Family SES, Non-cognitive Skills and Achievement Inequality in Children's Early Life Course

by

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To my parents and grandparents.

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Chapter I. Introduction

In the first chapter of my dissertation, "Why Do Asian Americans Academically Outperform Whites? --- The Cultural Explanation Revisited", I take an interactive approach to examining the role of culture and SES in explaining Asian Americans' achievement. Researchers have long pointed to two explanations for why Asian American children outperform their white peers in education: Asian American families are comparatively well-off, and they emphasize academic success for their children. However, few studies have examined how economic and cultural forces interact to produce Asian Americans' achievement advantage, which is addressed by this work. I propose that the cultural orientation of Asian American families is different from that of white American families in ways that weaken the impact of family SES on achievement for Asian American children and advantage them. Using data from the baseline wave of Education Longitudinal Study (ELS) 2002, we find that Asian Americans' academic attitudes and behaviors, such as expectations and work ethic, are less influenced by family SES than those of whites. This difference helps generate Asian American's premium in achievement – as is especially evident at lower levels of SES.

The second chapter, "Non-cognitive Skills and the Growing Achievement Gap" (under review), focuses on the relationship between non-cognitive skills and education achievement from a dynamic and longitudinal perspective, and examines the role of non-cognitive skills in maintaining and widening SES inequality in achievement as children progress through school. Using data from the Early Childhood Longitudinal Program (ECLS), I assess whether and how

non-cognitive skills evolving after school entry account for the growing SES achievement difference. I find that the emerging SES differences in non-cognitive skills at the entry into kindergarten persist throughout early school years as non-cognitive skills develop along a path-dependent pathway. The persistent differences in non-cognitive skills account for the growing SES achievement gap as non-cognitive skills consistently mediate family SES's positive effects on learning, measured by monthly improvement in math and reading ability.

The third chapter, "Can Non-cognitive Skills Compensate for Background Disadvantage? --- The Moderation of Non-cognitive Skills on Family SES and Achievement during Early Childhood and Early Adolescence", examines whether family SES effects on achievement are contingent on – or moderated by – children's non-cognitive skills such as motivation and self-control. As children's development is a longitudinal process, I approach this question using a longitudinal perspective and examine two developmental stages: early childhood and early adolescence. As non-cognitive skills moderate and mediate family SES effects on achievement at the same time, traditional regression methods are insufficient to answer this longitudinal moderation question and give rise to the problem of over-controlled intermediate variables and collider stratification. I use Structural Nested Mean Models (SNMM), a recent development in statistical methods designed to solve these challenges of time-varying confounders and moderators. Using data from the Early Childhood Longitudinal Program (ECLS), I found that better non-cognitive skills significantly weaken family SES effects on achievement during both early childhood and early adolescence. In other words, family SES impacts achievement less for children with better non-cognitive skills. The results also imply that individual level characteristics interact with family level resources to influence one's social outcomes in the stratification process, which should be given more attention in future studies of inequality.

Chapter II. Why Do Asian Americans Academically Outperform Whites? --- The Cultural Explanation Revisited

Introduction

Given their higher socioeconomic success than that of other U.S. minority groups and the population at large, Asian Americans have been characterized as a "model minority." At younger ages, this difference is manifested in Asian Americans' relatively high levels of school performance and educational attainment (Chan 1991; Kao 1995). Recent statistics show that, relative to U.S. Whites and other racial/ethnic groups, Asian Americans achieve higher test scores and obtain better grades (Hsia 1988; Caplan et al. 1991; Sanchirico 1991; Zhou and Bankston 1998; Kao 1995; Fejgin 1995; Hsin and Xie 2014), and they are more likely to complete high school and college, to obtain postgraduate degrees, and to attend first-tier universities (Xie and Goyette 2003; Lee and Zhou 2014). As educational achievement is highly correlated with labor market outcomes, Asian Americans' academic achievement is viewed as an important factor in their later career success and thus has been of interest to scholars in social stratification.

Research has established two main explanations for Asian Americans' premium in academic achievement. The first explanation focuses on their advantage in structural resources. Because family socioeconomic status (SES) is perhaps the most important predictor of children's academic achievement (e.g., Duncan, Featherman, and Duncan 1972), the relatively high levels of education and income that recent Asian American immigrants have achieved are viewed as an advantage in the provision of educational resources in the home for their children (e.g., Kao 1995;

Sun 1998; Sakamoto and Furuichi 1997; 2002). However, studies have found that family SES alone does not fully account for Asian Americans' higher levels of educational achievement (Goyette and Xie 1999; Kao 1995) and, in particular, that it does not explain the academic achievement of children whose parents immigrated from Southeast Asian countries, most of whom arrived with low levels of human capital and economic resources. Moreover, it has also been observed that even Asian American children from disadvantaged family backgrounds enjoy the Asian premium in academic achievement, suggesting that access to more and better home resources is not the key to their success (Lee and Zhou, 2014).

The second explanation emphasizes the role of culture. Some scholars have argued that Confucianism exerts an influence on Asian families' strong emphasis on education (Wong 1990; Schneider and Lee 1990, Nagasawa and Espinsoa 1992; Stevenson and Stigler 1992; Barringer, Gardner, and Levin 1993; Jiménez and Horowitz 2013). Others have posited that the selectivity of recent Asian immigrants to the U.S. contributes to their strong belief in and optimism about the value of education for social mobility (Sue and Okazaki 1990; Kao and Tienda 1998; Xie and Goyette 2003). It is believed that these cultural differences from Whites shape Asian Americans' behaviors and attitudes in school and equip them with stricter work ethics and higher educational aspirations, all of which benefit their academic achievement (Hsin and Xie 2014).

Most existing studies on Asian Americans' achievement premium treat SES and culture as two discrete factors. Implicit in this approach is an assumption that SES and culture influence Asian Americans' achievement in independent and additive ways. However, culture and SES's effects can be interactive rather than additive. Specifically, culture can serve as a moderator of the effects of family's SES on children's educational achievement, which makes family SES's effects on children's educational achievement incomparable across Asian Americans and other

groups. In fact, recent qualitative work has hinted at this possibility. For example, Lee and Zhou (2014), in their most recent study, observed that even Asian American children from disadvantaged family backgrounds enjoy the Asian premium in academic achievement, suggesting that the effects of family's SES on achievement may be less significant among Asian Americans than among Whites. Nevertheless, to our best knowledge, no quantitative work has yet systematically examined the potential interactive relationship between culture's and SES's effects on Asian Americans' achievement premium.

In this paper, we propose that cultural factors and family's SES influence Asian Americans' achievement premium interactively and that the cultural orientation of Asian Americans compared to that of white Americans acts as a moderating factor in the effects of SES on educational achievement. In our work, we do not measure culture by variables pertaining to beliefs and values, as has been done in previous research, but we capture the influence of culture by looking at the relationship between family SES on the one hand and achievement and education-related behaviors and attitudes on the other hand. Drawing on prior work by psychologists Stevenson and Stigler (1992), we conjecture that SES has weaker effects on academic achievement for Asians than for Whites in the U.S. If this is true, the achievement difference between Asian Americans and Whites is larger at low than at high levels of SES.

Our study fills a gap in the current literature by examining the heterogeneous effects of family SES on children's academic achievement across Asians and Whites in the U.S. We argue that the weaker association of SES and achievement among Asian Americans relative to Whites epitomizes cultural differences and accounts for much of the observed overall achievement gap. To test our hypotheses, we analyze data from the 2006 Educational Longitudinal Studies (ELS).

Family SES vs. Culture: Two Explanations for the Asian-White Achievement Gap

Currently, there are two main sociological explanations for the achievement differences between Asian-Americans and Whites. The first explanation attributes Asian-Americans' academic success to the socioeconomic, or the structural, advantage of their families and parents. Though most immigrants from Asia to the U.S. prior to World War II arrived to meet low-wage, low-human-capital labor needs, changes since then in immigration laws and in the demand for scientific and technical personnel have meant that more recent Asian immigrants are likely to be well-trained professionals (Cheng and Bonacich, 1984; Nee and Wong 1985). While this selection may contribute to the educational achievement of high-SES Asian American immigrants' children (Barringer et al. 1993), it fails to account for the high levels of achievement among children whose parents immigrated from Southeast Asian countries, such as Vietnam, Laos, and Cambodia, often arriving with little economic or human capital. In addition, recent studies have found that academic differences between white and Asian American children persist even after controlling for family structural characteristics such as parental education, household income, and family composition (Harris, Jamison, and Trujillo 2008).

The view that Asian Americans' advantage in educational achievement is rooted not so much in family SES as in the high value placed on education in Asian cultures has gained traction in recent studies. Researchers have presented evidence that Asian American immigrants carry their home countries' pro-educational cultural values with them and that these beliefs shape their daily home practices to the educational advantage of subsequent-generation Asian Americans (Portes and Zhou 1993; Zhou and Bankson 1994; Portes and Fernández-Kelly 2008). For example, evidence indicates that, compared to parents in other U.S. racial/ethnic groups, Asian American parents are more highly motivated to make sacrifices for their children's education, to put more emphasis on educational effort and attainment, and to have higher

standards for children's academic achievement after controlling for SES (Sun 1998; Wong 1990; Corwyn and Bradley 2008; Schneider and Lee 1990). In their most recent study, Hsin and Xie (2014) also find that Asian American students outperform Whites in school because Asian American students tend to have stricter work ethics and higher educational aspirations than white students.

Culture's Effects: Intercept Effects vs. Interaction Effects

As we have discussed above, most of the current studies treat structural (socioeconomic) factors and cultural factors as two competing explanations for Asian-Americans' superior achievement. A typical research strategy for gauging effects on educational achievement across racial/ethnic/immigrant groups in the U.S. has thus been to disentangle structural (SES) from cultural factors (values, beliefs). This approach, which generally relies on multiple regression analyses to separate out the effects of one factor by controlling for the others, is known as statistical adjustment. It implicitly assumes that the effects of structural and cultural factors are additive, with cultural factors represented by differences in the intercept by racial/ethnic/ immigrant groups, i.e., intercept effects. In other words, by controlling for structural differences, the approach tests whether Asian Americans have an overall advantage in academic achievement because they have higher SES. The achievement differences that remain after controlling for SES characteristics are interpreted as suggesting cultural effects (e.g. Kao and Tienda 1998; Hao and Bonstead-Bruns 1998; Goyette and Xie 1999). This way of measuring cultural difference is also called the residual approach, which is a conventional method for studying group differences in social science (Cole 1979).

Though the residual approach has long been employed to examine the effects of culture and SES on Asian Americans' achievement premium and has yielded fruitful findings, its

implicit additive assumption, without further scrutiny, prevents us from fully capturing the way in which culture produces the achievement premium for Asian Americans. In particular, it keeps us from detecting how SES and culture may impact achievement interactively and, if they do, its sociological implications.

The additive, i.e., intercept, approach assumes that (1) the effects of SES on achievement are the same for Whites and Asian Americans, and, equivalently, (2) the effects of cultural differences on achievement are constant across SES levels. In other words, it hypothesizes that cultural and SES effects are discrete and parallel to one another and can be added together to explain Asian Americans' achievement advantage. Graphically speaking, the additive, or residual, approach assumes that either A or B in Figure II-1 is true.

As the additive assumption is implicitly embedded in the residual approach, few studies have examined the assumption empirically. However, we believe that the additive assumption deserves more careful and serious consideration and examination, since if it is violated, the traditional statistical adjustment strategy, the residual approach, will not adequately characterize the achievement difference between Asian Americans and Whites. One example of how the assumption does not hold is the fact that Asian-White achievement differences may be negligible at high SES but large at low SES, which is not what the traditional approach would show. Thus, a simplistic characterization of the achievement difference pattern by the traditional additive approach may prevent us from better understanding the factors and mechanisms that give rise to Asian Americans' achievement premium. For example, there may exist such an interaction pattern between SES and race that even when Asian Americans and Whites have identical SES distributions, Asians still enjoy an aggregate advantage (see C and D in Fig 1). In other words, we are interested in examining a previously overlooked sociological explanation that cultural

factors may work, rather than in parallel, interactively with structural factors to produce the achievement difference. Specifically, we evaluate the hypothesis that culture produces Asian Americans' achievement premium over Whites not only by boosting Asian Americans' average educational motivation and efforts, as argued by past literature, but also by moderating family SES's effects. This approach necessitates a close examination of achievement differences between Asian Americans and Whites across SES levels, as we will show in this paper.

To better gauge the effects of culture and family SES, we distinguish two types of cultural effects on the Asian-White educational achievement gap as the intercept (or residual) effect and the interaction effect, with a particular emphasis on and examination of the latter. In this case, the intercept effect is the intercept difference between the Asian and white groups captured by the coefficient of race after statistical adjustment. The interaction effect refers to cultural differences in the strength of the association between family SES and the outcome variable of educational achievement, with the total cultural effect being a combination of intercept and interaction effects.

Broadly speaking, four potential scenarios may explain the observed Asian-White academic achievement gap (Figure II-1). The first possibility is that the achievement advantage is rooted in structural differences in family SES between Asian Americans and Whites, with Asian Americans more densely distributed around high SES levels (A in Figure II-1). The second possible scenario is that in addition to the achievement difference due to Asian-White SES distributional differences, Asian Americans maintain a culture-based achievement premium throughout the entire SES distribution (B in Figure II-1). This is what the additive approach implicitly assumes – that the effects of cultural factors on Asians' academic premium can be added to the effects of structural factors independently. The third possibility is that the effects of

SES on achievement are stronger for Asian Americans than for Whites, resulting in a smaller achievement gap at the lower end of the SES distribution than at the higher end (C in Figure II-1). The fourth possibility, which is what we are particularly interested in and will test in this study, is that the effects of SES on achievement are weaker for Asian Americans than for Whites, resulting in a larger achievement gap at the lower end of the SES distribution than at the higher end (D in Figure II-1).

