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Family Socioeconomic Status and

Inequality of Opportunity

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ABSTRACT

Research has shown that family socioeconomic status (SES) is related to educational and labor force outcomes over the life course. Thus, children from socioeconomically disadvantaged families are more likely to have low SES as adults. The present dissertation examines three key aspects related to the intergenerational transmission of family SES.

The first is the relationship between family SES and achievement growth in school. Most studies indicate that children from high SES families grow more rapidly in their skills than those from low SES families, thereby favoring a widening gap in academic achievement. Often, these studies suffer from multiple methodological flaws, though. The present analyses with data from Hamburg, Germany (N = 12,959), and Canada (N = 6,290) add to previous research by drawing on a greater source of intra-individual variability (3 and 4 four measurement points, respectively) and by using a variety of regression techniques well suited to the longitudinal data. The results reveal that the gap in academic achievement widens in Canada and narrows in Hamburg. This is explained in terms of the relatively open and egalitarian school policies and practices in Hamburg.

The second key aspect is the role of achievement growth in teacher's school track recommendations. The literature conclusively shows that recommendations are affected by current academic achievement levels and family SES, but neglects the influence of achievement growth. Drawing on longitudinal data from Berlin, Germany (N = 2,242), consisting of 3 measurement points, reliability-adjusted measures of individual growth and their effect on teacher's recommendations are estimated. The analyses indicate that teachers reward achievement growth in their track recommendations, so that students growing more rapidly in their skills are more likely to obtain a recommendation for the college preparatory

track even taking into account their family SES or initial achievement levels. Also, females, immigrants, and higher SES students are more likely to obtain a college track recommendation other things being equal. And the probability of a college track recommendation decreases in classes with higher achievement levels and smaller proportion of immigrants.

The third aspect is the study of the dominating gateways for family SES influences on academic achievement, course-enrollment decisions in high school, college attendance, and labor force outcomes. The analyses are based on a single cohort followed longitudinally in a U.S. study spanning 17 years (N = 2,264). The results indicate that in the U.S. the achievement gap associated with family SES widens from early to late adolescence due in part to course-enrollment decisions; that college enrollment is largely explained by achievement levels and gains in school but is also directly influenced by family income and father's occupational status; that educational attainment and cognitive skills fully mediate the effects of family SES on earnings and occupational status; and that cognitive skills are valued in the labor market irrespective of educational attainment and family SES.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AP	Advanced Placement
CAT/2	Canadian Achievement Test, Second Edition
CTC	Canadian Test Centre
EB	Empirical Bayes
HLM	Hierarchical Linear Models
IRT	Item Response Theory
ISEI	International Socioeconomic Index of Occupational Status
KFT	*Kognitiver Fähigkeitstest* [Basic Cognitive Skills Test]
LAU	*Aspekte der Lernausgangslage und der Lernentwicklung* [Study of Initial Achievement Levels and Academic Growth in Secondary Schools in the City of Hamburg]
MICE	Multiple Imputation by Chained Equations
MSALT	Michigan Study of Adolescent Life Transitions
NLSCY	National Longitudinal Study of Children and Youth
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PISA	Programme for International Student Assessment
PMK	Person Most Knowledgeable About the Children
SES	Socioeconomic Status

INTRODUCTION

Extensive research has clearly established that there is a positive relationship between family SES and academic achievement in school (Sirin, 2005; White, 1982). Differences in academic achievement related to family SES appear to be the result of genetic influences, environmental influences, and their interplay. The relationship emerges early in life and has consequences for long-term socioeconomic attainment. Already in the preschool years, children growing up in low SES families are more likely to exhibit slower cognitive development than those of high SES families (e.g., Bradley & Corwyn, 2002; Freijo et al., 2006; Hertzman & Wiens, 1996; Hofff, 2003; Yeung, Linver, & Brooks-Gunn, 2002). Furthermore, recent findings indicate that they might not get full brain development from the stressful and relatively impoverished environment associated with low SES (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009).

The problems of low SES children tend to worsen as they get older. Once they enter school they are prone to leave school early, in part due to their poorer academic performance (Alexander, Entwisle, & Kabbani, 2001; Battin-Pearson et al., 2000; Cairns, Cairns, & Neckerman, 1989; Janosz, LeBlanc, Boulerice, & Tremblay, 1997; Rumberger, 2004; Schargel, 2004). Also, they are less likely to enroll in or be assigned to the college preparatory track (Condron, 2007; Davies & Guppy, 2006; Gamoran & Mare, 1989; Krahn & Taylor, 2007; Maaz, Trautwein, Lüdtke, & Baumert, 2008a; Oakes, 1985; Schnabel, Alfeld, Eccles, Köller, & Baumert, 2002). Socioeconomically biased tracking, in turn, often leads to a widening achievement gap among students of high and low SES families as they advance in school (Condron 2007; Kerckhoff, 1993; Oakes, 1985; Pallas, Entwisle, Alexander, & Stiuka, 1994; Gamoran & Mare, 1989; Maaz et al., 2008a; Oakes, 1985). In the longer term, as a cumulative result, children of low SES families are less likely to enter the labor market successfully or pursue post-secondary education (e.g., Alexander, Entwisle, & Olson, 2007; Cabrera & La Nasa, 2001; Kerckhoff, Raudenbush, & Glennie, 2001; Organisation for Economic Co-operation and Development (OECD) & Statistics Canada, 2000; Raudenbush & Kasim, 1998). In other words, children from low SES families are more likely to have low SES as adults.

That educational and labor opportunities are unequally distributed among individuals of varying socioeconomic backgrounds poses concerns and challenges in societies that value equal opportunity irrespective of family SES. Therefore, sociological studies in education have aimed at getting a better grasp of how inequalities are configured in order to identify avenues to improve the opportunities of underprivileged children. This dissertation aims to contribute to this strand of research. It draws on a variety of longitudinal datasets from Canada, Germany, and the United States to examine some of the mechanisms underlying the intergenerational transmission of family SES. More specifically, it examines the influence of family SES on achievement growth; the influence of achievement growth on school track placements; and the long-term influences of family SES on college attendance and labor force outcomes. The methods are innovative and advance prior research.

The remainder of this dissertation is organized as follows. The first section introduces the definition of family SES and the methodological framework for estimating family SES and analyzing its relationship with academic achievement. Particularly, it draws on census data from Hamburg, Germany, to illustrate the operationalization of family SES and to evaluate key hypotheses for policy research regarding the SES-achievement relationship. Importantly, this section is not meant to be seen as an exhaustive investigation of a specific research topic. Rather, it provides a theoretical and methodological ground for subsequent sections. In this regard, subsequent sections generally assume that the reader is familiar with the concept of family SES and with the methodological approach underlying its calculation and the evaluation of family SES effects.

The second section examines the trajectory of the achievement gap related to family SES in Canada for students aged 7 to 15 and in Hamburg, Germany for students aged 10 to 15. It presents theoretical considerations regarding the impact of school and non-school factors on the trajectory of the gap. The methodological approach consists of a variety of regression techniques that account for ceiling effects in test scores, the multilevel nature of the data, and the possibility of students to change schools over time. These techniques soundly distinguish intra-individual, inter-individual, and intra-school variation. The data from Canada and Germany consist of four and three measurement points. Instead, previous studies rely mostly on two data points or cross-sectional data. The use of more data points (i.e., greater source of intra-individual variation) and statistical techniques well suited to the longitudinal data contribute to the methodological advance of measurement of the gap trend. The findings are discussed in light of previous literature and the characteristics of the educational systems under consideration.

The third section examines whether the capacity of students to acquire skills is rewarded for school track placements and, therefore, may help to reduce initial disparities associated with achievement levels and family SES. It explores the role of achievement growth in school track recommendations using longitudinal data from Berlin, Germany consisting of three measurement points. The analysis proceeds in two stages. First, predictors of achievement growth are evaluated and reliability-adjusted measures of individual growth are estimated. Secondly, the influence of individual growth on the probability of obtaining a recommendation to the college preparatory is examined. The analyses also help clarify how school track recommendations are related to family SES, migration background, gender, and group reference characteristics.

The fourth section investigates the influence of family SES on several educational and labor force outcomes using a regional U.S. longitudinal data set spanning 17 years. Particularly, it examines family SES influences on academic achievement, course-enrollment decisions in high school, college enrollment, earnings, and occupational status. The analyses distinguish family SES influences mediated by educational outcomes from those that persist when these are controlled to shed light on the dominating gateways for family SES influences. Additionally, this section examines the influence of educational attainment and skills, separately and in combination, on earnings and occupational status. Here, the literature is conclusive on the role of educational attainment but equivocal on the role of skills. The analyses close an important gap in the literature by examining the reproduction of family SES from adolescence to adulthood for a single cohort. The findings elicit new insights into the mechanisms whereby family SES is passed from parents to children.

Finally, the last section presents a summary of this dissertation work and the main conclusions.

1. FAMILY SOCIOECONOMIC STATUS AND ACADEMIC ACHIEVEMENT

Although there is no strong consensus on the conceptual meaning of *socioeconomic status* (Bornstein & Bradley, 2003), sociologists typically use this term to refer to the relative position of an individual or family within a hierarchical social structure, based on their access to, or control over wealth, prestige, and power (Mueller & Parcel, 1981). This concept is traditionally operationalized through measures characterizing parental educational levels, parental occupational prestige, and family wealth (Gottfried, 1985; Hauser, 1994; Mueller & Parcel, 1981).

Scholars have widely studied the relationship between family SES and academic achievement in school (Sirin, 2005; White, 1982). This relationship is referred to in the literature as a *socioeconomic gradient* because it is gradual and increases across the range of SES, or as a *socioeconomic gap* because it implies a gap in academic achievement among students of high and low SES families. Research has shown that the socioeconomic gap emerges early in life (Entwisle & Hayduck, 1982; Hertzman, 1994; Hertzman & Weins, 1996; Kagan & Moss, 1962) and has lasting consequences on adult's educational and labor opportunities (e.g., Alexander et al., 2007; Cabrera & La Nasa, 2001; Kerckhoff et al., 2001). As a cumulative result, children from low SES families are more likely to have low SES as adults.

To prevent the reproduction of family SES over the life course, scholars have devoted a great deal of effort into understanding and explaining the processes that configure socioeconomic gradients in the early school years. For example, they have examined the underlying family processes that mediate the relationship between family SES and academic achievement (Chao & Willms, 2002; Guo & Harris, 2000; Hanson, McLanahan, & Thomson, 1997; Lareau, 2002; Willms, 2003; Yeung et al., 2002); the extent to which socioeconomic gaps in academic achievement are consistent across subject areas (Ma, 2000); the school practices that can effectively reduce achievement inequalities across SES groups (Bridge, Judd, & Moock, 1979; Cohen, 1982; Rutter, Maughan, Mortimore, & Ouston, 1979; Rutter & Maughan, 2002; Scheerens, 1992); whether socioeconomic gradients vary between communities and why (OECD, 2003, 2004, 2007; Willms & Somers, 2001); and how economic and political forces act upon the relationship between socioeconomic background and schooling outcomes over time (Heath & Clifford, 1990; Willms & Raudenbush, 1989).

Also, Willms (2002, 2003) and colleagues (Willms & Shields, 1996; Willms & Somers, 2001) have developed a framework for studying socioeconomic gradients which has been applied in several national and international comparative studies with fruitful policy guidelines (e.g., OECD, 2003, 2004, 2007; OECD & Statistics Canada, 1995). The framework provides a readily implemented method to estimate family SES (Willms & Shields, 1996) and to examine socioeconomic gradients (Willms, 2002, 2003). Three aspects contain critical information of socioeconomic gradients: the degree of inequalities in academic achievement attributable to family SES (the slope); the extent to which variation in academic achievement is explained by family SES (the R-squared); and the functional form of socioeconomic gradients (i.e., linear or curvilinear). Furthermore, other tests of socioeconomic gradients serve to gain insights into how socioeconomic gradients are configured and can be altered (Willms, 2002).

1.1 Practical Application of the Socioeconomic Gradients Framework: An Example

Drawing on the work of Willms (2002, 2003), this subsection presents an applied example of the socioeconomic gradients framework. As mentioned earlier, it is not meant to be seen as an exhaustive investigation of a specific research topic. Rather, it provides a theoretical and methodological ground for subsequent sections by defining family SES and illustrating its estimation and the evaluation of key hypotheses for policy research regarding socioeconomic gradients. The data, SES estimation methodology, and hypothesis tests for this example are presented next.

1.1.1 Data

The data stem from the *Study of Initial Achievement Levels and Academic Growth in Secondary Schools in the City of Hamburg* (LAU, hereafter, for its abbreviation in German). LAU collected information on the learning progress and experiences throughout secondary school of the student population in Hamburg. It started in September 1996 with all students then enrolled in Grade 5 (LAU 5), continued in September 1998 with students in Grade 7 (LAU 7), September 2000 with students in Grade 9 (LAU 9), September 2002 with students in Grade 11 (LAU 11), and concluded in April 2005 with students in Grade 13 (LAU 13). [1] LAU gathered socioeconomic information of students and their families in Grades 5, 9, 11, and 13. Socioeconomic data of LAU 5 are not publicly available and key socioeconomic variables are neglected in LAU 11 and 13. Therefore, the present analysis used data from LAU 9 only.

[1] There is also a continuation of the longitudinal design into the vocational upper secondary schools. The LAU 5, 7, 9, 11, and 13 reports can be consulted in Lehmann and Peek (1997), Lehmann, Gänsfuß, and Peek (1998), Lehmann, Peek, Gänsfuß, and Husfeldt (2002), Lehmann, Hunger, Ivanov, Gänsfuß, and Hoffmann (2004), and Lehmann, Vieluf, Nikolova, and Ivanov (2006), respectively.

Academic achievement data are based on students' scores in the math and reading tests part of the test batteries SL-HAM 8/9 in LAU 9 (Behörde für Schule, Jugend und Berufsbildung, Amt für Schule, 2000). The math test included 64 multiple choice format tasks. It covered the areas of arithmetic, geometry, algebra, and stochastic problems. The reading test included 72 multiple choice format tasks. It evaluated the ability to extract and locate relevant information and to make direct inferences from a text. Item response theory (IRT) was carried out to scale the math and reading items. Item difficulty for each item was estimated through a one-parameter Rasch model (Masters & Wright, 1997; Rasch, 1960). Drawing on these estimates, the final math and reading achievement IRT scores were obtained using weighted likelihood estimation. Scores are measured in a continuous scale and were standardized to have a mean of 100 and a standard deviation of 20 in Grade 5. Both the math and reading achievement scores are reliable (a=0.85 and 0.89, respectively).

1.1.2 The Estimation of Family SES

The operationalization of family SES emulated the traditional approach of including measures of parental occupational status, parental education, and parental economic positions. It was, however, restricted by data availability considerations and framed by the peculiarities of the German educational system. Particularly, family SES lacked parental occupational status because the data were not collected in LAU and distinguished parental schooling from parental vocational training to adapt to the nature of the German educational system.[2] As a result, the family SES measure is a composite of parental schooling, parental vocational training, and family wealth.

[2] In the German education system, education is separated into compulsory education, post-compulsory academic education, and vocational training. Compulsory education lasts between nine and ten years, depending on the school track the student follows. Post-compulsory academic schooling refers to the pre-

Two major methods were involved in the calculation of family SES: IRT and Principal Component Analysis (PCA). First, a family wealth index was estimated through a one-parameter Rasch model. Secondly, the family wealth index was summarized together with the parental schooling and vocational training variables into a single SES index using PCA. The SES inputs and final index are presented separately, next.

Parental schooling. Parents reported their highest level of schooling completed. Responses were ordinally coded into a father's and mother's schooling variable, ranging from 1 to 5[3]: (1) no school leaving certificate, (2) secondary lowest track, (3) secondary intermediate track, (4) admission level for advanced technical college, and (5) admission level for university.

Parental vocational training. Parents reported their highest level of vocational training completed. Responses were ordinally coded into a mother's and father's vocational training variable, ranging from 1 to 6: (1) no training certificate, (2) apprenticeship certificate, (3) full time vocational or commercial school certificate, (4) technical college, master craftsman, or technical school certificate, (5) technical degree or diploma, and (6) university degree.

Family wealth. A family wealth index was estimated from responses of students on the availability of the following items at home: a room, a desk, books, a computer, a dictionary, a CD-player, a cassette recorder, a TV, and a DVD. IRT was carried out on these data. Item parameters were estimated with a one-parameter Rasch model. Item parameter estimates, standard errors, fit statistics, and characteristics curves indicated in unreported analyses that the items fitted the one-parameter model well. Weighted likelihood estimation was

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university stage of Gymnasium (Grades 11-13) and some equivalent forms of schooling. Vocational training includes technical degrees, apprenticeships, and university degrees.

[3] Comparability problems related to the German reunification in 1990 are taken into account by reclassifying the East German Polytechnic High School up to Grade 8 as Secondary Lowest Track and the Polytechnic High School up to Grade 10 as Secondary Intermediate Track. The Extended Polytechnic High School up to the successful completion of grade 12 was considered equivalent to the West German *Abitur* (i.e., admission level for university).

performed to obtain individual family wealth scores. Scores are measured in a continuous scale and were standardized to have a mean of zero and a standard deviation of one for the student population in LAU 9.

Family SES. A single SES measure is obtained from the five SES inputs introduced above: father's schooling, mother's schooling, father's vocational training, mother's vocational training, and the family wealth index. These variables are summarized into a single variable using PCA. The analysis produced a one-component solution with the first component accounting for about 60% of the total variability of the five SES inputs. Family SES scores are derived from this component. High SES scores indicate higher SES families and low SES values, lower SES families. The family SES index was standardized to have a mean of zero and a standard deviation of one. The quality of the SES index was not exhaustively evaluated. Nevertheless, unreported PCA within school tracks offer a rough indication of validity. They consistently indicate that factor loadings of parental schooling and vocational training remain relatively invariant across school tracks, ranging from 0.47 to 0.51. In contrast, the factor loading of family wealth varies across school tracks, from 0.12 in the lowest track to 0.03 in the academic track. While it is possible that the weight of family wealth is greater in lower tracks, another plausible explanation lies in the way information was reported. Parental schooling and vocational training were reported by parents and family wealth information by students. Students may lack a precise knowledge of their home possessions, or may tend to give socially desirable responses (Schulz, 2005). As a result, their responses potentially undermine the quality of the family wealth index.

1.1.3 Socioeconomic Gradients: Hypothesis Testing

In a previous study, Willms (2003) tested ten hypotheses relevant to policy research regarding the relationship between family SES and vocabulary skills. This section draws on this exercise and adapts it to the German case to test five hypotheses on the relationship between family SES and the math and reading academic achievement of nine graders in Hamburg schools. The hypotheses are that (1) there is a gradient relationship between SES and academic achievement; (2) that family SES influences on academic achievement are weaker at higher levels of SES; (3) that the school's socioeconomic composition has an effect on academic achievement over and above the effects associated with the student's SES; (4) that the impact of family SES on academic achievement varies among schools tracks; and (5) that academic achievement gaps among school tracks are partly, but not entirely, explained by the school SES.

Hypotheses are tested invariantly by means of hierarchical linear models (HLM; Raudenbush & Bryk, 2002) of students (level 1) nested within schools (level 2). The sample underpinning multilevel models consists of 10,235 students in 186 schools. It is restricted to students with a math and reading academic achievement measure in the full sample of nine graders. They represent 81% of the student population and 98% of schools. Descriptive statistics of variables included in regression models are presented in Table A, Appendix A. They are reported for students in the full, analytic, and excluded sample.

Excluded students come from less advantaged backgrounds: their parents attained lower schooling and vocational training levels, and their families are less wealthy. Yet, socioeconomic differences between the analytic sample and full sample are not huge. Furthermore, to the extent that the large majority of the student population in Grade 9 is included in the analytic sample, it is safe to assume that the potential bias due to sample selection in the estimates of the SES effects is rather small. Explanatory variables in the analytic sample had a considerable number of missing values (see Table A, Appendix A). The Hot Deck multiple imputation method was carried out to account for this potential source of bias (Little & Rubin, 1987). Overall, multilevel models included imputed values for the SES index (24%), the family wealth index (15%), father's vocational training (36%), mother's vocational training (27%), father's schooling (36%), and mother's schooling (26%).

1.1.3.1 The Hypothesis of a Socioeconomic Gradient

The first and most basic hypothesis is that a positive and statistically significant relationship exists between family SES and academic achievement. The first level for each student *i* attending school *j* is

$$y_{ij} = \beta_{0j} + \beta_{1j} SES_{ij} + \varepsilon_{ij} \qquad \ldots(1.1)$$

where y_{ij} is the math/reading academic achievement measure, SES_{ij} is the student's SES, and ε_{ij} are the residuals. Parameters β_{0j} and β_{1j} are the level and slope of the gradient for each school, respectively. In a second level, the β_{0j}'s may vary between schools, but β_{1j}'s are fixed:

$$\beta_{0j} = \alpha_{00} + \mu_{0j} \qquad \ldots(1.2)$$

$$\beta_{1j} = \alpha_{10} \qquad \ldots(1.3)$$

In equation (1.2) a_{00} is the grand mean, or the mean of the school means, and μ_{0j} is school level error term, or the deviation from the grand mean. For this hypothesis, SES effects on academic achievement are fixed between schools at a_{10} in equation (1.3). Evidence of a socioeconomic gradient exists if a_{10} is positive and significantly different from zero.

The socioeconomic gradient hypothesis was supported by the data. Particularly, estimates of the math and reading slopes, a_{10}, are 2.43 (s.e.=0.25) and 2.59 (s.e.=0.27) score points, respectively. Given the SES scale (*M*=0, *SD*=1), slopes can be interpreted as academic achievement differences due to an average SES gap of one standard deviation. For this gap size, achievement differences amount to about 16% of a math and reading achievement standard deviation, evidencing that gaps among higher and lower SES students are certainly not negligible.

1.1.3.2 The Hypothesis of Diminishing Returns

This hypothesis states that SES effects increase across the range of SES, but that they increase at a decreasing rate, or show diminishing returns. From this it follows that the educational system introduces a ceiling for high SES students in terms of their academic achievement rewards.

This hypothesis is tested by adding the SES quadratic term into equation (1.1):

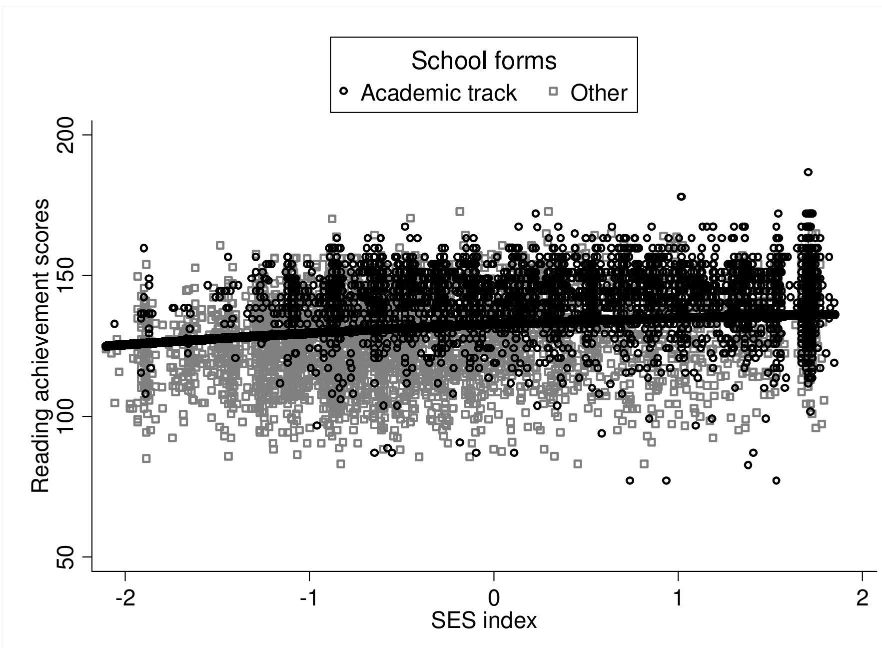
$$y_{ij} = \beta_{0j} + \beta_{1j}SES_{ij} + \beta_{2j}SES^2{}_{ij} + \varepsilon_{ij} \qquad \ldots(1.4)$$

where β_{0j} and β_{1j} are equal to equations (1.2) and (1.3), respectively, and β_{2j} is fixed between schools at the average effect of a_{20}. If a_{20} is statistically significant and negative, family SES effects decrease across the range of SES, supporting the diminishing returns hypothesis. If a_{20} is statistically significant and negative, family SES effects increase for students with higher SES levels.

The dark line in Figure 1.1 depicts the reading achievement socioeconomic gradient estimated from equation (1.4). The shape of the math achievement gradient is roughly similar and so it is not presented here. The horizontal axis shows the SES index and the vertical axis reading achievement scores. Each dot represents a student, his/her academic achievement, and SES score. Students attending the academic track are distinguished from those in the other school forms (i.e., comprehensive schools, the intermediate track, and the lowest track).

The gradient is slightly curvilinear and shows small but statistically significant diminishing returns across the range of SES. The coefficient of the SES-squared term, a_{20}, is statistically significant and negative for math and reading achievement (-0.38 and -0.46 score points, respectively). Thus, the impact of SES on academic achievement increases at a decreasing rate. Or, the SES achievement gap narrows at higher SES levels.

Figure 1.1. Socioeconomic Gradient for Reading Achievement



As discussed before, achievement inequalities due to family SES are not negligible (see Figure 1.1). Yet, about 15% and 11% of the math and reading achievement differences among students are explained by their SES only. In other words, the relationship between SES and academic achievement is not deterministic and many students from disadvantaged backgrounds can attain good academic qualifications. This suggests that there should be other family, school, and community factors determining schooling outcomes.

Of important note is the considerable number of students in the academic track from lower SES families (see Figure 1.1). They outperform students with similar SES levels in the other school forms. The reasons behind this gap are not addressed here but are certainly relevant to policy research in education. One may speculate, for example, that the quality of educational processes in the academic track contributes to improve the performance of low SES students. More generally, the literature has identified several institutional aspects that may lead to a gap among tracks when SES is controlled (e.g., Baumert, Trautwein, & Artelt, 2003; Baumert, Stanat, & Watermann, 2006).

1.1.3.3 The Hypothesis of Double Jeopardy

The hypothesis holds that the school's socioeconomic composition has an effect on academic achievement above and beyond the effect of student's SES. That is, not only the student's SES affects his/her academic achievement, but there is an additional *contextual effect* associated with the socioeconomic characteristics of the school's student intake. A fair amount of research supports this hypothesis in educational systems where segregation of students between schools or classes is based on their family SES, like in the German case. In such systems, low SES students are in *double jeopardy*. Not only they are in disadvantaged because of their relatively poor resources at home, but when they are also segregated into low SES schools they are likely to perform even worse.

This hypothesis is tested simply by adding the school mean SES into equation (1.2):

$$\beta_{0j} = \alpha_{00} + \alpha_{01}\overline{SES}_{\bullet j} + \mu_{0j} \qquad \ldots(1.5)$$

where $\overline{SES}_{\bullet j}$ is the school mean SES and parameter a_{01} determines school SES effects on the gradient's level adjusted for the student's SES. The hypothesis is supported if a_{01} is positive and statistically significant. Since socioeconomic gradients are curvilinear, level 1 equation is (1.4) with linear and curvilinear SES effects fixed.

Results are in accordance with this hypothesis: the school SES has an impact on academic achievement beyond and above that of the student's SES. Lower SES students are in double jeopardy. In particular, school achievement differences due to an average SES school gap of one standard deviation amount to 7.6 and 5.8 score points in math and reading achievement (a_{01} is 13.5 and 10.4 score points, respectively). They represent about 48% and 38% of a standard achievement deviation in math and reading, respectively, and suggest that contextual effects markedly shape the achievement of nine graders in Hamburg.

1.1.3.4 The Hypothesis of Socioeconomic Gradients by School Tracks

This hypothesis states that socioeconomic gradients vary between school tracks. Whether SES effects vary randomly among schools needs to be evaluated prior to its test, as only in this case the hypothesis is feasible. This evaluation is performed by introducing a random term into the linear and curvilinear SES effect between schools:

$$\beta_{1j} = \alpha_{10} + \mu_{1j} \qquad \ldots(1.6)$$

$$\beta_{2j} = \alpha_{20} + \mu_{2j} \qquad \ldots(1.7)$$

where level 1 equation is (1.4), the school's gradient level is defined in equation (1.2), and the significances of σ_{μ_1} and σ_{μ_2} in equations (1.6) and (1.7), respectively, determine whether SES linear and curvilinear effects vary randomly among schools or not.

While SES linear effects varied randomly between schools for math and reading achievement, curvilinear SES effects did not. In other words, SES shows positive and disparate effects among schools. In some schools the importance of SES to academic achievement is weaker and in others stronger. Yet, the way in which these effects decrease across the range of SES is invariant among schools.

Thus, there is reason to explore this hypothesis. It is tested by estimating equation (1.4) with level 2 equations

$$\beta_{0j} = \alpha_{00} + \alpha_{01} academ_j + \mu_{0j} \quad \ldots(1.8)$$

$$\beta_{1j} = \alpha_{10} + \alpha_{20} academ_j + \mu_{1j} \quad \ldots(1.9)$$

$$\beta_{2j} = \alpha_{20} + \alpha_{21} academ_j \quad \ldots(1.10)$$

where $academ_j$ distinguishes students in the academic track from the rest (i.e., comprehensive schools, lowest track, and intermediate track). The estimate of a_{20} in equation (1.9) determines whether the impact of SES on academic achievement varies between the academic track and the other school forms. Particularly, a positive and statistically significant estimate indicates that SES effects are larger in the academic track and vice versa.

