SES gaps are increasing globally, we would expect this coefficient to be positive. The coefficients $\boldsymbol{B}$ for time-varying country covariates are of interest in predicting variation in gaps across countries, as these represent the association between change in covariates and change in gaps within countries over time.

Results

First, the trends in 90/10 SES achievement gaps are estimated for each individual country using weighted least squares models with controls for age of testing and subject. An example of the gap trend in one country (the United States) for one SES variable (parent education) is displayed in Figure 1. Each data point is the estimated achievement gap between students at the 90^{th} and 10^{th} percentiles of parent education in the US subsample of a particular international assessment, meaning that higher values correspond to larger 90/10 parent education achievement gaps. The gaps are plotted against the birth year of sampled students, which runs from approximately 1950, corresponding to 14-year-old students tested in FIMS 1964, to approximately 2001, corresponding to 14-year-old students tested in TIMSS 2015. Figure 1

[15] Models were also run without precision weighting, and results were similar (see Appendix L).

shows that the parent education achievement gap has declined very slightly in the US over the past 50 years, from about 1.19 standard deviations (SDs) of achievement in the 1950 birth cohort to about 1.13 SDs in the 2001 cohort, a decline that is not statistically significant. This result is consistent with Reardon's (2011) study, which, in contrast with a substantial increase in the achievement gap based on *income*, did not find any significant change in the achievement gap based on *parent education*. Thus, the results of this study using US subsamples of international assessments are consistent with a study using similar methodology and US national datasets.

(Figure 1 about here)

Figure 2 plots the estimated increase in the 90/10 parent education achievement gap for all available countries in the dataset. In this figure, each data point is the estimated annual change in SDs of achievement in the parent education achievement gap across cohorts, multiplied by 55, the total number of cohort years in the data. Thus, higher values indicate larger estimated increases, and values below 0 indicate a decline in the gap. Countries are sorted from the largest estimated increase to the largest decline in the gap. The US is highlighted in black and is plotted at approximately -0.06 SD, the total decline in the parent education gap observed in Figure 1. Also visible in Figure 2 are the estimated trends for two other countries that have been studied in prior research, South Korea and Malaysia, with total gap changes of about +0.35 SD ($p < .01$) and -0.06 SD (not significant), respectively. The finding for South Korea is consistent with the increasing SES achievement gap observed by Byun and Kim (2010) for this country, but the small, non-significant decline for Malaysia is inconsistent with the increasing gap described by Saw (2016). It should be noted that both of these prior studies use somewhat different data and measures than the current study. Byun and Kim (2010) use three waves of TIMSS 8th grade (1999, 2003, and 2007), while this study adds three more waves of TIMSS 8th grade (1995, 2011, and 2015), as well as SISS 1984 and five waves of PISA. Saw (2016) uses four waves of TIMSS 8th grade (1999-2011), while this study adds another wave of TIMSS 8th grade (2015) and two waves of PISA. Additionally, SES measures differ: Byun and Kim (2010) use an SES index composed of parent education, household books, and other household possessions, while the trend in Figure 2 refers only to the achievement gap based on parent education (the gap based on household books is also estimated separately). Saw (2016) uses a dichotomized measure of parent education, while this study retains all values of parent education and uses the 90/10 gap estimation method described in the previous section. The discrepancy in the Malaysian findings appears primarily due not to the difference in SES measures but the inclusion of more recent data, as the Malaysian parent education achievement gap declined markedly in TIMSS 2015. The Malaysian 90/10 gap trend estimated using data only up to 2011 is positive, consistent with Saw (2016).

(Figure 2 about here)

It is evident in Figure 2 that both the US and Malaysia have smaller estimated gap increases than the average across the international sample. In the US, the parent education achievement gap was already substantially above average in FIMS 1964 and remained relatively constant over the next 50 years while many other countries "caught up." Reardon's (2011) findings show that, during this same period in the US, family income was gaining new salience relative to parent education. The countries with larger estimated increases in the parent education achievement gap may share certain characteristics. Prior research argued that countries at lower levels of economic development experienced larger increases in SES achievement gaps between the 1970s and 1990s (Baker, Goesling and LeTendre 2002). Figure 2 color-codes countries' trend estimates based on their level of economic development in the early years of the sample, specifically whether their GDP per capita in 1980 was above or below $6000, the approximate median in the sample. It is visually evident that there is no strong relationship between gap increases and economic development in 1980.[16] Additional models (not reported here) also show no strong association between the size of gap increases and geographical world region, which can be observed visually in Figure 2 by the great diversity of countries at the extreme right and left of the graph.[17] One observable pattern is that countries at lower levels of development tend to have less precisely estimated trends (i.e., wider confidence intervals), which is mainly due to the smaller number of assessments available for these countries.