Our work examines whether and how structural and cultural factors work interactively to give rise to the achievement gap between Asians and Whites, focusing on the fourth scenario. By estimating both the intercept and the interaction effects, the analysis aims to more accurately identify factors contributing to the Asian American-White achievement difference and, more broadly, to further explicate causal mechanisms behind educational achievement in the U.S.

The Sociological Significance of Culture as an SES Moderator

Why might SES have different impacts on academic achievement for Asian Americans than for Whites? To answer this question, we must first take a step back and think about the mechanisms through which SES influences one's achievement.

Past research offers potential explanations. Ever since Blau and Duncan's (1967) pioneering empirical work found a high correlation between occupational attainment and family social standing, sociological scholars have set out to find reasons for this association. The Wisconsin Model, developed by Sewell and his colleagues (e.g., Sewell, Haller, and Portes 1969), elaborates and extends the basic Blau-Duncan model by incorporating social psychological factors, such as attitudes and aspirations, in explaining the association between family SES and achievement. Basically, the Wisconsin Model posits that family SES affects children's achievement by influencing their attitudes and behaviors.

Recent advancements in social science research have provided further support for this model by extending our understanding of the role of attitudes and behaviors in social stratification and achievement. For example, sociological studies have found that social-emotional attributes such as valuing hard work and having high aspirations are closely tied to children's success at school (Hsin and Xie 2014) and that socio-psychological pathways are key in transmitting family members' characteristics to children, particularly by affecting children's educational outcomes (Heckman 2006; McLanahan and Percheski 2008).

Fruitful findings from other social science disciplines also shed light on the significance for cognitive and academic performance of social-psychological attributes such as motivation, locus of control, aspiration, and self-discipline. For instance, psychological studies of academic performance have shown that traits like self-discipline can make up for shortcomings in IQ (Duckworth and Seligman 2005, 2006), while economic studies have documented that motivation and preference influence performance on cognitive and academic tests (Borghans, Meijers and Wheel 2008; Heckman, Stixrud, and Urzua 2006; Claessens, Duncan, and Engel 2009). Given this body of work, it is reasonable to assume that children's attitudes and behaviors are important pathways through which family socioeconomic advantage or disadvantage affects their educational achievements. In other words, an SES gradient in children's academic behaviors and attitudes may account for the SES gradient observed in children's achievement.

Culture affects individuals' behaviors and attitudes. Sociologists have conceptualized culture in numerous ways, but two perspectives are predominant (Small, Harding, and Lamont 2010). Some scholars conceptualize culture as a repository of values, beliefs and preferences that motivate people's behaviors (Hitlin and Piliavin 2004; Kaufman 2004), while others view culture as a repertoire or toolkit of symbols, behavioral strategies, and decision sets that individuals

make use of in their daily lives (Swidler 1986; DiMaggio 1997). Though these two perspectives on culture differ in whether or not it directly dictates individuals' attitudes and behaviors, they agree that culture significantly influences or shapes them.

In studying culture as a potential explanation for the Asian-white gap in educational achievement, we make use of two key theoretical features of culture. First, culture is a multilevel concept. It can account for differences in individual behaviors only if patterns in individual-level behaviors are common at the group level (Hitlin and Piliavin 2004; Polavieja 2015). That is to say, one can only use culture as an explanatory factor for individual-level behaviors if there is sufficient similarity among individuals belonging to the same cultural group.

Second, culture should not be defined within a single dimension by a univariate variable. Rather, it encompasses a comprehensive worldview that helps individuals understand the social world around them. Thus, culture may significantly shape or constrain how a child views his/her family socioeconomic background and how that background may facilitate or hamper his/her educational outcomes. Psychological studies have suggested that mindsets or implicit beliefs will influence children's perception of their potential and ability and thus their development and achievement (Dweck 2006; Dweck, Chiu, and Hong 1995). Specifically, children with an implicit belief that intelligence and ability is fixed and that socially relevant traits are unchangeable have been shown to interpret academic challenge as a sign that they lack intelligence, and their academic performance is more likely to suffer when facing adversities in life. In contrast, those with a mindset that says ability is malleable, responding to effort and the process of learning, are more resilient and can even achieve improvement under challenging conditions, such as a disadvantaged family background (Dweck 2006; Yeager and Dweck 2012).

Different cultures shape individuals' mindsets differently. For example, in contrast with Western society, in East Asian societies, the malleability of human ability and behavior is a central precept in Confucianism and is widely accepted (Munro 1977). Effort is thus seen as a major avenue to improvement and achievement and is highly emphasized for success in East Asian cultures. In fact, empirical studies have corroborated these cultural differences in perception of effort, ability and achievement between East Asian and American societies. In a study of children's achievement, Stevenson and colleagues (1992) found that compared with American mothers, Chinese and Japanese mothers assigned greater importance to effort than innate ability for leading to academic success. These cultural differences in mindsets are also observed among children. While American children place more emphasis on innate ability as a key success factor, Chinese and Japanese children believe continuous effort is much more important (Stevenson et al. 1992).

For our study, one important implication of the above discussion is that ethnic culture may modify the relationship between social class and academic behaviors and attitudes, accounting for Asian-White achievement differences. Past studies have well documented that children, along with their parents, differ in academic attitudes and behaviors by social class (Calarco 2011, 2014; Khan 2011; Lubrano 2004; Lareau 2011). Middle- and upper-middle-class parents and students, in contrast to their lower-class peers, are much more likely to adopt the attitudes, beliefs and practices which are beneficial to academic success. However, most of these studies have focused on White or Black populations. It is implicitly assumed that the pattern of such stratification and the strength of the relationship is more or less the same across different ethnic groups.

Due to differences in ethnic cultures, the strength of the above relationship between social class and academic attitudes and behaviors may differ across different ethnoracial groups, as between Whites and Asian Americans. In particular, as we hinted earlier and will discuss below, academically oriented attitudes and behaviors could be more differentiated by social class among Whites than among Asian Americans. The ethnoracial differences in the relationship can further translate into an overall advantage for Asian Americans over Whites, as we will show later.

In this paper, we view culture as a toolkit for individuals' behaviors (Swidler 1986). Specifically, we propose that cultural differences between Asians and Whites modify the relationship between family SES and academic attitudes and behaviors for these two groups. In doing so, we assume that culture is a multi-level concept and is better measured at the group level.

Several cultural attributes may contribute to the ethnic difference in the relationship between SES and behaviors and attitudes between Asian Americans and Whites. To begin with, numerous studies in cultural psychology have shown that the East Asian concept of self views individuals as more malleable than does the Western Caucasian concept of self (cf. Chiu et al. 1997; Heine 2001; Neisser et al. 1996). In East Asian cultures, individuals are expected to achieve certain social outcomes by molding themselves (Morling, Kitayama, and Miyamoto 2002). Also, it is widely believed in East Asia that achievement is a function of consistent practice and single-minded effort rather than inborn ability or family origins. Add to these beliefs the strong emphasis that Confucianism places on education and effort-based achievement, and it is not surprising that many East Asians believe that children from a disadvantaged social background are capable of success that equals that of peers from superior social backgrounds as

long as they are willing to put in persistently strong effort. In particular, many Asians subscribe to the notion that social mobility can be obtained through education (Stevenson and Stigler 1992; Chen and Stevenson 1995; Xie and Goyette 2003). Though these beliefs originated in East Asia, it is possible they have spread to other Asian ethnic groups in the U.S. (Hao and Bonstead-Bruns 1998; Lee and Zhou 2014).

The strength of SES effects on attitudes and behaviors may also be tempered for Asian Americans by the forces of selectivity in international immigration. Immigrants, a self-selected group of people who often have high motivation to achieve, are likely to expect upward mobility for themselves or their offspring in the receiving country even if they start low on the socioeconomic ladder (Ogbu 1978; Kao 1995). Such optimism may translate into resourceful and strategic behavior designed to overcome obstacles and advance social status. It may also be transmitted to the children of immigrants, increasing their expectations of upward social mobility via high academic achievement, regardless of their social backgrounds (Caplan, Choy, and Whitmore 1992; Zhou and Bankston 1998).

Another cultural factor to consider, as Sue and Okazaki (1990) argue, is that Asian-Americans may face disadvantages in pursuing social status through other means but view education as an equal-opportunity, objectively measured, and valued means of upward mobility – a means that may have particular salience for Asian American families in low-SES situations (Xie and Goyette 2003).

Another side-effect of Asian American culture that may weaken the impact of SES on academic performance is the U.S. stereotype of Asian Americans as high achievers (Jiménez and Horowitz 2013; Lee and Zhou 2014). This stereotype, although emanating from cultural characteristics, may magnify the culture-based expectations of Asian American parents and

children for high levels of success in relation to people with loftier social standing, to native-born Americans, and to other Asian Americans. As this stereotype is mainly based on ethnoracial category rather than family background, every Asian student, regardless of socioeconomic status, is likely to be influenced by it.

In sum, the above distinct features of the culture shared by Asian Americans as an ethnic group can modify the relationship between SES and academically beneficial attitudes and behaviors. Compared with Whites, the distribution of beliefs and behaviors important to academic success may be less differentiated by social class among Asian Americans as an ethnic group.

In light of the above discussion, we argue that a significant proportion of the overall Asian-White achievement difference is attributable to cultural differences in the association between SES and educational achievement being weaker for Asian Americans than for Whites. To test our proposition, we make use of the following three hypotheses. First, certain behaviors and attitudes are important to academic success. Second, the distribution of these attitudes and behaviors by family SES differs between Asian Americans and Whites, being less stratified by family SES among Asian Americans than among Whites. In regression terms, this is equivalent to hypothesizing that the SES slope coefficients on attitudinal or behavioral outcomes are smaller for Asian Americans than for Whites. Third, the patterns suggested by the above two hypotheses give rise to the overall Asian-White difference in the relationship between family SES and achievement.[1]

Data and Measurements

[1] In the results section, we present results in deductive order. We begin by showing the ethnoracial differences in the relationship between family SES and achievement (hypothesis (3)); we then present the ethnoracial differences in the relationship between family SES and attitudes and behaviors (hypothesis (2)); finally, we show that these attitudes and behaviors are important to achievement (hypothesis (1)).

Our statistical analyses draw data primarily from the Education Longitudinal Study (ELS) of 2002. Conducted by the National Center for Education Statistics (NCES), the ELS is a nationally representative longitudinal survey of U.S. high school students with a two-stage sampling design: in the 2002 baseline survey, 750 schools were selected, and then about 15,000 10th-grade students were selected randomly from all the schools. In addition to surveying students, the 2002 ELS surveyed parents, math and English teachers, school principals, and heads of school libraries or media centers, asking questions about students' and parents' beliefs, attitudes, and behaviors, as well as students' daily behaviors in school (reported by their teachers). Also, the ELS oversampled Asian students, greatly facilitating White-Asian group comparisons for this study. Our sample was restricted to white and Asian students whose parents completed the questionnaire and were enrolled in schools with both Whites and Asians present. This yielded an analytical sample of 8,978 students.

We use multivariate imputation to deal with all missing values from ELS variables of interest, which are described in Table II-1. The primary dependent variables are scores on a standardized mathematics test, scores on a standardized reading test, overall GPA in the 10^{th} grade, and academic GPA in the 10^{th} grade. Math test score, measured by the IRT T-score provided by NECS, is a standardized transformation of the IRT ability estimates based on the population and is the key dependent variable throughout our main analysis, as it provides a more objective and norm-referenced measurement of a student's academic achievement.

For demographic control variables, we include student's gender, family SES, immigrant generation, intact family (1= lives with both mother and father), number of siblings, and ever held back in school (1= held back). Family SES, an index constructed by NCES, is a composite based on mother's and father's education, both parents' occupations, and

family income, with each component equally weighted. It is standardized with a mean of 0 and a standard deviation of 1 for the entire sample[2] (NCES 2002).

We use five variables to measure student behaviors and attitudes toward education and academic achievement. *Hard Working* measures level of perseverance and effort from two questions self-rated by students on a four-point scale (1= almost never, 2= sometime, 3= often, and 4= almost always): How often do you work as hard as possible when you study? How often do you do your best to learn what you study? We average the ratings for the two questions for a composite score ranging from 1 to 4, with a higher score indicating higher self-rated effort. *Importance of Good Education* is measured using student ratings of this from 1 to 3, with a higher score indicating a greater value (1= not important, 2= somewhat important, 3= very important). *Students' Education Expectation* and *Parents' Education Expectation* (for their children) are measures coded as expected years of schooling: less than high school graduation =11; high school graduation or GED only =12; attend (or complete) 2-year college or attend college with incomplete degree =14; graduate from college =16; obtain master's degree or equivalent and above =18. Finally, *Behavior in Math Class* is math teacher's ratings on a five-point scale of student's classroom behaviors[3] based on questions about how often (1= Never, 2= Rarely, 3= Some of the time, 4= Most of the time, 5= All of the time) the student (1) completes homework, (2) is absent from class, (3) is attentive in class, and (4) is tardy for the class. We average the ratings for all questions for a composite score from 1 to 5, with a higher value indicating more disciplined behavior.

Descriptive Results

[2] As family's SES is constructed from both parents' education, occupation, and family's income, we do not take separate measurements on these as controls in our analysis.
[3] As our key dependent variable is math standardized test score, we use math teacher's evaluations on classroom behaviors.

Table II-2 presents the summary descriptive statistics for the entire sample and separately for Asian American and white students. First, although we find that Asian Americans overall have lower SES than Whites (with the average SES index score being 0 for Asian Americans and 0.25 for Whites), they enjoy an achievement premium over Whites in their scores on the math standardized test, overall GPA, and academic GPA. Asian American students have lower scores on the standardized reading test, which for many resulted from their status as first-generation Americans.

Asian Americans and Whites also differ in behaviors and attitudes related to education. Compared to white students, Asian American students give themselves higher self-ratings for hard work and place higher value on a good education. Asian American students and parents hold higher expectations for educational attainment than their white counterparts. In addition, math teachers rate Asian American students higher in disciplined class behavior than they do Whites.