There is slight evidence of relatively weaker SES effects for students in the academic track. The estimate of a_{20} is negative for math and reading academic achievement (a_{20} is -1 and -1.2 score points, respectively). Yet, it is statistically significant at 10% and 5%, respectively, indicating moderate support for this hypothesis only.

1.1.3.5 The Hypothesis of School Track Gaps Mediated by the School SES

This hypothesis states that school track gaps are partly, but not entirely, explained by the school SES. It postulates that performance of the various school forms is shaped by the socioeconomic composition of the school's student intake, but that there are other school aspects besides its socioeconomic composition explaining these gaps.

This hypothesis is evaluated by comparing the achievement gap between students in the academic track and the other school forms when controlling and not controlling for the school SES. In particular, equation (1.4) is estimated with linear and curvilinear SES effects fixed, and estimates of

$$\beta_{0j} = \alpha_{00} + \alpha_{01} academ_j + \alpha_{02} \overline{SES}_{\bullet j} + \mu_{0j} \qquad \ldots(1.11)$$

are compared with those of equation (1.8). The hypothesis is supported if a_{01} and a_{02} in equation (1.11) are positive and statistically significant, but a_{01} is smaller than in equation (1.8).

Estimates of a_{01} in equation (1.8) are positive and statistically significant for math and reading achievement (a_{01} is 18 and 14 score points, respectively). As expected, students in the academic track perform better than students in other tracks. The academic achievement gap between academic schools and the other schools is considerable: it is larger than one standard deviation for math and amounts to almost one standard deviation for reading.

Differences among school tracks are partly explained by the socioeconomic composition of the student intake. Particularly, as much as 18% and 21% of the math and reading achievement gap between the academic track and other schools forms is explained by the school SES, respectively. Nevertheless, a substantial gap among school tracks remains unexplained even when the school SES is controlled. The non-SES achievement gap in equation (1.11) amounts to about 94% and 70% of a standard deviation in math and reading achievement, respectively (a_{01} is 14.8 and 10.7 score points). This is consistent with the hypothesis and suggests that other factors besides SES configure differences in achievement among school tracks.

1.2 Discussion

This section has introduced key definitions and methods to be used in subsequent sections. It presented the definition of family SES, its operationalization, and the socioeconomic gradients framework. Furthermore, it gave a practical example of the socioeconomic gradients framework. This example draws on data from Hamburg, Germany to show how family SES is calculated with PCA and how critical hypotheses regarding socioeconomic gradients can be tested with HLM. Both PCA and HLM are applied in the next sections to estimate family SES and to test critical hypotheses regarding the effects of family SES on educational and labor force outcomes. In this regard, the concepts and applied examples presented here provide a ground for the analyses of subsequent sections.

A graded relationship between family SES and math and reading academic achievement for nine graders in Hamburg schools was found. Higher SES students perform better than lower SES students. Yet, the gap between these groups of students narrows at higher SES levels, or SES effects show diminishing returns across the range of SES. Apparently, Hamburg's educational system is configured in such a manner so that achievement rewards of students from more advantaged socioeconomic background decrease gradually.

As in most systems where selection of students into schools is socioeconomically biased, students in Hamburg are in *double jeopardy*. That is, not only lower SES students perform worse than higher SES students, but when located in lower SES schools, they are at an even greater disadvantage. Of important notice is that a considerable proportion of lower SES students in Hamburg schools attend the academic track. Inasmuch as these students outperform their peers in other school forms, they seem to benefit from better educational opportunities.

Indeed, school processes taking place in the academic track apparently account for part of the performance gap among students in the academic track and the other school forms. Or, at least, there is evidence that this gap is not entirely explained by the socioeconomic composition of the school's student intake. In fact, a large proportion of it remains unexplained even when the school SES is controlled. Other aspects thus should shape the performance gap among school tracks and may contribute to the better performance of lower SES students in the academic track compared to their peers in the other school forms. Some of these aspects have been investigated in the literature, but they certainly deserve the attention of further research.

2. FAMILY SOCIOECONOMIC STATUS AND ACHIEVEMENT GROWTH

This section comprehensively examines another critical aspect of the socioeconomic gap: whether it changes with increasing age during schooling and, if so, how it changes. If family SES contributes to higher achievement growth rates, the gap will tend to widen; if it contributes to lower growth rates, the gap will tend to narrow; and, if it is unrelated to achievement growth, the gap will tend to stabilize. Examining the trajectory of the gap is important to policy research because it can offer insights into how and when inequalities reproduce and can be altered over the course of schooling. To date, most studies lend support for a positive relationship between family SES and achievement growth and thus suggest a widening gap. Nonetheless, evidence is inconclusive, typically hinging on limited methodological designs, and has been interpreted differently.

The present section adds to the literature by examining the trajectory of the SES gap in Canada for students aged 7 to 15 and in Hamburg, Germany for students aged 10 to 15 with more refined methods than have been employed in past studies. The next subsection introduces the cumulative advantage theory, which frames the discussion of school and non-school processes leading to a widening gap. Then, the model specifications originating estimates of the trajectory of the gap are introduced. Subsequently, the case studies of Canada and Hamburg, Germany are presented. For each case, description of the data, sample, and measures, as well as, reports of the results of models, presentations of the limitations, discussion of the main findings, and recommendations for further research follow.

2.1 Cumulative Advantage Theory

In the literature, the purported phenomenon of a widening gap with age is often referred to as the *cumulative advantage process*. Merton (1973) first invoked this term to explain increasing success in scientific careers and his research has been extended to investigate stratification in other social domains. The central claim of this process is that the advantage of one individual over another accumulates over time. The advantage in question is typically a key resource in the stratification process, for example, academic achievement for school success. The cumulative advantage process explains growing inequality when current levels of accumulation directly affect future levels of accumulation. As a consequence, an individual who is behind at a point in time has difficulty catching up with the rest.

Psychologists and sociologists draw on the observation that inequalities between children of low SES families and high SES families tend to increase as they move from kindergarten to high school and they maintain that learning follows a cumulative advantage process (Bast & Reitsma, 1998; DiPrete & Eirich, 2006; Jensen, 1966, 1974). They argue that learning develops in a hierarchical fashion: more complex forms of learning build on simpler forms of learning. Therefore, inequalities at any stage create still greater inequalities at later stages. Although the cumulative advantage theory does not adopt any theoretical or explanatory notion, scholars have examined several school and non-school processes that may underlie this phenomenon.

2.1.1 School Influences on the Gap

Studies favoring school influences argue that because school practices are not neutral in their treatment of students of varying socioeconomic backgrounds, schools tend to produce a widening gap. For example, researchers have suggested that recognition and reward of cultural resources of students from advantaged backgrounds (Bourdieu, 1977; Condron, 2007) and disproportionate assignment of low SES students to lower school tracks (e.g., Kerckhoff, 1993; Oakes, 1985; Pallas et al., 1994) lead to increasing inequalities between high and low SES students over time. Further research has shown that the effects of tracking depend in part on the way tracking is organized (Gamoran, 1992).

In the United States and Canada tracking occurs within schools with students in high school choosing or being assigned to classes working at different levels or covering different content (i.e., course-level grouping). Broadly speaking, under this tracking form, high SES students are more likely to enroll in disproportionate numbers in advance courses leading to college education, while low SES students are more likely to enter vocational programs (Alexander et al., 2007; Davies & Guppy, 2006; Gamoran, Nystrand, Berends, & LePore, 1995; Hallinan, 1994; Hoffer, 1992; Jones, Vanfossen, & Ensminger, 1995; Krahn & Taylor, 2007). Students taking college preparatory courses increasingly diverge from those less academically inclined in terms of their academic achievement (Gamoran & Mare, 1989; Gamoran et al., 1995; Hallinan, 1994; Hoffer, 1992).

Germany has a more stratified form of tracking in which students are placed into different schools earlier in their school careers (Grade 4 in most federal states). Achievement disparities related to family SES under this form of tracking also widen (Becker, Lüdtke, Trautwein, & Baumert, 2006; Becker & Schubert, 2006; Maaz et al., 2008a; Neumann et al., 2007) and, apparently, they do so even to a greater extent than under within school tracking (Schnabel et al., 2002). Students of high SES families in Germany tend to grow faster in their skills than students of low SES families because they are more likely to be placed in the academic track, where they benefit from better learning opportunities characterized by a more favorable school composition and institutional learning environment. And yet, inasmuch as school practices and tracking policies vary significantly among federal states, the extent to which students of high SES families benefit from their locations also varies. In fact, evidence within federal states has not always been consistent with a widening SES gap (Schneider, Knopf, & Stefanek, 2002; Schneider & Stefanek, 2004).

2.1.2 Non-School Influences on the Gap

Another argument is that the out-of-school context is the main gateway for increasing inequalities over the course of schooling. Students spend much of their time outside of school and the quality of non-school environments varies dramatically. Therefore, some scholars contend that the gap widens in spite of schools and not because of them. Alexander, Entwisle, and Olson (2001, 2007) maintain that the gap increases during the summer break and not when school is in session. They show that high and low SES students grow equally during the school term but, while high SES students continue to grow during the summer break, low SES students do not. They attribute this differentiated growing pattern to family processes, material resources, affective context and, more generally, the out-of-school social context.

Similarly, Downey, von Hippel, and Broh (2004) draw on evidence that every academic achievement gap grows faster during summer than during the school period to conclude that schools serve as important equalizers. Schooling does not equalize the achievement of students of high and low SES families in the absolute sense, but it does reduce the rate at which inequality grows, compared to the rate when school is out of session. In this regard, schools play a compensatory role that is often neglected because achievement is compared on an annual basis. Findings in Berlin, Germany, consistently indicate that the atmosphere of the summer vacation period contributes to increase reading achievement disparities among SES groups (Becker, Stanat, Baumert, & Lehmann, 2008).

Some scholars claim that the gap widens because of the way students of varying SES regulate their effort as they get older. For example, Guo (1998) argues that SES effects on achievement are greater in adolescence than in childhood because achievement is very much a function of motivation and opportunity and because a disadvantaged SES is more likely to affect a child's motivation and opportunity when the child becomes an adolescent. Then, students become aware that society's opportunity structure rewards individuals of varying socioeconomic backgrounds differently and that their future opportunities depend on their current SES. Students of low SES families realize they are likely to be excluded from desirable jobs and, consequently, go through a process of disillusionment and tend to put less effort into their academic activities.

In the same line, Goldthorpe (1996) and Breen and Goldthorpe (1997) maintain that students make educational decisions by calculating their costs, anticipated benefits, probability of success, and the attractiveness of alternative options. Because these aspects vary among SES reference groups, the degree to which students of varying SES view schooling as desirable also varies. As students get older, they are more aware of their SES reference group and start to think more seriously about future careers. Students of low SES families will likely deem the prospect of exerting great effort in school to be undesirable, given the anticipation of eventually paying high tuition fees for university while lacking resources to afford them.

2.2 Well-conceived methods in past studies

While most theories point to a widening gap with age, empirical evidence is limited in that it stems largely from cross-sectional designs or two-time point longitudinal designs (e.g., Becker et al., 2006; Becker et al., 2008; Becker & Schubert, 2006; Gamoran, 1992; Gamoran & Mare, 1989; Guo, 1998; Ross & Wu, 1996; Schnabel et al., 2002; Willms, 2002). The former confound age and cohort effects and the latter provide a very limited source of intra-individual variability to study change in the gap (Baltes, Reese, & Nesselroade, 1988; Bryk & Raudenbush, 1987). Some studies, however, rely on more adequate designs and statistical methods and their exposition is instructive.

For instance, Downey et al. (2004) estimated the effect of SES on achievement growth when the school is and is not in session, drawing on four data points from the United States representative *Early Childhood Longitudinal Study—Kindergarten Cohort*: spring and fall of kindergarten and the spring and fall of first grade. By means of growth models consisting of three levels, with test scores (level 1) nested within students (level 2), and students nested within schools (level 3), they estimated growth rates during kindergarten, the summer break and first grade, and evaluated whether the effect of SES on the growth rate varied across these periods. They found that the SES gap was greatest during the summer break, namely, when school was not in session. The multilevel approach applied to a four time point longitudinal design enables to separate student and school variation from variation due to test-level measurement error while drawing on a substantial source of intra-individual variation to examine change.

Alexander, Entwisle, and Olson (2001) used five waves from the *Baltimore-based Beginning School Study* to study the effect of family SES on achievement growth during all 5 years of elementary school. Two-level models of test scores (level 1) nested within students (level 2) were used to estimate growth curves that accounted for differential learning during summer vacations with summer indicator variables in level 1. Family SES was included in level 2 to evaluate its effect on level 1 school year and summer growth coefficients. Results indicate a widening SES gap over the course of elementary school, which unfolds during the summer break and not when school is in session. Most noticeably, achievement gains are greater for high SES students than for low SES students during the first two years of elementary school and level off thereafter.

Wilkins and Ma (2002) predicted achievement growth in statistics, algebra, and geometry for students in the *Longitudinal Study of American Youth* as they advanced from Grade 7 to 12. Achievement scores for each year were calibrated to be comparable across the 6 time point observations using IRT. The authors predicted the effect of parental education and home resources on math initial status and growth in middle school and high school using a three-level model of test scores (level 1) nested within students (level 2) nested within schools (level 3). They found a positive relationship to initial status but negative or nonexistent to growth in middle school and high school, suggesting that students of higher SES families exhibit lower rates of growth than do lower SES students, or that the SES gap tends to narrow. The authors do not rule out, however, that this is a *learning curve* effect. That is, higher SES students start out in Grade 7 near their peak of growth, whereas lower SES students, starting far below the peak, exhibit faster growth rates.

2.3 Model Design

Two model specifications are used to test whether the gap in academic achievement related to SES changes as students age and, if so, how it changes. They vary in the way they restrict the trajectory of the gap. *Specification 1* provides point estimates of the gap at each age level and thus allows for the gap to flexibly vary across age. *Specification 2* restricts the trajectory of the gap to a quadratic functional form.

Specification 1

Its empirical specification for each individual *i* in each period or cycle *j* is

$$y_{ij} = \alpha_0 + \alpha_1 C_{ij} + \alpha_2 age_{ij} + \alpha_3 ses_i + \alpha_4 ses_i age_{ij} + \alpha_5 C_{ij} age_{ij} + v_i + \varepsilon_{ij} \qquad \ldots(2.1)$$

where y_{ij} is the academic achievement score, v_i is an unobserved random individual effect, and ε_{itj} has the standard properties of a regression residual. C_{ij} is a matrix of control variables. It includes 8 variables in the Canadian case (i.e., sex, migration background, single-parent family, teenage mother, siblings, and 3 time period dummies for cycles 2, 3, and 4) and 3 variables in the Hamburg case (i.e., sex, retention in grade, and the number of time-point observations). age_{ij} is a set of age level dummy variables. It includes 8 variables for ages 7 to 15 years in the Canadian case (group of comparison is age 12) and 5 variables for ages 11 to 15 years in the Hamburg case (group of comparison is age 10). ses_i is the student's family SES. The interaction term $ses_i age_{ij}$ allows the effect of SES to vary at each age level, or does not restrict SES effects across age to a particular functional form. All except age variables were centered at their population means. The intercept in equation (2.1) is interpreted as the mean achievement for a representative 12 year old and 10 year old student in Canada and Hamburg, respectively.[4]

In the Canadian case, for the sake of parsimony, the matrix C_{ij} in equation (2.1) was interacted with age in months instead of each age level. C_{ij} has thus a main effect on academic achievement that varies at a constant rate of change with age and mean effects of

[4] The reader may consult Raudenbush and Bryk (2002) for the effects of centering.

age in months were introduced accordingly. They latter add a general effect of the variation of student's age in months to the discrete variation of age in years.

The parameter a_4 evaluates whether SES effects on achievement vary with age and, if so, how. A positive estimate indicates that the achievement gap widens with age, a negative estimate that it narrows, and a statistically nonsignificant estimate, that it remains stable. For instance, in the Hamburg case, where the age range is 10-15 years, the effect of SES on academic achievement is

$$\frac{\partial y}{\partial ses} = \alpha_3 + \alpha_{41} age_{11} + \alpha_{42} age_{12} + \alpha_{43} age_{13} + \alpha_{44} age_{14} + \alpha_{45} age_{15} \qquad \ldots(2.2)$$

where the age_{it} matrix in equation (2.1) has been expanded into five dichotomous variables, each distinguishing whether the student is aged 11 (age_{11}), 12 (age_{12}), 13 (age_{13}), and so on. Parameter a_3 captures the effect of SES on academic achievement at age 10 and parameters a_{41} to a_{45} determine whether this effect increases, decreases, or remains stable. For instance, if a_{43} is positive and statistically significant, the SES effect of a_3 at the age of 10 increases to (a_3+ a_{43}) at the age of 13.

Specification 2

This specification evaluates the trajectory of the SES gap with a two-level model of achievement measures (level 1) nested within students (level 2). The level 1 specification for each student *i* in each period or cycle *j* is

$$y_{ij} = \pi_{oi} + \pi_{1i} age_{ij} + \pi_{2i} age_{ij}^2 + \varepsilon_{ij}\ , \qquad \ldots(2.3)$$

where y_{ij} is the achievement score, age_{ij} is the age of the individual in months, and ε_{ij} has the standard properties of a regression residual. The intercept, π_{0i}, is the initial status and represents the average achievement of person *i* at the age centering value (i.e., 144 months for the Canadian case and 120 months for the Hamburg case). The linear component, π_{1i}, is the rate of change in academic achievement for person *i* at the corresponding age centering value. And π_{2i} captures the acceleration in each growth trajectory. The initial status and the rate of change vary depending on where the age of the individual is centered and the acceleration parameter is a characteristic of the entire trajectory.

There is a separate equation for each level 1 coefficient at level 2:

$$\pi_{oi} = \beta_{00} + \beta_{01} C_i + \beta_{02} ses_i + \upsilon_{0i} \qquad \ldots(2.4)$$

$$\pi_{1i} = \beta_{10} + \beta_{11} C_i + \beta_{12} ses_i + \upsilon_{1i} \qquad \ldots(2.5)$$

$$\pi_{2i} = \beta_{20} + \beta_{21} ses_i \qquad \ldots(2.6)$$

with $\begin{pmatrix} u_{0i} \\ u_{1i} \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \tau_{oo} & \tau_{01} \\ \tau_{10} & \tau_{11} \end{pmatrix}\right]$

C_{ij} and ses_i were defined before. They are also centered at their population means. The acceleration parameter does not include a random component. This parameter needs at least four data points to be random. The Hamburg data include three data points and only 13.5% of students in the Canadian sample have four data points; the rest have either three or two time points (41.6% and 44.9%, respectively). Because only a small proportion of the Canadian sample has sufficient degrees of freedom to evaluate whether this parameter is random or not, the parameter is held fixed in both case studies.

In equation (2.5), parameter β_{12} captures the effect of SES on the growth rate. A positive and statistically significant estimate would indicate that higher SES students grow more rapidly in their academic skills than lower SES students and vice versa. If SES is positively related to academic achievement levels (i.e., β_{02} is positive) and higher SES students grow at faster rates, then the academic achievement gap associated with SES will tend to widen with age. Thus, the critical test regarding the trajectory of the gap is whether β_{12} is equal to, greater than, or less than zero.

By substituting equations (2.4), (2.5), and (2.6) in equation (2.3), the two-level model is consolidated in a combined model:

$$\begin{aligned} y_{ij} &= \beta_{00} + \beta_{01}C_i + \beta_{02}ses_i + \beta_{10}age_{ij} + \beta_{11}C_i age_{ij} + \beta_{12}ses_i age_{ij} \\ &+ \beta_{20}age_{ij}^{\ 2} + \beta_{21}ses_i age_{ij}^{\ 2} + (u_{0i} + u_{1i}age_{ij} + \varepsilon_{ij}) \end{aligned} \quad \text{...(2.7)}$$

The combined model in equation (2.7), which includes both fixed and random effects, is referred to in the literature as *mixed model* (Diggle, Liang, & Zeger, 1994). Fixed effects are represented by each β_s and random effects by both u_{0i}, u_{1i}, and the level 1 residual ε_{ij}.

SES coefficients in both specifications can be expressed interchangeably in terms of the gap or SES effects. Given the SES scale (*M*=0, *SD*=1), SES effects can be interpreted as an academic achievement gap for an average change of SES of one *SD*.

Specification 1 and *Specification 2* were estimated by means of panel data models, hierarchical linear models, and crossed-random effects models. Because of their nature, hierarchical linear models are applied to *Specification 2* only. For the Canadian case, in addition to the traditional random and fixed effects panel data models, censored random effects models are estimated to control for ceiling values in the math achievement measure. In cycle 1, 38% and 16% of students in Grades 3 and 5, respectively, achieved the maximum score in the math test. This introduces a potential source of bias in the estimates of SES effects. In cycles 2, 3, and 4 more versions of the math tests, with different levels of difficulty, were prepared to offset this problem; however, this source of bias continued to a certain degree in these later cycles. Intuitively, censored random effects models counteract ceiling effects by accounting for the probability of scoring at or above the ceiling value and introducing this probability within the estimation algorithm, which is conducted via maximum likelihood (e.g., Greene, 2003). Family SES effects are thus estimated for a latent uncensored math variable, rather than for the observed math variable.

Crossed-random effects models are applied to the Hamburg data only. These models introduce in equations (2.1) and (2.7) unobserved random school effects in addition to the unobserved random individual effect (v_i) and the regression residual (ε_{itj}). The traditional panel data models and hierarchical linear models account for intra- and inter- individual variability. Additionally, crossed-random-effects models (Bates, 2007) soundly account for intra-school variability in completely crossed or partially crossed designs. The longitudinal data from Hamburg are partially crossed because students can migrate between schools over time and thus its pure nesting structure breaks down. Crossed-random-effects models efficiently handle large partially crossed data sets within the likelihood framework. Statistical models in past studies have not accounted for crossed grouping factors in the data when estimating the trajectory of the SES gap.

2.4 The Case of Canada

This case study examines the trajectory of the academic achievement gap among high and low SES Canadian students from childhood to adolescence. Focusing on mathematics academic performance, this study seeks to establish whether the achievement gap associated with family SES widens with increasing age. It does not test the relative validity of the theoretical processes presented in section 2.1. Rather, these processes were discussed to frame the research question and to acknowledge that most theoretical argumentations indicate that the gap widens as students advance in school.

While these theories are not tested, this case study does represent an initial step to address this topic in Canada using a sophisticated and appropriate methodological design. The methods advance previous research by drawing on a four-time point longitudinal design and using statistical techniques well-suited to analyze longitudinal data (i.e., hierarchical linear models and panel data models). They address the potential source of bias that may emerge from having ceiling values in the math achievement measure. Both, the use of four-time point observations and the application of these sophisticated statistical modeling techniques are more appropriate than those used in past studies.

2.4.1 Data

The data stem from the first four cycles (1994-1995, 1996-1997, 1998-1999, and 2000-2001) of Canada's National Longitudinal Study of Children and Youth (NLSCY). The NLSCY followed a representative sample of Canadian children from birth to 11 years of age into adulthood, with data collected at two-year intervals. It collected information on children, their families, health, development, temperament, behavior, relationships, school experiences, participation in activities, among other aspects (Statistics Canada, 1999).

This case study draws on the socioeconomic data and the math tests applied to children from Grade 2 and onwards (Statistics Canada 2001a). The analytic sample consists of 6,290 students. It is restricted to students aged 7-15 who were attending school, took the math test, and had a math score in at least two cycles. Table 2.1 presents the sample distribution over time.

Table 2.1
Sample Distribution by Age
(Number of Participants)

Age	Cycles			
(in years)	1	2	3	4
7	411	586	419	0
8	571	690	541	0
9	507	682	449	429
10	550	785	642	463
11	526	667	439	653
12	0	687	644	631
13	0	600	397	628
14	0	0	563	679
15	0	0	402	606
Total	2,565	4,697	4,496	4,089

2.4.2 Measures

The dependent variable is math achievement. It was derived from a shortened version of the Mathematics Computation Test of the standardized Canadian Achievement Test, Second Edition (CAT/2). This version measures student's ability to do addition, subtraction, multiplication, and division operations on whole numbers, decimals, fractions, negatives, and exponents. Problem-solving involving percentages and the order of operations are also measured (Statistics Canada, 2001b). The test included about 15 questions and was administered in school. For Grade 2 students, an interviewer read the question and recorded the answers on an answer sheet. For students in Grade 3 or above, students read the question and gave an interviewer the answer.

Test difficulty varied with the schooling grade of the student. There were thus different test forms depending on the grade level in which a student was enrolled. They included a series of over-lapping items that were vertically equated such that a continuous scale was used to assess student growth. A gross score and a scaled score were calculated for each student. The gross score was obtained by adding the number of correct answers. The scaled score, the one used here, was derived from standards established by the Canadian Test Centre (CTC). The CTC developed these standards from a sample of the Canadian children from all 10 provinces of the country. The scaled scores ranged from 1 to 999. They were units of a single scale with equidistant intervals that cover all the grade levels.

The response rate of the math test was rather low: 48%, 74%, 49%, and 81% in cycles 1 to 4, respectively. This response rate introduces a potential source of bias that is not accounted for within the model framework due to the absence of suitable instrumental variables. However, the low response rate is not simply due to attrition. In the first cycle it mainly had to do with the three-tier process used by Statistics Canada to obtain permission to test children at school: students were tested only if permission were granted by the school district, the school principal, and the parents. The majority of non-response was attributable to school districts not granting permission, a factor that was not necessarily related to family SES.

In the second and subsequent cycles, permission was required only at the school and family levels. Therefore, many children in the sample were not tested at cycle 1 but were subsequently tested at cycles 2, 3, and 4. Also, models control for a number of demographic factors in addition to family SES that may be related to response rate, and therefore the potential bias in the SES relationship may be somewhat mitigated. In fact, unreported analyses show that SES is positively, albeit weakly, related to the non-response of the math test, but age and its interaction with SES are not. Hence, although estimates of SES mean effects on test scores may be slightly biased, findings are based on the interaction of SES with age, which is not systematically related to the response rate and therefore is less likely to be biased after controlling for other demographic factors.

Key explanatory variables are age and SES. Age is summarized in dichotomous variables at each age level and is also measured in months. Willms and Shields (1996) calculated SES for the NLSCY by means of PCA. Consistent with the literature, their SES variable is a composite of family income, parental education, and parental occupational prestige. For the present analysis, SES was averaged within-individuals across the various cycles for which data were available. The resulting time-invariant SES variable, measured on a continuous scale, was standardized to have a mean of zero and a standard deviation of one across the population of students represented by the sample. By measuring SES after, before, and at the occurrence of the math outcome, the validity of the SES measure might be improved over and above a single time point measure, and the bias of SES effects on math achievement due to unobserved SES aspects is reduced (Duncan & Brooks-Gunn, 1997).

Other family and student characteristics are included in response to theoretical considerations and as control variables. These are the students' sex, life in a single or a two parent family, immigration of the person most knowledgeable about the child (PMK) to Canada, mother's teenage status at the birth of the child, and the number of siblings in the family. The first four characteristics are summarized into dummy variables and the last one is measured as an absolute scale. Descriptive statistics of variables included in this study are presented in Table B1, Appendix B. Missing values for the number of siblings in the family and mother's teenage status were imputed with the Hot Deck method (Little & Rubin, 1987).

2.4.3 Results

Panel data fixed effects, random effects, and censored random effects estimates of *Specification 1* are reported in Table 2.2 in terms of unstandardized regression coefficients. The nature of fixed effects models (i.e., all variables are time-demeaned within students prior to estimation) precludes estimating effects of time-invariant covariates. And yet, these models can estimate effects of time-invariant covariates interacted with time-variant variables, as is the case of SES and its interaction with the age dummies. Although it is a common practice to choose between fixed or random effect estimates, here both are kept, given their remarkable underlying consistency with respect to the relationship between family SES and math achievement across age. This relationship is depicted in Figure 2.1.

Next, effects that were consistently significant in the different panel data models are reported. Effect sizes are reported in relation to a *SD* of the math achievement measure, i.e., 100 score points.