In addition to parent education, trends in achievement gaps based on parent occupation and number of household books are also estimated for each available country.[18] In the US, the parent occupation achievement gap has declined slightly, and the household books achievement gap has increased. In Korea, the gap based on parent occupation has increased, while the gap based on books has declined; in Malaysia, the books gap has declined, and there are not enough years of data to reliably estimate the trend in the parent occupation gap. Many other countries experience different achievement gap trends depending on the SES variable used, which implies that certain aspects of SES gain and lose salience in predicting achievement in a given country over time (as with the increasing salience of income relative to parent education in the US found by Reardon (2011)), but likely also in part reflects differences in which studies are included and the large amount of uncertainty associated with each individual country trend estimate. However, summarizing across the full international sample, results for parent occupation and books are

[16] There is likewise no association using GDP per capita from 1990 or 2000.
[17] The one exception is that Latin American countries have experienced smaller increases—or even declines—in gaps. See Appendix I for full model results.
[18] Figures similar to Figure 2 showing cross-national variation in gap trends for parent occupation and household books are displayed in Appendix J.

very consistent with those for parent education, both in terms of large cross-national variation in the size and direction of changes in gaps and the finding that most countries experience increasing gaps, as well as no consistent relationship between changes in gaps and countries' level of development or world region.

In order to more precisely estimate the average global gap trend, as well as to attempt to explain the large cross-national variation in gap trends, we turn to the hierarchical growth models. Table 1 presents coefficients from models predicting achievement gaps based on each of the three SES variables (parent education, parent occupation, and household books). For each variable, Model 1 estimates the global average gap trend by predicting gaps based on cohort birth year with only basic controls (age at testing and subject). Although there are significant differences in the size of gaps estimated from different age and subject assessments, additional analyses show that results for trends are very similar when different ages and subjects are analyzed separately.[19] Thus, the main models pool all available data.

(Table 1 about here)

The coefficient for cohort birth year measures the average annual global change in achievement gaps based on each of the three SES variables. The cohort coefficients are positive and significant in Model 1 for all three variables, indicating that on average across all sample countries, all three types of SES achievement gaps have increased. Each year, 90/10 parent education gaps increase 0.007 SD of achievement, 90/10 parent occupation gaps increase 0.004 SD, and 90/10 books gaps increase 0.009 SD. Although these annual increases are small, they correspond to quite large total gap increases across the full time span of the data: about 0.4 SD of achievement for gaps based on parent education and books, and about 0.2 SD of achievement for

[19] See Appendix K for results of separate models by age and subject.

gaps based on parent occupation. Figure 3 plots the estimated global increases in gaps for each SES variable based on Model 1. On average globally, the achievement gap between students at the 90th and 10th percentiles of parent education was 0.8 SD in the 1950 birth cohort and 1.2 in the 2005 birth cohort; the parent occupation achievement gap was 0.8 SD in the 1950 cohort and 1.0 SD in the 2005 cohort; and the books achievement gap was 1.0 SD in the 1956 cohort (the first year in which the variable was collected) and nearly 1.5 SD in the 2005 cohort.