In short, the descriptive statistics in the study are consistent with prior literature on Asian Americans' educational achievement advantage. Moreover, the summary statistics indicate that family SES is not an adequate explanation for Asian American students' higher academic achievement relative to that of Whites.

Regression Analysis

To test our hypothesized explanations for the Asian American advantage, we use regression analysis with a school-level, fixed-effects model to fully control for a school's characteristics. First, we examine whether or not the effects of family SES on educational achievement differ between Asian Americans and Whites. Second, we analyze, as pathways linking family SES and academic outcomes, how the influences of family SES on school-related behaviors/attitudes, i.e.,

students' behaviors and attitudes as well as parents' attitudes, differ between Asian Americans and Whites. Third, we examine the relationship between these behavioral/attitude measures and students' academic achievement. In particular, we are interested in whether the observed Asian-White differences in behaviors and attitudes account for the Asian-White achievement gap. We further carry out a counterfactual analysis to answer the following question: To what degree do the Asian-White differences in family SES effects on school-related behaviors/attitudes account for the observed Asian-White achievement gap?

SES, Ethnicity and Academic Achievement

Figure II-2 depicts the relationship between family SES and academic achievement for Asian Americans and Whites. The steeper slope for the Whites indicates a stronger positive effect for SES on achievement. The different inclinations of the fitted lines, together with Asian Americans' greater value in the intercept of the regression line, indicate that the Asian-White achievement gap varies across family SES levels – being greater at the lower than at the upper end of the distribution.

Table II-3, which presents the estimated coefficients for regression models corresponding to Figure II-2, demonstrates how basic demographic control variables and the interaction between race and family SES explain the Asian-White achievement differences. Model specifications are the same across the four models, with varying dependent variables of academic achievement.

The negative and significant coefficients of the interaction terms of family SES and Asian race in Model 1 (math test as the achievement outcome variable), Model 3 (overall GPA as the achievement outcome), and Model 4 (academic GPA as the achievement outcome) confirm weaker positive effects of SES on achievement for Asian American than for white

students. Though the insignificant negative interaction term in Model 2 (reading test as the achievement outcome) does not align well with our hypothesis, it may be impacted by the immigrant background of the Asian American students, as discussed above. In general, the results support our hypothesis that SES affects educational achievement less strongly among Asian Americans than among Whites.

SES, Ethnicity and Behaviors/Attitudes

Figure II-3 depicts the relationship between family SES and measures of behaviors/attitudes regarding education for Asian Americans and Whites. The patterns of the relationship between SES and behaviors/attitudes in Figure II-3 are similar to those in Figure II-2, with the slopes of the fitted lines less steep and the intercepts greater for Asian Americans than for Whites. The differences in slope and intercept indicate that the Asians' advantage over Whites in behaviors/attitudes is greater at lower than at higher levels of family SES. In fact, at very high SES levels, Whites gain the advantage in measures of parent and student educational expectations.

Table II-4 presents the results from regression analyses corresponding to Figure II-3. The five models in Table II-4 have the same specification with different outcome variables for attitudes/behaviors. As highlighted in the table, the interaction term of race and family SES is negative and significant across all five models. These results support our hypothesis of a weaker effect for SES on behaviors/attitudes among Asian Americans than among whites.

Behaviors, Attitudes, and Achievement Difference

To better understand how behaviors and attitudes influence academic achievement and also the extent to which the Asian American-White difference in the association between SES and these measurements accounts for the observed Asian-White achievement difference, we first turn to

regression analysis and, further, carry out a counterfactual analysis. We elect to use scores on the math standardized test as our main dependent variable for this part of the analysis,[4] viewing it as an objective and comparable measure of student achievement. Table II-5 shows the results from this analysis.

The interaction term of family SES and Asian race is included in all seven models, and their corresponding p-values are reported in the bottom row of the table for each model.[5] The first model in Table II-5 is the baseline model, with just demographic control variables. In Models 2 to 6, we add the five behavior/attitude measures separately. Model 7 is the full model, including demographic controls and all five behavior/attitude measures. The Asian American premium in academic achievement is 1.45 in the baseline model and statistically significant. In Models 2 to 6, both the magnitude and the significance of the premium decrease as we add measures into the models. In Model 7, the full model, the estimate for Asian Americans' premium decreases to 0.3, or to one fifth of its magnitude in the baseline model, and is no longer significant. The increasing p-values indicate that the significance of the interaction of race and family SES also fades gradually across Models 1 to 7, becoming insignificant in the full model.

These changes across models have several implications. The measures of education-related behaviors and attitudes are important correlates of students' academic achievement and seem to be the main pathways for conveying the Asian American achievement premium. Further, not only do Asian Americans' higher scores in these academic achievement-related behaviors and attitudes contribute to their academic advantage, but the weaker association between family SES and these behaviors/attitudes among Asian Americans moderates the direct effect of family

[4] Similar results are obtained using overall GPA and academic GPA as the outcome variables. These results are presented in the Appendix.
[5] We do not present the coefficient of the interaction in the table due to the space limitation.

SES on their academic achievement – as evidenced by the larger Asian American-White achievement gap at lower SES levels.

To gauge how the Asian-White difference in the relationship between family SES and behaviors/attitudes can help explain the Asian American-White achievement difference, we carry out a counterfactual exercise. The results are displayed in Figure II-4.

The predicted achievements for Asian Americans and Whites are calculated based on the full model (Model 7) in Table II-5, and the five models in Table II-4. First, we predict Asians' and Whites' behaviors and attitudes from models in Table II-4 using the overall sample mean for both Asians and Whites on all the variables other than Asian race and Asian race-SES interaction. Then, holding all the control variables constant other than race and race-SES interaction with overall sample mean, we enter the predicted behaviors and attitudes into Model 7 to predict the achievement for Asian Americans and Whites. By equalizing Asian-White differences in other socio-demographic factors, we observe how the Asian American-White differences in behaviors/attitudes influence the achievement gap.

We further construct the counterfactual achievement score for Whites from Model 7 in Table II-5 by using similar methods to those described above and replacing Whites' predicted score on the behaviors/attitudes with Asian-Americans' score. The counterfactual score for Whites can thus be interpreted as the score that would be obtained by white students if they and their families had the same behaviors/attitudes as their Asian peers. Specifically, it helps project white students' achievement under the condition that the effects of family SES on their behaviors/attitudes were as steep as those for Asian Americans.

Figure II-4 depicts a notable difference in the predicted achievement of Asian-Americans and Whites. Given the method used to calculate the predicted achievement, the Asian American

premium persists regardless of Asian-White differences in family background variables. This also supports our hypothesis that their achievement advantage is not completely dependent on their socioeconomic background. And once again, the steeper slope of the fitted line for Whites indicates a tighter relationship between family SES and achievement for Whites than for Asian-Americans.

We also note in Figure II-4 that the gap between Whites' counterfactual achievement and Asian Americans' predicted achievement is much smaller than the observed Asian American-White gap in predicted achievement. One major explanation for this discrepancy is the significant increase in Whites' counterfactual achievement at the lower SES distribution if Whites resembled Asian Americans in the relationships between family SES and schooling-relevant attitudes and behaviors. In other words, the gap between Asian Americans and Whites shrinks if Whites' achievement becomes less dependent on SES.

We are thus led to conclude that the Asian American-White differences in behaviors/attitudes, particularly in the strength of the effect of family SES on behaviors/attitudes, account for much of the observed Asian American-White achievement difference. In other words, Asian Americans enjoy a persistent achievement premium not only because they score higher in behaviors and attitudes important to academic achievement, but also because these behaviors and attitudes depend less on their family SES.

Sensitivity Analysis

Are the results in our analysis specific to Asian Americans or generalizable to other groups? Answering this question will illuminate us as to whether the moderated relationship between family SES and achievement among Asian Americans is rooted in Asian-specific culture or is shared by other immigrants as well. To help answer this, we conducted a sensitivity analysis by

replicating the regression analysis using Hispanic and white student subsamples. Appendix Appendix Table 1 presents the results (as specified in Table III-3) with achievement measures as the outcomes, and appendix Appendix Table 3 presents the results (as specified in Table II-4) with behavior/attitude measures as the outcomes.

Specifically, for standardized math and reading test scores (Model 1 and Model 2 in Appendix Table 1), the interactions between family SES and race are negative, but not significant. For overall GPA and academic GPA, the interactions are negative and significant. In addition, the interaction terms are significantly negative across all five behavior/attitude measures. These results indicate that, as we found for Asian Americans, family SES has less influence on Hispanic students' academic achievement and related behaviors/attitudes than it does on white students'.

However, in contrast with the results for Asian Americans, the moderated SES effects do not consistently yield a Hispanic advantage across all measures. As previously stated, a group's residual differences are the product of both intercept effects and interaction effects. With negative intercept effects in many of the models for Hispanic students, the negative interaction effects, though they moderate the impact of SES, exacerbate their disadvantage in achievement and behaviors in math class.

In sum, the moderated relationship between family SES and students' achievement, behaviors, and attitudes is not restricted to Asian Americans. However, compared with Asian Americans, findings for Hispanics are mixed and less consistent. In particular, the moderated relationship for Hispanic students does not lead to a significant premium over that for white students, and may even exacerbate their disadvantage.

As discussed, the literature suggests that East Asian cultures have been deeply influenced by Confucianism, which emphasizes "self-malleability" and education as a pathway to social mobility – values that help East Asian students achieve academic success regardless of their social origins (Peng and Wright 1994; Stevenson and Stigler 1992). However, the existing literature also indicates that Asian Americans are a heterogeneous group, with Asian ethnic groups tending to vary in cultural values and behavior patterns (Goyette and Xie 1999). To examine potential heterogeneity across Asian American subgroups, we conducted a sensitivity analysis by replicating the regression results and dividing Asian American students into two groups, East Asian (Chinese, Japanese, Korean) and Other Asian (Filipino, Southeast Asian, and South Asian),[6] with white students as the reference group. Appendix Table 2 presents the results (as specified in Table II-3) with standardized math and reading scores and the two GPAs as the measures for academic achievement. In Model 2, with the standardized math test score as the outcome, the interaction between Asian group and SES is significantly negative for students from the Other Asian group; however, in contrast with the results for East Asian students, the coefficient for Other Asian is also significantly negative. This suggests that, as with Hispanic students, the moderated association between SES and achievement exacerbates Other Asian students' disadvantage relative to white students. In Models 3 and 4, where the outcomes are GPA measurements, East Asian students and Other Asian students exhibit similar patterns in the results. Specifically, the intercept coefficients for ethnicity are significantly positive, while the coefficients for the interaction of SES and ethnicity are negative and significant. In Appendix Appendix Table 4, we present the results (as specified in Table II-4) with measures for behaviors/attitudes as outcomes. With few inconsistencies, the signs, significance, and

[6] East Asian includes Chinese, Japanese, and Korean; Other Asian includes Filipino, Southeast Asian, and South Asian. The sub-Asian ethnicity identification is provided by the ELS 2002 data.

magnitude of both the intercept coefficients for ethnicity and the interaction coefficients of ethnicity and SES are comparable between East Asian and Other Asian subgroups across all the models. These results indicate that we cannot differentiate groups within these two broad categories of Asian Americans and suggest that cultural effects on achievement are similar for all Asian American students.

Discussion and Conclusion

Numerous studies have characterized Asian Americans as a "model minority," owing to their attainment of high socioeconomic status (SES), and particularly their advantage in academic achievement (Hsia 1988; Caplan et al. 1991; Sanchirico 1991; Zhou and Bankston 1998; Kao 1995; Fejgin 1995; Hsin and Xie 2014). Sociological research so far has proposed two explanations for these observed premiums. The first explanation attributes Asian Americans' academic advantage to their more advantaged family backgrounds as measured by SES, while the second explanation emphasizes the role of the education- and effort-oriented culture shared by Asian Americans. However, most past studies have treated these two explanations as competing with one another. In other words, they have assumed, albeit sometimes implicitly, that SES and culture influence Asian Americans' achievement additively and independently.

In this paper, we propose an interactive rather than an additive approach to examining the role of culture and SES in explaining Asian Americans' achievement. We maintain that Asian American families have a different cultural orientation from that of white families that moderates the way family SES affects children's academic achievement. Our analyses indicate that such differences partly explain the observed achievement gap between Asian American and white students. Thus, our study fills the gap in the current literature by examining the potentially

heterogeneous effects of SES on the achievement gap between Asian Americans and Whites from a cultural perspective.

We test the hypothesis that Asian-White differences in the association between SES and achievement are products of race-based differences in the association between SES and social behavioral factors – manifested here as behaviors and attitudes deemed important to academic success. We find that the positive effects of family SES on achievement are stronger among white than among Asian American students, and that the association between SES and behaviors and attitudes is weaker among Asian-American than among white students. Furthermore, our counterfactual analysis reveals that a decent amount of the achievement difference can be accounted for by Asian American-White differences in behaviors and attitudes, particularly differences in the effects of family SES on behaviors and attitudes. All these findings support our argument that Asian Americans' behaviors and attitudes are less influenced by family SES than those of Whites are and that this difference helps generate Asians' premium in achievement – as is especially evident at lower levels of family SES.

Our findings yield policy implications as well, suggesting that differences in social behavioral characteristics, which are important for achievement, lead to achievement differences. However, these social behavioral skills are not rigidly determined by family SES, and the extent to which they are associated is malleable. This opens up the possibility of eliminating the achievement gap between different social groups through non-monetary channels – by instead working to encourage the social behaviors and attitudes that help determine academic success.