Table 2.2
The Relationship between SES and Math Achievement across Age: Estimates of *Specification 1* (*B*=Unstandardized Regression Coefficients; *SE*=Standard Error)

	Fixed Effects		Random Effects		Censored Random Effects	
Characteristic	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	481.68*	(2.14)	504.28*	(2.23)	508.96*	(2.31)
Period Effects						
Cycle2			0.52	(1.33)	-3.69*	(1.39)
Cycle3			-20.98*	(1.58)	-26.03*	(1.64)
Cycle4			-40.40*	(1.93)	-45.21*	(2.00)
Control Variables						
Sex (Female=1)			3.42*	(1.36)	3.36*	(1.40)
Teenage Mother			-11.15*	(3.45)	-11.26*	(3.55)
Number of Siblings	-0.32	(1.09)	0.10	(0.68)	0.05	(0.70)
Single Parent Family	0.37	(2.41)	-1.76	(1.61)	-1.96	(1.66)
Immigrated to Canada			7.41*	(2.56)	7.54*	(2.63)
Age Effects						

Age of 7	-42.20*	(12.86)	-44.44*	(9.18)	-43.99*	(9.49)
Age of 8	-15.78	(9.76)	-22.16*	(7.34)	-18.90*	(7.59)
Age of 9	-2.64	(8.20)	-2.28	(5.73)	-2.52	(5.91)
Age of 10	7.41	(5.03)	5.36	(3.89)	5.54	(4.02)
Age of 11	1.20	(4.03)	5.90*	(2.63)	5.76*	(2.71)
Age of 13	-2.41	(3.39)	2.90	(2.57)	3.53	(2.66)
Age of 14	29.16*	(5.14)	35.81*	(4.01)	35.67*	(4.15)
Age of 15	14.73*	(7.27)	27.58*	(5.68)	28.73*	(5.87)
SES across Age						
SES			19.57*	(1.48)	19.66*	(1.53)
SES × Age of 7	-9.29*	(3.48)	-7.93*	(2.35)	-7.25*	(2.44)
SES × Age of 8	-7.49*	(2.03)	-7.96*	(1.89)	-6.37*	(1.99)
SES × Age of 9	-9.91*	(3.13)	-7.89*	(2.04)	-8.18*	(2.11)
SES × Age of 10	-7.12*	(1.74)	-7.19*	(1.66)	-7.01*	(1.72)
SES × Age of 11	-7.85*	(3.07)	-6.00*	(1.97)	-5.90*	(2.04)
SES × Age of 13	1.83*	(3.15)	3.43	(2.10)	3.37	(2.17)
SES × Age of 14	12.62*	(2.10)	12.80*	(2.00)	12.42*	(2.06)
SES × Age of 15	5.20	(3.36)	7.42*	(2.37)	7.54*	(2.44)
Control Variables across Age						
Age in Months	2.16*	(0.20)	2.67*	(0.15)	2.66*	(0.15)
Sex × Age in Months	-0.01	(0.04)	0.00	(0.03)	0.00	(0.03)
Teenage Mother × Age in Months	-0.35*	(0.10)	-0.36*	(0.09)	-0.35*	(0.09)
Siblings × Age in Months	0.04	(0.02)	0.05*	(0.02)	0.05*	(0.02)
Single parent × Age in Months	0.07	(0.05)	0.09*	(0.05)	0.10*	(0.05)
Immigrated × Age in Months	0.11	(0.07)	0.08	(0.06)	0.08	(0.06)

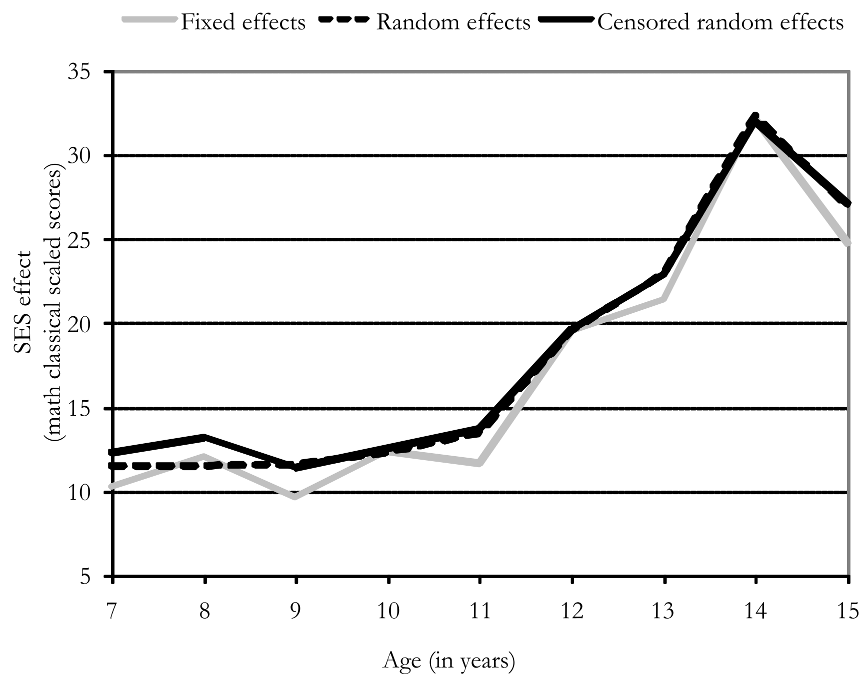
Note. The data consist of 6,290 individuals and 15,847 observations. The overall R^2 of the fixed effects and random effects model is 0.60 and 0.65, respectively.
* $p<0.05$

Females performed better than males in math. But the gender gap is negligible (about 3% of a *SD* in math achievement) and remains invariant as children get older (see nonsignificance of *Sex × Age in months* coefficient in Table 2.2). Children whose mothers were teenagers at their birth scored lower in math. On average, they performed 11% of a *SD* in math below the other students. And, this gap increased as they advance in school (*Teenage mother × Age in months* coefficient in Table 2.2 is negative and statistically significant). Children from immigrant families performed better than native Canadians irrespective of their family SES. The gap attributed to migration status amounts to about 8% of a *SD* in math and remains stable with age (see nonsignificance of *Immigrated* × *Age in months* coefficient in Table 2.2). The read should note that immigration policies in Canada seek to attract and retain a higher proportion of qualified workers and students than in Germany, which partly explains that the migration gap in Canada favors immigrants and in Germany, native Germans.

The relationship between age and math achievement was positive. For example, math scores increased in 25 points (i.e., 25% of a *SD* in math) from the age of 7 to 8 years according to the censored random effects model (in Table 2.2 compare *Age of 8* and *Age of 7* coefficients, i.e., -18.90+43.99 = 25.09). But this relationship was not constant. Evaluated by how age coefficients increased from the age of 7 to 15 years, a pattern of positive but decreasing age effects was revealed. This pattern indicates a curvilinear trend for the math achievement trajectory of students.

The relationship between family SES and math achievement was positive and remarkably consistent among panel data models. Measured through the censored random effect model, the model that counteracts ceiling values in the math measure, the math achievement gap related to family SES at the age of 12 was 19.66 points, at the age of 7 was 12.40 points (19.66-7.25), at the age of 8 was 13.29 points (19.66-6.37), and so forth (see *SES x Age* interactions in Table 2.2). Family SES was positively and significantly related to math achievement at each age level from the age of 7 to 15. That is, students of lower SES families performed at lower levels in math than their higher SES peers throughout this period. On average, achievement differences from the age of 7 to 15 associated with a *SD* gap in SES amount to 20% of a *SD* in math achievement. These differences are thus not negligible and, moreover, they increase with age (see Figure 2.1).

Figure 2.1
Family SES and Math Achievement at each Age Level: Estimates of *Specification 1*



Note. The fixed effects line assumes that the SES effect at age 12 is similar to that of the random effects model.

Indeed, results indicate a widening gap from the age of 11 to 15 years. The gap at the age of 11 of 13.75 points (19.66-5.90) increased to 19.66 points at the age of 12 and increased further up to the age of 15. Prior to the age of 11, the gap remains fairly invariant (see panel data censored random effects estimates in Tables 2.2). Table 2.3 offers more compelling evidence of this pattern. It reports mean comparison tests of SES effects across age based on the censored random effects model (results from other regression techniques are similar and so are not reported here). Table 2.3 reveals that the SES gap is positive but does not significantly change between the ages of 7 and 11 years. At the age of 12 years and beyond, the math achievement gap between students of higher and lower SES families significantly widens (see also Figure 2.1).

Table 2.3
Mean Comparison Tests of the SES gap in Math Achievement: Estimates of the Censored Random Effects Model

Age (in years)		7	8	9	10	11	12	13	14	15
	Mean gap	12.41	13.28	11.48	12.65	13.75	19.66	23.02	32.07	27.20
7	12.41	0								
8	13.28	1	0							
9	11.48	-1	-1	0						
10	12.65	1	-1	1	0					
11	13.75	1	1	1	1	0				
12	19.66	1	1	1	1	1	0			
13	23.02	1	1	1	1	1	1	0		
14	32.07	1	1	1	1	1	1	1	0	
15	27.20	1	1	1	1	1	1	1	-1	0

Note. A value of 1, -1, and 0, indicates that the SES gap at the age level in the row is higher, lower, and equal from that of the column, respectively. Shadowed cells indicate statistically significant differences ($p<0.05$).

In fact, the average gap from the age of 12 to 15 is twice as large as the average gap from the age of 7 to 11 years (26% and 13% of a *SD* in math achievement, respectively). The gap increases steadily at an average rate of 33% per year from the age of 12 to 14 years. At the age of 15 years the gap seems to level off (see Figure 2.1), but it is still significantly greater than the gap at the age of 12 or before (see Table 2.3). Also, though smaller, it is not significantly different from the gap at the age of 14 years. Data age range restrictions preclude examining whether the gap at the age of 15 announces the beginning of a new trend or not.

Table 2.4 reports estimates of *Specification 2* in terms of unstandardized regression coefficients. As mentioned earlier, this specification restricts the trajectory of the gap to a quadratic functional form to fit hierarchical linear models in addition to panel data models. To the extent that the SES gap derived from *Specification 1* seems to follow a curvilinear trend with age (see Figure 2.1), this restriction is defensible. In Table 2.4, age is expressed in months (i.e., its effects are for a one month change) and all covariates, except for age and the cycle dummy indicators, are fixed over time. Results that are consistent among the different regression techniques are reported next.

Table 2.4
Trajectory of the Math Achievement Gap attributed to Family SES: Estimates of *Specification 2* (*B*=Unstandardized Regression Coefficients; *SE*=Standard Error)

	Panel Data Model							
	Fixed Effects		Random Effects		Censored Random Effects		HLM	
	B	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	489.07*	(0.59)	515.07*	(1.60)	519.99*	(1.66)	492.87*	(0.86)
Period Effects								
Cycle 2			-3.13*	(1.34)	-7.52*	(1.40)		
Cycle 3			-21.56*	(1.57)	-26.88*	(1.63)		
Cycle 4			-40.59*	(1.94)	-45.80*	(2.01)		
Control Variables								
Sex (Female=1)			3.31*	(1.37)	3.25*	(1.41)	4.34*	(1.56)
Teenage Mother			-11.18*	(3.46)	-11.25*	(3.57)	-9.26*	(3.57)
Number of Siblings	-0.50	(1.12)	-0.01	(0.68)	-0.06	(0.71)	-1.30	(0.99)
Single Parent Family	-0.15	(2.47)	-1.97	(1.63)	-2.15	(1.68)	-3.90	(2.54)
Immigrated to Canada			7.63*	(2.57)	7.80*	(2.64)	8.64*	(2.91)
Age Effects								
Age	2.54*	(0.02)	3.18*	(0.03)	3.18*	(0.03)	2.64*	(0.03)
Age^2	-0.01*	(0.00)	-0.01*	(0.00)	-0.005*	(0.00)	-0.01*	(0.00)
SES across Age								
SES			17.29*	(0.88)	17.33*	(0.91)	16.87*	(0.93)
SES × Age	0.27*	(0.02)	0.27*	(0.02)	0.26*	(0.02)	0.27*	(0.03)
SES × Age^2	0.003*	(0.00)	0.003*	(0.00)	0.003*	(0.00)	0.003*	(0.00)
Control Variables across Age								
Sex × Age	-0.01	(0.04)	-0.01	(0.03)	0.00	(0.03)	0.03	(0.04)
Teenage Mother × Age	-0.35*	(0.10)	-0.37*	(0.09)	-0.35*	(0.09)	-0.30*	(0.09)
Number of Siblings × Age	0.04	(0.02)	0.05*	(0.02)	0.05*	(0.02)	0.02	(0.02)

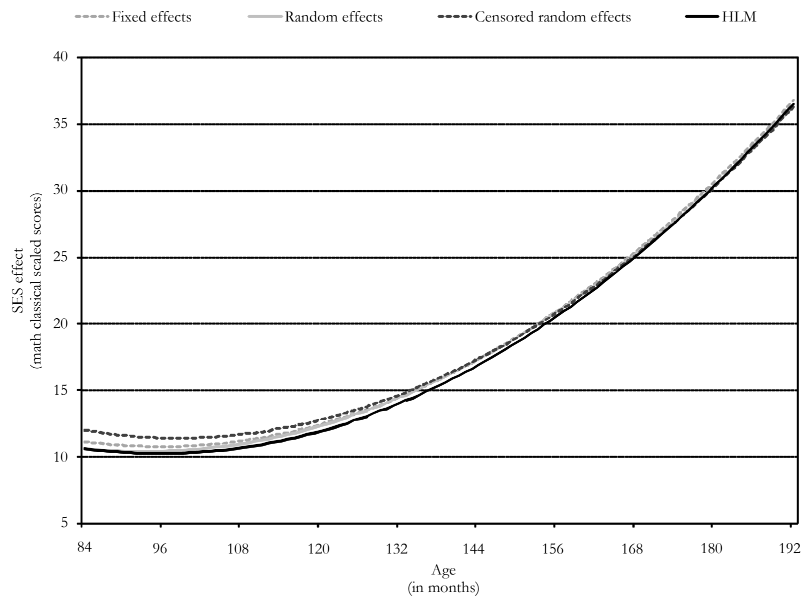
Single Parent Family × Age	0.08	(0.05)	0.11*	(0.05)	0.11*	(0.05)	0.04	(0.06)
Immigrated to Canada × Age	0.10	(0.07)	0.08	(0.06)	0.07	(0.07)	0.08	(0.07)

* $p<0.05$.
Note. The data consist of 6,290 individuals and 15,847 observations.

As with *Specification 1*, hierarchical linear model estimates of *Specification 2* indicate a negligible gender gap favoring females, a larger gap among students whose mothers were teenagers at their birth and the rest, and a gap in academic achievement favoring students from immigrant families. They also indicate that math achievement differences among students whose mothers were teenagers at their birth and the rest increase with age. Effect sizes are highly coincident with those emanating from *Specification 1*, thereby conveying evidence of the robustness of these results (see Table 2.2 and Table 2.4). Also, age coefficients from *Specification 2* confirm what one would anticipate based on results from *Specification 1*. That is, that the math achievement trajectory of students fits a curvilinear trajectory, with students growing in math at a decreasing rate of change (see *Age* and Age^2 coefficients in Table 2.4).

With respect to the trajectory of the math achievement gap related to family SES and, as expected from Figure 2.1, estimates of *Specification 2* reveal that this trajectory fits a quadratic functional form. Particularly, it widens at an accelerating rate of change. What is most striking in Table 2.4 is that estimates of the trajectory of the gap are remarkably consistent among hierarchical linear models and panel data models. The magnitude of *SES*, *SES* × *Age*, and $SES \times Age^2$ coefficients is quite similar among these models and thus, not surprisingly, these estimates underpin virtually overlapping trajectories. These trajectories are depicted in Figure 2.2.

Figure 2.2
Trajectory of the SES Achievement Gap: Estimates of *Specification 2*



Note. The fixed effects line assumes that the SES effect at age 144 months is similar to that of the random effects model.

As with Figure 2.1, Figure 2.2 shows that the gap remains fairly stable from the age of 7 up to the age 12 and sharply increases thereafter. In other words, students of lower SES families increasingly diverge from their high SES peers after the age of 12 years. Overall, hierarchical linear model estimates and panel data model estimates of *Specification 1* and *Specification 2* offer compelling evidence of a math achievement gap between students of higher and lower SES families that widens from childhood to adolescence. Particularly, the gap remains fairly stable from the age of 7 to 11 years and widens at an accelerating rate of change from the age of 11 up to the age of 15 years.

2.4.4 Discussion

The results indicate a widening gap in math achievement between students of higher and lower SES families in Canada. This finding is consistent with the cumulative advantage theory. It adds to the evidence that educational disparities associated with family background tend to increase as students advance in school (Bast & Reitsma, 1998; DiPrete & Eirich, 2006; Jensen, 1966, 1974). More specifically, the results provide evidence that the SES gap remains roughly stable from the age of 7 to 11 years, that is, more or less between Grades 2 and 6. Thereafter, the gap widens at an increasing rate of change up to the age of 15 years, that is, from about the beginning of Grade 7 to Grade 10. In other words, achievement differences among students of varying socioeconomic backgrounds remain invariant during elementary school and sharply widen in the transition from elementary school to middle school. Furthermore, throughout middle school years and up to the beginning of high school, the gap widens at an increasing rate of change. Ultimately, the average gap between the ages of 12 to 15 years is twice as large as the average gap between the ages of 7 to 11 years.

The presented analysis utilizes more appropriate and sophisticated methods than in previous studies. Particularly, it advances prior research by drawing on a four-time point longitudinal design and applying regression techniques suited for the analysis of longitudinal data whereby the ceiling effects problem in the math achievement measure is addressed. Most research relies on cross-sectional data or longitudinal data with two or, at best, three data points (e.g., Gamoran & Mare, 1989; Guo, 1998; Hoffer, 1992; Ross & Wu, 1996; Willms, 2002) and therefore tends to confound age and cohort effects or provides a rather limited source of intra-individual variation to study change in the gap, respectively. Instead, this analysis uses the first four data points of the NLSCY to estimate the trajectory of the gap in math achievement, thereby increasing the validity of the trajectory of the gap (Baltes et al., 1988; Bryk & Raudenbush, 1987).

Furthermore, both hierarchical linear models and panel data models are used to estimate the trajectory of the gap. Panel data models produce point estimates of the gap at each level from the age of 7 to 15 and the panel data censored model accounts for ceiling values in the math measure by incorporating the probability of scoring at or above the ceiling value within the model estimation algorithm. Hierarchical linear models enable estimating individual growth trajectories for higher and lower SES students as they get older. Estimates of the different regression techniques are strikingly similar with respect to the trajectory of the gap they produce, a conclusion which conveys that the results are quite robust.

This case study is not without limitations. A first limitation is the rather low response rate of the math tests whereby a potential source of bias is introduced. The low response rate, however, was not simply due to attrition, but had to do with the three-tier process used by Statistics Canada to obtain permission to test children at school. And this process was not necessarily related to family SES. Furthermore, regression models control for a number of demographic factors that may be related to the response rate and, in unreported analyses, SES was related to the response rate, but the interaction of SES with age was not. Therefore, although models may have failed to estimate unbiased mean effects of SES even after including controls, the findings are based on the interaction of SES with age, which is not systematically related to the response rate. Thus, this limitation is not to threaten seriously the validity of the results.

A second limitation is that the math tests included a small number of items and thus covered a fairly limited domain of mathematics skills. However, in earlier work based on a cross-sectional analysis of the NLSCY, Willms (1996) found remarkable consistency between results based on the NLSCY test and those based on more extensive curriculum-based measures. A related limitation is the restriction to match achievement. The gap widens for math but not necessarily for other subject areas. Here, based on a meta-analysis, Cooper, Nye, Charlton, Lindsay, and Greathouse (1996) expect an even greater gap with increasing age in reading skills in light of the limited access of lower SES families to reading materials and language learning opportunities compared to higher SES families. But Gamoran (1992) suggests that insofar as instructional differentiation is more variable among schools in math than in English as the language of instruction, one should expect a sharper widening achievement gap in math than in English. In this case, the widening math gap reflects greater between-school differences in the organization of math instruction. Further research should examine how this gap evolves in different subject areas.

A final limitation is the restriction of this analysis to tests of the effects of SES without direct tests of the mechanisms that produce these results. This factor certainly limits the ability to offer guidelines for the design and improvement of educational policies. As they are, the results suggest that children would benefit not only from intervention programs implemented early in their childhood, but from later programs implemented when they are adolescents. What is critical for policy research, however, is the focus of these programs at different life stages, which probably needs to differ. To define the focus of these programs, more precise theorizing and more systematic empirical study of the mechanisms giving rise to a widening gap are needed. And it is important to move beyond the descriptive characterization of the gap toward a deeper understanding of the reasons why achievement trajectories diverge among SES groups. This is beyond the scope of the present study, but some hypotheses can be postulated and their implications for policy and research discussed.

A first hypothesis is that school practices are not neutral in their treatment of students of varying socioeconomic backgrounds and that they mediate SES effects on academic achievement at increasing rates. This hypothesis is consistent with Kerckhoff's (1993) argument about institutional arrangements: socioeconomically biased assignment into groups during school years (i.e., low SES children being repeatedly located in low ability groups and high SES children, in high ability groups) produces divergent educational outcomes among SES groups. Even in systems that do not assign students into different schools, ability grouping within classes and/or course-enrolment patterns, as in Canada, can have the same effect (Gamoran & Mare, 1989; Hoffer, 1992; Schnabel et al., 2002).

If this is the case, ability grouping and course-level grouping practices are not necessarily to be abandoned, but they can be redefined in light of studies examining the effects of various grouping practices on the gap between higher and lower SES studies. It is important to examine how these practices affect what actually happens in the classroom, for example, teacher's pace of instruction and use of time, student participation, discussion, etc. And, based on this evidence, grouping practices that reduce the gap without compromising the advantages of students in higher ability groups should be encouraged. Teachers, principals, and all educational actors involved in the definition of grouping practices should be informed of the effect of groupings and they should make decisions based on this evidence. Then grouping could perhaps be more effectively implemented.

A second hypothesis is that the out-of-school context increases disparities among SES groups. Children spend the vast majority of their time outside school and the quality of non-school environments varies widely. Thus, some scholars argue that the out-of-school context, mainly, the family environment, produces divergent achievement trajectories among high and low SES students (Alexander, Entwisle, & Olson, 2001, 2007; Downey et al., 2004). The school serves actually as equalizer. Although schools do not reduce disparities in the absolute sense, these increase less when school is in session.

If this reason explains the widening gap, efforts should focus on improving the family environment of low SES children or increasing their exposure to schooling. While the former are less amenable to policy intervention, concrete actions can be taken to increase and improve the quantity and quality of time children spend in school. Summer and after-school programs targeted at students of low SES families are the most obvious approaches. For example, Alexander, Entwisle, and Olson (2001) suggest summer enrichment programs with a strong curriculum focused on reading, it being the foundation for all that follows. They argue that educational policies that increase access to books can have an important impact on achievement, particularly for less advantaged children. Also, non-academic activities can support learning outside the classroom setting and should be encouraged such as (a) visiting parks, museums, science centres, and zoos; (b) taking swimming, dance, and music lessons; (c) going to the library; or (d) practicing sports during the summer break.

Another hypothesis is that mathematics success in the higher grades places greater emphasis on reading skills and involves tasks that require higher-order skills. Inasmuch as these skills are related to SES, because the requirements for mathematics increase when students reach secondary school, then the SES-achievement gradient becomes stronger. Still another hypothesis is that the SES gap widens because low SES children are more negatively influenced by the transition from elementary school to middle school because they tend to migrate to lower SES schools compared to high SES children. The NLSCY does not have the available data to test these hypotheses, but they deserve attention in future longitudinal studies. Understanding the processes behind the trajectory of the gap is fundamental to provide information for the design and improvement of social policies.

2.5 The Case of Hamburg, Germany

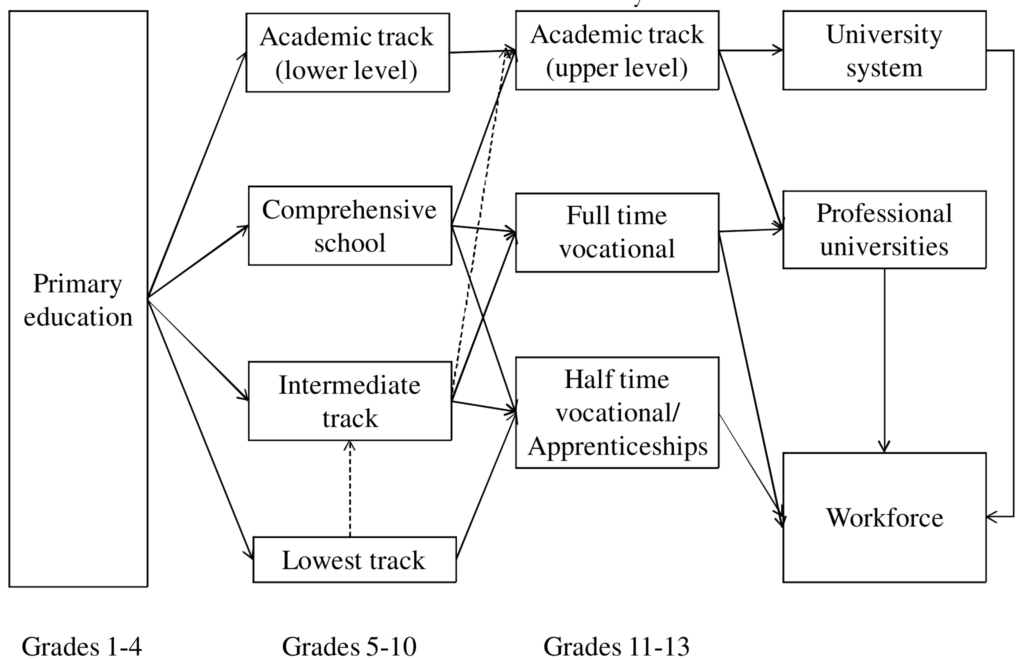
This study examines the trajectory of the SES gap in math and reading achievement from age 10 to 15 in Hamburg, Germany. It extends throughout the period beginning after the transition to secondary school (Grade 5) and up to the end of compulsory education (Grade 9). As with the previous case study, this one is not intended to be seen as a test of the relative validity of the theoretical processes discussed in section 2.1. It adds to previous analyses in two main aspects. First, by employing a more sophisticated and sound methodological approach consisting of cross-random-effects, panel data, and hierarchical linear models and a longitudinal design of three data points. Secondly, by focusing on a German federal state where, although tracking is between schools, it is less selective and more flexible than in most German federal states. Key characteristics of the German educational system and distinctive school tracking policies in Hamburg are discussed next.

2.5.1 The German Education System

2.5.1.1 Overview: Formal Structure

In Germany, federal states have jurisdiction over formal education. They define their own goals, structures, instructional content, and procedures in their respective systems. It is therefore difficult to characterize the German educational system in a single picture. But, in general terms, Figure 2.3 depicts its formal structure.

Figure 2.3
The German Education System



Note: For the purpose of clarity, a simplified version of the educational system is presented. Dashed arrows indicate less significant educational pathways.

Primary education normally includes the first four years of education with normal entry at age 6. At the end of Grade 4 students are given a recommendation for the three-tiered secondary system (i.e., lowest track, intermediate track, and academic track plus a comprehensive school form). These secondary school tracks differ importantly with regard to the depth and breadth of the curriculum. Teacher's track recommendation is based largely on the student's academic performance and the final decision as to which track the student will attend starting Grade 5 rests with the parents. Typically, students from disadvantaged backgrounds, such as low socioeconomic families or with poor language skills due to their immigrant background are disproportionally placed in lower school tracks and vice versa (Diefenbach, 2002, 2004).

School track allocation at this rather early stage has profound and diverse influences on future educational and professional opportunities of students from different socioeconomic backgrounds. The majority of students (about 60%) are enrolled in the lowest or intermediate school track, which comprise 5 and 6 years of secondary schooling, respectively. After graduation, these students typically pursue a half-time or full-time vocational apprenticeship, which usually involves a 3-year training program in a firm or company in combination with course-work offered in a public vocational school once or twice a week or, in some cases, full-time vocational training. About 30% of students attend the academic track. Those who successfully complete the final examination at the end of Grade 12 or13 of this track are entitled to attend university.

In addition to these three school tracks, some federal states include a mixed track or a comprehensive school form. Students in comprehensive schools may obtain school leaving certificates equivalent to those from any of the three schools tracks. These schools operate with internal setting by subject. Approximately 8% of students attend comprehensive schools between Grades 7 and 9 in Germany.

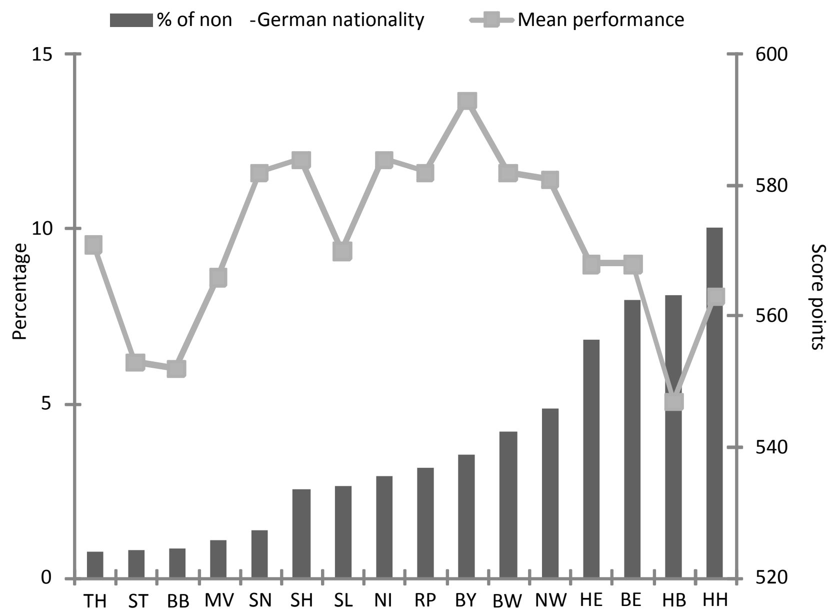
2.5.1.2 Hamburg: Equity for Quality?

Performance of Hamburg's educational system is relatively poor in terms of overall academic performance. According to the Programme for International Student Assessment 2000 (PISA 2000; Baumert et al., 2002; Prenzel et al., 2005), it is below the national average and ranks among the bottom four federal states out of sixteen. In terms of equity, however, its system is relatively successful at including immigrants and fairly distributing educational opportunities among students from different socioeconomic backgrounds. This is partly achieved through a weaker selection of students into school tracks.