(Figure 3 about here)

The models in Table 1 help to describe not only the average global increase in SES achievement gaps but also the cross-national variability in the size and direction of gap trends seen in Figure 2. First, the residual variance of the cohort slopes reported at the bottom of the table quantifies this cross-national variability. Chi-squared tests show that the variances of the cohort slopes are significant for all three SES variables ($p < .001$). Next, Model 2 attempts to explain this cross-national variability by adding time-varying country covariates (displayed in the upper "Within countries" portion of the table). Additionally, it compares these over-time results to traditional cross-sectional associations by reporting the associations between country mean covariates and the size of gaps in the 1989 birth cohort, which was tested in the early 2000s and is set as the intercept of the model (displayed in the lower "Between countries" portion of the table). In the "Within countries" results, the first two time-varying covariates pertain to the increasing diversity of the population of students included in international assessments. The coefficients for the proportion of the relevant age cohort enrolled in school are positive, as expected, indicating that countries with increasing school access tend to experience increasing SES achievement gaps. This is not surprising, as increasing school access corresponds to increasing population coverage of international assessments, which sample only those students enrolled in school. When the enrollment share increases by 10 percentage points, the parent education and occupation gaps are expected to increase by 0.01 SD, and the books gap to increase by 0.06 SD, though only the increase in the books gap is significant ($p < .001$). Contrary to expectation, an increasing share of immigrant students is associated with *declining* achievement gaps for two out of three SES variables, though this negative relationship is significant only when predicting parent occupation gaps. The cross-sectional “Between countries” results do not show very strong or consistent relationships for either variable when predicting the size of achievement gaps at the midpoint of the time period rather than change over time.

The next two covariates pertain to economic changes. Based on previous research (Baker, Goesling and LeTendre 2002), we might have expected countries with increasing GDPs per capita to experience increasing SES achievement gaps. Indeed, the cross-sectional “Between countries” results show that countries with higher average GDPs per capita do have larger achievement gaps at the midpoint of the time period. However, within countries, the relationship between *changes* in GDP per capita and changes in achievement gaps is negative for two out of three SES variables and never significant. Next, countries with increasing income inequality are expected to experience increasing SES achievement gaps. However, this expected relationship is relatively weak in the within-country, over-time results: it is positive for only two out of three SES variables and never significant. Cross-sectionally between countries, the positive relationship is stronger than between countries. However, it should be kept in mind that income inequality measures are not fully comparable between countries, as they are derived from two different sources. It should also be noted that, although intuitive, these results are not consistent with prior cross-sectional research, which has found no strong relationship between country income inequality and SES achievement gaps (Dupriez and Dumay 2006; Duru-Bellat and Suchaut 2005; Marks 2005). This discrepancy demonstrates the importance of examining changes over time rather than cross-sectional relationships, as previous research has done.

The next two variables pertain to changes in educational institutions. A very consistent finding in past international research is that countries where tracking begins at a younger age tend to have larger SES achievement gaps (Van de Werfhorst and Mijs 2010), though the evidence on how within-country de-tracking reforms are associated with changes in SES achievement gaps is mixed (Brunello and Checchi 2007; Van de Werfhorst 2013). Consistent with prior cross-sectional research, this study finds that between countries, a later age when tracking begins is strongly and significantly associated with smaller achievement gaps at the midpoint of the time period. Within countries over time, increasing the age when tracking begins is associated with declining SES achievement gaps, though this association is less consistently significant than the cross-sectional association. When the age of track selection increases by one year, the parent education gap is expected to decline by 0.05 SD ($p < .01$), the parent occupation gap to decline by a non-significant 0.01 SD, and the books gap to decline by a marginally-significant 0.06 SD ($p < .1$). An increasing share of students enrolled in private schools is expected to be associated with increasing SES achievement gaps. However, the within-country over-time coefficients for private school enrollment are unexpectedly *negative*, though relatively small and not significant. Cross-sectionally between countries, the association between countries' private school enrollment and achievement gaps at the midpoint of the time period is positive, as expected.

The last two variables pertain to changing families and intensified pressures around children's cognitive skills development. As expected, within countries, a declining fertility rate is associated with a growing SES achievement gap. When the fertility rate decreases by one child per woman, the parent education gap is expected to increase by 0.1 SD ($p < .001$), the parent occupation gap by 0.1 SD ($p < .05$), and the books gap by a non-significant 0.04 SD. Cross-sectionally between countries, the relationship between fertility rates and SES achievement gaps is also negative, though not significant. Finally, increasing demand for higher education—measured as an increasing share of students expecting to attend higher education relative to the actual enrollment level in higher education—is expected to be associated with increasing SES achievement gaps. Within countries over time, this association is in the expected positive direction but is not significant. But cross-sectionally between countries, the association is *negative* and not significant.