Still, we concede that the results from our study are only suggestive. One limitation is that we cannot yet uniquely attribute the explanation of our findings to Asian culture and to immigrant culture in general. Given that our sensitivity analyses suggest that the weaker

association between family SES and achievement is not restricted to Asian students but is also present for Hispanic students, it is possible that this pattern is characteristic of an optimistic immigrant culture rather than Asian culture per se (Gibson and Ogbu 1991; Kao 1995; Caplan, Choy, and Whitmore 1992). However, the moderated relationship does not provide Hispanic students with an academic premium as it does Asian American students.

Nor can we attribute the Asian-White differences in the effects of SES solely to Confucian culture, as the moderated SES effects are also observed among Other Asian students besides East Asian students. One possible explanation for this homogenous pattern is that Asian American students, regardless of specific ethnicity, feel pressured to live up to Asian achievement stereotypes (Jiménez and Horowitz 2013; Lee and Zhou 2014). However, these unresolved issues lie beyond the scope of the current study.

Understanding the achievement difference between Asian American and white students will not only give us better clues about how one immigrant group has attained social mobility in the U.S., it also provide deeper insights into broader racial/ethnic inequalities in the U.S. Our findings underline the need to examine culture's role in generating group achievement differences and to examine how culture works interactively with other traditional socioeconomic characteristics to influence children's development.

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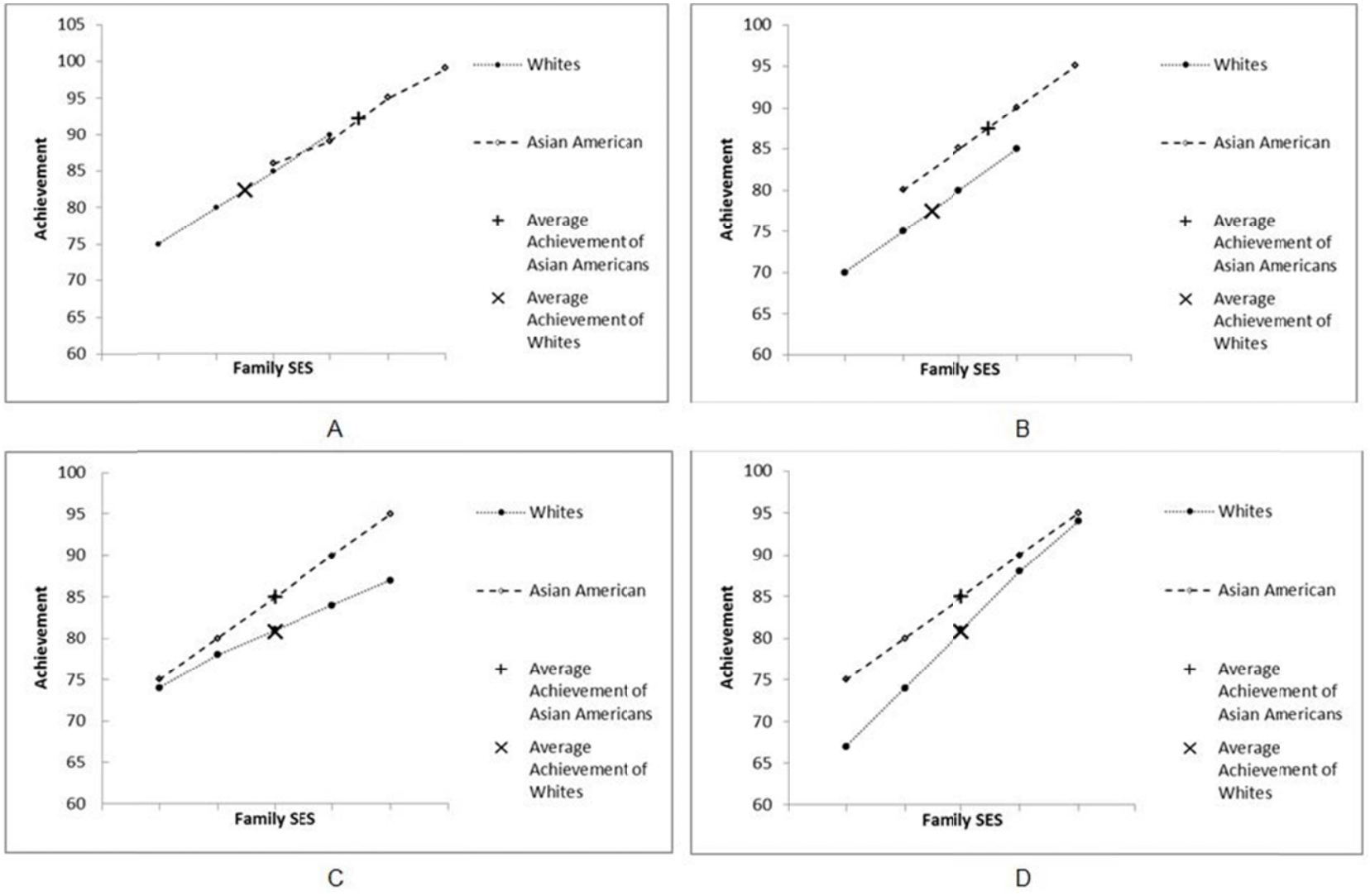
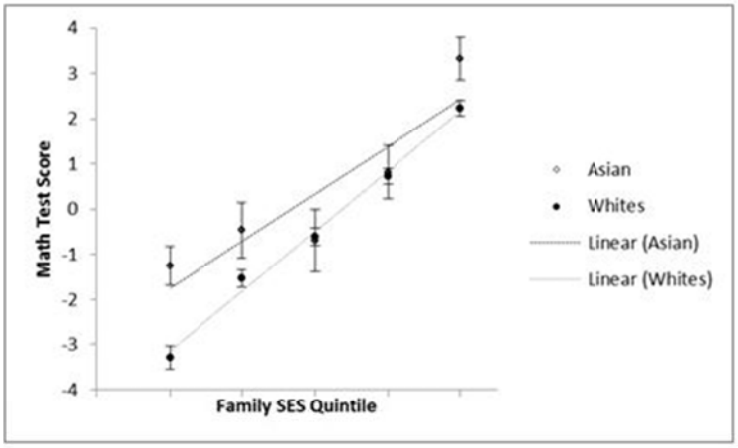
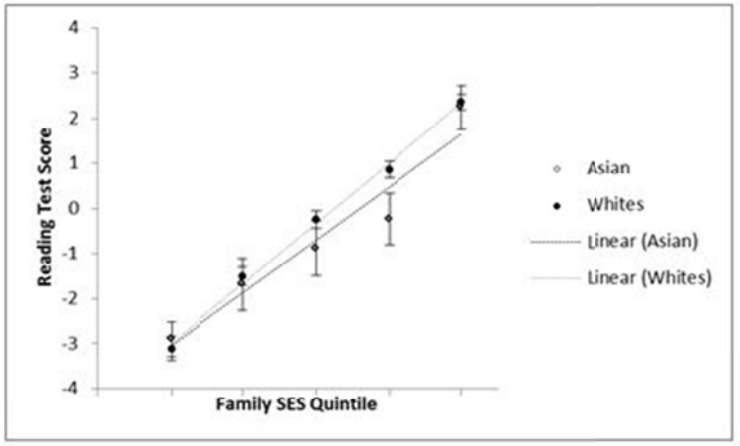


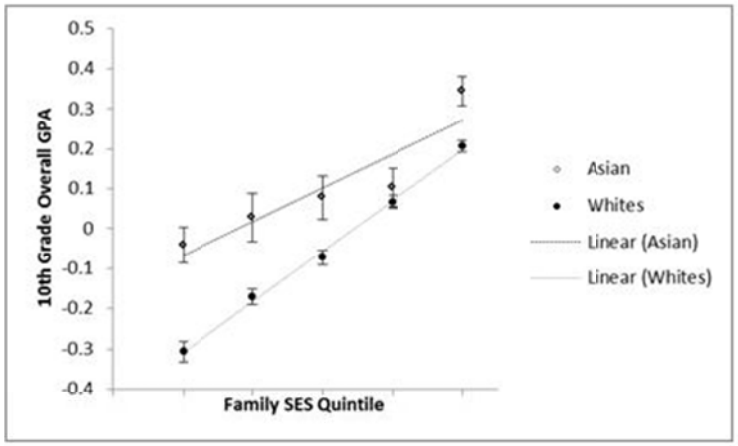
Figure II-1Four Possibilities of Family Socioeconomic Status and Achievement Difference (Adjustment has been made for School Effects)



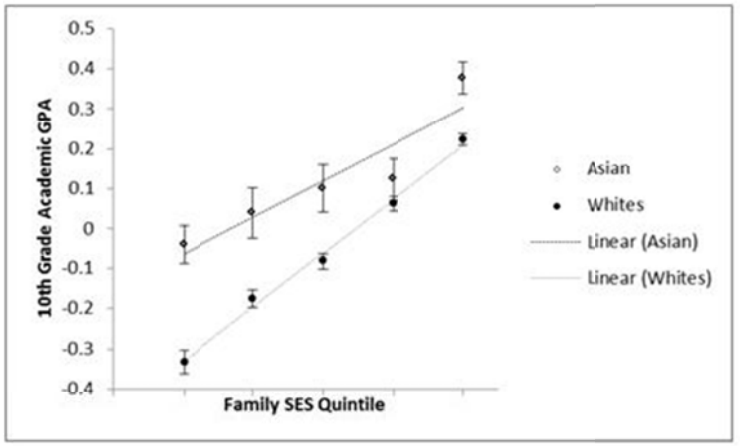
(1) Math Standardeized Test Score



(2) Reading Standardeized Test Score

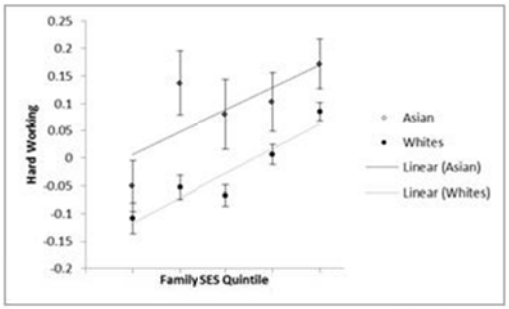


(3) 10th Grade Overall GPA

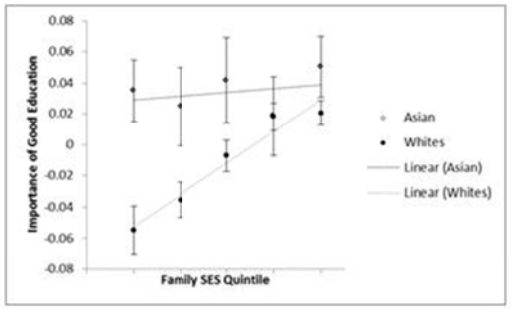


(4) 10th Grade Academic GPA

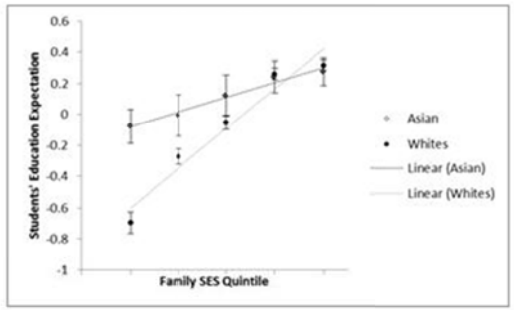
Figure II-2 Achievement and Family SES: Asian Americans and Whites, ELS 2002 10th Grade (Adjustment has been made for School Effects)



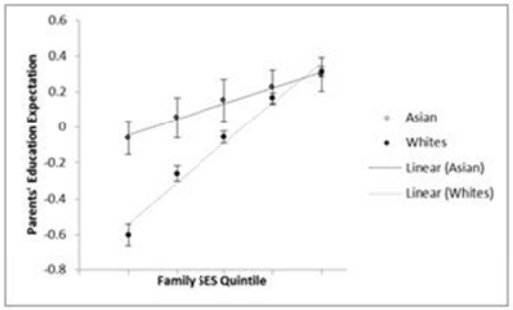
(1) Hard-Working



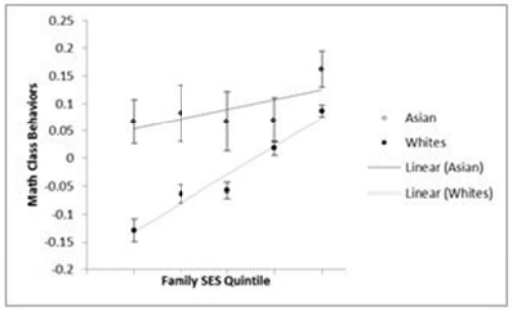
(2) Importance of Good Education



(3) Students' Education Expectation



(4) Parents' Education Expectation



(5) Math Class Behaviors

Figure II-3 Difference in Social-Psychological Factors and Family SES: Asian Americans and Whites, ELS 2002 10th Grade
(Adjustment has been made for School Effects)