For instance, Hamburg includes the comprehensive school form and an *observational* stage between Grades 5 and 6 during which no distinction exists between the lowest and intermediate track and students may change between school tracks. Approximately 30% of students in Hamburg attend comprehensive schools. Also, during the *observational* stage around 4% of students in this integrated track (i.e., lowest and intermediate track) are promoted into the academic track and 6% of students in the academic track are relocated into lower tracks (Lehmann et al., 2006).

Figure 2.4 depicts the performance of the Hamburg educational system, in terms of quality and equity, in relation to other federal states. The solid line represents federal states' average reading performance in the academic track based on PISA 2000 (Baumert et al., 2002). The bars indicate the percentage of students of non-German nationality in the academic track. Federal states are sorted in ascending order by these percentages. The first five federal states are of the former GDR and historically have a lower proportion of immigrants.

Figure 2.4
Equity and Quality across Federal States: Reading Performance (PISA) and Students of Non-German Nationality (%) in the Academic Track



Note. Federal states are: Thüringen (TH), Sachsen-Anhalt (ST), Brandenburg (BB), Mecklenburg-Vorpommern (MV), Sachsen (SN), Schleswig-Holstein (SH), Saarland (SL), Niedersachsen (NI), Rheinland-Pfalz (RP), Bayern (BY), Baden-Württemberg (BW), Nordrhein-Westfalen (NW), Hessen (HE), Berlin (BE), Bremen (HB), and Hamburg (HH).
Source: Baumert et al., (2000) and Statistisches Bundesamt (2005).

Hamburg includes a large proportion of students of non-German nationality in its school system (20% in Grades 5 to 10) compared to the national picture (10%). Furthermore, it has the largest percentage of students of non-German nationality in the academic track (10%). In other words, its educational system not only includes a larger than average proportion of non-nationals but also places them less frequently in lower tracks and, consequently, offers them better educational opportunities. Yet, there seems to be a curvilinear relationship between overall performance and inclusion of students of non-German nationality in the academic track (see Figure 2.4). Overall performance increases at a decreasing rate as the proportion of non-nationals grows. After a particular threshold, a larger proportion of non-nationals is related to lower overall performance in the academic track. Hamburg certainly exceeds that level. From this perspective, its system seems to promote more equal opportunities among students of varied socioeconomic background but, possibly, at the expense of lower levels of performance.

2.5.2 Data

The data stem from LAU 5, 7, and 9. The LAU project was introduced in section 1.1.1. LAU 5 addressed the transition from primary to secondary school and depicted the respective achievement levels observed at this point (Lehmann & Peek, 1997). It focused on student performance in language, reading, and mathematics. The following studies examined changes in student performance over time and across school tracks. Language awareness was evaluated up to Grade 9 and reading performance up to Grade 11. In addition to the subject areas evaluated in LAU 5, English performance was evaluated from Grade 7 and beyond.

The analytic sample is limited to students in Grades 5, 7, and 9 aged 10-15 who took the math and reading test (N = 12,959). These students represent 80% of the full sample, that is, of the student population in these grades (N = 16,266). The excluded sample (N = 3,307) is somewhat older and less socioeconomically advantaged, but excluding these students does not translate in substantial SES and age differences between the full sample and analytic sample (see Table B2, Appendix B). Higher rates of retention in grade in the excluded sample, however, do lead to important differences between the full sample and analytic sample, with students in the analytic sample having lower retention rates. Underrepresentation of retained students in the analytic sample may introduce a bias in the estimates; this represents a limitation of this examination. The analytic sample is unbalanced, that is, the number of time-point observations varies among students. Particularly, 28%, 13%, and 59% have one, two, and three data points, respectively. The age distribution of this sample is presented in Table 2.5.

Table 2.5
Sample Distribution by Age
(Number of Participants)

Age (in years)	Grades		
	5	7	9
10	6,108	4	0
11	4,102	48	1
12	499	5,265	0
13	24	3,445	63
14	6	383	5,534
15	0	22	4,522
Total	10,739	9,167	10,120

Sample attrition in the analytic sample is reasonably low: 76% of the student population in Grade 5 was present in Grade 9. The main reasons for sample attrition were retention in grade and natural mobility. While some students drop out of the sample because of these reasons, new students enter the study over time. For instance, 11% of the Grade 5 sample is not present in Grade 7, but a new group of students, equivalent to 13% of the Grade 5 sample, enters the study in Grade 7. Similarly, 17% of the Grade 7 sample is not present in Grade 9, but this is replenished with new students in Grade 9 equivalent to 12% of the Grade 7 sample.

Table B3 in Appendix B compares the sample that drops out in Grade 5 and 7 to the sample that enters the study in Grade 7 and 9. The sample that drops out comes from relatively disadvantaged backgrounds; for instance, the proportion of fathers with university degree is lower (16% versus 21%), the percentage of mothers with admission level to university (*Abitur*) is smaller (23% versus 27%), and the SES level is lower (mean differences amount to 11% of a *SD* in SES). Overall, however, socioeconomic composition differences are not huge and both samples are fairly similar. Furthermore, regression models control for the effects of retention in grade and the number of time-point observations on achievement level and achievement growth. Therefore, sample attrition is expected not to critically bias regression estimates.

2.5.3 Measures

Dependent variables are math and reading achievement. They are based on students' scores in the math and reading tests part of the test batteries KS HAM 4/5 in Grade 5 (Mietzel & Willenberg, 1996), SL-HAM 6/7 in Grade 7 (Behörde für Schule, Jugend und Berufsbildung, Amt für Schule, Hamburg, 1998), and SL-HAM 8/9 in Grade 9 (Behörde für Schule, Jugend und Berufsbildung, Amt für Schule, Hamburg, 2000). Standardized achievement tests were developed by a group of experts in Hamburg.

The math test included 30, 35, and 64 multiple choice format tasks in Grades 5, 7, and 9, respectively. Overall, they covered the areas of arithmetic, geometry, algebra, and stochastic problems. The reading test included 27, 29, and 72 multiple choice format tasks in Grades 5, 7, and 9, respectively. It evaluated students' ability to extract and locate relevant information and make direct inferences from a text. The difficulty of the math and reading items varied across grades and between school tracks in Grade 9.

IRT was used to scale the math and reading items. Item difficulty for each item was estimated through a one-parameter Rasch model (Masters & Wright, 1997; Rasch, 1960). Drawing on these estimates, final math and reading IRT scores were obtained using weighted likelihood estimation. These scores are measured on a continuous scale and were standardized to have a mean of 100 and a *SD* of 20 in Grade 5. Both the math and reading achievement scores are reliable (a=0.85 and 0.89, respectively).

Independent variables are age and family SES. Age is expressed in months and years. The estimation of family SES was described in detail in section 1.1.2. Additionally, models control for sex, the number of longitudinal time points, and retention in grade. Sex is 1 for females and 0 for males. The number of longitudinal time points for each student ranges from 1 to 3. Retention in grade is a dichotomous variable distinguishing retained students (value of 1) from the rest (value of 0).

Descriptive statistics of dependent and independent variables used in regression analyses are presented in Table B2, Appendix B. Socioeconomic variables had missing values prior to model estimation: mother's education (17%), mother's vocational training (25%), father's vocational training (19%), family wealth (16%), and SES (26%). Missing values were multiply imputed using techniques that draw on information from the observed part of the data set to create plausible versions of the complete data set (Schafer, 1999). Although not reported here, regression analyses based on the raw data set convey the same findings.

2.5.4 Results

In general, regression estimates under the various techniques are fairly robust and so only cross-random-effects estimates are reported here. Estimates of *Specification 1* and *Specification 2* are reported in Tables 2.6 and 2.7. They underpin the trajectory of the SES gap depicted in Figure 2.5 and Figure 2.6. Achievement gaps in these figure lines are for an SES mean difference between the top and bottom SES quarters. Similarly, hereafter in this section results on the gap refer to this difference.

Table 2.6
Crossed-Random-Effects Model Predicting Reading and Math Achievement from *Specification 1*
(*N*=12,959; *B*=Unstandardized Coefficient; *SE*=Standard Error)

	Reading						Math					
	(1)		(2)		(3)		(1)		(2)		(3)	
Characteristic	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	99.98***	(0.53)	99.89***	(0.58)	99.95***	(0.56)	98.86***	(0.60)	98.86***	(0.64)	99.05***	(0.64)
Age of 11	-0.32	(0.29)	-0.46	(0.30)	-0.40	(0.30)	0.71**	(0.30)	0.39	(0.31)	0.11	(0.31)
Age of 12	17.38***	(0.20)	17.47***	(0.20)	17.17***	(0.21)	17.68***	(0.21)	17.69***	(0.21)	17.35***	(0.21)
Age of 13	18.52***	(0.30)	18.31***	(0.31)	17.99***	(0.31)	18.13***	(0.32)	18.02***	(0.32)	17.35***	(0.32)
Age of 14	30.88***	(0.21)	31.04***	(0.21)	30.64***	(0.21)	29.04***	(0.21)	29.09***	(0.21)	28.69***	(0.21)
Age of 15	30.79***	(0.29)	30.51***	(0.29)	30.09***	(0.31)	28.71***	(0.30)	28.47***	(0.30)	27.62***	(0.32)
Mother's Schooling	1.03***	(0.19)					1.01***	(0.17)				
Father's Schooling	0.82***	(0.15)					0.69***	(0.15)				
Mother's Vocational Training	0.17*	(0.12)					0.25**	(0.12)				
Father's Vocational Training	0.21*	(0.11)					0.25**	(0.12)				
Family Wealth Index	3.16***	(0.13)					2.45***	(0.13)				
SES			4.08***	(0.21)	4.05	(0.21)			2.55***	(0.24)	2.35***	(0.24)
SES x (Age of 11)			-0.46	(0.32)	-0.48	(0.32)			-0.02	(0.31)	-0.15	(0.31)
SES x (Age of 12)			-0.71***	(0.22)	-0.71***	(0.22)			1.42***	(0.22)	1.45***	(0.22)
SES x (Age of 13)			-1.38***	(0.32)	-1.32***	(0.33)			0.85**	(0.36)	0.81**	(0.36)
SES x (Age of 14)			-1.99***	(0.21)	-1.97***	(0.21)			-0.18	(0.21)	-0.14	(0.21)
SES x (Age of 15)			-2.44***	(0.30)	-2.38***	(0.30)			-0.47	(0.35)	-0.49	(0.35)
Control Variables	No		No		Yes		No		No		Yes	

* p<0.10, ** p<0.05, *** p<0.01.
Note. The smaller size of the *Age of 15* coefficient compared with the *Age of 14* coefficient reflects that the correlation between age and academic achievement is negative within grades.

The SES achievement gap is expressed in score points, in the first Y-axis, and as a percentage of a *SD* (20 score points) in the corresponding achievement measure in Grade 5, in the second Y-axis (see Figure 2.5 and Figure 2.6). The second Y-axis thus offers a benchmark for interpreting the size of the SES achievement gap over time. Figure lines are based on model estimates not accounting for retention in grade and the number of longitudinal observations, but these controls have a negligible effect on the relationship between SES and the growth trajectory (see Tables 2.6 and 2.7).

Family SES is positively related to reading and math performance at each age level from the age of 10 to 15 years (see Figure 2.5 and Figure 2.6). Students of higher SES families outperform students of lower SES families in these subject areas and throughout this life stage. At age 10, the estimated reading and math achievement gap associated with family SES amounts to 53% and 33% of a *SD* of these achievement measures in Grade 5, respectively. In other words, the gap in reading and math achievement related to family SES is considerable and, apparently, it is wider for reading than for math at the beginning of secondary school.

When the effect of SES is broken down, the evidence suggests that parental education and family wealth explain largely this effect. In particular, for a one *SD* change, the effect of mother's education, father's education, mother's vocational training, father's vocational training, and family wealth is equivalent to 7%, 5%, 1%, 2% and 15% of a *SD* in reading achievement, respectively. These effects are fairly similar for math (see Table 2.6). Interestingly, while mother's schooling has a stronger effect than father's schooling, father's vocational training is a better predictor of achievement differences among students than mother's vocational training.

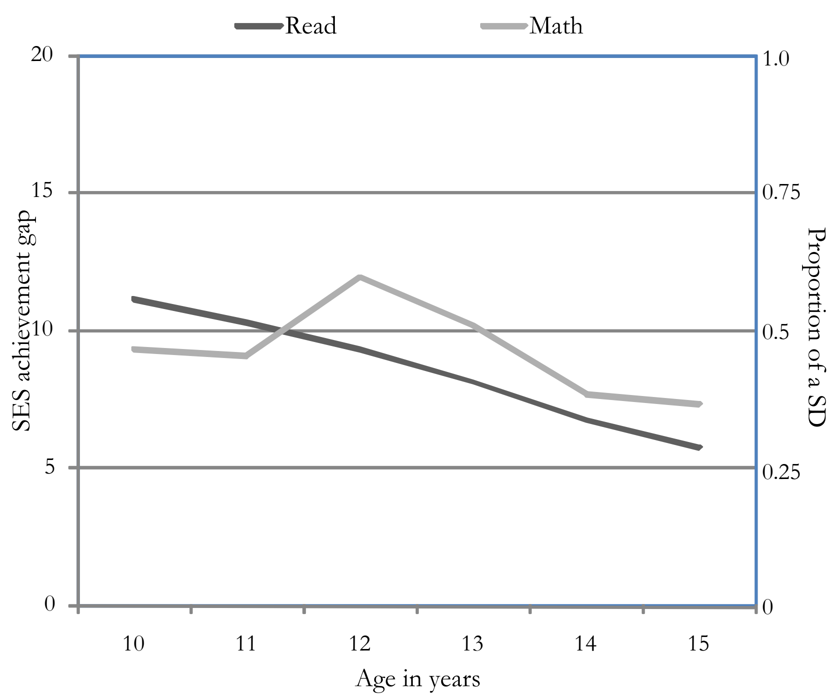
Table 2.7
Crossed-Random-Effects Model Predicting Reading and Math Achievement from *Specification 2*
(*N*=12,959; *B*=Unstandardized Coefficient; *SE*=Standard Error)

	Reading						Math					
	(1)		(2)		(3)		(1)		(2)		(3)	
Characteristic	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Intercept	119.70***	(0.52)	119.62***	(0.58)	119.18***	(0.60)	118.40***	(0.59)	118.38***	(0.64)	117.86***	(0.67)
Age in Months	6.00***	(0.04)	5.99***	(0.04)	4.68***	(0.09)	5.41***	(0.04)	5.39***	(0.04)	4.25***	(0.10)
Age in Months^2	-0.22***	(0.02)	-0.23***	(0.02)	-0.19***	(0.02)	-0.35***	(0.02)	-0.36***	(0.02)	-0.33***	(0.02)
Mother's Schooling	1.20***	(0.18)					1.16***	(0.17)				
Father's Schooling	0.95***	(0.16)					0.81***	(0.16)				
Mother's Vocational Training	0.10	(0.12)					0.19	(0.12)				
Father's Vocational Training	0.19*	(0.11)					0.24*	(0.13)				
Family Wealth Index	3.46***	(0.14)					2.71***	(0.14)				
SES			3.19***	(0.19)	3.02***	(0.19)			3.63***	(0.18)	3.35***	(0.18)
SES x Age in Months			-0.44***	(0.04)	-0.43***	(0.04)			-0.22***	(0.04)	-0.20***	(0.04)
SES x Age in Months^2			-0.02	(0.02)	-0.01	(0.02)			-0.14***	(0.02)	-0.13***	(0.02)
Control Variables	No		No		Yes		No		No		Yes	

* p<0.10, ** p<0.05, *** p<0.01.
Note. For ease of interpretation coefficients of Age in Months were multiplied by 10.

The SES reading achievement gap appears to narrow with age at a constant rate of change (see Figure 2.5). Indeed, the trajectory of this gap fits a linear function with a negative slope from the age of 10 to 15 years (see Table 2.7 and Figure 2.6). In particular, the gap narrows because students of lower SES families grow more rapidly in their reading skills than their higher SES peers. While students from the bottom SES quarter grow 36% in their mean reading achievement between the ages of 11 and 15, students in the top SES quarter grow in 25%. As a result, the SES gap in reading achievement shrinks 40% during this period.

Figure 2.5
Trajectory of the SES Achievement Gap: Estimates of *Specification 1*

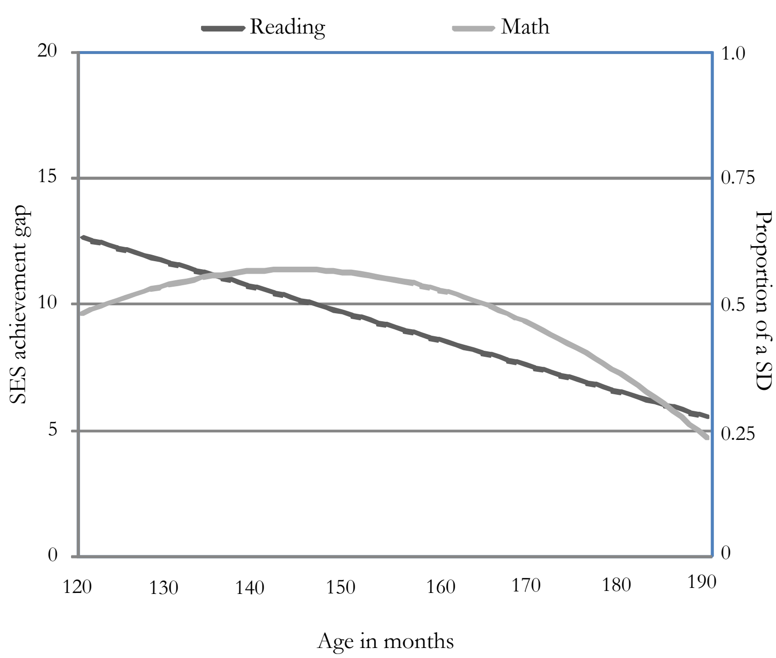


Note. The SES achievement gap between students in the top and bottom SES quartiles in the first Y-axis is expressed as a proportion of an achievement *SD* in the second Y-axis.

On average, the reading achievement gap narrows at a rate of 16% per year between the ages of 10 and 15. It amounts to about one-half *SD* of the reading achievement measure at the age of 10 and to about one-quarter of a *SD* of this measure at the age of 15 (see Table 2.6 and Figure 2.5). Thus, despite its narrowing, the SES achievement gap persists to a significant extent at the age of 15.

The math achievement gap associated with family SES follows a curvilinear trajectory (see Figure 2.5 and Figure 2.6). It fits roughly a quadratic functional form from the age of 10 to 15 years: it widens during the first two years and narrows thereafter (see Table 2.7 and Figure 2.6). Although the math achievement gap widens between the age of 10 and 12 years, students in the top and bottom SES quarters grow similarly (about 17%) in their mean math achievement score during this period. The gap widens due to initial achievement levels (age of 10), which are higher for students in the top SES quarter. This ought to be taken into account for making a fair comparison of the math achievement growth among SES groups.

Figure 2.6
Trajectory of the SES Achievement Gap: Estimates of *Specification 2*



Note. The SES achievement gap between students in the top and bottom SES quartiles in the first Y-axis is expressed as a proportion of an achievement *SD* in the second Y-axis.

As with the reading achievement gap, the math achievement gap between higher and lower SES students narrows from the age of 12 to 15 because of lower SES students growing more rapidly in their skills. For instance, students in the bottom and top SES quarter grow 11% and 6% in their mean math achievement score from the age of 12 to the age of 14 years. But, compared to the reading gap, the math gap narrows to a lesser extent (see Figure 2.5 and Figure 2.6). Math achievement differences among students in the top and bottom SES quarter also remain at the age of 15 and amount to about one-third of a *SD* of the math achievement measure in Grade 5 (see Table 2.6 and Figure 2.5).

Importantly, this pattern is not an artifact of ceiling limits on achievement levels or growth of higher SES students. At each grade level, achievement tests distinguish well among students in their math and reading abilities or achievement levels. The proportion of students achieving the maximum score in Grades 5, 7, and 9 is negligible for reading (1.6%, 0.6%, and 0.1%, respectively) and math (0.5%, 0.5%, and 0.1%, respectively). Also, within the academic track, the one with the highest SES level, the math and reading achievement distributions fit nicely a normal distribution and less than 3% of students achieved the maximum score in these measures.

The extent to which anchoring items[5] limit the growth of socially advantaged students was also examined. Table B4 and Table B5 in Appendix B report the percentage of students correctly answering reading and math anchoring items in Grades 7 and 9 by school form. Specific reading (A, B, and D) and math (B and C) anchoring items perform relatively poor at capturing growth in the academic track. Compared to other school forms, a smaller proportion of students exhibited growth in these items from Grade 7 to 9 and, in Grade 9, about 90% of students had mastered them. These non-growth-sensitive items seem to

[5] The items used in IRT to equate achievement scores over time in the scale.

impose ceiling limits to students in the highest SES school track. Nevertheless, unreported analyses show that the narrowing achievement gap between higher and lower SES students remains when these items are excluded from the estimation of reading and math IRT scores. Furthermore, the results are maintained when the raw score of math and reading anchoring items (excluding non-growth-sensitive items) are used as dependent variables.

2.5.5 Discussion

This study has examined the trajectory of the SES achievement gap with more advanced methods than in the past. First, three data points were used. Instead, previous studies rely largely on cross-sectional data or two data points, designs which either confound age and cohort effects or contain a very limited source of intra-individual variability to study change in the gap (Baltes et al., 1988; Glenn, 1977). Research has shown that with three data points the straight-line achievement growth model can be evaluated and the precision of the parameter estimates improves (Raudenbush & Liu, 2000; Rogosa, Brand, & Zimowski, 1982).

Secondly, the trajectory of the SES gap from the age of 10 to 15 years was estimated by means of crossed-random-effects, panel data, and hierarchical linear models. These techniques properly distinguish intra- and inter-individual variability. Furthermore, cross-random-effects models soundly account for within school variability in partially crossed designs (Bates, 2007). The longitudinal data (N = 12,959) from the city of Hamburg, Germany, are partially crossed because students can migrate between schools over time and therefore the multilevel structure breaks down. Cross-random-effects model efficiently handle large and partially crossed datasets and thus nicely correspond to the data. Previous methodological examinations have neglected the crossed nature of the data when modeling trends of the SES gap.

The method employed is innovative and advances prior research. While this is likely the main contribution to the literature, theoretical and policy intervention implications are also important. In line with the literature, the analysis shows that students aged 10-15 of higher SES families perform better in math and reading than their lower SES peers. Achievement differences related to family SES are primarily explained by parental education and family wealth influences. What is new and intriguing from results is that they reveal that the achievement gap among SES groups tends to narrow during secondary school years.

On the one hand, the reading achievement gap between higher and lower SES students narrows at a constant rate of change from the age of 10 to 15 years because lower SES students increase their reading skills at a faster pace than higher SES students. On the other hand, the math achievement gap widens from the age of 10 to 12 years and narrows thereafter. The initial widening is explained, however, by superior achievement levels of higher SES students at the beginning of secondary school and not by constant differential achievement growth. In fact, from the age of 12 to 15 years, lower SES students grow similarly or more rapidly than higher SES students. And, ultimately, the math achievement gap attributed to SES slightly narrows during this period.

These findings are fairly robust with respect to different model specifications and regression techniques suited for this investigation. Nonetheless, they are not in accordance with what most studies anticipate (e.g., Alexander, Entwisle, & Olson, 2001, 2007; Becker et al., 2006; Condron, 2007; Guo, 1998; Kerckhoff, 1993), namely, that the gap between students of high and low SES families widens with age. Scholars invoke structural and cultural theories related to the effect of tracking policies, the summer break, and the effort students place in school to explain increasing inequalities among SES groups. The relative validity of these theories was not tested here. The results suggest, however, that while all these processes may well occur in Hamburg schools, stronger forces lead to a narrowing SES gap as students progress through secondary school.

The specific mechanisms generating the pattern of decreasing inequalities were not investigated and therefore conclusions are best considered speculative. That said, the narrowing gap can be understood in light of the distinctive characteristics of the Hamburg educational system. As with the rest of Germany, students in Hamburg are placed into different school forms at a relatively early stage (end of Grade 4). Hamburg has, however, relatively open and egalitarian school tracking policies. For instance, selection of students into schools is apparently less socioeconomically biased than normally occurs in educational systems with explicit school tracking policies: Hamburg has the largest percentage (10%) of students of non-German nationality in the academic track in relation to other federal states in Germany. And, in addition to the traditional three school tracks, Hamburg includes a comprehensive school form with internal setting by subject and differential leaving certificates. Approximately 30% of students attend this school form. Also, Hamburg's school system includes an *observational* stage (Grades 5 and 6) in which no distinction is made between the lowest and intermediate track and students from lower tracks can be promoted into the academic track.

Furthermore, teachers in Hamburg schools are known for practicing adaptive teaching techniques with variable teaching aims. Not only in the academic track but in every school form, they seek to reach out to all students, regardless of their migration background and family SES. To this end, teachers place a particular emphasis on the learning of disadvantaged students and on how they can catch up with the rest. Apparently, students of low SES families and, in general, those in the lower end of the ability distribution benefit from teacher practices that focus on their particular needs (Lehmann, Gänsfuß, & Peek, 1998). Altogether, the combination of these school tracking policies and teacher practices are, apparently, conductive to fostering the growth of low SES students and thus explain the narrowing trend of the SES gap.

The case of Hamburg is interesting because typically explicit school tracking tends to benefit students of high SES families. Overall in Germany, for example, students of high SES families are disproportionally placed in relatively homogeneous groups, classes with more qualified teachers, and are exposed to richer curricula. Due to these advantageous learning conditions, they develop their skills at a faster pace than students of low SES families (Becker et al., 2006; Becker & Schubert, 2006). In contrast, lower SES students in Hamburg grow either similarly or more rapidly than their higher SES peers. They seem to benefit from a less socioeconomically biased tracking system accompanied by egalitarian school policies and practices.

And yet, while these policies seem to narrow the SES gap, they also seem to constrain the growth of students of high SES families. Particularly, because students of high SES families are placed into relatively heterogeneous schools, together with low SES students and immigrant students, they seem to lose from these locations or face a ceiling in the growth of their skills. Hamburg's educational system may be introducing this ceiling for the sake of reducing inequalities across SES lines. In other words, Hamburg seems to sacrifice its overall performance for a more equal distribution of educational opportunities among SES groups. How profoundly more open and egalitarian educational policies can reduce socioeconomic inequalities? To which extent this is achieved at the expense of lower overall educational quality? Which specific educational policies contribute to the gap narrowing? These are all relevant questions that deserve the attention of future research.

Also, competing hypotheses need to be taken into account. One is that the SES achievement gap begins to narrow as students of higher SES families get close to tapping out the top of the test and begin to learn other skills in the curriculum that may not be well covered in the math and reading standardized achievement tests. Thus, students of lower SES families may be catching up on the test by learning more of the predominantly basic-skills content that students of higher SES families have already mastered. There is, however, no evidence of ceiling limits imposed by the tests on the achievement levels or growth of higher SES students. Even within the academic track the percentage of students achieving the maximum score is negligible. And, while it is true that certain anchoring items perform relatively poor at capturing growth in the academic track, the results are maintained even when these are excluded from the estimation of the final reading and math scores.

Another rival hypothesis is that the sample and data attrition that occurred tended to favor the achievement growth of students of lower SES families, because the retained students were likely to be disproportionately represented within the lower SES group. Thus, the poorest performing students would be falling out of the lower SES sample at greater rate than from the higher SES group. Excluding these students may distort estimates of the trajectory of the gap. While this is a shortcoming of the design, not only students are lost but also new students from other cohorts enter the study because of retention. And, socioeconomic characteristics of students who drop out and enter the sample over time are fairly similar. Also, models control for retention in grade and the number of data points to counteract this effect. Overall, however, evidence to rule out ceiling effects and the potential bias due to retention in grade might not be sufficient and so these data restrictions remain somewhat a limitation of this case study.

3. ACHIEVEMENT GROWTH AND SCHOOL TRACK RECOMMENDATIONS

Several European countries track students into different school types in the transition from primary to secondary schooling. Tracking decisions have profound and lasting consequences for future educational and professional careers of students. Their underlying mechanisms are therefore of great interest to education researchers and policy makers. Extensive research has documented that school track placements are largely influenced by prior academic performance of students and that family SES plays an additional role in that parents with high levels of education or employed in high-prestige occupations tend to enroll their children in the academic track (i.e., the track leading to college education) irrespective of their school performance (Baumert & Schümer, 2001; Bos et al., 2004; Ditton, 2007; Ditton & Krüsken, 2006; Lehmann & Peek, 1997; Merkens & Wessel, 2002; Schnabel et al., 2002). Boudon's theoretical model is often invoked to frame family SES and academic performance influences at this transitional point (Boudon, 1974; Maaz et al., 2008a).

Next to academic achievement levels and family SES, recent research has shown the influence of aspects such as cultural capital (Condron, 2007), class and school composition characteristics (Tiedemann & Billmann-Mahecha, 2007; Trautwein & Baeriswyl, 2007), and gender (Updegraff, Eccles, Barber, & O'Brien, 1996) on the tracking decision. The literature, however, has neglected the role of academic achievement growth in track recommendations, in spite of increased attention of educational researchers in growth rather than status in learning (Willet, 1988). In the words of Willet (1988) "The very notion of learning implies growth and change" (p. 346). Conceptually, the distinction between achievement levels and growth has important implications for the research on school tracking. Whereas achievement levels reflect, to a substantial extent, innate ability and other individual attributes, achievement growth reflects better the capacity of students to acquire skills over their school careers and their potential for academic success.