After controlling for these eight time-varying country covariates, a reduction in the size of the cohort birth year coefficients suggests that the covariates have helped to explain the large average global increases in SES achievement gaps. In Model 2, the cohort birth year coefficients predicting parent education, parent occupation, and books achievement gaps are reduced by about 30%, 5%, and 90%, respectively. All three coefficients lose significance due to these reductions and/or increases in their associated standard errors. We can also examine how successfully the model has explained variance in the size of SES achievement gaps over time and cross-nationally by looking at the change in residual variances at the bottom of the table. Relative to Model 1, Model 2 explains an additional 6%, 10%, and 5% of the within-country year-to-year variance in gaps based on parent education, occupation, and books, respectively. It explains an additional 50% of cross-national variance in cohort slopes based on parent education, but no additional variance in cohort slopes based on parent occupation or books. Cross-sectionally, it explains an additional 31%, 38%, and 65% of the country-level variance in gaps at the midpoint of the time period. However, with country-level sample sizes of only 63-70, this portion of the model may be overfit.

Thus, the covariates included in Model 2 cannot fully account for the large observed global increase in SES achievement gaps, nor the substantial cross-national variation in gap trends. However, they do suggest some educational and social trends that may be responsible for this increasing inequality. The strongest predictor of increasing parent education and occupation gaps is a declining fertility rate, and the strongest predictor of increasing books gaps is an increasing school enrollment rate.

A number of robustness checks were performed on these results, which are reported in the online appendices. The results of these analyses show that global increases in SES gaps do not appear to be an artifact of increasing levels or narrowing variability of achievement or of SES, nor an artifact of declining measurement error in achievement or in SES.[20]

Discussion

This study has found strong and robust evidence of increasing SES achievement gaps worldwide over the past 50 years. Gaps are consistently increasing for a variety of different model specifications and for three different measures of SES. Gaps based on parent education have increased by about 47%, gaps based on parent occupation by about 28%, and gaps based on

[20] Robustness checks pertaining to changing distributions of achievement and SES are available in Appendices C and E, and those pertaining to changing measurement error are available in Appendices D and H. Additional supplementary analyses show that gap increases are positive when analyzing the different trend studies separately (PISA reading, TIMSS 8th grade science, PIRLS, etc.), although the increases do not reach significance in every case (see Appendix B). Further examination of the trend studies shows that increasing gaps in these studies correspond to large increases in the achievement of high-SES students, coupled with stagnation or declines in the achievement of low-SES students (Appendix C). Gaps increase more between high- and middle-SES students than between middle- and low-SES students (Appendix E). Gaps increase more among secondary than primary school students; and they increase more for math and science than for reading (Appendix K). Increases in SES achievement gaps appear to be approximately linear over the entire time period—a squared cohort birth year term was not significant—and robust to a variety of different specifications of the hierarchical growth model (Appendix L).

household books by about 52%. Trends are estimated separately for each SES variable in an effort to maximize sample coverage.[21] Results for all three variables are broadly consistent, but differences across variables in the size of increase may warrant substantive interpretation. For example, one might expect that household books would grow less salient as a predictor of achievement over time due to the rising popularity of digital reading devices. This does not appear to be an issue in the present study, as, on average across countries, the gap based on books has increased at a *faster* rate than those based on parent education and occupation. Supplementary analyses show that the annual increase in the books gap has not slowed in the most recent years of the data.[22] It may be that the impact of e-readers may simply be not yet fully evident in these data, which end in 2015. However, it may also be that the cultural capital aspect of SES captured by household books is growing in salience relative to the more economic and status-based aspects of SES captured by parent education and occupation.

The findings of large global increases in SES achievement gaps corroborate Baker et al.'s (2002) claim that the importance of family background to educational achievement is growing worldwide relative to the importance of school effects. They also support Baker et al.'s (2002) argument that growing SES achievement gaps are driven in part by expanding access and an increasingly diverse population of students included in schools and in international assessments. An increasing share of youth enrolled in school is a consistently positive predictor of increasing SES achievement gaps in the hierarchical growth models in this paper. At the same time that school systems around the world are expanding access, they are also loosening rigid curriculum differentiation, a trend that this paper finds is associated with declining SES achievement gaps.