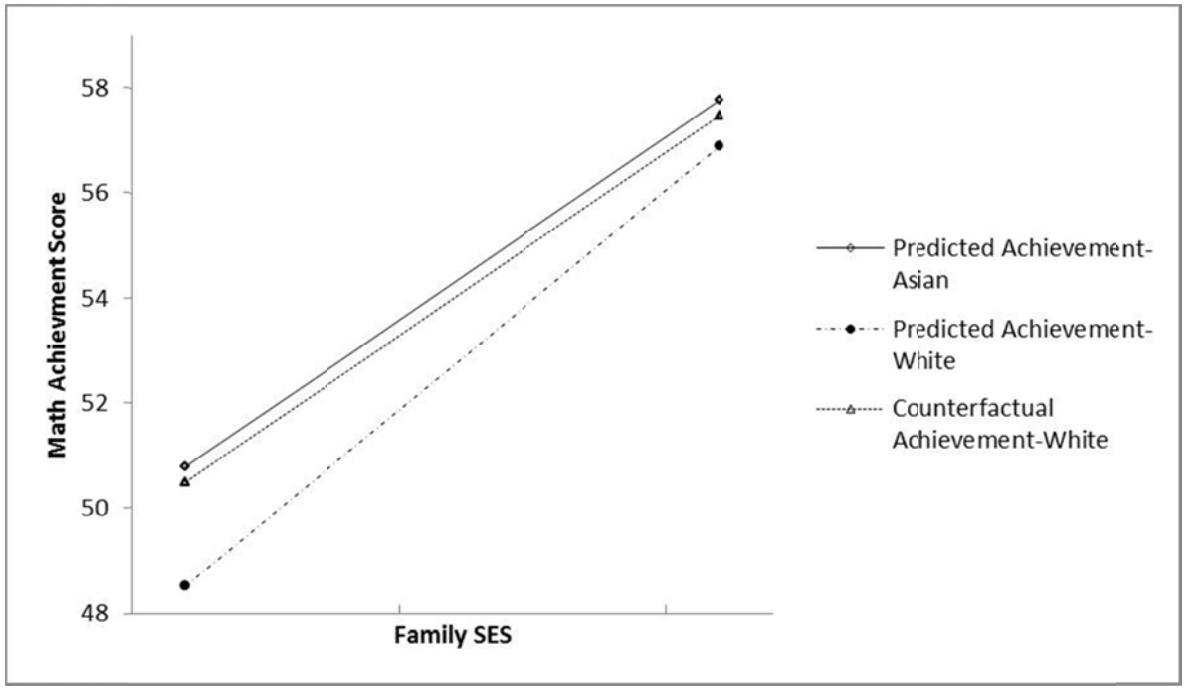


Figure II-4 Counterfactual Analysis

Table II-1 Descriptions of Variables

Demographic Controls	
SES	SES Index from ELS. It is constructed based on mother's and father's education, mother's and father's occupation, and family income
Immigrant Generation	First Generation is the baseline group
Intact Family	Whether children lives in a family with both mother and father. Non-intact family as the reference group (coded as 0).
Number of Siblings	Number of Siblings the 10th grader has.
Female	Female is coded as 1. Male is the reference group (coded as 0).
Held Back in School	Coded as 1 if the 10th grader had ever been held back for a grade
Behaviors and Attitudes	
Hard Working	Constructed from students' responses to two questions: (1) Work as hard as possible when studies; (2) Does best to learn what studies
Importance of Good Education	Student's rating on the importance of good education.
Students' Education Expectation	How far in school the 10th grader wants to go.
Parents' Education Expectation	How far in school parents want the 10th grader to go.
Math Class Behavior	Composite measurement based on students' behaviors in math class. Reported by math teacher.
Achievement	
Math Test	Mathematics standardized score, ranging from 10 to 90.
Reading Test	Reading standardized score, ranging from 10 to 90.
10^{th} Grade overall GPA	GPA for all 10th grade courses, ranging from 0 to 4.
10^{th} Grade Academic GPA	GPA for all academic 10th grade courses, ranging from 0 to 4.

Table II-2 Descriptive Statistics on Parents and Students' Demographic and Socioeconomic Characteristics, Behaviors, Attitudes, and Achievement: Asian Americans and Whites from ELS 2002 10th Grade

	Whole Sample		Asian		White	
Variable	Mean	SD	Mean	SD	Mean	SD
Demographic Controls						
SES	0.19	0.71	0.00	0.87	0.25	0.68
Immigrant Generation						
Second Generation	0.09		0.46		0.03	
Third Generation	0.82		0.09		0.94	
Intact Family	0.67		0.70		0.67	0.47
Number of Siblings	1.79	1.52	1.96	1.78	1.77	1.47
Female	0.50		0.50		0.05	0.22
Held Back in School	0.09		0.07		0.50	0.50
Behaviors and Attitudes					0.09	0.29
Hard Working	2.76	0.78	2.90	0.76	2.74	0.78
Importance of Good Education	2.82	0.42	2.86	0.36	2.81	0.42
Students' Education Expectation	16.12	1.70	16.24	1.61	16.10	1.72
Parents' Education Expectation	16.20	1.45	16.51	1.41	16.15	1.45
Math Class Behavior	4.16	0.61	4.26	0.64	4.15	0.60
Achievement						
Math Test	53.57	9.31	54.01	10.62	53.50	9.08
Reading Test	53.10	9.55	50.54	10.06	53.51	9.40
10^{th} Grade overall GPA	2.88	0.79	2.97	0.82	2.87	0.79
10^{th} Grade Academic GPA	2.76	0.87	2.88	0.89	2.75	0.86
Sample Size	8978		1248		7730	

Note: (1) Missing values are excluded for calculation of means; (2) Based on unweighted data.

Table II-3 Coefficients from School-Fixed Effects Regression of Achievement on Selected Variables: Asian Americans and Whites from ELS 2002 10th Grade

	1 Math Test	2 Reading Test	3 10th Grade overall GPA	4 10th Grade Academic GPA
Asian	1.71 ***	-0.43	0.24 ***	0.28 ***
	(0.48)	(0.50)	(0.04)	(0.05)
SES	3.73 ***	3.70 ***	0.34 ***	0.38 ***
	(0.17)	(0.17)	(0.02)	(0.02)
Asian # SES	-0.95 ***	-0.38	-0.14 ***	-0.16 ***
	(0.34)	(0.35)	(0.03)	(0.03)
2nd Generation	0.50	1.62 ***	-0.04	-0.07
	(0.43)	(0.44)	(0.04)	(0.04)
3rd Generation	0.42	1.64 ***	-0.10 **	-0.12 **
	(0.47)	(0.48)	(0.04)	(0.05)
Intact Family	0.96 ***	1.02 ***	0.21 ***	0.21 ***
	(0.19)	(0.20)	(0.02)	(0.02)
Number of Siblings	-0.03	-0.09	-0.00	-0.00
	(0.06)	(0.06)	(0.01)	(0.01)
Female	-1.58 ***	1.09 ***	0.27 ***	0.34 ***
	(0.18)	(0.19)	(0.02)	(0.02)
Held Back in School	-6.17 ***	-4.99 ***	-0.41 ***	-0.44 ***
	(0.31)	(0.32)	(0.03)	(0.03)
Constant	53.06 ***	50.39 ***	2.64 ***	2.50 ***
	(0.50)	(0.52)	(0.05)	(0.05)
Observations	8,978	8,978	8,299	8,288
R-squared	0.13	0.12	0.17	0.17

Note: Standard errors in parentheses,*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Table II-4 Coefficients from School-Fixed Effects Regression of Behavioral and Attitudes Measurements on Selected Variables: Asian Americans and Whites from ELS 2002 10th Grade

	1 Hard Working	2 Importance of Good Education	3 Students' Education Expectation	4 Parents' Education Expectation	5 Math Class Behavior
Asian	0.15***	0.05 **	0.32 ***	0.57 ***	0.19 ***
	(0.05)	(0.02)	(0.10)	(0.08)	(0.03)
SES	0.16***	0.05 ***	0.67 ***	0.61 ***	0.14 ***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)
Asian # SES	-0.06*	-0.05 ***	-0.33 ***	-0.24 ***	-0.09 ***
	(0.03)	(0.02)	(0.07)	(0.06)	(0.02)
2nd Generation	-0.02	0.02	-0.07	0.02	-0.05
	(0.04)	(0.02)	(0.09)	(0.07)	(0.03)
3rd Generation	-0.13***	-0.04	-0.15	-0.06	-0.06 *
	(0.04)	(0.02)	(0.09)	(0.08)	(0.03)
Intact Family	0.10***	0.03 ***	0.15 ***	0.06 *	0.13 ***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Number of Siblings	0.00	0.00	-0.01	-0.01	-0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Female	0.15***	0.12 ***	0.37 ***	0.10 ***	0.15 ***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Held Back in School	-0.17***	-0.03 *	-0.84 ***	-0.65 ***	-0.18 ***
	(0.03)	(0.02)	(0.06)	(0.05)	(0.02)
Constant	2.67***	2.74 ***	15.93 ***	16.12 ***	4.01 ***
	(0.05)	(0.03)	(0.10)	(0.08)	(0.04)
Observations	8,978	8,978	8,978	8,978	8,978
R-squared	0.04	0.03	0.10	0.10	0.07

Note: Standard errors in parentheses,*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Table II-5 Coefficients from School-Fixed Effects Regression of Math Achievement on Behavioral/Attitudes Measurements and Other Selected Variables: Asian Americans and Whites from ELS 2002 10th Grade

	1 Null	2 Hard Working	3 Importance of Good Education	4 Students' Education Aspiration	5 Parents' Education Aspiration	6 Math Class Behavior	7 Full
Asian	1.45**	1.26**	1.39**	1.17*	0.74	0.87~	0.30
	(0.47)	(0.47)	(0.47)	(0.46)	(0.46)	(0.46)	(0.45)
SES	3.53***	3.31***	3.45***	2.78***	2.74***	3.12***	2.16***
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
2nd Generation	0.38	0.41	0.35	0.51	0.39	0.59	0.65
	(0.43)	(0.43)	(0.43)	(0.42)	(0.42)	(0.42)	(0.40)
3rd Generation	0.32	0.51	0.39	0.54	0.44	0.55	0.77~
	(0.47)	(0.46)	(0.46)	(0.45)	(0.45)	(0.45)	(0.44)
Intact Family	0.98***	0.84***	0.92***	0.78***	0.89***	0.52**	0.41*
	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.18)
Number of Siblings	-0.02	-0.03	-0.03	-0.02	-0.01	-0.02	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Female	-1.59***	-1.81***	-1.80***	-2.05***	-1.73***	-2.11***	-2.40***
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.17)
Held Back in School	-6.19***	-5.95***	-6.13***	-5.15***	-5.27***	-5.55***	-4.37***
	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.30)
Hard Working		1.45***					0.56***
		(0.11)					(0.12)
Importance of Good Education			1.76***				-0.43*
			(0.21)				(0.22)
Students Education Aspiration				*** 1.24			*** 0.79
				(0.05)			(0.06)

Parents Education Aspiration					1.40***		0.92***
					(0.06)		(0.07)
Math Class Behavior						3.45***	2.56***
						(0.15)	(0.15)
Constant	53.19***	49.31***	48.34***	33.45***	30.58***	39.33***	15.12***
	(0.50)	(0.58)	(0.77)	(0.98)	(1.15)	(0.77)	(1.31)
Observations	8,978	8,978	8,978	8,978	8,978	8,978	8,978
R-squared	0.13	0.15	0.14	0.19	0.18	0.19	0.24
p-value for Asian#SES	0.006	0.010	0.013	0.124	0.067	0.064	0.791

Note: Standard errors in parentheses,*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Appendix Table 1 Ethnicity, Family SES and Achievement (Hispanic and White)

	1 Math Test	2 Math Test	3 Reading Test	4 Reading Test	5 10th Grade overall GPA	6 10th Grade overall GPA	7 10th Grade Academic GPA	8 10th Grade Academic GPA
Hispanic	-3.25***	-3.25***	-2.66***	-2.67***	-0.18***	-0.18***	-0.19***	-0.19***
	(0.32)	(0.32)	(0.33)	(0.33)	(0.03)	(0.03)	(0.03)	(0.03)
SES	3.72***	3.83***	3.59***	3.71***	0.31***	0.33***	0.33***	0.36***
	(0.15)	(0.17)	(0.15)	(0.17)	(0.01)	(0.02)	(0.02)	(0.02)
Hispanic # SES		-0.49		-0.50		-0.13***		-0.14***
		(0.32)		(0.33)		(0.03)		(0.03)
2nd Generation	0.97*	1.01**	1.23**	1.27***	-0.04	-0.03	-0.07	-0.06
	(0.43)	(0.43)	(0.44)	(0.45)	(0.04)	(0.04)	(0.04)	(0.04)
3rd Generation	0.56	0.65	1.45***	1.54***	-0.12**	-0.1**	-0.16***	-0.13***
	(0.39)	(0.40)	(0.41)	(0.41)	(0.04)	(0.04)	(0.04)	(0.04)
Intact Family	0.98***	0.96***	0.94***	0.92***	0.21***	0.21***	0.21***	0.21***
	(0.18)	(0.18)	(0.19)	(0.19)	(0.02)	(0.02)	(0.02)	(0.02)
Number of Siblings	-0.01	-0.01	-0.1~	-0.1*	-0.01	-0.01	-0.00	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)
sibling miss	-1.03**	-1.02***	-0.91*	-0.9**	-0.11**	-0.11***	-0.12**	-0.12***
	(0.38)	(0.38)	(0.40)	(0.40)	(0.04)	(0.04)	(0.04)	(0.04)
Female	-1.41***	-1.42***	1.21***	1.21***	0.28***	0.28***	0.35***	0.35***
	(0.17)	(0.17)	(0.18)	(0.18)	(0.02)	(0.02)	(0.02)	(0.02)
Held Back in School	-5.45***	-5.45***	-4.48***	-4.48***	-0.36***	-0.36***	-0.39***	-0.39***
	(0.27)	(0.27)	(0.28)	(0.28)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	52.44***	52.33***	50.36***	50.25***	2.66***	2.63***	2.52***	2.49***
	(0.43)	(0.44)	(0.45)	(0.46)	(0.04)	(0.04)	(0.04)	(0.05)
Observations	9,613	9,613	9,613	9,613	8,844	8,844	8,831	8,831
R-squared	0.16	0.16	0.13	0.13	0.16	0.16	0.16	0.16
Number of sid	731	731	731	731	708	708	707	707

Standard errors in parentheses

Appendix Table 2 Ethnicity, Family SES and Achievement (Asian subgroups and White)