The German Education Ministers' decree for primary school level establishes that irrespective of a child's origin, he/she shall enter a path of the education system in accordance with his/her capacity to acquire skills, aptitude, disposition, and its will to intellectual work (Sekretariat der Ständigen Konferenz der Kulturminiser der Länder in der Bundesrepublik Deutschland, 2006). Thus, from a theoretical and policy perspective, the question arises, whether the capacity to acquire skills is valued for school track placements. In this regard, this section adds to the research on school tracking by evaluating whether teachers reward the achievement growth of students, over and above their other often involved characteristics, while issuing track recommendations. The guiding question is: Are students who have grown more rapidly in their skills more likely to be recommended to the academic track and therefore benefit from further educational opportunities irrespective of their background and initial achievement levels?

Secondary research questions are: How is achievement growth affected by socioeconomic and demographic characteristics? To what extent does family SES affect school track recommendations indirectly via academic achievement and directly when achievement is controlled? What are the specific gateways for the effect of SES? Are students with immigrant background less likely to obtain a recommendation for the academic track once family SES and academic achievement are controlled? What is the effect of reference group characteristics on school track recommendations? They are addressed using three measurement points from the Berlin study ELEMENT (Grades 4, 5, and 6). ELEMENT official reports can be consulted in Lehmann and Nikolova (2005) and Lehmann and Lenkeit (2008).

The analysis proceeds in two stages. First, predictors of achievement growth were evaluated and reliability-adjusted measures of individual growth were estimated. Secondly, antecedents of school track recommendations were identified, placing emphasis on the role of achievement growth. These analyses helped clarify how school track recommendations are affected by individual, family, and school factors. Methodological examinations are innovative and advance prior research in various respects. Data are more recent and include a greater source of intra-individual variability than were possible in past studies (i.e., three measurement points as opposed to two measurement points or cross-sectional designs). Estimates of achievement growth were adjusted for reliability with the Bayes estimator.

The remainder of this section is organized as follows. Firstly, it describes tracking policies in Germany overall and in Berlin in particular. Secondly, it discusses theories regarding the antecedents of school track placements. Thirdly, it describes the data, dependent variables, independent variables, and the analytical strategy. Fourthly, it reports the results of longitudinal and multilevel models of achievement growth and school track recommendations, respectively. Finally, the last subsection discusses main findings, limitations, and recommendations for further research.

3.1 Tracking Policies in Germany[6]

The Standing Conference of the Ministers of Education and Cultural Affairs of the Federal States in the Federal Republic of Germany (*Kultusministerkonferenz*) has issued some

[6] The reader may consult section 2.5.1 for an overview of the German educational system.

policy guidelines for the transition from primary school to the different forms of secondary schooling. They state that the decision as to which track a child enters after primary school is not to be based on the outcome of a single examination, but should pay respect to evidence collected on a period of time during which teachers had sufficient opportunities to judge the child's suitability for one of the secondary school tracks. Each child should, irrespective of his/her family SES, enter a suitable track in accordance with his/her capacity to acquire skills, aptitude, disposition, and his/her will to perform intellectual work (Sekretariat der Ständigen Konferenz der Kulturminiser der Länder in der Bundesrepublik Deutschland, 2006).

In practice, all federal states have determined that the decision for a certain secondary track be mainly based on an overall grade given by teachers at the end of primary school. Federal states differ, however, with respect to the grade range associated with each recommendation and with the composition of this grade, namely, apart from the school years covered, the consideration and weighting of school subjects. They also differ with regard to the number and forms of offered secondary tracks, ultimate parental rights of decision or co-decision, opportunities to revise the final decision for a secondary school track, and with regard to the diagnostic evidence required, e.g. standardized achievement tests or a detailed primary teacher reports (Ditton & Krüsken, 2006; Sekretariat der Ständigen Konferenz der Kulturminiser der Länder in der Bundesrepublik Deutschland, 2006).

3.1.1 Tracking Regulations in Berlin

In Berlin the majority of children start secondary schooling after Grade 6, while less than approximately 10% of the age cohort enter the academic track (*Grundständiges*

Gymnasium) after Grade 4 already. For those starting secondary school in Grade 7, the initial decision as to which track a child enters lies within the hands of the parents. Nevertheless, teachers have to articulate a school track recommendation for each child at the end of Grade 6. They are not legally binding, but parents in most cases decide accordingly (Lehmann & Lenkeit, 2008, Arnold, Bos, Richert, & Stubbe, 2007). The receiving secondary school, however, is allowed to reject a child if discrepancies with the given recommendation occur (Grundschulverordnung, 2005; Maaz et al., 2008b).

Specific regulations for this recommendation are issued by the Berlin Senate. The school track recommendation is intended to be given on the basis of the child's performance and the observed competencies. Since 2002 the estimation of a child's suitability for one or the other track is determined by the grades in core subjects from school years 5 and 6, which are averaged to an overall grade. Thus, grades from the subjects German, first foreign language, mathematics, and science are accounted for twice. Up to an overall grade of 2.2, recommendation for the academic track is granted. Students within the range of 2.8 to 3.2 receive a recommendation for the intermediate track, while in case of an overall grade equal to or lower than 3.8, a recommendation for the lowest track is mandatory. In cases where overall grades fall in between these ranges, teacher's assessment of the student's learning skills is decisive (Grundschulverordnung, 2005). According to this scheme, school track recommendations are essentially linked to students' academic performance as reflected in school grades (Thiel, 2008).

3.2 Factors Affecting School Track Recommendations

When discussing social inequality in educational careers, different stages of transition are viewed as an important source of this inequality. In any form of tracking, there are normally higher percentages of students from advantaged backgrounds attending the more demanding and qualifying tracks. Social selectivity in the transition process has been well documented in the research literature, not only in the German context, with its explicit between-school tracking (e.g. Arnold et al., 2007, Ditton & Krüsken 2006, Lehmann & Peek 1997), but also in other national contexts, where tracking is established more implicitly (e.g. Caro, McDonald, Willms, in press; Condron, 2007; Dauber, Alexander, & Entwisle, 1996; Schnabel et al., 2002).

Boudon (1974) distinguished primary and secondary effects of family SES to characterize the diverse mechanisms by which inequalities are amplified at points of transition. For example, in the transition from primary to secondary school, primary effects are all those expressed via the impact of family SES on academic achievement which, in turn, affects school track recommendations issued by teachers. And secondary effects are those expressed via disparate educational choices among students of comparable achievement levels but of differing family SES. While primary effects largely explain the influence of family SES on school track placements in Germany, secondary effects are also significant (Arnold et al, 2007; Ditton, Krüsken, & Schauenburg, 2005; Ditton & Krüsken, 2006; Tiedemann & Billmann-Mahecha, 2007). But they appear to be less critical for teacher's school track recommendations. Baumert and Schümer (2001), Ditton et al. (2005) and Ditton and Krüsken (2006) showed that parents' aspirations for their children's careers depend less on academic achievement than do teachers' recommendations, leaving secondary effects of social reproduction mitigated by the latter.

Using the LAU data, Lehmann and Peek (1997) found that teachers generated different *critical values* for the academic track recommendation for different groups of students. Students from lower SES backgrounds on average had to reach higher levels of achievement than those from more advantaged background to obtain a recommendation for the academic track. These effects were also found by Bos and Pietsch (2005) in the census study KESS (*Kompetenzen und Einstellungen von Schülerinnen und Schülern*). They are more than often mediated by the school grades given by teachers and upon which the track recommendations are based.

Although in Germany recommendations seem to be based mainly on achievement, that is, the given grades (Arnold et al., 2007; Ditton et al., 2005; Ditton & Krüsken, 2006; Kristen, 2002; Lehmann & Peek, 1997), teachers also include other characteristics in this complex diagnostic decision. Arnold et al. (2007) found that the perceived parental involvement in school issues, educational valuation, and the cultural fit are also considered. Moreover, the influence of several characteristics of a social and cultural nature has been established. There is, however, no consensus on whether the sources of those effects are intentionally discriminating teachers or whether they should be interpreted as more or less subconsciously perceived general dispositions and aptitudes, which teachers, like any other person, are not immune against.

In Germany, students with migration background are, on average, of an academically less successful group and often have highly adverse educational careers. But, despite common belief, migration background of students in and of itself does not seem to affect track recommendations. After controlling for general cognitive competences and achievement scores, Arnold et al. (2007), Ditton et al. (2005), Kristen (2002, 2006), and Tiedemann and Billmann-Mahecha (2007) could not make out significant effects on the given grades or on track recommendations. Furthermore, Lehmann and Peek (1997) found smaller *critical values* for children with migration background for an academic track recommendation. They also found that females were more likely to obtain a recommendation to the academic track when their academic achievement levels were controlled. Additionally, Arnold et al. (2007) and Trautwein and Baeriswyl (2007) found moderate effects for academic self-concept, fear to fail, and willingness to make an effort after controlling for academic achievement.

Overall, it thus seems that track recommendations are mainly based on academic achievement levels. However, this impression has to be relativized in the sense that recommendations are mainly based on grades given to the students, which in turn are highly dependent on the average ability in the class. Already in some *classical* analyses (Marsh, 1978; Ingenkamp, 1969), and more often still in recent investigations (e.g. Ditton et al., 2005; Lehmann & Peek, 1997; Trautwein & Baeriswy, 2007; Treutlein, Roos, & Schöler, 2008) a systematic negative relationship between the average academic achievement of a class and the given individual grade has been revealed. Given two students with comparable ability, the one in a relatively low achieving class receives a better grade than the one in a high achieving class. This is due to teachers evaluating students with reference to the group they teach rather than with regard to external criteria such as performance standards or competency levels. To the extent that teachers' track recommendations are based on grades, students with similar competencies may receive different track recommendations. Reference group effects are one of the main sources leading to the broad overlap of competencies observed in and between the secondary school tracks in Germany.

In another study, Kristen (2002) examined whether the composition of the class with regard to migration background shows similar effects. She found that chances to receive a recommendation for the academic or intermediate track decrease with increasing percentage of students with migration backgrounds in the class while controlling for achievement. Instead, Lehmann and Peek (1997) found that chances to receive an academic track recommendation decrease with decreasing percentage of students with migration background in the class and Tiedemann and Billmann-Mahecha (2007) found no such effects at all. Moreover, the latter found beneficial effects of an averagely disadvantaged class composition with regards to socioeconomic background for chances to receive an academic track recommendation.

3.3 Data

The data stem from the German longitudinal study ELEMENT (*N* = 4,925; Lehmann & Nikolova, 2005; Lehmann & Lenkeit, 2008). In the years 2003 to 2005, ELEMENT gathered academic achievement, socioeconomic, and demographic information of students in Berlin at the beginning of Grade 4, end of Grade 5, and end of Grade 6. The study covered 3,168 untracked students (64%) and 1,757 (36%) students already assigned to the academic track (*Grundständiges Gymnasium*). Because this study is, among other things, concerned with the mechanisms underlying track recommendations at the end of Grade 6, i.e., the regular point of transition in Berlin, students in the academic track are not part of the target population. Also, out of the original sample (*N* = 3,168), students with less than three time point observations (27%) and those who have attended different classes over time (2%) are excluded in order to obtain reliable information on growth and to allow for teachers to observe the progress of students over these grades prior to their recommendations, respectively. The sample available for analysis consists of 2,242 students.

Although students excluded from the original sample come, on average, from less advantaged backgrounds and have lower academic achievement, differences between the original sample and the analytic sample are very small (see Table C, Appendix C). For instance, the percentage of foreign students (25% versus 26%), the percentage of German students with immigrant background (10% versus 11%), the percentage of females (48% versus 49%), the average parental occupational status (46.3 points and 46.9 points), and the average SES (0 points and 0.03 points) are notably similar. Sample attrition is therefore unlikely to have seriously biased model estimates.

Missing values were imputed for mother's education (26%), father's education (28%), mother's vocational training (25%), father's vocational training (27%), family's occupational status (25%), and track recommendations (11%). Multiple imputation methods were used to predict missing values of these variables from the available data (including dependent variables). In particular, multiple imputation by chained equations (MICE) was carried out to generate 5 imputed versions of the raw data (Royston, 2004, 2005) and Rubin's rule (1987) was applied to estimate standard errors that account for missing data uncertainty. Mean and standard errors of dependent and independent variables are reported in Table C, Appendix C.

3.3.1 Dependent Variables

Math achievement. This variable is derived from a battery of 49 selected items from the LAU study in the city of Hamburg (Lehmann et al., 1998), the IGLU study (Bos et al., 2003), and the QuaSum study in the federal state of Brandenburg (Lehmann et al., 2000). Essentially, test items measure skills in arithmetic and geometry. They were scaled using IRT with 15 over-lapping items vertically equated to create a longitudinally comparable scale suited to assess student growth. Math IRT scores (*M*=100, *SD*=15) are reliable (*a*=0.92).

Math school grade. They are math school grades given by teachers in Grade 6. Scores range from 1 to 6, where 1 indicates best performance.

Track recommendation. It is a dichotomous variable distinguishing academic track recommendations (value of 1) from recommendations to lower tracks (value of 0).

3.3.2 Independent Variables

Basic cognitive abilities. Two sub-tests including 44 items of the *Basic Cognitive Skills Tests* (KFT for the abbreviation in German; Heller & Perleth, 2000) evaluate basic cognitive skills of students by the end of Grade 4. Specifically, they assess verbal and figurative reasoning and provide an indication of fluid intelligence. The complete version of the test is reliable (*a*=0.93). Here, the basic cognitive skills variable is the raw score (0 to 44).

Age. It is the age of the student in years.

Sex. It is a dichotomous variable distinguishing females (value of 1) from males (value of 0).

Parental schooling. Parents reported their highest level of schooling. Responses were classified into: (1) none /special education, (2) secondary school – lowest track, (3) secondary school – intermediate track, (4) admission level for technical college, and (5) admission level for university. The parental schooling variable is the higher schooling level of either parent.

Parental vocational training. Parents were asked if they had obtained any vocational training certificate: (0) no training certificate, (1) apprenticeship certificate, (2) college or commercial school certificate, (3) technical college, master craftsman, or technical school certificate, (4) technical degree or diploma, (5) university degree, and (6) doctoral degree. The mother's and father's vocational training variable corresponds to the highest vocational training certificate obtained, where *no training certificate* (value of 0) is the lowest certificate and *doctoral degree* the highest (value of 6). The parental vocational training variable is the higher level of vocational training of either parent.

Parental occupational status (HISEI). Occupational data for both the father and the mother were obtained with open-ended questions. Lehmann and Nikolova (2005) classified these responses in accordance with Erikson, Goldthorpe, and Portocarero (1979) and then mapped them to the International Socioeconomic Index of Occupational Status (ISEI; Ganzeboom, de Graaf, & Treiman, 1992). HISEI corresponds to the higher ISEI score of either parent. Scores range from 16 to 85, where higher values indicate a higher occupational status.

Family SES. It is a composite measure of 5 variables: mother's education, father's education, mother's vocational training, father's vocational training, and parental occupational status (HISEI). Principal component analysis was applied to these data to obtain a single SES variable. The SES index was standardized to have a mean of 0 and a *SD* of 1 for the student population represented by the analytic sample.

Migration background. Two dichotomous variables were created to distinguish German students with migration background and foreign students from German students without migration background (reference group). Lehmann and Nikolova (2005) used data on German citizenship, the student's mother tongue, language spoken at home, and the country of birth of the student, and his/her parents to define these categories.

3.4 Two-Stage Analytical Strategy

In a first stage, growth models of math measurements (level 1) nested within students (level 2) were estimated to characterize individual achievement growth trajectories and examine the effect of various socioeconomic and demographic variables on math achievement growth. Also, reliability-adjusted measures of initial achievement level and achievement growth were calculated for each student with the Empirical Bayes (EB) estimator. Potential sources of bias due to ceiling effects, achievement growth measuring ability rather than skills, and regression toward the mean were also considered.

In the second stage, multilevel models of students (level 1) nested within classes (level 2) were estimated to evaluate the effect of achievement growth (EB), achievement levels (EB), family SES, migration background, gender, and group reference characteristics on the formation of teacher's track recommendations. In particular, predictors of the math school grades given by teachers in Grade 6 and of the probability of obtaining a recommendation to the academic track were evaluated. The analyses place special attention to the influence of the EB estimate of achievement growth in math.

3.5 Math Growth Curves

Table 3.1 reports estimates of math growth models. Independent variables were grand-mean centered and age was centered at 10 years to have a meaningful intercept and reduce the degree of multicollinearity arising from the correlation between age and its squared term. The initial status (intercept) can be interpreted as the expected value of math achievement at age 10 given a student population with average characteristics in independent variables. The growth rate (age coefficient) is the rate of change in math achievement at age 10. The acceleration parameter (age-squared coefficient) captures the acceleration in the entire growth trajectory. Random effects were introduced for the initial status and growth rates to allow for these parameters to vary among students.

Table 3.1
Math Learning Curves: Predictors of Initial Status and Growth
(Unstandardized Regression Coefficients)

Fixed Effects	(1)	(2)	(3)	(4)	(5)
Initial Status (Intercept)	92.01***	91.08***	91.08***	91.07***	91.26***
Family SES			5.95***		
Parental Schooling				2.20***	1.94***
Parental Vocational Training				-0.01	0.10
Parental Occupational Status				0.25***	0.19***
German with Migration Background (ref: German)					-5.58***
Foreign (ref: German)					-5.95***
Sex (Female=1)					-5.29***
Growth Rate (Age)	9.59***	11.28***	11.25***	11.26***	11.01***
Family SES			0.79***		
Parental Schooling				0.30*	0.32
Parental Vocational Training				0.07	0.07
Parental Occupational Status				0.02	0.02
German with Migration Background (ref: German)					-0.34
Foreign (ref: German)					0.02
Sex (Female = 1)					0.74***
Acceleration Rate (Age^2)		-0.56***	-0.55***	-0.55***	-0.47***

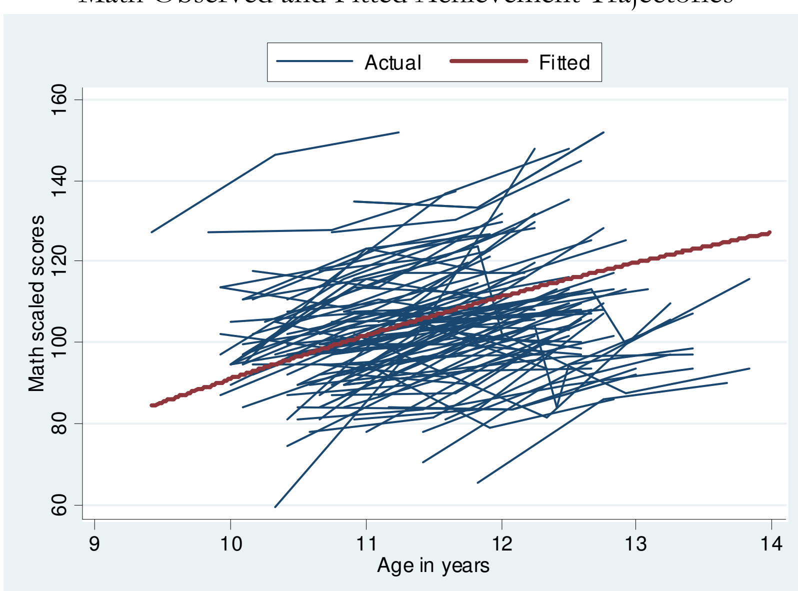
Random Effects			*SD*		
Intercept	13.14***	13.56***	12.20***	12.29***	11.70***
Age	2.95***	2.75***	2.62***	2.64***	2.66***

*** p<0.01, ** p<0.05, * p<0.10
Note. Sample consists of 2,242 students. All variables were grand mean centered. Five imputed datasets account for missing data uncertainty and cases were weighted to represent the student population.

Students grow significantly in their math skills as they advance in school from Grade 4 to 6. Measured by the growth rate coefficient, they grow in 9.6 score points per year, that is, two-thirds of a *SD* of the math measure (see model 1 in Table 3.1). But they do not grow at a constant rate of change over this period. The negative estimate of the acceleration parameter (see model 2 in Table 3.1) indicates a curvilinear growth trajectory, i.e., that students grow in their math skills at a decreasing rate of change. The rate of change decelerates on average 12% per year, from 11.3 score points at the age of 10 to 7.9 score points at the age of 13.

Figure 3.1 depicts actual growth trajectories for 100 students randomly selected from the population and the fitted trajectory for the population of students. As expected, the fitted line shows a slightly curvilinear growth curve. Additionally, observed growth trajectories anticipate significant variation in initial achievement levels and growth rates among students. Initial achievement levels and growth slopes differ among students. Model estimates confirm that variation around the grand mean of the initial status and the growth rate is statistically significant (see random effects in Table 3.1).

Figure 3.1
Math Observed and Fitted Achievement Trajectories



Note. Observed trajectories are for 100 students randomly selected from the population. HLM estimates of the initial status, growth rate, and acceleration rate parameter of the math growth curve were used to construct the fitted line (see model 2 in Table 3.1).

3.6 Predictors of Initial Status and Math Growth

Because random effects for the initial status and growth rate are statistically significant, it is possible to model inter-individual variation in these parameters. Models 3 to 5 in Table 3.1 include stepwise socioeconomic and demographic independent variables to evaluate their effect on the initial status and achievement growth of students. Family SES is positively related to initial achievement levels. For 1 *SD* increment in SES, math achievement increases in 5.95 score points (see model 3 in Table 3.1), that is, in about 40% of a *SD* of the math measure. Furthermore, results of model 3 (see Table 3.1) indicate that family SES contributes to higher growth rates. Measured by the reduction of the *SD* of the growth rate random component, SES accounts for 5% of the differences in growth among students.

When the effect of family SES is broken down (see model 4 in Table 3.1), the relationship between SES and initial achievement levels is found to be mostly driven by parental schooling and parental occupational status. Children whose parents have attained higher educational levels or are employed in higher-prestige occupations have higher achievement levels. For 1 *SD* increment in parental education and parental occupational status, math achievement increases in 2.7 and 3.9 score points. There is weak evidence that parental education contributes to explain the relationship between family SES and achievement growth. The parental education coefficient is positive but significant at 10% only (see model 4 in Table 3.1). Otherwise, none of the SES characteristics have a statistically significant effect on the growth rate when evaluated separately.

Irrespective of their family SES, children with migration background perform worse in math than those without migration background. Differences in math achievement attributed to migration background when SES is controlled amount to about one-third of a *SD* of the math measure and are thus considerable (see model 5 in Table 3.1). There are no apparent differences in growth rates related to migration background. Girls have lower achievement levels than boys but, interestingly, they grow in their math skills at faster rates (see model 5 in Table 3.1). Gender differences at the age of 10 amount to one-third of a *SD* of the math achievement measure and reduce in about 40% by the age of 13.

Growth differences remain statistically significant when family SES, migration background, and sex are controlled. Yet, limited intra-individual variation in math achievement due to the three data point design precludes evaluating predictors of growth comprehensively.

3.7 Empirical Bayes Estimates of Initial Status and Growth

The EB or *shrunken* estimator is applied to model 1 (see Table 3.1) to obtain individual measures of initial status and growth. Essentially, the EB estimator penalizes Ordinary Least Squares (OLS) estimates for reliability. Its calculation is such that highly reliable OLS estimates of the initial status/growth tend to their individual values and unreliable OLS estimates are *pulled* towards the grand mean estimate (Lindley & Smith, 1972; Raudenbush & Bryk, 2002). Random effects in model 1 enable Bayesian *shrinkage*.

The reliability of OLS estimates of the initial status and the growth rate is 0.69 and 0.35, respectively, indicating that the individual estimate of the initial status is fairly precise and that growth rates are estimated with less precision. In this regard, while the longitudinal design of three math occasions spaced one year apart provides a greater source of intra-individual variability than in most past studies, it is still limited for reliably measuring growth. As a result, reliability-adjusted measures of individual growth calculated with the EB estimator will be biased towards the grand mean. Only with more data points and greater spacing between waves the reliability of the growth measurement can be improved (Willet, 1988).

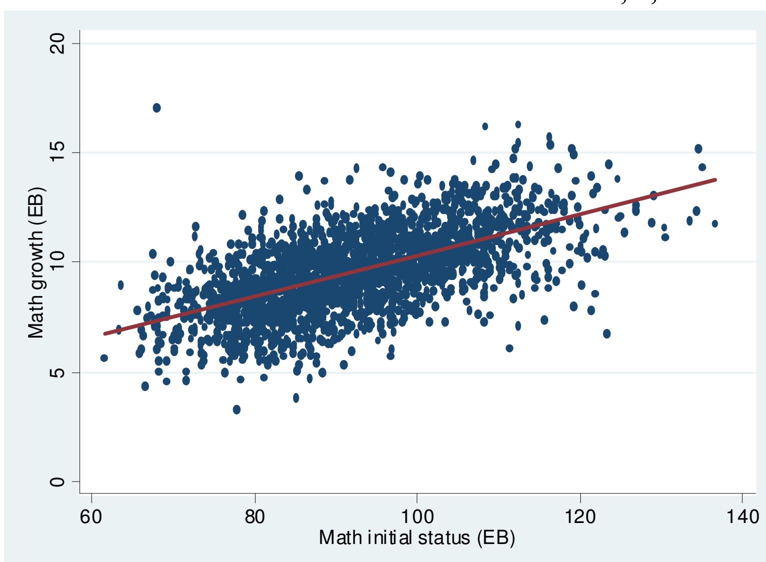
While the calculation of the initial status estimate depends only upon the OLS initial status estimate and its reliability, the individual math growth estimate depends upon the OLS individual growth estimate, the OLS initial status estimate, and their corresponding reliabilities. In cases where the initial status and achievement growth are highly correlated, EB estimates of math growth can be equally affected by the OLS math growth estimate and the OLS initial status estimate, thereby making their behavior and interpretation more complex (Raudenbush & Bryk, 2002). Also, the correlation between the initial status and growth varies for different choices of the time at which initial status is measured. Thus, the value of age for the initial status should be chosen for substantive reasons and needs to be declared. Here, the initial status was set at age 10, when most students attended Grade 4. At this point, the correlation between the initial status and math growth derived from model 1 (see Table 3.1) is 0.18. To the extent that the correlation is small, the calculation of the math growth EB estimate is fairly independent of the calculation for the initial status EB estimate.

3.8 Potential Sources of Bias

At least three sources of bias need to be considered when estimating individual measures of achievement growth and their effect on school track recommendations. The first is *ceiling effects* in math growth. That is, that the math test was not sufficiently difficult to capture growth of best performing students. If this source of bias were present, one would expect a negative relationship between initial status and growth.

Figure 3.2 depicts the relationship between the initial status and growth based on the EB estimates. Each dot represents a student and his/her math initial status and growth rate. The fitted line is the linear prediction of math growth using the initial status solely. Clearly, students starting with a higher initial status tend to grow more rapidly in their math skills. To the extent that initial status and growth are positively related, it can be somewhat ruled out that estimates of growth effects on school track recommendation models are an artifact of ceiling effects.

Figure 3.2
Initial Status and Math Growth over Grades 4, 5, and 6



Theoretically, the fact that the initial status and growth rate are correlated is not surprising because a student's status is a consequence of his/her growth history. Since each variable contains information about the other, an *ability bias* may arise if ability information embedded in the initial status is also reflected in the growth estimate. Growth effects on school track recommendations would confound both ability and skill effects. Although the initial status and growth rate are positively related (see Figure 3.2), the relationship is not deterministic. A considerable number of students start with low achievement levels and exhibit relatively high growth rates and vice versa, suggesting that growth reflects other aspects besides achievement levels. Furthermore, school track recommendation models in the next subsection control for basic cognitive abilities and the initial status to counteract this source of bias.

The third source of bias is *regression toward the mean*. It occurs when scores far from the mean in a first observation tend to regress towards the mean in subsequent observations. This phenomenon is most apparent in two time point study designs, where most lucky and unlucky students on the first test will perform worse and better on the second test, respectively. If present, it gives the false impression that growth rates are higher for worst performers and lower for best performers on the first evaluation. Here, the longitudinal design of three measurement points and the use of Bayesian shrinkage limit the effect of extreme unreliable scores on the growth rate and so counteract this source of bias.

3.9 Achievement Growth and School Track Recommendations

OLS and logistic multilevel models of students (level 1) nested within classes (level 2) were estimated to evaluate the effect of achievement growth and other variables on the math school grades given by teachers by the end of primary school and on the probability of obtaining a recommendation to the academic track, respectively. For ease of interpretation of effect sizes, all except dummy variables were standardized to have a mean of 0 and *SD* of 1. Also, due to the German grading scale (1 to 6), where lower school scores represent better school performance and vice versa, the dependent variable is the negative value of math school grades. Estimates of math school grade models and school track recommendation models are reported in terms of unstandardized regression coefficients and odds ratios in Table 3.2, respectively.

Irrespective of math initial achievement levels and basic cognitive skills, math growth contributes to better math school performance and, in turn, to obtain a recommendation to the academic track. For 1 *SD* increment in math growth, math school grades increase in 0.24 score points and the probability of obtaining a recommendation for the academic track increases by a factor of 1.61 (see models 1 and 6 in Table 3.2). While the importance of math growth to primary school exit grades and the track recommendation is considerable, the contribution of initial achievement levels is even more pronounced. For 1 *SD* increment in the math initial status, math school grades increase almost by one-half point and the probability of being recommended to the academic track increases by a factor of 3.93 (see models 1 and 6 in Table 3.2). The impact of the math initial status on the track recommendation is 2.4 times as large as the impact of math growth.