[21] See Appendix G for models including all three SES variables.
[22] See Appendix L for estimates of nonlinearities in gap trends.

This result is consistent with findings by van de Werfhorst (2013) for childhood data from the 1960s-1980s but contradicts Brunello and Checchi's (2007) findings using adult data.

Thus, SES achievement gaps are increasing globally, even as formal educational institutions grow more equitable. This suggests that out-of-school environments may be to blame, an argument that Downey and Condron (2016) have recently made in the US context. This paper explored several possible non-school explanations for growing SES achievement gaps, including rising income inequality, declining fertility rates, and changing middle- and high-SES parenting practices in response to increasing pressures of higher education admissions (Alon 2009; Liu 2016; Ramey and Ramey 2010; Schaub 2010). The strongest support was found for the relationship between declining fertility rates and rising SES achievement gaps, suggesting that high-SES parents may choose smaller family sizes in order to focus greater attention on their children's cognitive development. After controlling for fertility rates, rising income inequality and rising demand for higher education were weakly positively associated with growing SES achievement gaps, as expected.

Growing SES achievement gaps raise serious concerns about equality of opportunity in many countries, as educational achievement (not on these particular tests—which are low-stakes—but on other national exams and in school grades) is an important predictor of higher educational attainment and life chances in adulthood. With broadening access to higher education, there is some evidence that the share of attainment inequality explained by achievement is declining in the US and UK (Bailey and Dynarski 2011; Belley and Lochner 2007; Galindo-Rueda and Vignoles 2005). However, in the US, the story changes when looking at *selective* university admissions, where the role of test scores appears to be increasing, meaning that SES gaps in enrollment are increasingly explained by SES achievement gaps (Alon and

Tienda 2007; Bastedo and Jaquette 2011). International evidence also shows that SES achievement gaps explain a great deal of high-SES students' advantage in enrolling in high-status institutions in two other countries with highly stratified university systems, the UK and Australia (Jerrim, Chmielewski and Parker 2015). Unequal access to selective higher education may be a mechanism by which SES achievement gaps drive income inequality. A recent international study shows that a society's variability in childhood test scores predicts its level of income inequality decades later (Checchi and van de Werfhorst 2014).

That the global increase in SES achievement gaps appears more driven by out-of-school than by school factors suggests the importance of focusing policy efforts not only on continued expansion of educational access but also on broader social reforms. Efforts to curb income inequality and neighborhood segregation, as well as to provide supplemental educational services, such as preschool and summer programs, may prove more effective than an exclusive focus on the regular K-12 school day.

In addition to policy implications, this study has important methodological implications. It implies that any future cross-cohort studies should take into account increasing SES achievement gaps, even when SES is merely a control variable, because SES is expected to explain larger amounts of variance in achievement over time in most countries around the world. It also demonstrates the power of examining data from a wide variety of countries, years, and sources. Unlike most prior cross-national evidence on the causes of SES achievement gaps, this study was not cross-sectional but instead examined changes over time within a large number of countries. Results from the multivariate models demonstrated that several key predictors had over-time relationships with SES achievement gaps that were different in size or direction from cross-sectional relationships. In addition, results for trends across multiple waves of a single international assessment, such as PISA, are sometimes contradicted by results from other assessments, such as TIMSS or PIRLS. For example, the OECD (2016) finds declining SES achievement gaps across the last four waves of PISA, but this study finds increasing gaps when pooling these PISA datasets together with 26 other assessments.[23] These differences are due not only to the broader set of countries included when incorporating all international assessments, but also to occasional differences in findings even for the same country. These discrepancies are likely due to differences in the testing frameworks and SES measures of different international assessments, although this paper has made a variety of efforts to harmonize measures where possible. Nevertheless, the precise trends in the SES achievement gap for each individual country remains more uncertain than the overall average global trend.

Despite this uncertainty, the overall global increase in SES achievement gaps is alarming. However, there may be some cause for optimism. Recent data show evidence of declining SES achievement gaps in some countries where they were previously increasing, including the US and Malaysia (OECD 2016; Reardon and Portilla 2016). The large international dataset compiled for this study will be an important source of future evidence on a possible reversal of the global increase in SES achievement gaps and educational and social policies that may help to mitigate disparities in learning opportunities for high- and low-SES children.