	1	2	3	4	5	6	7	8
	Math Test	Math Test	Reading Test	Reading Test	10th Grade overall GPA	10th Grade overall GPA	10th Grade Academic GPA	10th Grade Academic GPA
East Asian	2.36***	2.63***	0.32	0.40	0.17***	0.22***	0.20***	0.26***
	(0.48)	(0.50)	(0.49)	(0.51)	(0.04)	(0.05)	(0.05)	(0.05)
Other Asian	-1.41**	-1.23**	-2.04 ***	-1.99***	0.09*	0.11**	0.11*	0.13***
	(0.48)	(0.48)	(0.49)	(0.50)	(0.04)	(0.04)	(0.05)	(0.05)
SES	3.50***	3.72***	3.65 ***	3.71***	0.31***	0.34***	0.34***	0.38***
	(0.15)	(0.17)	(0.15)	(0.17)	(0.01)	(0.02)	(0.01)	(0.02)
East Asian # SES		-0.63		-0.19		-0.13***		-0.13***
		(0.45)		(0.46)		(0.04)		(0.05)
Other Asian # SES		-1.21***		-0.31		-0.14***		-0.17***
		(0.40)		(0.41)		(0.04)		(0.04)
2nd Generation	0.48	0.59	1.55 ***	1.58***	-0.04	-0.03	-0.07~	-0.05
	(0.41)	(0.41)	(0.42)	(0.43)	(0.04)	(0.04)	(0.04)	(0.04)
3rd Generation	-0.46	-0.37	0.98 *	1.00**	-0.15***	-0.14***	-0.18***	-0.16***
	(0.44)	(0.44)	(0.45)	(0.45)	(0.04)	(0.04)	(0.04)	(0.04)
Intact Family	0.98***	0.96***	0.98 ***	0.97***	0.21***	0.20***	0.21***	0.20***
	(0.19)	(0.19)	(0.20)	(0.20)	(0.02)	(0.02)	(0.02)	(0.02)
Number of siblings	-0.02	-0.03	-0.08	-0.08	-0.00	-0.00	-0.00	-0.00
	(0.06)	(0.06)	(0.06)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)
Female	-1.54***	-1.53***	1.09 ***	1.09***	0.27***	0.27***	0.34***	0.34***
	(0.18)	(0.18)	(0.18)	(0.18)	(0.02)	(0.02)	(0.02)	(0.02)

Held Back in School	-6.40***	-6.39***	-5.01 ***	-5.01***	-0.40***	-0.40***	-0.44***	-0.44***
	(0.31)	(0.31)	(0.32)	(0.32)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	53.90***	53.77***	51.02 ***	50.98***	2.70***	2.68***	2.56***	2.54***
	(0.47)	(0.47)	(0.49)	(0.49)	(0.04)	(0.04)	(0.05)	(0.05)
Observations	9,224	9,224	9,224	9,224	8,533	8,533	8,521	8,521
R-squared	0.14	0.14	0.12	0.12	0.16	0.16	0.17	0.17
Number of sid	720	720	720	720	699	699	698	698

Standard errors in parentheses*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Appendix Table 3 Family SES, Behaviors and Attitudes (Hispanic-White)

	1 Hard Working	2 Importance of Good Education	3 Students' Education Expectation	4 Parents' Education Expectation	5 Math Class Behavior
Hispanic	0.09***	0.03*	-0.06	0.11 *	-0.10***
	(0.03)	(0.02)	(0.07)	(0.05)	(0.02)
SES	0.16***	0.05***	0.69***	0.63 ***	0.13***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)
Hispanic # SES	-0.10***	-0.06***	-0.19***	-0.11 **	-0.05**
	(0.03)	(0.02)	(0.07)	(0.05)	(0.02)
2nd Generation	-0.04	-0.02	-0.02	0.14 *	-0.07**
	(0.04)	(0.02)	(0.09)	(0.07)	(0.03)
3rd Generation	-0.13***	-0.05**	-0.21**	-0.10	-0.09***
	(0.04)	(0.02)	(0.08)	(0.07)	(0.03)
Intact Family	0.08***	0.03***	0.14***	0.04	0.13***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Number of Siblings	0.00	-0.00	-0.02*	-0.01	-0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Female	0.19***	0.12***	0.42***	0.16 ***	0.15***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Held Back in School	-0.15***	-0.03**	-0.73***	-0.60 ***	-0.19***
	(0.03)	(0.01)	(0.06)	(0.05)	(0.02)
Constant	2.67***	2.77***	15.95***	16.13 ***	4.06***
	(0.04)	(0.02)	(0.09)	(0.07)	(0.03)
Observations	9,613	9,613	9,613	9,613	9,613
R-squared	0.04	0.03	0.10	0.09	0.07
Number of sid	731	731	731	731	731

Standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Appendix Table 4 Family SES, Behaviors and Attitudes (Asian Subgroups-White)

	1 Hard Working	2 Importance of Good Education	3 Students' Education Expectation	4 Parents' Education Expectation	5 Math Class Behavior
East Asian	0.10**	-0.01	0.22**	0.36***	0.13***
	(0.05)	(0.03)	(0.10)	(0.09)	(0.04)
Other Asian	0.12**	0.04	0.09	0.39***	0.12***
	(0.05)	(0.02)	(0.10)	(0.08)	(0.03)
SES	0.15***	0.05***	0.69***	0.62***	0.14***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)
East Asian # SES	-0.05	0.00	-0.24**	-0.19**	-0.09***
	(0.04)	(0.02)	(0.09)	(0.08)	(0.03)
Other Asian # SES	-0.04	-0.06***	-0.42***	-0.27***	-0.08***
	(0.04)	(0.02)	(0.08)	(0.07)	(0.03)
2nd Generation	-0.07*	0.01	-0.02	0.10	-0.07**
	(0.04)	(0.02)	(0.08)	(0.07)	(0.03)
3rd Generation	-0.15***	-0.05**	-0.22**	-0.10	-0.11***
	(0.04)	(0.02)	(0.09)	(0.07)	(0.03)
Intact Family	0.09***	0.03***	0.17***	0.05*	0.14***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Number of siblings	0.00	0.00	-0.01	-0.01	-0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Female	0.16***	0.12***	0.38***	0.11***	0.15***
	(0.02)	(0.01)	(0.04)	(0.03)	(0.01)
Held Back in School	-0.19***	-0.04**	-0.86***	-0.67***	-0.20***
	(0.03)	(0.02)	(0.06)	(0.05)	(0.02)
Constant	2.71***	2.76***	15.98***	16.15***	4.05***
	(0.05)	(0.02)	(0.10)	(0.08)	(0.03)
Observations	9,173	9,223	9,147	9,154	9,188
R-squared	0.04	0.03	0.10	0.10	0.07
Number of sid	718	720	719	719	719

Standard errors in parentheses*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.1

Chapter III. Non-cognitive Skills and the Growing Achievement Gap

Introduction

Intergenerational transmission of social class via children's academic attainment is an important area of research in sociology. Over the past decades, it has been well established that measures of children's educational achievement, such as standardized test scores and GPAs, are strongly associated with their socioeconomic status (SES). Research has shown that, upon entrance to kindergarten, low-SES children are already behind their peers from high-SES groups in achievement test scores (Entwisle, Alexander, and Olson 1997; Lee and Burkam 2002; Mayer 1997; Reardon 2011). Because early achievement differences can lead to inequality in secondary education and later occupational attainment, this issue has received considerable scrutiny, with researchers examining the causes and mechanisms of SES-gradients in educational achievement.

Many of these studies have found that early achievement disparities across children from different socioeconomic backgrounds increase as students progress through primary and secondary school (Downey, von Hippel, and Broh 2004; Phillips, Crouse, and Ralph 1998; Reardon 2003; Reardon 2013). Cumulative advantage – whereby advantages of one group over another continue to grow over time - serves as an explanation for this increasing SES-based achievement gap. In this case, cumulative advantage suggests that the relationship between characteristics of SES and children's educational success become magnified over time, with initially advantaged children's achievement bonus compounding as they progress through schooling.

Studies on accumulated educational achievement differences have assessed the contribution of school and non-school factors. While some have found that structural factors, such as school quality or separate ability tracks within schools, have significant influences (Gamoran & Mare 1989; Lucas 1999; Kerckhoff 1995; Kerckhoff & Glennie 1999), others claim that non-school factors, such as family circumstances or parenting styles, have the greatest impact (Downey, von Hippel, and Broh 2004; Cheadle 2008; Cheadle and Amato, 2011; Potter and Roksa 2013). While this body of research has led to many fruitful discoveries, I examine a question here that has not yet been explored: What role do SES-gradients in non-cognitive skills play in magnifying over children's school years the early SES-based gaps in educational achievement?

As early as in 1970s, Bowles and Gintis (1976, p131) argued for the importance of non-cognitive skills and traits in predicting attainment, success, and persistent class reproduction over generations. Their proposition was a reply to Herrnstein's (1973) argument for the deterministic role of cognitive ability in social stratification. Bowles and Gintis' arguments were among the first, and remain among the foremost, of the non-cognitive inheritance views of the American stratification system (Farkas 2003). Since then, a new cross-disciplinary paradigm has emerged, focusing on how behaviors related to non-cognitive skills are associated with school success and occupational attainment.

Much of the evidence to date from across the social sciences strongly suggests that non-cognitive skills such as conscientiousness, motivation, and perseverance are important in the stratification process. Most of this literature focuses on the predictive power of non-cognitive skills for individual achievement and success (e.g. Heckman 2006; Duckworth & Seligman 2005, 2006; Claessens, Duncan & Engel 2009). However, as Farkas (2003) points out, we still do not

understand how non-cognitive skills may influence individual trajectories of achievement or development of cognitive skills, or group-level growth of cumulative disadvantage and advantage. Given the significance of non-cognitive skills to individual achievement, it is reasonable to conjecture that early SES-based differences in non-cognitive skills could exert compounding effects on educational achievement over time, increasing SES-based differences as children advance through school.

Using longitudinal data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), I first investigate whether and how children's non-cognitive skills influence their growth trajectories. Then I examine whether SES stratification in non-cognitive skills account for the widening achievement gap between high- and low-SES groups from kindergarten to fifth grade. I draw on DiPrete and Eirich's (2006) classifications of cumulative advantage to specify a model of achievement over early school years that suggests path-dependent processes.

Theoretical Framework

Cumulative Advantage and the SES-Based Achievement Gap

Socioeconomic disparities in academic achievement remain a stubborn feature of U.S. society. Many studies have documented pronounced learning differences in early childhood by socioeconomic background, typically measured by parents' income, education, and occupation, which persist despite the many efforts mounted by policy makers, and educators (Applebee, Langer, and Mullis 1988; Farkas and Beron 2004; Hart and Risley 1995; Lee and Burkam 2002; Phillips, Brooks-Gunn et al. 1998; Stipek and Ryan 1997). Moreover, much evidence suggests that these disparities tend to grow as children progress through school, though the observed patterns and magnitudes of the growth differ depending on the metric used (Daneman 1991; Bast

and Reitsma 1998; Kerckhoff and Glennie, 1999; Downey, von Hippel, and Broh 2004; Fryer and Levitt 2004; Cheadle 2008; Reardon 2011; Pfost et al. 2013). For example, in a study focusing on the Baltimore area, Alexander and Entwisle (2007) showed that differences in reading test scores between high- and low-SES children widen from first to ninth grade. Using U.S. national data from the Early Childhood Longitudinal Program (ECLS), Downey and colleagues (2004) also reported that SES-based educational achievement differences grew from kindergarten to first grade, while Reardon and colleagues (2007), using data from both the ECLS-K and the National Assessment of Educational Progress (NAEP), found that SES-based achievement differences appear to narrow modestly in the first one to two years of schooling, but widen thereafter.

Cumulative advantage is a useful perspective in examining patterns of increasing achievement difference by children's socioeconomic background. Originally proposed by Merton (1968) to explain stratification in scientific careers, the term cumulative advantage has since been widely adopted by social scientists analyzing inequality over time in areas such as wealth, criminal activity, health, and education. It also has been used as a lens to understand children's development and group-based inequality. One large body of research has shown how placement of students in different ability tracks in school can trigger a cumulative process that exacerbates early inequality by compounding differences in academic achievement over time. Some studies have documented that ability tracking increases the variance in outcomes because it directly affects both educational outcomes and future track placement (Gameron and Mare 1989; Kerckhoff 1993; Kerckhoff & Hlennie 1999; Lucas 1999). However, other research indicates that tracking is not a cumulative advantage mechanism in the contemporary U.S.

educational system because ability tracking varies across school (Sorensen 1970; Gamoran 1992), and schools no longer assign students to single overarching tracks (Lucas 2001).

Another area of scholarly debate is the degree to which "school effects" occur throughout schooling – from preschool to university – and whether these magnify the initial achievement difference (DiPrete and Eirich 2006). For example, researchers find that higher quality schools – which are more available to children from high- than low-SES families – confer a positional advantage reflected in later educational careers (e.g. Edmonds 1979; Rutter 1983; Bowles and Gintis 1976; Bourdieu and Passeron 1977; Condron and Roscigno 2003). Thereby, early SES-based school quality differences contribute to achievement differences at each stage of schooling. However, other recent studies point out that high-quality schools may have *negative* effects on subsequent educational quality for children with only average achievement. That is, children of average performance in top-quality schools are less likely than their peers with similar ability but higher relative standing in less prestigious schools to qualify for or enroll in advanced subjects, which decreases their chances of entering elite colleges (Attewell 2001). Finally, a long tradition of stratification research argues that, rather than exacerbating early life inequality, schools act as a "great equalizer" among socioeconomic groups (Alexander, Entwisle, and Olsen 2007; Downey, von Hippel and Broh 2004).

The alternative, suggested by research showing no or contradictory educational effects by school factors such as ability tracking or school quality, is that the observed SES-based achievement gap is a function of non-school factors, chiefly family characteristics. Since the Coleman report in the 1960s, myriad studies have suggested that the family, rather than the school, is the primary source of inequality in children's academic performance (Coleman 1966, 1968; Laureau 2011). As to the growth of the achievement gap after school entry, recent studies

have suggested that within-family processes such as purposeful parenting and concerted cultivation enhance children's learning rate, which act to widen over time the initial achievement difference across socioeconomic groups (Cheadle 2008, 2011; Laureau 2011; Cheadle 2008; Potter and Roksa 2013).