Table 3.2
Math Growth and the Formation of School Track Recommendations

	Math School Score in Grade 6 (Scale Reversed)					Track Recommendation (Gymnasium=1)				
	Beta					*Odds ratios*				
Student Level	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Basic Cognitive Abilities	0.13***	0.13***	0.13***	0.12***	0.12***	1.67***	1.69***	1.64***	1.54***	1.55***
Math Initial Status (BE)	0.45***	0.46***	0.45***	0.49***	0.52***	3.93***	4.22***	3.87***	5.39***	5.55***
Math Growth (BE)	0.24***	0.24***	0.24***	0.22***	0.23***	1.61***	1.70***	1.62***	1.62***	1.63***
Initial Status X Growth		-0.04***	-0.04***	-0.05***	-0.04***		0.74***	0.75***	0.74***	0.74***
Family SES			0.05*					1.80***		
Parental Schooling				0.07	0.07**				1.23***	1.24***
Parental Vocational Training				-0.01	0.00				1.21**	1.21**
Parental Occupational Status				-0.01	0.00				1.25**	1.26**
German with Migration Background (ref: German)				0.24***	0.18***				1.65***	1.45***
Foreign (ref: German)				0.23***	0.17***				1.24**	1.08
Sex (Female=1)				0.18***	0.18***				3.31***	3.34***
Class Level										
Mean Math Initial Status					-0.18***					0.85**
Foreign/German with Migration Background (%)					0.01					1.13**

*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Note. Sample consists of 2,242 students. Effect sizes of all except dummy variables are for one *SD* change. Five imputed datasets account for missing data uncertainty and cases were weighted to represent the student population.

Students growing more rapidly in their math skills are more likely to obtain an academic track recommendation irrespective of their initial achievement levels. But the effect of growth is not constant throughout the range of the initial status scale. The interaction of the initial status and growth rate is negative and statistically significant in models 2 and 7 (see Table 3.2). Growth effects on math school grades and the track recommendation decrease at higher levels of initial achievement. In other words, the growth of less well performing students at age 10 is valued more strongly by teachers for school track recommendations than the growth of best performing students.

Family SES mediates the relationship between math achievement and the track recommendation. The math initial status coefficient and the math growth coefficient reduce in 8% and 5% when SES is controlled (see models 7 and 8 in Table 3.2). Family SES is indirectly related to the track recommendation via the effect of math achievement (see model 3 in Table 3.1), but it also has direct effects. The family SES coefficient remains significant when academic achievement is controlled. For 1 *SD* increment in SES, the probability of getting a recommendation for the academic track increases by a factor of 1.8 (see model 8 in Table 3.2). Parental occupational status, parental schooling, and parental vocational training, in this order, drive the direct influence of family SES on the track recommendation.

The SES effect on math school grades is mostly an indirect effect expressed via academic achievement. Evidence for an SES direct effect is weak. When academic achievement is controlled, the family SES coefficient amounts to less than 0.1 score points and is significant at the 90% confidence level only (see model 3 in Table 3.2). Also, when the SES effect is broken down, none of the SES components turns out to be statistically significant (see model 4 in Table 3.2). Furthermore, in unreported analyses the SES effect on math school grades was nonsignificant when both reading and math achievement were controlled, but it was still significant and considerable for the track recommendation.

Students with migration background perform lower in math and are less likely to be recommended to the academic track. On average, Germans without migration background obtain better grades in math (2.83 score points) than Germans with migration background (2.92 score points) and foreign students (3.05 score points). While 45% of German students without migration background obtain a recommendation for the academic track, only 27% of foreign students and 32% of German students with migration background obtain this recommendation. Interestingly, when family SES and achievement variables are controlled, the relationship reverses. Students with migration background are given higher grades in math (by 0.24 score points) than Germans without migration background (see model 4 in Table 3.2). They are also more likely to obtain an academic track recommendation: Germans with migration background by a factor of 1.65 and foreign students by a factor of 1.24 (see model 9 in Table 3.2).

Evidence that girls had poorer math performance in the ELEMENT math test, but grew at faster rates than boys in their math skills was reported earlier (see model 5 in Table 3.1). Additionally, results of models 4 and 9 (see Table 3.2) indicate that, when academic and socioeconomic variables are controlled, girls are given higher grades in math by the end of primary education (by 0.18 score points) and are more likely to obtain an academic track recommendation by a factor of 3.31.

Other things being equal, students in classes with higher than average math achievement tend to obtain lower grades in math and are less likely to get an academic track recommendation (see models 5 and 10 in Table 3.2). The class's mean initial status and proportion of students with migration background (i.e., German students with migration background or foreign students) account for about 25% of math grade differences attributed to migration background (see models 4 and 5 in Table 3.2). These class composition variables explain the relationship between migration background and the school track recommendation even to a greater extent (see models 9 and 10 in Table 3.2). Once they are controlled, foreign students are no longer more likely to obtain an academic track recommendation. Students have higher changes of getting an academic track recommendation in classes where the proportion of students with migration background is higher (see model 10 in Table 3.2).

3.10 Discussion

Extensive analyses have evaluated the influence of achievement levels, family SES, migration background, and group reference characteristics on school track placements. The literature, however, has neglected the role of achievement growth, in spite of increased interest of researchers in progress rather than in status. Achievement growth reflects better the capacity of students to continue learning and their potential for academic success than achievement levels, which represent innate ability and other individual attributes in addition to skills. In societies that value equal opportunities and reward merits irrespective of status characteristics this distinction is critical. The German Education Ministers' decree for primary school level establishes that students shall enter a track of the education system in accordance with their capacity to acquire skills, aptitude, disposition, and their will to perform intellectual work irrespective of their origin. From this perspective, the sequence of analyses presented in this section adds an important theoretical and policy dimension to the research on school tracking.

The analyses advance prior methodological examinations by using three measurement points of the Berlin study ELEMENT to estimate reliability-adjusted measures of individual growth with the EB estimator (Lindley & Smith, 1972; Raudenbush & Bryk, 2002). This examination is not without limitations, though. One is that it is based on a local study in the city of Berlin restricted to a target group already *creamed* of a very select group of early transition into certain advanced placement programs and it is not certain that these findings hold if referring to data from another German federal state or educational system practicing between-school tracking. There is, however, no better data source for informing the issues addressed in this study. Available data sets contain fewer measurement points and/or neglect information on school track recommendations.

Another limitation is data loss due to missing values and attrition. The achievement test data are complete, but about 25% of socioeconomic data are missing. Yet, the MICE method (Royston, 2004, 2005) was applied to predict missing values and estimate standard errors that account for missing data uncertainty. Students with less than 3 math measurements (27%) are excluded from the analytic sample to safeguard the reliability of math growth rates. These students come from relatively less advantaged backgrounds. Nevertheless, differences between the original sample and analytic sample are small. Thus, data loss should not seriously bias the model estimates.

Still another limitation is the low reliability of achievement growth (a=0.35). The EB estimator is used to counteract the lack of precision of individual achievement growth measures. And yet, while the EB estimator penalizes estimates for reliability, this deficiency could only be improved with additional points of measurement. Due to these limitations, the results are best considered suggestive, and certainly odds ratios and unstandardized coefficients reported should not be easily generalized. With these caveats understood, main finings emanating from this study are discussed next.

In general, the findings align well with the literature on school tracking. What is new from the results is that they offer evidence that students growing more rapidly in their math skills are more likely to obtain a recommendation for the academic track. This finding is not an artifact of ceiling effects, regression toward the mean, or growth measuring ability rather than skills. The relationship between achievement growth and school track recommendations remains significant even when achievement levels, ability, and a group of socio-demographic characteristics are controlled. Throughout the range of academic achievement, students growing at faster rates are more likely to obtain an academic track recommendation irrespective of their socioeconomic background or ability levels. The effect of growth is more pronounced for students starting with low levels of academic achievement than for students with high initial levels of math achievement. Apparently, teachers reward more strongly the growth of originally academically disadvantaged students than the growth of students starting with higher achievement levels.

The relationship between achievement growth and school track recommendations is partly explained by the association between achievement growth and the math grades given by teachers at the end of primary education (Grade 6). Teachers seem to monitor and evaluate student progress individually in that they reward growth in math with higher grades over and above math achievement levels. Inasmuch as school track recommendations are largely determined by school grades, math grades directly mediate the relationship between math growth and school track recommendations.

From this perspective, school factors driving achievement growth can contribute to reduce educational inequalities associated with family SES groups. The literature has shown the influence of teachers and teaching. Teachers have a substantial impact on achievement growth in relation to other school factors (Nye, Konstantopoulos, & Hedges, 2004). The quality of their instructional practices (Guarino, Hamilton, Lockwood, & Rathbun, 2006; Lee, Burkam, Ready, Honigman, & Meisels, 2006; Palardy & Rumberger, 2008; Shacter & Thum, 2004), positive attitudes of teachers towards their ability to teach and about students' ability to learn (Goddard, Hoy, & Hoy, 2000; Palardy & Rumberger, 2008; Shacter & Thum, 2004), and a constructivist pedagogical orientation (Staub & Stern, 2002) tend to positively affect the achievement growth of students. The effect of teacher background characteristics, such as their educational attainment, achievement and intelligence test scores, experience, and credentials, has also been evaluated. Here, the literature is equivocal, with some studies finding a consistent positive effect (Greenwald, Hedges, & Laine, 1996; Wayne & Youngs, 2003) and others not (Hanushek, 1997; Muñoz & Chang, 2007).

Beyond the effect of teachers and teaching, evidence for classroom and school composition effects on student learning has been found in the literature. Particularly, peer ability (Hanushek, Kain, Markman, & Rivkin, 2003; Hoxby, 2000) and the mean school SES (Chubb & Moe, 1990, Lee & Smith, 1997; Lee, Smith, & Croninger, 1997; Rumberger & Palardy, 2005) have shown to impact individual achievement growth. Furthermore, other studies indicate that the frequency of homework assignments (Trautwein, Köller, Schmitz, &

Baumert, 2002) and school policies promoting parent involvement and academic counseling (Holt & Campbell, 2004) contribute to the achievement growth of students.

Although achievement growth is valued for school track recommendations and may contribute to reduce inequalities attributed to status characteristics, the level of achievement is a more critical factor. Particularly, the effect of the math achievement level on the track recommendation is 2.4 times as large as the effect of math growth. Furthermore, from a set of socio-demographic and achievement variables, the level of achievement is the most important predictor of differences in school track recommendations. The influence of achievement growth and family SES, though considerable, is less significant when achievement levels are taken into account. Certainly, this finding raises questions on the extent to which school track recommendations ought to reflect achievement levels (status) and achievement growth (progress). Is the capacity of students to learn equally, more, or less important than their actual achievement levels to their future educational opportunities? This question is beyond the scope of this study but deserves the attention of further research and policy.

Other findings emanate from the analyses. Evidence for the so-called primary effect of SES is unequivocal (Boudon, 1974). Family SES is indirectly related to math school grades in Grade 6 and, in turn, to the track recommendation via its effect on math achievement levels and growth. Not only higher SES students perform better in math than lower SES students but they also grow more rapidly in their math skills (Alexander, Entwisle, & Olson, 2001; Becker et al., 2008; Caro, McDonald, & Willms, in press). Once achievement variables are controlled, family SES is unrelated to math school grades, but is still positively associated to the track recommendation. To the extent that the recommendation is based on school grades and teacher individual assessment of students, direct effects of family SES appear to play a role in the individual assessment of students.

Strictly speaking, direct effects of family SES here are not equivalent to the so-called secondary effects of family SES because choices of parents have not been revealed yet (Boudon, 1974). But these effects do announce a source of inequality of opportunity in track enrollment due to teacher influences. Although they are less significant than the primary effects, their presence is particularly troubling because it suggests that high-achieving students of low SES families are in *double-jeopardy*. Compared to high SES students, they are less likely to be recommended to the academic track and, furthermore, even if they obtain the academic track recommendation, their parents are less likely to enroll them in the academic track (Bos et al., 2004; Ditton, 2007; Ditton et al., 2005; Maaz et al., 2008a).

That parental occupational status and parental vocational training drive the direct effect of family SES may suggest that teachers perceive and reward the value students and their families attach to education (Arnold et al., 2007). In this regard, research shows that parental vocational training levels and parental occupational preferences are a source of class-based culture and values that influences the value students attach to education (Bourdieu, 1977; Karlsen, 2001; Koo, 2003). Also, scholars argue that socioeconomically advantaged parents instill in their offspring favorable attitudes towards education which, in turn, positively affect their educational plans (Carpenter & Fleishman 1987; Crosnoe, Mistry, & Elder, 2002; Eccles, Vida, & Barber, 2004; Hossler & Stage 1992).

The results on the relationship between migration background and school track recommendations are quite interesting. As expected, students with migration background are less likely to obtain an academic track recommendation than students without migration background. Nonetheless, when academic achievement and family SES are controlled, students with migration background are given better math school grades and are more likely to be recommended to the academic track (Lehmann and Peek, 1997; Limbos, & Geva, 2001). Using data from Hamburg, Germany, Lehmann and Peek (1997) also found that, compared to other students, those with migration background need to attain lower achievement levels to obtain an academic track recommendation.

In part, the better prospect of students with migration background regarding their academic careers is explained by class composition characteristics. Where the proportion of immigrant students is higher, students with migration background are more likely to obtain an academic track recommendation because referrals of teachers are not only based on individual performance but also on the class composition. But even in socioeconomically comparable classes, students with migration background are more likely to obtain an academic track recommendation. One may speculate, for example, that teachers are less confident about their ability to distinguish academic performance of students with migration background and, thus, accept some level of underachievement in this group as part of their normal development (Limbos, & Geva, 2001), or that teachers in Berlin tend to share liberal beliefs and try to compensate immigrants for their disadvantaged position in the hierarchical social structure by providing them with better chances of pursuing academic careers. And still another argument could be that other class-level socioeconomic and achievement characteristics not considered here contribute to explaining this effect.

As with other studies, evidence of a negative relationship between the class mean achievement and the individual math grades and the probability of being recommended to the academic track was found (Maaz et al., 2008b; Tiedemann & Billmann-Mahecha, 2007;

Trautwein & Baeriswyl, 2007). Given two students with comparable ability, the one in a class with higher mean math achievement receives a lower grade in math and is less likely to obtain an academic track recommendation. This is very likely due to teachers evaluating students in relation to the group and not to an external criterion. Finally, although girls perform less well than boys in mathematics, they grow more rapidly in their math skills. And in Grade 6 they are given higher grades in math and are more likely to be recommended to the academic track when math achievement levels are controlled. Higher chances of girls to obtain an academic track recommendation are certainly not solely the result of math performance, but reading competences and possibly other traits may play a critical intervening role.

4. FAMILY SOCIOECONOMIC STATUS, EDUCATION, AND LABOR FORCE OUTCOMES

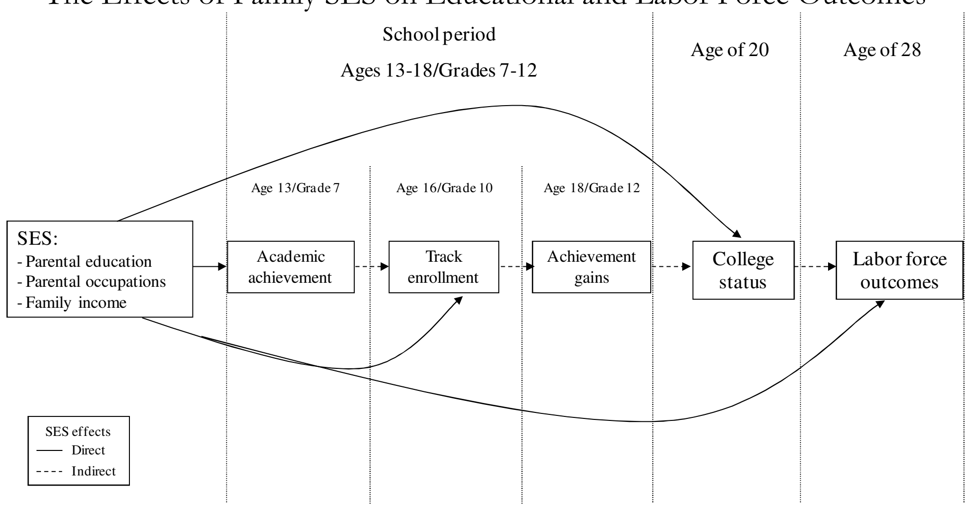
This section examines the dominating gateways for family SES influences on schooling outcomes, college enrollment, and labor force outcomes. The preceding analyses were limited to family SES and achievement growth influences throughout the school period. Additionally, this section draws on full longitudinal data from a regional United States sample starting when the students were in 6th grade and following them until 10 years after finishing college to investigate the transition from school to college and the labor market. It thus elicits new insights on the mechanisms underlying the intergenerational transmission of family SES. Figure 4.1 illustrates the analytical model framing this investigation. The model takes into account data restrictions and outlines key mechanisms behind the influence of family SES on educational and career paths throughout life course.

Specific research questions are: How does family SES affect course-enrollment decisions in high school? Does the SES gap in academic achievement changes as students advance in school? And, if so, what is the role of course-level tracking? How does family SES affect college enrollment and labor force outcomes? What is the relative contribution of skills to the explanation of earnings and occupational status when educational attainment is controlled? The analyses are significant from a policy perspective since they suggest avenues to effectively reduce inequalities. They distinguish between direct and indirect influences of family SES.

4.1 Direct and Indirect Effects of Family SES

Boudon (1974) distinguished between primary and secondary effects of family SES to explain increasing inequalities at educational transitional points. His model was introduced in section 3.2. Drawing on Boudon's theoretical model and previous related work (Boudon, 1974; Jackson, Erikson, Goldthorpe, & Yaish, 2007; Kerckhoff et al., 2001; Maaz et al., 2008a), family SES influences mediated by educational variables are referred to as *indirect* (primary) and those that persist when these variables are controlled as *direct* (secondary), irrespective of whether family SES influences occur at transitional points or not.

Figure 4.1
The Effects of Family SES on Educational and Labor Force Outcomes



Family SES indirectly affects track enrollment in high school, that is, whether a student takes advanced courses leading to college education or not, via its association with academic and social skills, but also directly through family factors such as parental expectations and parental involvement (Baker & Stevenson, 1986; Condron, 2007; Dauber et al., 1996; Gamoran & Mare, 1989; Schnabel et al., 2002). Compared to students of low SES families, high SES students are more likely to enroll in advance placement (AP) courses because they have better academic achievement records and their parents attach a greater value to education. Track enrollment, in turn, produces differential achievement gains among SES groups (Gamoran et al., 1995; Gamoran, Porter, Smithson, & White, 1997; Hallinan, 1994; Hoffer, 1992; Oakes, Gamoran, & Page, 1992). This is in part due to better educational opportunities offered to students in higher tracks (Gamoran & Carbonaro, 2002-03; Pallas et al., 1994). AP course students also exert greater effort in school than do students in lower tracks (Carbonaro, 2005).

After high school completion, the association of family SES with college enrolment is mainly an indirect effect of prior track enrollment and academic achievement in school, so that students of low SES families are less likely to be academically prepared for and enroll in college (Cabrera, Burkum, & La Nasa, 2005; Cabrera & La Nasa, 2000, 2001; Terenzini, Cabrera, & Bernal, 2001). Also, family SES is likely to affect the decision to go to college directly via the influence of parental occupational status and family income. Other things being equal, parents with college education encourage their children more to attend college than parents without college experience (Carneiro & Heckman, 2002; Chevalier & Lanot, 2002; Harrington & Sum, 1999; Karlsen, 2001; Koo, 2003). The latter is particularly important in societies like the United States where college tuition can be prohibitive for low income families. Low SES students are also more likely to interrupt their college careers (Goldrick-Rab, 2006) and, in the longer term, because of their lower educational attainment and poorer skills, they earn less and attain a lower occupational status in the labor market (e.g., Kerckhoff et al., 2001). The labor force outcomes - earnings and occupational status - considered here are closely related to the formation of SES in adulthood. Therefore, the direct and indirect effects of family SES on these outcome variables represent intergenerational transmission of family SES from parents to children.

4.2 Skills and Labor Force Outcomes

Education is certainly a key intervening process for the intergenerational transmission of family SES. The literature is conclusive on the importance of educational attainment to labor force outcomes, but it is equivocal regarding the relative contribution of skills when educational attainment is controlled. Signaling theory (Spence, 1974) states that even though employers seek to reward employees' skills, they have limited information to go on and therefore prefer to use educational credits as a proxy of actual skills. Credential theory (Collins, 1979) maintains that powerful groups in society base labor force rewards on educational credentials rather than skills to filter out equally talented but uncertified employees. Levin and Kelley (1994) concluded in a review of the literature that skills are weakly related to earnings because most tests measure memorization rather than the ability to understand or to use information (see also Hartigan & Wigdor, 1989).

Human capital theory (Becker, 1975) contends that earnings reflect skills at least as much as they reflect educational attainment. Murnane, Willet, and Levy (1995) and Grogger and Eide (1995) showed that between the 1970s and the 1980s the relative importance of math skills in predicting earnings grew substantially. Johnson and Neal (1998) found that basic skills, as measured by the Armed Forces Qualification Test, are related to subsequent earnings. Kerckhoff et al. (2001) maintain that, although educational attainment and cognitive skill are closely linked measures, they contribute independently to the explanation of labor force outcomes.

4.3 Expected Results

In accordance with prior research, direct effects of family SES are expected to be less pronounced than indirect effects overall. The effect of family SES via academic achievement on course-enrollment decisions and college enrollment will be greater than the effect of family SES via nonacademic variables. With this, academic merits are expected to be more important than nonacademic factors in explaining educational inequalities related to family SES. Other family SES related factors will compound educational inequalities at transitional points, undermining the meritocratic principle of status allocation as the implicit norm of Western societies. Track enrollment is expected to underlie differential achievement gains among SES groups. Higher SES students in the college track will grow faster in their academic skills compared to lower SES students.

The effect of family income and parental occupational status is expected to be more apparent for the college decision than for academic achievement gains or course-enrollment decisions. Financial constraints directly determine the ability of families to pay college tuition and parental occupational status is closely related to the value youths attach to postsecondary education. The governing mechanisms for the effects of family SES on college attendance in young adulthood will differ from those underlying differences in academic achievement and course-enrollment during adolescence. Later in life, education is expected to largely explain family SES effects on earnings and occupational status. The relevance of family SES in childhood to labor force outcomes in young adulthood should be small or even disappear entirely when education is controlled. In other words, direct effects of family SES on earnings and occupational status are not to be expected when educational attainment and skills are controlled. Derived from human capital theory and previous evidence, skills are expected to contribute to the explanation of earnings and occupational status above and beyond the contribution of educational attainment.

4.4 Data

The data stem from the Michigan Study of Adolescent Life Transitions (MSALT). This longitudinal study began in 1983 with early adolescents in Grade 6 (*N*=2,452, *M* age=11.5), their teachers, and their parents. Participants have been periodically surveyed, in a total of nine waves, up to the year 2000, when they had reached young adulthood (*N*=1,102; *M* age=28.1). The vast majority of the original sample consisted of lower middle and middle-class White (96.7%) students living in small industrial cities in Southeast Michigan who were recruited from 143 classrooms in 12 school districts. It included approximately 80% of the student population in these classrooms, 95% of teachers in these districts, and 72% of parents of students sampled. Participants completed several questionnaires during the course of this study either at home or at school. Additionally, data on grades, test scores, and course enrollment were gathered from the school records.

The present analysis draws on data from 1983 (wave 1), 1985 (wave 4), 1988 (wave 5), 1990 (wave 6), 1992 (wave 7), and 2000 (wave 9) to examine the effects of family SES on high school track enrollment, academic achievement, college attendance, and labor force outcomes. The sample size varies across analyses because each analysis included only those participants with non-missing data in the corresponding dependent variables. While the academic achievement model included 2,264 participants, the track enrollment model was limited to a subset of 1,631. For the college status model, data of 1,601 subjects were available, for the occupational status model 907, and for the earnings model 552. While missing data in dependent variables were not imputed, multiple imputation methods were carried out to predict missing values of independent variables from the available data (including dependent variables). The MICE method was employed to generate 5 imputed versions of the raw data (Royston, 2004, 2005) applying Rubin's rule (1987) to estimate descriptive statistics and regression coefficients with corrected standard errors.

4.4.1 Independent Variables

Family SES. Following standard operationalizations (Mueller & Parcel, 1981; Gottfried, 1985; Hauser, 1994), family SES is a composite of mother's education, father's education, mother's occupational status, father's occupational status, and family income. These variables are summarized into a single index by means of PCA and then standardized (M=0, SD=1 in the total sample). Given socioeconomic data availability, an SES variable was computed in Grades 6, 10, and 12 (1983, 1988, and 1990). As expected, SES remained relatively stable over time (correlation between SES in Grade 6 and Grade 10 was $r = 0.84$ and between Grade 6 and Grade 12 $r = 0.79$). Since SES variation over time did not substantially alter the findings, SES was averaged over time and treated as time-invariant for the sake of parsimony of the statistical model.

Parental education. Father's and mother's education are interval variables taking values between 6 and 20 years of formal schooling. Parents reported their highest educational certificate obtained when students were in Grade 6, 10, and 12. These data were transformed into schooling years and averaged over time. In Grade 10, if parents' responses were missing, they were replaced with students' information on their parents education. Self- and student reports correlated highly (r's > 0.73).

Parental occupational status (SEI). Parents reported their occupations as students were in Grades 6, 10, and 12. These data were collected with an open question and coded in accordance to the Duncan Socioeconomic Index (Duncan, 1961; Entwisle & Astone, 1994).

Father's and mother's occupational indexes were also averaged over time. In Grades 10 and 12, if parents' responses were missing, the respective information from the student was used.

Family income. Parents were asked to report their average yearly income in dollars from a set of interval categories. Their responses were recoded into an ordinal scale, ranging from 1 to 6: (1) less than 10 thousand dollars, (2) 10-20 thousand dollars, (3) 20-40 thousand dollars, (4) 40-60 thousand dollars, (5) 60-80 thousand dollars, and (6) more than 80 thousand dollars per year. Income information was reported by the father in Grade 6 and the mother in Grades 10 and 12. If mother's responses were missing, they were replaced with information provided by the student, which were moderately correlated with mother's responses ($r = 0.60$).

Sex. It is a dichotomous variable distinguishing females (value of one) from males (value of zero).

Educational attainment. It is the number of schooling years at age 28 (in 2000). Participants reported their highest educational level, which was transformed into schooling years.

4.4.2 Dependent Variables

Course track enrollment. This dichotomous variable takes the value of one for students on the academic track and zero for those on the general or vocational track. Track was determined based on the math course enrollment for Grade 10 taken from the school record. Three levels were distinguished: college track (e.g., algebra 2 and trigonometry), general track (e.g., algebra 1, applied algebra, and applied geometry), or vocational track (e.g., general/basic/remedial or no math class).

Academic achievement. It is the grade point average (GPA) taken from school records in Grades 7, 10, and 12.

College attendance. This variable takes the value one if the subject was enrolled in a full-time four-year college program at age 20 (about 50%) and zero for the rest.

Earnings. It is the natural logarithm of yearly earnings at age 28 (in 2000). Earnings were reported for different time spans (from weekly to annually). Only annual and monthly earnings were considered and transformed into yearly earnings.

Occupational status (SEI). As with parental occupational status, participants' responses of an open question on occupations were coded in accordance to the Duncan Socioeconomic Index (Duncan, 1961; Entwisle & Astone, 1994).

4.4.3 Attrition and Missing Values

The MSALT study covers a relatively long time span (17 years from 1983 to 2000) with a substantial attrition rate particularly in the post high school phase when mobility was high. For the academic achievement model 92% of the original sample provided sufficient data, for the track enrollment model 67% of the original sample was included, and for the college enrollment model still 65%. For the earnings model data for only 23%, and for the occupational status model, 37% of the original sample was available. Table D in Appendix D reports multiply imputed descriptive statistics (mean and standard error) for independent variables included in each analytical model. Data loss due to attrition and missing values in dependent variables is sizable and limits the generalizability of the findings.

The academic achievement model is least affected by data loss. Criterion for selection is having non-missing academic achievement data in Grade 7. Out of these participants, 81% and 75% have non-missing academic achievement data in Grades 10 and 12, respectively. Thus, coverage of achievement data over time is fairly complete. Sex is known for everyone, but socioeconomic data were imputed for 20% of the sample, father's education for 28%, mother's education for 21%, father's occupational status for 28%, mother's occupational status for 37%, and family income for 18%. Subsequent models draw on the sample and multiply imputed data of the academic achievement model. Point estimates of model parameters using imputed and non-imputed data are very similar and so are not reported here.

The track enrollment and college status models include less than 70% of participants in the original sample. Nevertheless, mean values for SES and academic achievement data are roughly similar to those of the academic achievement model (see Table D, Appendix D). Therefore, attrition is not expected to critically bias parameter estimates. The occupational status model, however, as well as the earnings model not only includes a smaller proportion of participants but the sample represents a positive selection with respect to SES of the participants. Compared to the academic achievement model, participants of the occupational status and earnings models come from higher SES families, performed better in school, and completed higher levels of education.