[23] Trends are also positive when limiting only to recent years (see Appendix B).

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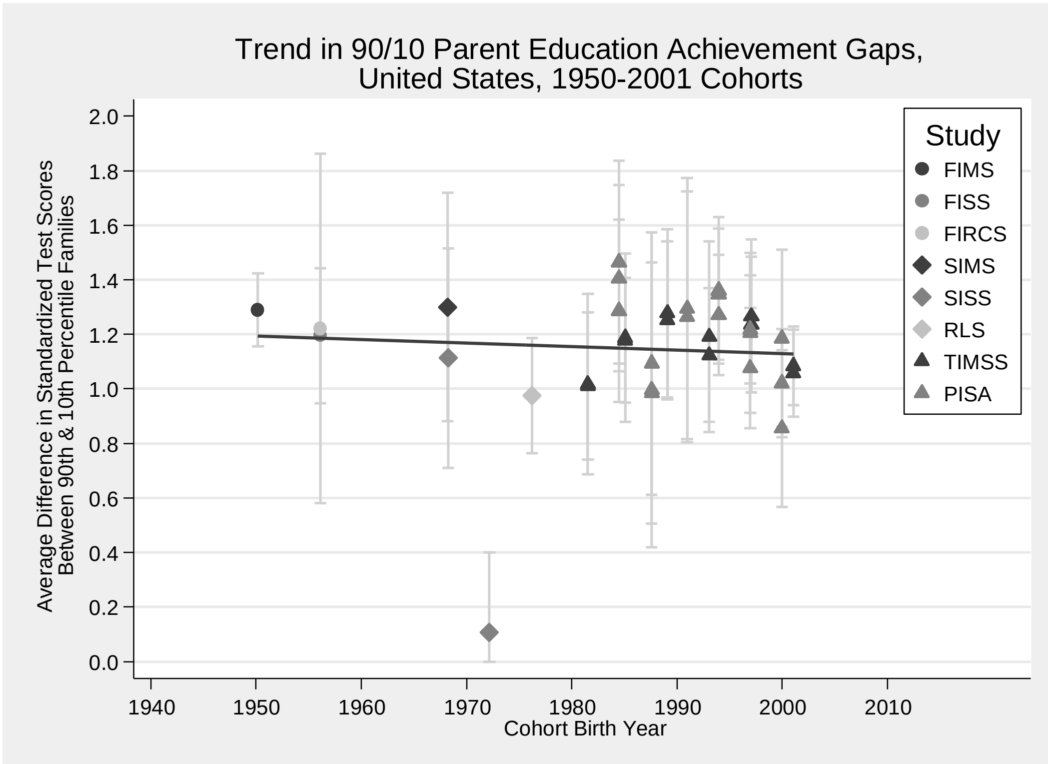
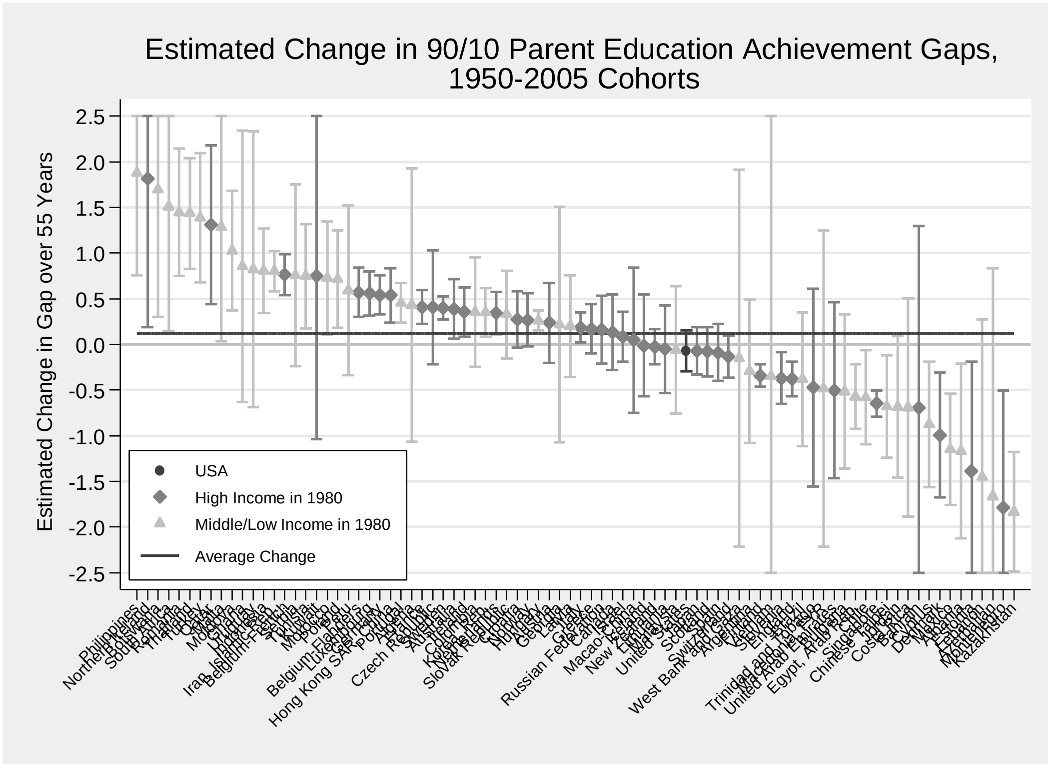
Figure 1