Much remains unexplained about the underlying causes and mechanisms of SES group disparities in academic achievement. As shown in past studies (Downey and Hippel 2004; Cheadle 2008, 2011 etc.), school and family factors do not fully explain the observed achievement gap – nor its growth over time – indicating the significance of other as yet unexplored factors.

Non-cognitive Skills and Achievement Difference across Social Groups

Students' non-cognitive skills comprise an understudied area in analyses of the trajectory of the educational achievement gap. Non-cognitive skills such as motivation, perseverance and tenacity are known to be important for success throughout life. (e.g. Almlund et al 2006; Heckman et al 2010; Cuhan, Heckman and Schennach 2010; Borghans, Meijers and Wheel 2008; Heckman, 2006; Claessens, Duncan and Engel 2009) One convincing piece of evidence on the importance of non-cognitive skills came from the well-known Perry School Intervention Study, in which children with sub-normal IQ scores were selected to participate in an intervention program fostering non-cognitive skills such as planning, executing plans, and reviewing their work. Follow-up studies showed that students in the treatment group not only improved in their cognitive ability, but also became more successful than the control group in terms of socioeconomic achievement in later life (Heckman, Malofeeva, Pinto et al. 2010).

Since the Perry School study, empirical evidence on the significance of non-cognitive skills in individuals' education attainment and academic achievement has been piling up across social

science disciplines, with traits such as conscientiousness, self-discipline, perseverance, and attention consistently associated with educational attainment and achievement (e.g. Almlund et al 2006; Heckman et al 2010; Cuhan, Heckman and Schennach 2010; Borghans, Meijers and Wheel 2008; Heckman, 2006; Claessens, Duncan and Engel 2009).

For instance, studies of both American and Chinese students showed that self-control strongly predicts subsequent changes in grades, and it can even make up for shortcomings in IQ (Duckworth, Tsukayama and May 2010; Duckworth & Seligman 2005, 2006; Zhou, Main and Wang 2010). Also, Martin and colleagues (1989) found teacher and parent ratings of early childhood persistence, distractibility, and (low) activity prospectively predicted both course grades and standardized achievement test scores. In addition, Alexander, Entwisle and Dauber (1993) analyses of a representative sample of Baltimore first graders showed that teacher ratings of attention span and restlessness in the first grade predicted both course grades and standardized achievement test scores four years later. In more recent work examining school readiness (academic, attention, and socio-emotional skills) and later academic achievement, Duncan and colleagues (2007) found further support for the role of school-entry attention skills in predicting later achievement test scores. Studies using ECLS-K data to examine the effects of kindergarten skills on subsequent performance suggest that school-entry socio-emotional skills, particularly attention skills, are important predictors of academic achievement in fifth grade. (Claessens, Duncan and Engel 2007; Duncan et al 2007)

Recent work has also found associations between non-cognitive skills and observed achievement gaps across social groups. In research examining school achievement differences between Asian and white students, Hsin and Xie (2014) attributed much of the Asian advantage

to their stronger work ethic and greater academic efforts – characteristics that served to widen the Asian-white achievement gap over time.

While these studies offer an important basis from which to predict that early non-cognitive skill differences play a role in growing achievement gaps over educational careers, few empirical studies have actually examined this question. Importantly, past studies have documented that (1) children's non-cognitive skills are not randomly distributed across the population, but are stratified by their socioeconomic background; and (2) the development of non-cognitive skills is highly influenced by the family (Hanushek, Machin, and Woessmann 2011; Reardon and Portilla 2015). In this analysis I hypothesize that the initial SES-based gap in non-cognitive skills upon children's entry to school triggers a cumulative process by which group differences in achievement grow over time. Specifically, I posit that children from higher SES backgrounds are equipped with better non-cognitive skills upon school entry than their less advantaged peers, allowing them to learn at higher rates throughout their school years and, in this sense, compound their initial advantage.

Non-cognitive Skills and Cumulative Achievement Advantage

Non-cognitive skills can influence the development trajectory of achievement, whereby children with greater non-cognitive skills learn faster than those with lower non-cognitive skills resulting in a growing achievement disparity between the skill groups over time (Figure III-1).

To illustrate more clearly how non-cognitive skills can contribute to a cumulative achievement advantage over time, we refer to following equations (DiPrete and Enrich 2006). In its most basic form, the cumulative advantage mechanism can be summarized by equation (1):

$$\underbrace{\Delta Y_t}_{Increment\ between\ \boldsymbol{t}\ and\ \boldsymbol{t-1}} = Y_{it} - Y_{i,t-1} = \underbrace{\alpha_t Z_{i,t-1}}_{Critical\ resources\ at\ \boldsymbol{t-1}} + \beta' X_i + \nu_{it} \quad (1)$$

In this and the following equations, *t* indexes time and *i* indexes individual; Z is a critical resource of interest; X is a vector including all the other covariates influencing the development of the outcome variable Y over time; ν is the error term; and ΔY_t is the change in Y in period t (period between time t and t-1). To examine how the differences in Y due to Z can accumulate over time, we can carry out an exercise. We first apply equation (1) iteratively over time and thus write out the following equations:

$$\Delta Y_{t-1} = Y_{i,t-1} - Y_{i,t-2} = \alpha_{t-1} Z_{i,t-2} + \beta' X_i + \nu_{i,t-1}$$

…

$$\Delta Y_1 = Y_{i1} - Y_{i,0} = \alpha_1 Z_{i,0} + \beta' X_i + \nu_{i0}$$

Assume that we have two groups that are identical on every aspect except for variable Z. Group A have more resources in Z than Group B at each time point, and the difference at time t is ΔZ_t. Then for the t[th] period, Group A's gains in Y will be $\alpha_t \Delta Z_t$ higher than Group B.

$$(\Delta Y_t^A) - (\Delta Y_t^B) = \alpha_t (Z_{i,t-1}^A - Z_{i,t-1}^B) = \alpha_t \Delta Z_t$$

$$(\Delta Y_{t-1}^A) - (\Delta Y_{t-1}^B) = \alpha_{t-1} (Z_{i,t-2}^A - Z_{i,t-2}^B) = \alpha_{t-1} \Delta Z_{t-1}$$

…

$$(\Delta Y_1^A) - (\Delta Y_1^B) = \alpha_1 (Z_{i,0} - Z_{i,0}^B) = \alpha_1 \Delta Z_1$$

Group A's advantage in Y over Group B over the total t periods will be the sum of the difference in gains in each period, which equals $\sum_{i=1}^{i=t} \alpha_i \Delta Z_i$. If α_i is consistently positive throughout each time period, the difference in outcome Y between the two groups grows as time passes, with group A enjoying a cumulative advantage. The source for this accumulated difference is that Z affects Y's growth trajectory positively, and group A and B differ in Z. Figure III-1 depicts this trajectory based cumulative difference.

In this study, the variable Y will be an achievement test score. the variable Z will be non-cognitive skills, and Groups A and B will be different SES groups. Thus, if non-cognitive skills affect children's achievement growth trajectory, or their learning rate, an initial difference in non-cognitive skills by SES groups can trigger a process whereby the achievement difference between groups grows over time.

Data and Methods

Data and Measurement

The data used in this study come from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), a nationally representative study designed to assess social-group differences in U.S. children's social-emotional and cognitive development. The survey, conducted by the National Center for Education Statistics (NCES), used a three-stage stratified sampling procedure in following a group of selected children from school entry through 8th grade. Data were collected from children and their families, teachers, and schools on children's cognitive, social, emotional, and physical development. In addition, information was included on children's home environment, home educational activities, school environment, classroom environment, classroom curriculum, and teacher qualifications. The current analysis is restricted the sample to children who did not change schools[7] during the period from kindergarten to fifth grade, and who had taken a cognitive ability assessment (math or reading test) at least once in the five waves. This yields a sample of 14,583 children who were assessed on math at 55,002

[7] There are 6403 students in the original sample who have changed schools within the period from kindergarten to fifth grade. T-tests suggest that these students differ from those do not change school in their social background, for example they are more likely to come from low SES families. To examine whether the differences in socio-demographic and family characteristics between the analytical sample and the sample of students who changed schools during kindergarten to fifth grade will bias the results in the main analysis, I conduct a sensitivity analysis. The details and results are presented in the appendix. Basically, the sensitivity analysis results suggest that by excluding the children who changed schools from the analytical sample will not change the results in this study much.

person-periods and a sample of 14,478 children who were assessed on reading at 54,337 person-periods. Table III-1 1 presents the information on observations for each of the five waves. As shown, the period length between waves varies from seven months to around two years.

Math and reading IRT scaled scores provided by NCES are used to measure educational achievement. Math tests assessed children's achievement in number sense, properties, and operations, measurement, geometry and spatial sense, data analysis, statistics and probability, patterns, algebra, and functions. The reading test assessed children on initial understanding, developing interpretation, personal reflection and response, and demonstration of a critical stance. The scaled test scores, established using Item Response Theory (IRT) statistical procedures that account for patterns of right, wrong, and omitted responses and each item's difficulty and "guess-ability," –place each child on a continuous ability scale. IRT scores help account for testing issues such as a low-ability child guessing several difficult items correctly and allow comparisons of a child's ability longitudinally, even with different assessments administered in each wave. However, a key criticism of using IRT scores to gauge ability disparities concerns the interpretation of the magnitude of difference or change in scores over time and across groups. Because an IRT score is an interval-scaled metric reflecting only a specific set of test items, a different set of test items administered in a different wave can yield IRT scores that are not easy to compare to previous scores. In addition, as these test scores are measured on ordinal scales and are transformed monotonically using a specific scale, they are subject to the changes in the transformation scales. Therefore, Although for these reasons IRT scores present challenges (Reardon 2007; Bond and Lang 2013; Lang 2010; Bond and Lang, 2015), they are still a valid and frequently used measure of children's developing ability.

Non-cognitive skills, the key predictor variables in this study, are constructed from the ECLS-K Social Rating Scales (SRS) as provided by the children's teachers. This scale is adapted from the Social Skills Rating System (Gresham and Elliott, 1990). At each wave of the survey from the fall of kindergarten through the third grade, teachers were asked to use a frequency scale to report how often students exhibit a certain social skill or behavior (1 = never to 4 = very often), from which the ECLS constructed five SRS scales[8]: Approaches to Learning, Self-Control, Interpersonal Skills, Externalizing Problem Behaviors, and Internalizing Problem Behaviors. In this analysis, non-cognitive skills are measured using an unweighted averaged composite[9] of scales for Approaches to Learning, Self-Control, and Interpersonal Skills that is standardized within each wave (kindergarten–fall, kindergarten–spring, first grade, and third grade) to ease interpretation.

As shown in Table III-2, demographic and other background control variables include children's age in months when they entered kindergarten at the baseline survey, gender (male = 1), immigrant generation (second generation, first generation, and native as the reference), intact family (living with both parents = 1), number of siblings, language spoken at home (Non-English = 1), and whether child is a second time kindergartener (second time = 1). Family SES, an index constructed by NCES, is a composite based on mother's and father's education, both parents' occupations, and family income, with each component equally weighted. It is standardized with a mean of 0 and a standard deviation of 1 across the sample being surveyed (NCES 2002). This study uses the SES composite measured at baseline to measure children's family SES. Though family SES may change as children grow up, the correlation analysis Appendix Table 5 in the

[8] There are 24 items in total for SRS in kindergarten and first grade waves, and 26 items in third grade and fifth grade wave.

[9] I conduct a Confirmatory Factor Analysis to examine the validity of such construct. The RMSEA for the model is 0.063 (with a 90% confidence interval 0.061 to 0.064), and the CFI is 0.962. Conventionally, a RMSEA less than 0.1 and CFI greater than 0.9 suggest a well fitted model.

Appendix) across the available SES measurements from different waves suggest that it is quite stable within this sample over this time period.

Five measures control for parenting and family environment, as these aspects are highly correlated with both children's development and family's SES[10]. Since the ECLS used different questions on parenting and home environment at different waves, instead of constructing time-varying measurements, I incorporated all information available from kindergarten–fall to fifth grade and construct five broad measures to characterize and control for children's home environment and parenting generally. As parenting and home environment are control rather than key variables in this analysis, this procedure should not significantly influence or bias results and interpretations. The first measure is a composite of average weekly frequencies of six in-home activities between parents and children (telling stories, singing songs, etc.). The second measure uses a composite and sample-standardized score for five items capturing parent-child communication: the extent to which parents listen to and help with children's problems, know their friends, and are patient with their children. The third measure captures the frequency with which parents help children with homework, and is standardized across the sample. The fourth measure is the natural log of the average number of books parents estimate are in the home in kindergarten–fall, first grade, and third grade. The fifth standardized measure estimates the diversity of children's extracurricular activities such as dance lessons, instrument classes, clubs, and art programs. For all these five measures of parenting and home environment, a higher score indicates a family with more diverse activities, a more stimulating environment, and more attentive parents.

[10] For detailed information on the construction of these five measurements, please refer to Appendix Table 6 in Appendix.

Missing values are assumed to be missing at random (Allison 2002; Little and Rubin 2014). The magnitude of missing values differed across variables in the same wave as well as across waves for the same variable, and Table III-1 presents the observations and missing patterns of the sample. As the longitudinal models do not require that all children be tested on all occasions, randomly missing tests scores are not very problematic (Singer and Willett 2003; Raudenbush and Bryk 2002). However, because randomly missing covariates can lead to bias and inefficiency, I employ a multiple imputation strategy[11] to deal with these. Five data sets were imputed, using all the covariates in the model. Imputation was performed with data on the individual level, and then the imputed data were transposed into a person-period layout. To assess the sensitivity of the results to the multiple imputation process, I replicate the main analysis over all the five imputed data sets, and also tested the main models using the list wise deletion method. The results from these replication analyses follow similar patterns to the ones presented in this paper, and only differ slightly in the coefficient estimates.