4.5 Family SES Influences on Track Enrollment and Academic Achievement

First, the influence of family SES on course-enrollment decisions and academic achievement in school was evaluated. To this end, logit models of the probability of enrolling in the college track (i.e., taking advanced math courses in Grade 10) and panel data models of academic achievement (GPA in Grades 7 to 12) were estimated. Effect sizes of logit and panel data models were calculated for 1 *SD* change in independent variables. They are reported in terms of odds ratios and unstandardized coefficients, respectively, in Table 4.1.

Table 4.1
Family SES Influences on Track Enrollment and GPA
(Effect Sizes for a 1 *SD* Change)

	Track Enrollment (Odds Ratios)			GPA (Unstandardized Coefficients)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept				9.85**	9.85**	9.85**	9.85**
Grade 10				-0.26**	-0.26**	-0.26**	-0.26**
Grade 12				-0.24**	-0.24**	-0.24**	-0.24**
GPA Grade 7			1.82**				
Female	0.92	0.91	0.87	0.39**	0.39**	0.39**	0.41**
Father's Education		1.41**			0.29**		
Mother's Education		1.09			0.15*		
Father's Occupational Status		1.13**			0.17*		
Mother's Occupational Status		0.99			0.09		
Family Income		1.08			0.14		
SES	1.60**		1.46**	0.60**		0.60**	0.47**
SES x Grade 10						0.10**	0.07*
SES x Grade 12						0.10**	0.09**
Track Enrollment							0.62**
Track Enrollment x Grade 10							0.14**
Track Enrollment x Grade 12							0.07*
Number of Students		1,631			2,264		
Estimation Method		Logit			Panel Data		

**p<0.01, *p<0.05.

Overall, results in this section are in accord with Schnabel et al. (2002). Family SES is related to course-enrollment decisions in high school. Compared to lower SES students, high-SES students are more likely to enroll in advance courses that lead to college preparation (see column 1 in Table 4.1). Father's education and, to a lesser extent, father's occupational status are the main gateways for the SES gap in track enrollment (see column 2 in Table 4.1). In part, the relationship between family SES and track enrollment is explained indirectly via academic achievement, which accounts for about 20% of the SES coefficient. But family SES is also directly related to track enrollment because a significant SES effect persist when academic achievement before tracking (GPA in Grade 7) is controlled (see column 3 in Table 4.1).

As expected, family SES also positively affects academic achievement in school (see column 4 in Table 4.1). Father's education, father's occupational status, and mother's education, in that order, are the major gateways for this effect (see column 5 in Table 4.1). Furthermore, academic achievement differences among higher and lower SES students tend to increase from the beginning of middle school to the end of high school. The SES effect in Grade 7, measured by the SES mean effect in column 6 (0.60), significantly increases in Grade 10 and 12 by 0.10 (see SES interaction effects in column 6, Table 4.1). In other words, the SES gap in academic achievement widens by about 17% from Grade 7 to Grade 12.

Track enrollment mediates the widening of the SES gap in academic achievement. Higher SES students are not only more likely to enroll in the college track (direct effect), but also more likely to be college bound due to the widening of the SES gap in academic achievement (indirect effect). This can be derived from the comparison of the SES-Grade interaction coefficients before and after accounting for track enrollment effects (columns 6 and 7 in Table 4.1). Coefficients are lowered by including track enrollment effects over time and, although not shown here, this reduction is statistically significant.

4.6 Family SES Influences on College Attendance at Age 20

In a second step, the relationship between family SES and the probability of being a full-time college student two years after high school completion (roughly at the age of 20) was examined. Logit models of college status as a function of SES variables, track enrollment in high school, academic achievement in Grade 10, and academic achievement gains from Grade 10 to 12 were estimated. Effect sizes were calculated for 1 *SD* change and are reported in terms of odds ratios in Table 4.2.

Table 4.2
Family SES Influences on College Attendance
(Effect Sizes for a 1 *SD* Change)

	College Attendance (Odds Ratios; *N* = 1,601)				
	(1)	(2)	(3)	(4)	(5)
Female	1.07	1.08	1.12	0.98	0.88
SES	2.26**				
Father's Education		1.42**	1.33**	1.24*	1.21*
Mother's Education		1.27**	1.27**	1.20*	1.20*
Father's Occupational Status		1.31**	1.29**	1.29**	1.29**
Mother's Occupational Status		0.98	0.98	0.97	0.93
Family Income		1.35**	1.35**	1.48**	1.47**
Track Enrollment			1.59**	1.25*	1.22
GPA Grade 10				1.56**	1.75**
GPA Gains (Grade 10 to 12)					1.30**

**p<0.01, *p<0.05.

Coming from a higher SES family increases the chances of enrolling in college substantially (see column 1 in Table 4.2). Whereas the predicted probability of attending college for those in the top SES quartile is 0.74, it is 0.30 for those in the bottom SES quartile. More specifically, parental education, family income, and father's occupational status, in that order, mainly contribute to explain the relationship between SES and college attendance at age 20 (see column 2 in Table 4.2). As with track enrollment and academic performance, father's education exerts the strongest influence. What is new at this stage is the relevance of family income as a critical predictor of college enrollment. Its predictive power is exceeded only by the effect of father's education (see column 2 in Table 4.2). Interestingly the importance of father's occupational status to college enrollment is greater than in previous models as well.

Not surprisingly, college bound students in high school are, in fact, more likely to be enrolled in college four years down the road than those in the general/vocational track (see column 3 in Table 4.2). The track enrollment effect is partly mediated by academic achievement levels (see column 4 in Table 4.2) and entirely mediated by both academic achievement levels and gains (see column 5 in Table 4.2). It was demonstrated earlier that course-enrollment decisions in high school produce differential achievement gains among tracks (see column 7 in Table 4.1). Additionally, results in Table 4.2 suggest that differential achievement gains among tracks fully explain the relationship between track enrollment and college attendance. Stated in another way: track enrollment does not directly affect the decision to enroll in college once academic achievement levels and gains are controlled.

Track enrollment and academic achievement partly explain the relationship between parental education and college status. Measured by the reduction of parental education coefficients, track enrollment and academic achievement, in combination, account for 15% and 6% of the effect of father's and mother's education, respectively (compare columns 2 and 5 in Table 4.2). While family SES is related to college status indirectly via its impact on track enrollment and academic achievement, it also exhibits direct effects. Particularly, the family income and father's occupational status coefficients remain significant even after academic performance and track enrollment in high school are controlled. For 1 *SD* increment in family income and father's occupational status, the odds of attending college increase by a factor of 1.5 and 1.3, respectively (see column 5 in Table 4.2). The direct relationship between family SES and college status is predominantly explained by family income and, to a lesser extent, by father's occupational status. These aspects critically determine the decision to go to college. And yet, family SES direct effects are less pronounced than those expressed via academic achievement. When academic achievement and SES variables are included in combination, academic achievement exerts the strongest impact on the college decision (see column 5 in Table 4.2).

4.7 Family SES Influences on Labor Force Outcomes at Age 28

Finally, the influence of family SES, educational attainment, and academic achievement on earnings and occupational status at age 28 was examined. The extent to which educational attainment and academic achievement mediate the relationship between family SES and labor force outcomes was analyzed. And the extent to which academic achievement and educational credentials, together and independently, explain differences in earnings and occupational status when family SES is controlled. To this end, earnings and occupational status regression models with family SES, educational attainment, and academic achievement as predictors were estimated. The earnings-models include unemployed participants as part of the economically active population (i.e., the temporarily laid off, unemployed looking for work, and part-time workers) and so are unconditional on employment. These participants are 15% of the total sample and their earnings have been censored into the value of one. Due the censored nature of the earnings variable, Tobit regressions were carried out to estimate these models. Occupational status, in contrast, fitted a normal function and these models were estimated by traditional OLS regressions. Table 4.3 reports earnings and occupational status model estimates in terms of unstandardized regression coefficients.

Participants who grew up in lower SES families earn less and attain a lower occupational status at age 28 than those from higher SES families (see columns 1 and 5 in Table 4.3). Mother's education, family income, and father's occupational status, in this order, are the major gateways for the relationship between family SES and occupational status (see column 6 in Table 4.3). When the overall SES effect on earnings is broken down, none of the SES variables turns out statistically significant and therefore it is not possible to characterize this effect.

Family SES is indirectly related to labor force outcomes via its impact on educational attainment and academic achievement. Compared to academic achievement, educational attainment mediates family SES effects on earnings and occupational status to a greater extent. In particular, educational attainment and academic achievement, respectively, account for 47% and 36% of the family SES effect on earnings (see reduction of SES coefficient from column 1 to 2 and column 1 to 3 in Table 4.3). Similarly, though not included in Table 4.3, they account for 81% and 41% of the family SES effect on occupational status, respectively. When academic achievement and educational attainment are jointly included, they entirely account for the effect of family SES on earnings and occupational status (see columns 4 and 9 in Table 4.3).

Table 4.3
Family SES Influences on Labor Force Outcomes at Age 28
(Effect Sizes for a 1 *SD* Change; Unstandardized Coefficients)

	Earnings				Occupational Status				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	8.95**	8.95**	8.95**	8.95**	57.09**	57.09**	57.09**	57.09**	57.09**
Female	-0.73**	-0.78**	-0.91**	-0.88**	0.60	0.65	0.18	-0.58	-0.25
SES	0.69**	0.37*	0.44*	0.31	5.82**				
Father's Education						1.11	-0.32	-0.01	-0.58
Mother's Education						2.16**	0.19	1.46	0.17
Father's Occupational Status						1.85*	0.32	0.96	0.17
Mother's Occupational Status						1.02	0.84	1.04	0.88
Family Income						2.11**	0.64	1.58*	0.63
Educational Attainment at Age 28		0.845**		0.575**			11.27**		9.77**
GPA (mean Grades 7,10, and 12)			0.810**	0.508**				7.57**	3.00**
Estimation Method	Tobit				OLS				
Number of Participants	552				907				

**p<0.01, *p<0.05.

Table 4.3 also reveals the mechanisms for the mediating effect of educational attainment and academic achievement in the relationship between family SES and occupational status. While educational attainment fully mediates family income effects on occupational status, academic achievement reduces, but does not wholly account for these effects alone (see columns 7 and 8 in Table 4.3). This is consistent with previous results on the antecedents of college attendance and academic achievement. That is, while family income was directly related to the decision of enrolling in college, its association with academic achievement was nonsignificant (see column 5 in Table 2 and column 5 in Table 4.1).

But besides mediating the relationship between family SES and labor force outcomes, educational attainment and academic achievement are also directly associated to these outcomes. Treating SES as control variable, academic achievement and educational attainment are positively related to earnings and occupational status (see columns 2, 3, 7, and 8 in Table 4.3). They contribute to the explanation of earnings and occupational status in different ways. For example, educational attainment has a more pronounced influence on occupational status than academic achievement. The explanatory power of occupational status increased to a greater extent when educational attainment is included instead of academic achievement.

Using one of the five imputed datasets, the R-squared statistic of an occupational status model on family SES alone is 0.09 and increases to 0.39 and 0.23 when educational attainment or academic achievement are included, respectively. Similarly, the effect of educational attainment is clearly greater than that of academic achievement. For 1 *SD* change in educational attainment and academic achievement, respectively, occupational status increases by 11.27 and 7.57 points, which is equivalent to 60% and 40% of a *SD* in occupational status. Also, when these variables were included in combination, their specific coefficients were reduced, but for educational attainment to a lesser extent (see columns 7, 8, and 9 in Table 4.3). Altogether, these results point to a greater effect of educational attainment compared to academic achievement.

The relative contribution of these aspects is less obvious for earnings. Educational attainment and academic achievement effects are fairly similar when included separately and in combination (see columns 2, 3, and 4 in Table 4.3). And, even though educational attainment effects appeared to be slightly greater than academic achievement effects, unreported analyses show that these differences are nonsignificant. Thus, academic achievement seems to be as important as educational attainment to the explanation of earnings differences, favoring the idea that academic achievement is valued more for income than for occupational status. Perhaps the most striking result in Table 4.3 is that the relationship between academic achievement and labor force outcomes persists even after accounting for family SES and educational attainment. This suggests that academic achievement and educational attainment make independent contributions to the explanation of earnings and occupational status (see columns 4 and 9 in Table 4.3).

4.8 Discussion

The purpose of the sequence of analyses presented above was to uncover the underlying mechanisms for the effects of family SES on track enrollment in high school, college enrollment, and labor force outcomes. To this end, longitudinal data were used from a regional United States study, the MSALT, which has followed participants from about the age of 11 to about the age of 28 years. The longitudinal span and comprehensive set of variables allow exploring these mechanisms prospectively for one single cohort through major life transitions into early adulthood. Schnabel et al. (2002) analyzed family SES effects on academic achievement and track enrolment using the MSALT data. The present analysis considerably extends their research.

As expected, indirect effects of family SES via academic achievement on track enrollment are greater than direct effects. And track enrollment gives rise to a widening achievement gap among higher and lower SES students from middle school up to the end of high school. Inasmuch as higher SES students are more likely to take college track courses while lower SES students tend to prefer general or vocational track classes, the achievement differences between these students become amplified towards the end of high school. Track enrollment, however, is not the only reason that the gap between high and low SES widens. Other mechanisms, not investigated here, apparently produce diverging achievement trajectories among SES groups even within school tracks (Alexander, Entwisle, & Olson, 2001; Downey et al., 2004; Guo, 1998). These mechanisms configure unequal opportunities across SES groups. They are not fully understood yet and deserve the attention of further research.

Differential achievement gains arising from course-enrollment decisions help to explain differences in college participation rates among SES groups. Higher SES students taking advanced courses grow faster in their academic skills and are therefore more likely to enroll in college by the age of 20 than lower SES students. At the same time, it is important to acknowledge that college enrollment is mostly driven by academic achievement levels and gains as the meritocratic principle would suggest if one is willing to ignore the indirect effects of SES at prior stage of the educational pathway. The meritocratic principle alone, however, does not sufficiently explain college attendance. Irrespective of academic achievement in school, family income and father's occupational status, in this order, are the major causes for the association between family SES and college status. As anticipated, direct effects of family income are not significant for track enrollment or academic performance, but they emerge at this point of transition from high school to college.

The fact that financial constraints at home are related to the college decision is particularly troubling because it indicates that highly skilled youths from low income families will benefit less from further educational opportunities and, consequently, will be less likely to enter the labor market at the educational level they could have mastered. Furthermore, inasmuch as tuition costs in the United States have increased more than family income in the past thirty years while returns to education have increased at the same rate, it is not surprising that the increasing rate of college attendance and graduation was mainly carried by the increase of educational participation of the middle class.

In light of these findings, it seems not far reaching enough to improve the financial situation for college students because it addresses the issue too late in the sequence of relevant events (Dynarski, 1999, 2000). Due to the way income information in the MSALT was collected, it was not possible to evaluate its absolute effect here. In relative terms, however, results reveal that the effect of academic performance in school is, by and large, greater than that of family income. This finding is in accordance with other studies (Carneiro & Heckman, 2002; Chevalier & Lanot, 2002; Harrington & Sum, 1999) and suggests that long term family factors *crystallized* in skills, i.e., through long-lasting mediation effects, are the major gateway for the decision of attending college. While financial constraints can be alleviated through financial aid or credits programs, no similar alternatives exist to compensate for family influences at earlier stages.

Father's occupational status is also directly related to the decision of attending college irrespective of other family socioeconomic characteristics and academic performance in school. The association between father's occupational status and the goals and aspirations of youths seems the most likely explanation for this finding drawing on theories that maintain that occupational preferences of fathers are a source of class-based culture and values which, in turn, influence youths' value attachment on educational outcome (Bourdieu, 1977; Karlsen, 2001; Koo, 2003). More generally, persisting direct effects of family SES on college attendance reflect that socioeconomically advantaged parents instill in their offspring favorable attitudes towards education which, in turn, positively affect their postsecondary plans and their actual college attendance decision (Carpenter & Fleishman, 1987; Crosnoe et al., 2002; Eccles et al., 2004; Hossler & Stage, 1992). These attitudes and beliefs are configured at a relatively early age. According to Atanda (1999) they are manifest as early as Grade 8 when students select courses that predetermine whether they are considered college-bound or not. Eccles et al. (2004) found that postsecondary educational plans are made already in elementary school. This literature and the findings reported here underline the importance of interventions at all levels of the educational career if the goal is to substantially and sustainably reduce the association between family SES and the educational success and social status of their offspring.

The findings also indicate that the effects of SES prevail into young adulthood following the suggested theoretical model: Children growing up in lower SES families perform less well in school, are less likely to attend college after high school completion and, ultimately, because of their poorer skills and lower completed levels of education, earn less in the labor market and attain a lower occupational status as adults than those coming from higher SES families. As expected, education is the critical channel for the intergenerational transmission of family SES. In combination, educational attainment and academic achievement fully account for the relationship between family SES and earnings and occupational status. These aspects are affected differently by family SES and, similarly, contribute to explain SES effects on labor force outcomes in different ways. In this regard, as hypothesized, albeit not tested, by Kerckhoff et al. (2001), the findings suggest that the family SES effect on educational attainment reflects more financial resources while its effect on academic achievement reflects more the cultural capital and socialization aspects.

Educational attainment and cognitive skills make independent contributions to the explanation of earnings and occupational status. Previous literature offers conclusive evidence for educational attainment effects on labor force outcomes, but is equivocal on skill effects when SES and educational attainment are controlled. The findings here suggest that irrespective of educational attainment, the labor market also rewards the cognitive skills represented by the academic achievement measure and, apparently, it does so more for earnings than for occupational status. This supports claims put forth by Grogger and Eide (1995), Johnson and Neal (1998), Kerckhoff et al. (2001), and Murnane et al. (1995). Accordingly, this study does not provide evidence to the contrary reported in older work (Collins, 1979; Hartigan & Wigdor, 1989; Spence, 1974).

The generalizability of results is limited by the positive bias in SES and attrition. Participants remaining in the sample at the age of 28, that is, 17 years after the first wave, come from higher SES families. However, to the extent that the mediating roles of academic achievement and educational attainment in the relationship between family SES and labor force outcomes tend to be underestimated given the structure of the sampling bias, then one can be confident that that findings are not an artifact of sample selection.

5. SUMMARY AND CONCLUSIONS

The goal of this dissertation was to further our understanding of the mechanisms underlying the intergenerational transmission of family SES. Focusing mainly on the mediating role of education, it sought to identify specific avenues whereby the reproduction of family SES over the life course can be reduced. To this end, longitudinal data from Germany, Canada, and the United States and a variety of statistical techniques well suited to these data were used. Specifically, the present work examined the trajectory of the achievement gap related to family SES over the course of schooling; the influence of achievement growth on school track placements; and the long-term effects of family SES on high school tracking, college attendance, and labor force outcomes. In the following, the main findings emanating from these analyses are discussed separately in light of prior research. Limitations are outlined and directions for future research are suggested. The last subsection briefly presents the conclusions of this dissertation.

5.1 The Trajectory of the Achievement Gap related to Family SES

Most studies lend support for a widening SES gap in academic achievement as students advance in school. One argument is that the gap between students of high and low SES families tends to increase because students of low SES families are disproportionately assigned to lower school tracks (e.g., Kerckhoff, 1993; Oakes, 1985; Pallas et al., 1994). Structural location influences are most apparent in educational systems that practice between school tracking, such as the German (Becker et al., 2006; Becker & Schubert, 2006; Maaz et al., 2008a; Neumann et al., 2007). There, students of low SES families are less likely to enter the academic track and therefore fail to benefit from better learning opportunities characterized by a more favorable school composition and institutional learning environment.

But even in systems where tracking is within schools, like in Canada and the United States, the gap also seems to widen (Gamoran & Mare, 1989; Gamoran et al., 1995; Hallinan, 1994; Hoffer, 1992). There, high SES students are more likely to enroll in advance courses leading to college education in disproportionate numbers and low SES students are more likely to enter vocational programs (Alexander et al., 2007; Davies & Guppy, 2006; Gamoran et al., 1995; Hallinan, 1994; Hoffer, 1992; Jones et al., 1995; Krahn & Taylor, 2007; Schnabel et al., 2002). Students taking college preparatory courses increasingly diverge from those less academically inclined in terms of their academic achievement.

Another argument is that non-school factors explain the widening. Specifically, the out-of-school context and the way students of varying socioeconomic backgrounds regulate their effort as they get older are a source of increasing inequalities among SES groups. Here, researchers have shown that the gap between high and low SES students grows faster during the summer break than when school is in session (Alexander, Entwisle, & Olson, 2001, 2007; Downey et al., 2004). Apparently, students of high SES families benefit more from family processes, material resources, affective context and, more generally, the out-of-school social context during the summer break than students from low SES families (Alexander, Entwisle, & Olson, 2001, 2007).

Also, other studies suggest that students of low SES families tend to put less effort into their academic pursuits as they get older because they realize they are likely to be excluded from desirable jobs and, consequently, they go through a process of disillusionment (Guo, 1998). Or, they may deem the prospect of exerting great effort in school to be undesirable, given the anticipation of eventually paying high tuition fees for university while lacking resources to afford them (Breen and Goldthorpe, 1997; Goldthorpe, 1996).

Although these studies and theories point to a widening gap, the majority of empirical evidence is limited in that it stems largely from cross-sectional designs or two-time point longitudinal designs (e.g., Becker, et al., 2006; Becker, et al., 2008; Becker & Schubert, 2006; Gamoran, 1992; Gamoran & Mare, 1989; Guo, 1998; Ross & Wu, 1996; Schnabel et al., 2002; Willms, 2002). The former confound age and cohort effects and the latter provide a very limited source of intra-individual variability to study change in the gap (Baltes et al., 1988; Bryk & Raudenbush, 1987; Raudenbush & Liu, 2000).

Instead, four measurement points from Canada's NLSCY (N = 6,290) and three measurement points from the Hamburg School Achievement Censuses (N = 12,959) were used here to examine the trajectory of the gap from age 7 to 15 and from age 10 to 15, respectively. The analytical strategy consists of a variety of regression techniques that account for ceiling effects in test scores, the multilevel nature of the data, and the possibility of students to change schools over time. These techniques soundly distinguish intra-individual, inter-individual, and intra-school variation. Thus, the methodological design advances the examination of the gap trend.

5.1.1 Limitations

A first limitation is the low response rate of the NLSCY math test. Yet, the low response rate was not simply due to attrition, but had to do with the process to obtain permission to test children at school, which was not necessarily related to family SES. Also, regression models control for a number of demographic factors that may be related to the response rate. And the SES-age interaction on which the findings are based was not systematically related to the response rate.

A second limitation is the small number of math items of this test. However, in earlier work based on a cross-sectional analysis of the NLSCY, Willms (1996) found remarkable consistency between results based on the NLSCY test and those based on more extensive curriculum-based measures.

A third limitation is that data attrition in the Hamburg data tended to exclude students of low SES families. Yet, not only students are lost but also new students from other cohorts enter the study because of retention in grade. And, socioeconomic characteristics of students who drop out and enter the study over time are fairly similar. Also, models control for retention in grade and the number of data points to counteract this source of bias.

A more general limitation is the restriction of the analysis to tests of the effects of family SES without direct tests of the mechanisms that produce these results, e.g., school tracking, the summer break, and individual effort. This factor certainly limits the ability to offer guidelines for the design and improvement of educational policies. More precise theorizing and more systematic empirical study of the mechanisms underlying changes in the gap are necessary to define the foci of intervention programs. Certainly, it is important to move beyond the descriptive characterization of the gap toward a deeper understanding of the reasons why achievement trajectories diverge among SES groups. Nonetheless, this work represents an initial step to study this issue with more sophisticated methods than in the past.

5.1.2 Findings

The analyses indicate that the achievement gap widens in Canada and tends to narrow in Hamburg, Germany. Specifically, the math gap among higher and lower SES Canadian children remains roughly stable from the age of 7 to 11 years, that is, more or less between Grades 2 and 6, and widens thereafter at an increasing rate of change up to the age of 15 years, that is, from about the beginning of Grade 7 to Grade 10. Thus, the math gap in Canada remains invariant during elementary school and sharply widens in the transition from elementary school to middle school. Throughout middle school years and up to the beginning of high school, the math gap widens at an increasing rate of change. This finding is consistent with the literature; plausible explanations for it and their implications are discussed in section 2.4.4.

What is most striking, however, is the finding of a narrowing gap in Hamburg. Most studies anticipate a widening gap through secondary school years, especially in educational systems that assign students into different schools in the transition from primary to secondary education, as is the case of Hamburg. Instead, it was found that both the math and reading gap tend to narrow from the age of 10 to 15. The reading gap narrows at a constant rate of change because lower SES students increase their reading skills at a faster pace than higher SES students. The math gap widens from the age of 10 to 12 and narrows thereafter. Importantly, the initial widening is explained by achievement levels and not by differential growth. In fact, students of lower SES families grow equally or more rapidly in their math skills than those of higher SES families from the age of 10 to 15. The specific mechanisms generating the pattern of decreasing inequalities were not investigated.

Nonetheless, it is argued here that this pattern should be interpreted in light of the relatively open and egalitarian school policies and practices in Hamburg.

School tracking in Hamburg is, apparently, less socioeconomically biased than in the rest of Germany: Hamburg's school system includes the largest percentage (10%) of students of non-German nationality in the academic track; a comprehensive school form with internal setting by subject and differential leaving certificates; and an *observational* stage (Grades 5 and 6) in which no distinction is made between the lowest and intermediate track and students from lower tracks can be promoted into the academic track. Also, teachers in Hamburg seek to reach out to all students regardless of their family SES. To this end, they seem to place a place a particular emphasis on the particular needs of disadvantaged students. Altogether, these school policies and practices appear to be conductive to fostering the growth of low SES students.

5.2 Achievement Growth and School Track Recommendations

Research has shown that school track recommendations are related to academic achievement and family SES. But it has neglected the influence of achievement growth in spite of increased attention of researchers in growth rather than in status in learning (Willet, 1988). Here, the influence of achievement growth is distinguished from that of achievement levels. This distinction is important from a theoretical and policy point of view. Theoretically, achievement levels reflect to a substantial extent innate ability and other individual attributes, whereas achievement growth reflects better the capacity of students to acquire skills over their school careers and their potential for academic success. From a policy perspective, the German Education Ministers' decree for primary school level establishes that irrespective of a child's origin, he/she shall enter a path of the education system in accordance with his/her capacity to acquire skills, aptitude, disposition, and its will to perform intellectual work.

With data from Berlin, Germany, the role of achievement growth in school track recommendations while controlling for achievement levels and family SES was examined. The analysis proceeds in two stages. First, predictors of achievement growth were evaluated and individual measures of achievement growth were estimated with the Bayes estimator (Lindley & Smith, 1972; Raudenbush & Bryk, 2002). Secondly, the influence of achievement growth on school track recommendations was analyzed. Also, drawing on Boudon's (1974) model, direct influences of family SES on school track recommendations expressed via the impact of academic achievement were distinguished from those influences that remain when academic achievement is controlled to shed light on the gateways for the effect of family SES. The influence of other family background and class level characteristics was also studied. The analyses draw on three data points from the Berlin longitudinal study ELEMENT (N = 2,242).

5.2.1 Limitations

A first limitation is that the analysis is based on a local study in the city of Berlin. Data from other German federal states or educational systems practicing between-school tracking are needed to ascertain whether the findings are maintained. Currently, however, there is no better data source for informing the issues addressed here. Available data sets contain fewer measurement points and/or neglect information on school track recommendations.

Another limitation is data loss due to missing values and attrition. Yet, MICE (Royston, 2004, 2005) was employed to predict missing values and estimate standard errors that account for missing data uncertainty. Students with less than 3 math measurements (27%) were excluded from the analytic sample to safeguard the reliability of math growth rates. These students come from relatively less advantaged backgrounds. Yet, differences between the original sample and analytic sample are small. Data loss is thus expected not to seriously bias model estimates.

Still another limitation is the low reliability of achievement growth (a=0.35). The empirical Bayes estimator was used to counteract the lack of precision of individual achievement growth measures. But actually this deficiency can only be improved with additional points of measurement. Given these limitations, results are best considered suggestive and should not be easily generalized.

5.2.2 Findings

The most important finding is that students growing more rapidly in their math skills are more likely to obtain a recommendation for the academic track. This finding is not an artifact of ceiling effects, regression toward the mean, or growth measuring ability rather than skills (see section 3.8). Irrespective of family SES and achievement levels, achievement growth is positively related to the academic track recommendation. This lends support to the idea that teachers monitor and evaluate student progress individually and reward growth with higher chances to benefit from better educational opportunities. Particularly, the results suggest that teachers reward more strongly the growth of students starting with low levels of math achievement but growing faster than what was expected for their initial status.

And yet, while the influence of growth is significant, the influence of the level of achievement is greater. In fact, when a set of socio-demographic and achievement variables are included in combination, the level of achievement turns out to be the most important predictor of school track recommendations. This finding is in accordance with the literature. What needs to be explored and discussed in future studies is to which extent school track recommendations ought to reflect achievement levels (status) and achievement growth (progress). Scholars and policy makers should add to the discussion on whether growth or the capacity to learn is equally, more, or less important than the levels of achievement. The presented analysis represents an initial step in this direction.