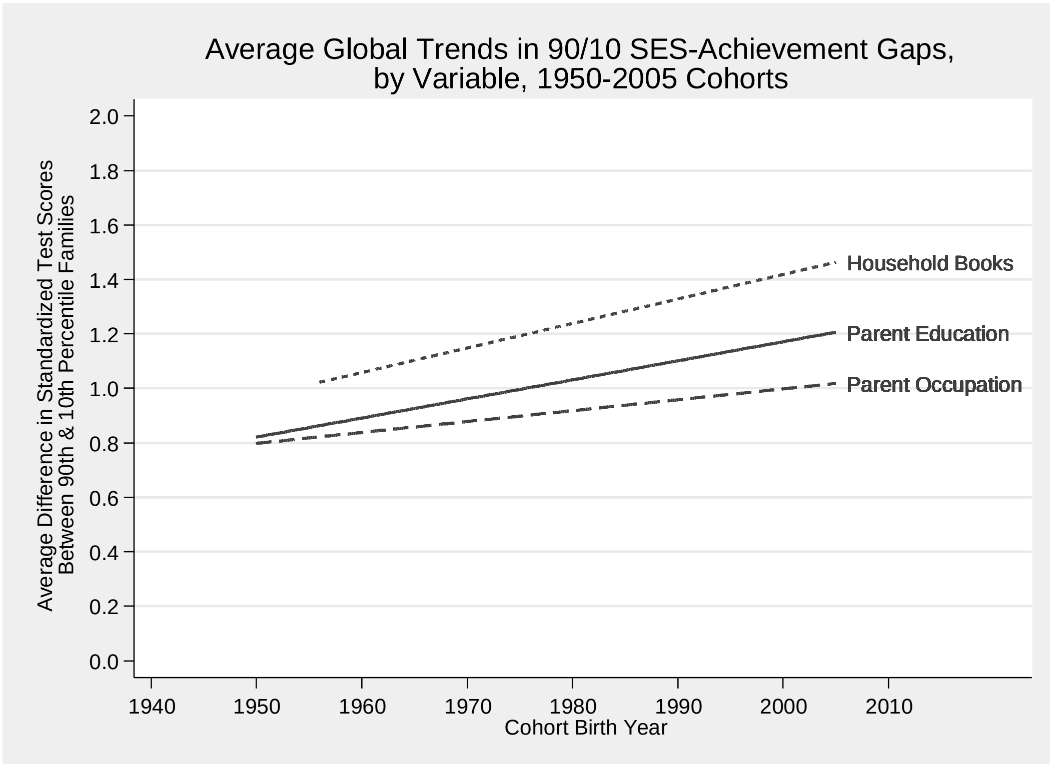
Notes: Gaps and fit line adjusted for age of testing and subject. Gray brackets are 95% confidence intervals.