The analyses have also shown that family SES is related to the track recommendation indirectly via its impact on academic achievement but also directly via teacher influences. Given two students with comparable achievement levels and growth, teachers are more likely to recommend the student of a higher SES family to the academic track. This finding and previous literature suggest that, irrespective of their academic achievement, students of low SES families are in *double-jeopardy* due to teacher influences firstly and parental influences secondly. Compared to high SES students, they are less likely to be recommended to the academic track and, furthermore, even if they obtain the academic track recommendation, their parents are less likely to enroll them in the academic track (Bos et al., 2004; Ditton, 2007; Ditton et al., 2005; Maaz et al., 2008).

Another important finding is that students with migration background are more likely to obtain an academic track recommendation when family SES and academic achievement are controlled. Lehmann and Peek (1997) found similar evidence in Hamburg, Germany, but others studies favor a nonsignificant relationship (Arnold, et al 2007; Ditton et al., 2005; Kristen 2002, 2006; Tiedemann & Billmann-Mahecha, 2007). The relationship between migration background and school track recommendations was partly but not entirely explained by class composition characteristics. Even in socioeconomically comparable classes, students with migration background are more likely to obtain an academic track recommendation.

5.3 Family SES, Education, and Labor Force Outcomes

Finally, the influence of family SES on course-enrollment decisions in high school, college enrollment, and labor force outcomes was analyzed drawing on a longitudinal dataset spanning 17 years from a regional United States sample (MSALT; N = 2,264). These data facilitated the investigation of family SES influences in the transition from school to college and the labor market in addition to family SES influences in school. The analyses closed an important gap in the literature in that they allow examining several mechanisms related to the intergenerational transmission of family SES for a single cohort. They distinguished indirect influences of family SES mediated by educational outcomes from direct influences that remain when educational variables are controlled.

The relative contribution of skills to the explanation of labor force outcomes was also evaluated. Here, the literature is conclusive on the contribution of educational attainment but equivocal regarding the role of skills. Scholars favoring a negligible or nonsignificant influence of skills argue, for example, that employers have limited information on skills and therefore prefer to use educational attainment as a proxy of actual skills (Spence, 1974) or that powerful groups in society base labor force rewards on educational credentials rather than skills to filter out equally talented but uncertified employees (Collins, 1979). But researchers have also found evidence for significant effects of skills (Grogger & Eide, 1995; Johnson & Neal, 1998; Kerckhoff et al., 2001; Murnane et al., 1995). Furthermore, human capital theory (Becker, 1975) contends that earnings reflect skills at least as much as they reflect educational attainment.

5.3.1 Limitations

One limitation is that the vast majority of the MSALT sample consisted of lower middle and middle-class White (96.7%) students living in small industrial cities in Southeast Michigan. Because the mechanisms underlying family SES influences may vary among black and white families, the findings cannot be generalized. Another limitation is the use of middle school and high school GPA data as proxy of skills. No better data on skills were available when participants were in the labor market.

Still another limitation is the substantial attrition rate arising from the relatively long time span of the study. Attrition is particularly problematic for models of labor force outcomes at the age of 28. Here, the analytic sample represents a positive selection with respect to family SES of participants. Missing data in the analytic sample are another limitation. Yet, the MICE method and Rubin's rule (1987) were employed to estimate descriptive statistics and regression coefficients with corrected standard errors.

5.3.2 Findings

In line with previous literature, indirect effects of family SES mediated by educational outcomes were found to be greater than direct effects. For instance, academic achievement is affected by family SES and contributes to explain course enrollment decisions in high school to a greater extent than family SES. Also, achievement levels and gains in high school are a more important predictor of the decision to enroll in college than family SES. Although less critical, direct effects of family SES are also significant.

The direct influence of family SES on course enrollment decisions was not examined thoroughly. But the literature suggests that it may be explained by family factors such as parental expectations and parental involvement (Baker & Stevenson 1986; Condron 2007;

Dauber et al., 1996; Gamoran & Mare 1989; Schnabel et al., 2002). Family income and father's occupational status largely explain the direct influence of family SES on college attendance. The effect of family income becomes significant at the transition from high school to college. Then, financial constraints at home limit the capacity of highly skilled youths from low income families to benefit from further educational opportunities. The direct influence of father's occupational status may reflect that youths whose fathers are employed in high prestige occupations attach a greater value to education irrespective of their academic performance in high school (Bourdieu 1977; Karlsen 2001; Koo 2003). No evidence for direct effects of family SES on earnings and occupational status was found. When educational attainment and skills are controlled, the effect of family SES is nonsignificant. Thus, education appears to entirely explain the intergenerational transmission of family SES.

Educational attainment and skills are affected differently by family SES and, similarly, they mediate the effect of family SES on labor force outcomes in different ways. Apparently, educational attainment reflects more financial resources while skills reflect more the cultural capital and socialization aspects. Finally, the results indicate that, irrespective of educational attainment, the labor market also rewards skills. Apparently, the influence of skills when educational attainment is controlled is greater for earnings than for occupational status. The mechanisms whereby skills influence these labor force outcomes were not examined, though.

5.4 Conclusions

This dissertation has identified several mechanisms underlying the reproduction of family SES over the course of schooling and later on in life. With that, it has aimed to elicit new insights into how the opportunities of children from low SES families can be enhanced as they get older. In the following, these mechanisms and their importance at different stages are discussed: (1) in the transition from primary to secondary school, (2) throughout the school period, and (3) in the transition from school to college and the labor market, separately.

In the transition from primary to secondary education, family SES influences on school track placements are largely explained via the effect of academic achievement. Furthermore, teacher and parental influences can amplify socioeconomic inequalities at this transitional point.

In accordance with other studies, it was found that in educational systems with course-level tracking, like in the United States and Canada, students of high SES families are more likely to enroll in advanced placement courses leading to college education irrespective of their academic achievement (Baker & Stevenson, 1986; Caro, Schnabel, & Eccles, 2009; Condron, 2007; Dauber et al., 1996; Gamoran & Mare, 1989; Schnabel et al., 2002). Apparently, high SES parents instill in their offspring favorable attitudes towards education, which, in turn, positively influence their postsecondary plans and course-enrollment decisions in high school (Atanda, 1999; Carneiro & Heckman, 2002; Chevalier & Lanot, 2002; Eccles et al., 2004; Hossler & Stage, 1992; Karlsen, 2001; Koo, 2003).

Also, it was found that in systems with explicit between-school tracking, like in Germany, teachers are more likely to recommend students of high SES families to the academic track irrespective of their academic achievement (Arnold et al., 2007; Bos & Pietsch, 2005; Caro, Lenkeit, Lehmann, & Schwippert, 2009; Lehmann & Peek, 1997). Besides academic achievement, recommendations of teachers seem to take into account parental involvement in school issues, educational valuation, and the cultural fit. Parental influences also occur with high SES parents being more likely to enroll their children in the academic track (Arnold et al, 2007; Ditton et al., 2005; Ditton & Krüsken, 2006; Tiedemann & Billmann-Mahecha, 2007). Students of low SES families are thus in *double-jeopardy*, due to teacher influences on the recommendation firstly and due to parental influences on the final decision secondly.

Achievement growth can also alter the reproduction of family SES in the transition from primary to secondary school. With data from Berlin, Germany, evidence that achievement growth can compensate for status disadvantages was found. Irrespective of initial achievement levels and family SES, students growing more rapidly in their skills are more likely to be recommended to the academic track and therefore benefit from a university education (Caro, Lenkeit, Lehmann, & Schwippert, 2009). Teachers seem to monitor and reward student growth individually while issuing school track recommendations. From this perspective, school factors driving achievement growth can contribute to reduce educational inequalities associated with family SES.

The literature stresses the importance of teachers' instructional practices (Guarino et al., 2006; Lee et al., 2006; Palardy & Rumberger, 2008; Shacter & Thum, 2004), teachers' attitudes towards their ability and the ability of students to learn (Goddard et al., 2000; Palardy & Rumberger, 2008; Shacter & Thum, 2004), and teachers' background characteristics (Greenwald et al., 1996; Wayne & Youngs, 2003) to achievement growth. Also, some studies indicate that the frequency of homework assignments (Trautwein et al., 2002) and school policies promoting parent involvement and academic counseling (Holt & Campbell, 2004) contribute to the achievement growth of students.

More generally, several studies indicate a widening gap in academic achievement among students of low and high SES families over the course of schooling. Scholars invoke cultural and structural theories to explain this pattern. Evidence of a widening gap attributed partly to course-level tracking was found with data from a regional U.S. study (Caro, Schnabel, & Eccles, 2009). Findings in Canada and Berlin, Germany also revealed a widening gap as students advance in school (Caro, Lenkeit, Lehmann, & Schwippert, 2009; Caro, McDonald, & Willms, in press). But perhaps the most striking result of this work is that the gap tends to narrow in Hamburg, Germany in spite of between-school tracking (Caro & Lehmann, in press). The relative validity of the different theories predicting changes in the gap was not tested. The present work was more concerned with the methodological advance of measurement of the gap trend. Nonetheless, it is argued that Hamburg's relatively open and egalitarian school tracking policies are conductive to fostering the growth of low SES and thus lie behind the narrowing gap (Caro & Lehmann, in press).

Drawing on U.S. data, it was found that family income and father's occupational status affect the college decision irrespective of academic performance in school (Caro, Schnabel, & Eccles, 2009). Thus, given two youths with comparable skills the one from a higher SES family is more likely to benefit from college education. Highly skilled youths of low income families are less able to afford tuition costs and therefore less likely to enroll in university than their high income peers. Tuition costs in the United States have increased more than family income in the past thirty years, thus strengthening the transmission of family SES from parents to children. Some studies maintain that the influence of father's occupational status is explained via the association between occupational preferences and the value youths attach to education (Bourdieu, 1977; Karlsen, 2001; Koo, 2003).

In agreement with other studies, it was found that the influence of family SES on college enrollment is largely mediated by the effect of academic performance in school (Carneiro & Heckman, 2002; Caro, Schnabel, & Eccles, 2009; Chevalier & Lanot, 2002; Harrington & Sum, 1999). Long term family factors *crystallized* in skills are the major gateway for the decision of attending college. Therefore, interventions that alleviate financial constraints and raise educational aspirations of low SES youths, though important, address the issue too late in the sequence of events and are thus less effective than those aimed at improving academic skills of low SES students.

Adults coming from low SES families earn less and attain a lower occupational status than those coming from higher SES families. The influence of family SES on these labor force outcomes is fully mediated by educational outcomes (Caro, Schnabel, & Eccles, 2009). Once educational attainment and skills are controlled, family SES does not contribute to explain differences in earnings and occupational status. Educational attainment and skills are affected differently by family SES and, similarly, they make independent contributions to the explanation of labor force outcomes (Caro, Schnabel, & Eccles, 2009; Kerckhoff et al., 2001). Apparently, the SES effect on educational attainment reflects more financial resources while its effect on skills reflects more the cultural capital and socialization aspects.

Clearly, individual merits do not suffice to succeed in life. Family SES critically determines educational and labor opportunities over the life course. Several mechanisms underlie the transmission of family SES from parents to children. Many are related to family processes and are thus less amenable to policy intervention from the educational sector, but call for interventions from other social sectors and actors. Various strategies can contribute to reduce socioeconomic inequalities from the educational side. They vary depending on the educational setting and transitional point. In general terms, however, students of low SES families can benefit from instructional practices that foster achievement growth, more egalitarian and open school tracking policies, summer and after-school programs, vocational guidance programs, and financial aid interventions for college enrollment. Certainly, interventions implemented earlier in life are likely to be most effective.

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7. APPENDIXES

Appendix A

Table A. Descriptive Statistics of Variables Included in Multilevel Analyses

Characteristic	Full Sample			Final Sample			Excluded Sample		
	Obs	*Mean*	*SD*	*Obs*	*Mean*	*SD*	*Obs*	*Mean*	*SD*
Student Level									
Reading Achievement	12053	132.12	15.42	10235	132.88	15.10	1818	127.83	16.45
Math Achievement	11304	129.49	15.70	10235	129.86	15.71	1069	125.95	15.13
Sex (female=1)	12618	0.49	0.50	10235	0.49	0.50	2383	0.49	0.50
Mother's Schooling	8156	3.32	1.25	7566	3.33	1.25	590	3.13	1.24
Father's Schooling	7083	3.42	1.31	6601	3.44	1.31	482	3.28	1.33
Mother's Vocational Training	8040	3.07	1.67	7456	3.09	1.67	584	2.87	1.67
Father's Vocational Training	7015	3.53	1.74	6544	3.55	1.74	471	3.35	1.74
Family Wealth Index	9441	0.00	0.99	8739	0.03	0.97	702	-0.31	1.18
Family SES	8345	0.00	1.00	7779	0.01	1.00	566	-0.11	0.99
School Level									
School SES	187	-0.12	0.57	186	-0.12	0.57	185	-0.13	0.57
Lowest/Intermediate track	189	0.43	0.49	186	0.42	0.49	181	0.44	0.49
Comprehensive School	189	0.20	0.40	186	0.20	0.40	181	0.20	0.40
Academic Track	189	0.37	0.48	186	0.38	0.48	181	0.35	0.47

Appendix B

Table B1. Data from the Canadian Case: Main Statistics of Variables (*N*=15,847)

Characteristic	*Mean*	*SD*
Cycle 2	0.30	0.46
Cycle 3	0.28	0.45
Cycle 4	0.26	0.44
Sex (female=1)	0.50	0.50
Teenage Mother	0.04	0.20
Number of Siblings	1.27	0.88
Single Parent Family	0.16	0.36
Immigrated to Canada	0.08	0.27
Age of 7	0.09	0.29
Age of 8	0.11	0.32
Age of 9	0.13	0.34
Age of 10	0.15	0.36
Age of 11	0.14	0.35
Age of 12	0.12	0.33
Age of 13	0.10	0.30
Age of 14	0.08	0.27
Age of 15	0.06	0.24
Age in Months	133.77	27.69
Family SES	0.02	0.90

Table B2. Data from the Hamburg Case: Main Statistics of Variables

	Full Sample (*N* = 16,266)		Analysis Sample (*N* = 12,959)		Excluded Sample (*N* = 3,307)	
Characteristic	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Reading, Grade 5	100.00	20.00	101.11	19.62	91.21	20.83
Reading, Grade 7	118.91	15.81	119.48	15.68	111.89	15.64
Reading, Grade 9	132.12	15.42	132.63	15.27	126.76	15.93
Math, Grade 5	100.00	20.00	100.93	19.81	92.22	19.88
Math, Grade 7	117.73	18.99	118.26	19.04	111.30	17.15
Math, Grade 9	129.49	15.70	129.79	15.72	125.51	14.77
Age in Years, Grade 5	10.49	0.63	10.47	0.61	10.57	0.73
Age in Years, Grade 7	12.49	0.63	12.47	0.61	12.57	0.73
Age in Years, Grade 9	14.62	0.71	14.50	0.59	15.72	0.77
Age in Months, Grade 5	128.36	8.12	128.18	7.92	129.64	9.30
Age in Months, Grade 7	152.36	8.12	152.18	7.92	153.64	9.30
Age in Months, Grade 9	177.94	9.09	176.51	7.76	191.13	9.81
Proportion of Females	0.48	0.50	0.49	0.50	0.42	0.49
Mother's Schooling (1 to 5)	3.23	1.26	3.25	1.26	3.09	1.23
Father's Schooling (1 to 6)	3.33	1.32	3.36	1.33	3.15	1.30
Mother's Vocational Training (1 to 6)	2.91	1.65	2.93	1.65	2.81	1.59
Father's Vocational Training (1 to 6)	3.36	1.73	3.38	1.73	3.16	1.66
Family Wealth Index	0.01	0.99	0.04	0.95	-0.21	1.20
Family SES	0.00	1.00	0.01	1.00	-0.09	0.97
Retention in Grade 7	0.13	0.33	0.06	0.24	0.76	0.43
Retention in Grade 9	0.12	0.33	0.08	0.27	0.55	0.50
Longitudinal Time Points	2.40	0.81	2.69	0.58	1.27	0.52

Table B3. Attrition Analysis: Drop Out Sample in Grade 5 and 7 and Entering Sample in Grade 7 and 9

	Drop Out (N = 3,714)		Replenishment (N = 3,263)	
Characteristic	*Mean*	*SD*	*Mean*	*SD*
Proportion of Females	0.42	0.49	0.47	0.50
Proportion of Mothers Admitted to University (*Abitur*)	0.23	0.42	0.27	0.44
Proportion of Fathers Admitted to University (*Abitur*)	0.26	0.44	0.34	0.48
Proportion of Mothers with University Degree	0.10	0.30	0.13	0.34
Proportion of Fathers with University Degree	0.16	0.36	0.21	0.40
Family Wealth Index	-0.13	1.12	-0.06	1.13
Family SES	-0.07	0.99	0.04	0.98
Longitudinal Time Points	1.50	0.50	1.40	0.49

Table B4. Reading Anchoring Items: Correct Responses by School Form (% of students)

School form	Item A		Item B		Item C		Item D		Item E	
	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9
Lowest/Intermediate	36.70	57.30	61.40	78.60	31.00	38.10	50.90	71.00	40.70	64.30
Comprehensive	45.20	62.00	66.00	76.10	35.90	46.00	57.40	71.30	47.80	60.50
Academic	76.50	89.10	87.60	93.20	51.50	66.60	82.00	93.00	76.10	78.70
School form	Item F		Item G		Item H		Item I			
	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9		
Lowest/Intermediate	43.50	65.00	36.50	64.80	31.80	52.20	46.10	62.60		
Comprehensive	47.30	67.60	43.00	64.50	36.00	54.50	49.60	65.20		
Academic	69.20	93.60	66.90	90.30	50.30	71.70	73.20	88.90		

Table B5. Math Anchoring Items: Correct Responses by School Form (% of students)

School form	Item A		Item B		Item C		Item D		Item E	
	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9
Lowest/Intermediate	30.30	33.50	28.00	64.10	28.20	64.50	27.60	31.30	31.10	28.60
Comprehensive	29.50	33.40	34.60	64.90	35.90	67.50	23.80	30.60	32.20	31.80
Academic	66.40	78.20	75.50	91.00	71.90	91.60	63.00	74.90	61.20	64.10
School form	Item F		Item G		Item H		Item I		Item J	
	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9	Grade 7	Grade 9
Lowest/Intermediate	28.60	37.50	24.60	34.20	28.50	36.80	29.10	58.80	31.40	42.20
Comprehensive	27.10	36.00	30.00	42.00	29.90	38.50	31.50	57.00	32.60	44.20
Academic	58.30	73.50	67.70	75.10	55.60	62.60	56.40	82.10	49.50	57.20

Appendix C

Table C. Main Statistics of Dependent and Independent Variables

Characteristic	Original Sample (N = 3,168)		Analytic Sample (N = 2,242)		Excluded Sample (N = 926)	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Dependent Variables						
Math Achievement, Grade 4	95.66	(0.37)	96.58	(0.34)	93.41	(0.96)
Math Achievement, Grade 5	105.60	(0.32)	106.78	(0.35)	102.71	(0.69)
Math Achievement, Grade 6	113.91	(0.35)	115.03	(0.38)	111.13	(0.75)
Math School Grade, Grade 6	2.98	(0.02)	2.89	(0.02)	3.22	(0.04)
Track Recommendation (Academic = 1)	0.36	(0.01)	0.40	(0.01)	0.27	(0.02)
Independent Variables						
Basic Cognitive Abilities	25.24	(0.22)	25.83	(0.24)	23.80	(0.46)
Age in Years, Grade 4	10.65	(0.01)	10.60	(0.01)	10.79	(0.03)
Age in Years, Grade 5	11.57	(0.01)	11.52	(0.01)	11.70	(0.03)
Age in Years, Grade 6	12.49	(0.01)	12.44	(0.01)	12.62	(0.03)
Sex (Female = 1)	0.48	(0.01)	0.49	(0.01)	0.44	(0.02)
Parental Schooling	3.44	(0.03)	3.48	(0.03)	3.36	(0.07)
Parental Vocational Training	2.46	(0.05)	2.47	(0.05)	2.43	(0.11)
Parental Occupational Status	46.27	(0.42)	46.86	(0.40)	44.83	(1.11)
Family SES	0.00	(0.02)	0.03	(0.03)	-0.07	(0.05)
German with Migration Background	0.10	(0.01)	0.11	(0.01)	0.09	(0.01)
Foreign	0.25	(0.01)	0.26	(0.01)	0.22	(0.02)

Appendix D

Table D. Main Statistics of Independent Variables by Analytic Model

Characteristic	Academic Achievement		Track Enrollment		College Enrollment		Earnings		Occupational Status	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Female	0.54	(0.01)	0.53	(0.01)	0.57	(0.01)	0.57	(0.02)	0.59	(0.02)
Family SES	-0.02	(0.02)	0.03	(0.02)	0.04	(0.02)	0.30	(0.04)	0.18	(0.03)
Father's Education	13.75	(0.05)	13.80	(0.06)	13.87	(0.06)			14.16	(0.09)
Mother's Education	13.28	(0.04)	13.37	(0.05)	13.39	(0.06)			13.60	(0.08)
Father's Occupational Status	52.23	(0.40)	52.98	(0.46)	53.03	(0.45)			54.76	(0.63)
Mother's Occupational Status	47.13	(0.32)	47.68	(0.37)	47.76	(0.38)			49.28	(0.50)
Family Income	3.69	(0.03)	3.77	(0.03)	3.75	(0.03)			3.83	(0.04)
Track Enrollment	0.32	(0.01)			0.35	(0.01)				
GPA Grade 7	10.20	(0.04)	10.35	(0.05)						
GPA Grade 10	9.65	(0.06)			10.00	(0.07)				
GPA Gains (Grade 10 to 12)	0.04	(0.05)			0.03	(0.05)				
GPA (mean Grades 7,10, and 12)	9.93	(0.04)					10.74	(0.08)	10.52	(0.06)
Educational Attainment at Age 28	14.59	(0.07)					15.58	(0.09)	15.16	(0.07)
Sample Size	2,264		1,631		1,601		552		907	
% of Original Sample	92		67		65		23		37	

ZUSAMMENFASSUNG (GERMAN SUMMARY)

Die Forschung zeigt, dass über die Lebensspanne hinweg der Bildungserfolg und die Stellung im Erwerbsleben mit dem familiären sozioökonomischen Status (SES) verbunden sind. Kinder aus sozioökonomisch benachteiligten Familien haben auch im Erwachsenenalter mit höherer Wahrscheinlichkeit einen niedrigen SES. In dieser Arbeit werden drei Aspekte der intergenerationellen Weitergabe des familiären SES untersucht.

Der erste Aspekt betrifft den Zusammenhang zwischen familiären SES und dem schulischen Leistungszuwachs. Eine Vielzahl von Studien verweist auf größere Lernzuwächse von Kindern aus sozial begünstigten Familien und indizieren damit einen Schereneffekt auf die schulischen Leistungen. Oft weisen diese Studien jedoch methodische Mängel auf. Die vorliegende Analyse greift auf Daten aus Hamburg, Deutschland (N = 12.959) und Kanada (N = 6.290) zurück. Nicht nur bietet die Datengrundlage größere interindividuelle Variabilität (3 und 4 Messzeitpunkte), es wird außerdem eine Vielzahl von Regressionsverfahren genutzt, die im Besonderen für Längsschnittanalysen geeignet sind. Die Untersuchung liefert damit einen Beitrag, der über den bisherigen Forschungsstand hinaus geht. Die Ergebnisse zeigen, dass sich die Leistungsunterschiede in Kanada verstärken, in Hamburg hingegen verringern. Letzteres kann durch relativ offene und egalitäre schulische Richtlinien und Praktiken in Hamburg erklärt werden.

Der zweite Aspekt betrifft die Rolle des Leistungszuwachses für die Grundschulempfehlungen der Lehrkräfte. Bisherige Untersuchungen thematisieren übereinstimmend den Einfluss des Leistungsniveaus und des familiären SES auf die Empfehlungen, vernachlässigen jedoch die Rolle des Leistungszuwachses. Als

Datengrundlage für die Analysen dient eine Studie mit drei Erhebungszeitpunkten aus Berlin, Deutschland (*N* = 2.242). Anhand der Daten wird der um die Reliabilität angepasste Lernzuwachs und sein Effekt auf die Empfehlungen der Lehrkräfte geschätzt. Die Ergebnisse suggerieren, dass die Lehrkräfte den Lernzuwachs in ihren Empfehlungen berücksichtigen, so dass Schülerinnen und Schüler mit höheren Lernzuwachsraten unabhängig von ihrem familiären SES und ihrer Lernausgangslage eher eine Empfehlung für ein Gymnasium erhalten. Darüber hinaus bekommen, unter sonst gleichen Bedingungen, Mädchen, Schülerinnen und Schüler mit Migrationshintergrund und solche aus sozial begünstigten Familien eher eine Gymnasialempfehlung. Ferner verringert sich die Wahrscheinlichkeit für eine Gymnasialempfehlung in Klassen mit hohem Leistungsniveau und geringen Anteilen an Schülerinnen und Schülern mit Migrationshintergrund.

Der dritte Aspekt thematisiert die vorherrschenden Wirkmechanismen des familiären SES im Hinblick auf die schulischen Leistungen, die Kurswahlentscheidungen in der High School, den Besuch eines Colleges und den beruflichen Erfolg. Die Analysen werden auf der Basis von Daten einer Längsschnittuntersuchung aus den USA durchgeführt (*N* = 2.264), welche die gleiche Kohorte 17 Jahre verfolgt hat. Die Ergebnisse zeigen, dass die Leistungsschere, die mit dem familiären SES assoziiert werden kann, sich vom frühen bis zum späten Jugendalter weiter öffnet und dies teilweise in Folge von Kurswahlentscheidungen. Der Besuch eines Colleges wird zu großen Teilen durch das schulische Leistungsniveau und den Lernzuwachs erklärt, wird jedoch zusätzlich direkt von dem familiären Einkommen und der beruflichen Stellung des Vaters beeinflusst. Die Befunde indizieren außerdem, dass die Effekte des familiären SES auf das Einkommen und die berufliche Stellung vollständig über den Bildungsabschluss und die kognitiven

Grundfähigkeiten vermittelt werden. Letztlich zeigen die Ergebnisse auch, dass die kognitiven Grundfähigkeiten unabhängig vom Bildungsabschluss und dem familiären SES auf dem Arbeitsmarkt gewürdigt werden.

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INTERNATIONAL CONGRESS OF PSYCHOLOGY Berlin, Germany

Achievement Inequalities in Hamburg Schools: How do they Change as Students get Older? Symposium (Jul 08)

LIFE ACADEMIES

Max Planck Institute for Human Development Berlin, Germany

The Role of Academic Achievement Growth in School Track Recommendations

Poster presentation (Oct 08)

University of Virginia Charlottesville, USA

Socioeconomic Background, Education, and Labor Force Outcomes

Oral presentation (May 08)

University of Michigan Ann Arbor, USA

Cognitive Skill and Earning Differences between High and Low SES Youths.

Poster Presentation (Oct 07)

Max Planck Institute for Human Development Berlin, Germany

Achievement Gaps Associated with SES in Hamburg Schools: How do they Change as Students get Older?

Symposium (May 07)

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A Longitudinal Analysis of Math Achievement Gaps Associated with Socioeconomic Status: How do They Change From Childhood to Adolescence?

Oral Presentation (Oct 07)

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Oral Presentation (Jul 07)

PUBLICATIONS

Charyk, T., Polgar, D., Girotti, M. J., Vingilis, E., Caro, D. H., Corbett, B. A., & Parry, N. (2009). Evaluation of an Adolescent Hospital-based Injury Prevention Program. *The Journal of Trauma, 66*(5), 1451-1460.

PAPERS IN PRESS

Caro. D. H. & Lehmann, R. Achievement Inequalities in Hamburg Schools: How do they Change as Students get Older? *School Effectiveness and School Improvement*.

Caro, D. H., McDonald, J. T., & Willms, J. D. Socioeconomic Status and Academic Achievement Trajectories from Childhood to Adolescence. *Canadian Journal of Education*.

PAPERS SUBMITTED FOR PUBLICATION

Caro. D. H. & Lehmann, R. Measuring Socioeconomic Status and its Gradient Effect on Student Achievement in Hamburg.

Caro, D. H., Schnabel, K., & Eccles, J. Socioeconomic Background, Education, and Labor Force Outcomes.

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ERKLÄRUNG

Hiermit versichere ich, dass ich die vorgelegte Arbeit „Family Socioeconomic Status and Inequality of Opportunity" selbständig verfasst habe. Andere als die angegebenen Hilfsmittel habe ich nicht verwendet. Die Arbeit ist in keinem früheren Promotionsverfahren angenommen oder abgelehnt worden und wird zur Veröffentlichung eingereicht. Im Einzelnen handelt es sich um folgende Manuskripte:

1. Caro. D. H. & Lehmann, R. (im Druck). Achievement Inequalities in Hamburg Schools: How do they Change as Students get Older? *School Effectiveness and School Improvement*.
2. Caro, D. H., McDonald, J. T., & Willms, J. D. (im Druck). Socioeconomic Status and Academic Achievement Trajectories from Childhood to Adolescence. *Canadian Journal of Education*.
3. Caro, D. H, Schnabel, K., & Eccles, J. (2009). Socioeconomic Background, Education, and Labor Force Outcomes.
4. Caro, D. H, Lenkeit, J., Lehmann, R., & Schwippert, K. (2009). The Role of Academic Achievement Growth in School Track Recommendations.

Alle angeführten Koautoren werden bestätigen, dass ich an der Konzeption, Planung, und Durchführung der Forschungsprojekte hauptverantwortlich war.

Daniel H. Caro

Berlin, im September, 2009