Figure 2



Notes: “High income” countries had GDPs per capita of at least $6000 in 1980. Gray brackets are 95% confidence intervals. Trends adjusted for age of testing and subject.

Figure 3



Note: Estimated trends from Model 1 (see Table 1).

Table 1. Unstandardized Coefficients from Hierarchical Growth Models Predicting Achievement Gaps between 90th and 10th Percentiles of Three SES Variables from Country Covariates

	Education		Occupation		Books	
	(1)	(2)	(1)	(2)	(1)	(2)
Within countries						
Age 10 at testing	-0.038	-0.061 +	0.005	-0.003	-0.230 ***	-0.278 ***
	(0.038)	(0.036)	(0.019)	(0.027)	(0.032)	(0.038)
Age 15 at testing	-0.175 ***	-0.179 ***			0.102 ***	0.086 **
	(0.026)	(0.026)			(0.028)	(0.026)
Math	0.026 *	0.033 **	0.012	0.015 +	-0.026 +	-0.027 +
	(0.012)	(0.011)	(0.008)	(0.008)	(0.014)	(0.014)
Science	0.016	0.022 *	0.008	0.010 +	0.033 *	0.032 *
	(0.010)	(0.010)	(0.006)	(0.006)	(0.014)	(0.014)
Cohort birth year	0.007 ***	0.005	0.004 **	0.004	0.009 ***	0.001
	(0.001)	(0.005)	(0.001)	(0.004)	(0.002)	(0.004)
School enrollment (proportion)		0.143		0.079		0.567 ***
		(0.221)		(0.208)		(0.170)
Immigrant background (proportion)		-0.204		-0.511 *		0.087
		(0.339)		(0.250)		(0.351)
GDP per capita (logged)		-0.103		-0.075		0.125
		(0.108)		(0.089)		(0.082)
Income inequality (Gini)		1.075		-0.423		0.752
		(0.760)		(0.943)		(0.890)
Age when tracking begins		-0.046 **		-0.013		-0.056 +
		(0.015)		(0.016)		(0.030)
Private school enrollment (proportion)		-0.184		-0.054		-0.013
		(0.141)		(0.106)		(0.193)
Fertility rate (births per woman)		-0.142 ***		-0.106 *		-0.036
		(0.038)		(0.041)		(0.034)
Higher education demand (expectations – enrollment)		0.053		0.059		0.030
		(0.087)		(0.070)		(0.102)
Between countries						
Intercept	1.098 ***	0.704	0.956 ***	1.304 **	1.313 ***	0.007
	(0.034)	(0.546)	(0.026)	(0.499)	(0.043)	(0.533)
Mean school enrollment		0.195		-0.409		0.602 *
		(0.241)		(0.316)		(0.289)
Mean proportion immigrant background		-0.267		0.367		-0.081
		(0.370)		(0.339)		(0.358)
Mean GDP per capita (logged)		0.084		0.044		0.174 ***
		(0.053)		(0.042)		(0.043)
Mean income inequality		0.833 *		1.006 **		0.488
		(0.325)		(0.386)		(0.360)
Mean age when tracking begins		-0.054 ***		-0.040 **		-0.057 ***
		(0.012)		(0.014)		(0.013)
Mean private school enrollment		0.057		0.244 *		0.065
		(0.129)		(0.118)		(0.169)
Mean fertility rate		-0.022		-0.087		-0.047
		(0.047)		(0.057)		(0.049)
Mean higher education demand		-0.031		-0.256		-0.118
		(0.206)		(0.164)		(0.139)
Residual variance (within countries)	0.01269	0.01188	0.00593	0.00533	0.01805	0.01721
Residual variance (country intercepts)	0.04555	0.03154	0.03862	0.02387	0.08986	0.03139
Residual variance (cohort slopes)	0.00008	0.00004	0.00009	0.00010	0.00011	0.00012
N (observations)	1510	1510	1146	1146	1738	1738
N (countries)	68	68	63	63	70	70

+ p<.1, * p<.05, ** p<.01, *** p < .001. Two-tailed tests.

Note: In models predicting achievement gaps based on parent occupation, the dummy variable for age 15 is omitted, as there are very few age 14 assessments that collected parent occupation. Therefore, in the parent occupation models, the reference category is assessments of students who are age 14 *or* 15.