Analytic Models

Drawing on DiPrete and Eirich (2006), the model specified in this study is a path-dependent cumulative advantage model, where the key measures of non-cognitive skills are allowed to change over time. The basic structure of the achievement model draws on the hierarchical linear model (HLM; Raudenbush and Bryk 2002; Singer and Willett 2003; Downey et al. 2004; Marsh and Cormier 2002; Reardon 2003). The Level 1 model is a within-student model, which captures the growth trajectory of each individual student:

$$Y_{si,k} = \pi_{si0} + \sum_{k=1}^{K} \pi_{si,k} \Delta t_{si,k} + \epsilon_{si,k} \quad (3)$$

$$\text{where } \Delta t_{si,k} = month_{si,k} - month_{si,k-1}$$

[11] I use the ICE command in STATA (Royston, 2007) to deal with the imputation.

In the subscripts, i indexes students, s indexes school, and k indexes one wave from the survey[12]. In the equation, π_{si0} is a child's initial mathematic or reading test scores assessed at kindergarten–fall. $\Delta t_{si,1}$ is the months a child spent in kindergarten between the two assessments in the fall and the spring of kindergarten. $\Delta t_{si,2}$ is the months between the kindergarten–spring assessment and the first grade assessment. $\Delta t_{si,3}$ is the months between the first and third grade assessments. $\Delta t_{si,4}$ is the months between the third and the fifth grade assessments. $\pi_{si,k}$ is a child's monthly growth rates in math or reading test scores over the corresponding four periods. For instance, $\pi_{si,1}$ is the monthly math or reading learning rate for child i in school s during the months between the first assessment in kindergarten–fall and second assessment in kindergarten spring. It should be noted that some of the time interval measurements in equation (3) will equal zero if the achievement score of interest (Y in this equation) is assessed before fifth grade, which is the last wave in this study. For instance, if the outcome is the child's score at first grade, $\Delta t_{si,3}$ and $\Delta t_{si,4}$ will be zero in the equation. Thus, the actual model to be fitted in that case will be:

$$Y_{s,i,3} = \pi_{si0} + \pi_{si,1}\Delta t_1 + \pi_{si,2}\Delta t_2 + \epsilon_{s,i,1}$$

This Level 1 model is a piecewise specification and breaks time into meaningful intervals. One benefit of this piecewise specification is that it accommodates the possibility that children grow at different rates over different periods of their early schooling careers (Figure III-2). Also, it allows me to incorporate time-varying covariates, such as non-cognitive skills, in the level 2 model.

The Level 2 between-student model is based on the intuition that the initial status and the temporal slopes are conditioned on between-student covariates and can vary between students

[12] There are five waves: Kindergarten Fall (k=0), Kindergarten Spring (k=1), First Grade (k=2), Third Grade (k=3), and Fifth Grade (k=4).

and schools. In the Level 2 between-student model, $\pi_{si,k}$ [13] in equation (3), which is a child's the monthly growth rates in math or reading test scores, is further defined by the following equation:

$$\pi_{si,k} = \beta_{(si,k)_0} + \beta_{(si,k)_1} X_{si} + \beta_{(si,k)_2} NC_{si,k-1} + r_{sik} \quad (4)$$

In equation (4), X_{si} is the vector of the social and demographic control and background variables summarized in Panel A and B, Table III-2. These are constant variables over time and most of them are measured at the baseline survey. $NC_{si,k-1}$ is the time-varying measurement of children's non-cognitive skills. As denoted in the subscript, it is the non-cognitive skills measured at the beginning of a certain period of interest. For example, by equation (4), the growth rate between the first two assessments in kindergarten fall and kindergarten spring will be summarized in this form:

$$\pi_{si,1} = \beta_{(si,1)_0} + \beta_{(si,1)_1} X_{si} + \beta_{(si,1)_2} NC_{si,0} + r_{si,1}$$

where the non-cognitive skills are measured at the kindergarten fall. I use this lagged measurement in the model so as to better assess how the non-cognitive skills will influence a child's learning rate in the following period and thus to better understand how non-cognitive skills will influence the achievement gap. For the intercept π_{si0} in equation (3), which indicates a student's initial test scores, I apply the similar model specification:

$$\pi_{si0} = \beta_{(si,1)_0} + \beta_{(si,1)_1} X_{si} + \beta_{(si,1)_2} NC_{si,0} + r_{si,1}$$

as the data does not have the measurement on non-cognitive skills before the kindergarten fall, I use the non-cognitive skills measured at kindergarten fall to proxy that measurement. Thus, non-cognitive skills is always measured at the beginning or "baseline" wave of a particular period. To fix school's effects, I further define the level 3 between-school model:

$$\beta_{s,i,k} = \gamma_{0,i,k} + u_{s,i,k} \quad (5)$$

[13] t_i, t_{i+1} are two consecutive time points in Kindergarten Fall, Kindergarten Spring, First Grade, Third Grade and Fifth Grade.

Estimation results in the Level 2 model will be the most interesting because they can be used to test the hypotheses by showing how non-cognitive skills will influence children's growth rate in each period from kindergarten fall to fifth grade. If our hypothesis that non-cognitive skills are important factors in maintaining and widening the achievement gap over time is supported, we will see a significant positive coefficient associated with the non-cognitive skills measurement in the level 2 model.

Analysis and Results

Descriptive Results

Table III-3 summarizes the descriptive statistics of the variables in this study. Panel A and B are the achievement test scores over time, which are the outcome variables in the estimated models. Panel C and D are the social, demographic, parenting and family environment variables. These variables are explanatory variables I will use in the Level 2 model (equation (4)) specification. Panel D are the summaries of standardized non-cognitive skills scores over time, which are of focal interest. Panel F summarizes the time interval in months between each two consecutive assessments in this study. The average length between the first two assessments (kindergarten fall and kindergarten spring) is 7.13 months, the average length between the kindergarten spring's assessment and first grade's assessment is 13.01 months, that between the first grade and third grade's assessment is 24.77 months, and that between the third grade and fifth grade's assessment is 24.22 months.

Figure III-3 presents the development trajectory in math (left panel) and reading IRT scores (right panel) for children from different SES backgrounds. As we can tell from Figure III-3, children from different SES groups all experience growth in math and reading IRT test scores. In addition, there exist initial SES-based achievement differences among children at their

entry to kindergarten. Such differences are persistent and tend to widen as children progress through school, and become more significant over time. Visually speaking, the reason for this widening achievement difference is that children from different SES groups vary in the inclination of their growth trajectories. Specifically, the achievement of children from higher SES backgrounds grows at a higher rate than that for children from lower SES backgrounds. Suggested by Model B in Table III-4 and Table III-5, such SES difference in inclination is statistically significant. This SES-based difference in achievement growth trajectory seems to spike in the early school years around kindergarten to first grade, and becomes relatively stable since then.

Figure III-4 presents children's standardized non-cognitive skills from kindergarten to fifth grade by their family's SES. It shows that there exists a notable SES differentiation in children's non-cognitive skills. Though it is less clear from simple inspection of the figure whether the difference in non-cognitive skills also widens over time, there are consistent gaps from kindergarten to fifth grade that do not appear to narrow.

Non-cognitive Skills and Achievement Growth Trajectory

Table III-4 and Table III-5 present results from the multilevel analysis for math IRT score and reading IRT score respectively. Model A is the baseline model, which only includes gender and children's age in months upon entry into kindergarten as control variables in Level 2 model (equation (4)). In other words, in the baseline model, children's scores on the math or reading test upon their entry to kindergarten, as well as their monthly growth rate in these two test scores from kindergarten to fifth grade, are only influenced by their age at their entry into kindergarten and their gender. Model B further includes family's SES into the model. Model C adds all the social, demographic, parenting and family environment variables displayed in Table III-2 in the

Level 2 model (equation (4)). Under this specification, children's initial scores and their growth rate over the following periods are influenced by these demographic and social characteristics. Model C is the full model, specified similarly to Model B but with the further addition of the focal measurements of non-cognitive skills into the Level 2 model (equation (4)). The intercept for the initial points for each four models represent how many points will a score a child will have at the first day of kindergarten if the all the covariates, including age upon entry to kindergarten, equal zero. For example the initial points for Model A are what a child will score at the first day of kindergarten if he is a male and is age 0 upon the entry of kindergarten. The points gained per month in each of the periods are children's monthly growth rates. The intercept coefficients for the monthly gained points are the average growth rate if all the covariates influencing the growth rates are kept at zero. For instance, the 1.158 for the intercept of points gained per month, kindergarten 1998-99 in Model A, Table III-4 means that a child will gain 1.158 points in math achievement each month during kindergarten, if he is a male and is at age zero upon the entry of kindergarten. As we can tell, all the intercept coefficients for the monthly growth rate in Model A are positive and significant for each time period in both Table III-4 and Table III-5. This suggests that that children experience improvement in their reading and math achievement throughout kindergarten to fifth grade.

As Model B in Table III-4 and Table III-5 suggests, family SES is significantly and positively related with children's mathematic and reading learning rate for nearly all the periods. This is consistent with what we have observed from Figure III-1, and suggests that there exists significant difference in growth trajectories across different SES groups. Children from higher SES backgrounds will learn at an elevated rate compared with those from lower SES backgrounds, and this growth rate difference means that the achievement gap between high SES

and low SES children widens over time. The coefficient before family's SES is negative during first grade for math achievement.[14] Model C in Table III-4 and Table III-5 is the model which extends Model B by including all the control variables. The magnitude of the coefficient before family's SES shrinks after controlling for the covariates, while the significance of the coefficients does not change much. These results further supports that family SES positively influences children's math and reading achievement growth rate.

Model D is the full model which extends Model C by including measurements on lagged non-cognitive skills. Model D in Table III-4 and Table III-5 show that for both mathematics and reading test scores, the coefficients for non-cognitive skills are all significant and positive for each period from kindergarten fall to fifth grade. As the non-cognitive skills in the models are measured previous to the period during which I assess children's achievement growth, it suggests that non-cognitive skills significantly influence a child's growth rate in math and reading achievement, with higher non-cognitive skills boosting the learning rate. Specifically, a one standard deviation increase in a child's non-cognitive skills increases their monthly growth rate in mathematic achievement by 0.069 during the period of kindergarten fall to spring, 0.039 during that of kindergarten spring to first grade, 0.104 during the period spanning first grade to

[14] Though this is countervailing to our expectation, it is consistent with other studies on child development using ECLS-K data set, which, as argued by previous research, may be due to school's effects on reducing the achievement inequality (Downey, Hippel and Broh 2004). This may also be due to the model specification of a piece-wise growth curve, where the spline over each period is constrained to be connected to the adjacent ones. To further test whether family SES has a negative effect on one's learning rate during the first grade, I conduct a sensitivity analysis using school-fixed effects regression model. In the sensitivity analysis, the outcome variable is the gains in achievement during first grade, and the independent variables are the social demographic and background variables in the main analysis. As suggested by the results (Appendix Table 7), family's SES is not significantly associated with children's development during first grade. I further use a categorical SES quintile measurement to estimate the model. All the five coefficients before each SES groups are not significant. This further suggests that SES does not have significant effects on children's gains in mathematic achievement during first grade. These evidence suggest that the negative SES effects on math achievement growth rate during first grade in the main analysis is partly due to the model specification. In the meantime, as the sensitivity analysis also shows little evidence for significant positive effects of SES on math achievement gains, it also suggests that the argument by previous studies that school helps reducing the achievement inequality may be true. However, this needs more deeper and extensive analysis which is out of the scope of this current research.

third grade, and 0.046 over the period between third and fifth grade. Compared with their effects on math achievement score growth, the association between non-cognitive skills and their reading achievement growth rate is slightly greater in magnitude.

Table III-6 presents the changes in the variances of the initial achievement and the following growth rates over each period across Model A, B and C for math achievement (Panel A) and reading achievement (Panel B). These variances are calculated for the individual level, and thus suggest the amount of variation in growth rates across different individuals in our sample. By comparing the changes in the variances across different models, we can roughly assess whether and to what extent a certain set of variables account for the differences in children's growth rates, and thus infer whether and to what extent these variables influence children's growth trajectory. Mathematics achievement (Panel A) can be used as an illustration. The variances in the growth rates in math achievement decrease in all the periods from Model A to Model B when we add the social and demographic background variables to the baseline model, and the decline ranges from 2 to 13 percent. By including non-cognitive skills measurements into our model, these variances further decline (Model B to Model C) by 3 to 15 percent. These findings suggest that children's non-cognitive skills are an influential factor in influencing children's growth rate in math achievement. The amount of decrease in variance from Model B to Model C is similar to that from Model A to Model B. This further highlights the importance of non-cognitive skills to children's growth trajectory in math achievement, as it alone has similar explanatory power as all the other twelve social demographic and family background variables. Results for reading achievement in Panel B Table III-6 are similar to those for math achievement, suggesting that non-cognitive skills are also a significant factor in shaping children's reading achievement growth trajectory.

As I have argued earlier, an initial difference in non-cognitive skills can trigger a cumulative process by which the achievement difference between children who have higher non-cognitive skills and those who have less non-cognitive skills grow more significant over time. A simple simulation makes this clear. For example, if child A's non-cognitive skills are one standard deviation higher than child B's skills in the fall of their kindergarten year, child A's math IRT score will be about 0.5 points (0.069 times 7.13) higher than child B's by the spring of kindergarten if they are equivalent in initial scores and all other social and demographic aspects. If we add up this achievement bonus associated with higher non-cognitive skills over each period, we can roughly assess whether and how non-cognitive skills will influence the accumulation in achievement difference over time. Suppose child A is continuously one standard deviation higher than B on non-cognitive skills throughout fifth grade, then A's IRT score in math will be 1.0 points higher than B by first grade, 3.58 higher than B by third grade, and 4.69 points higher than B by fifth grade. Thus, a difference in initial non-cognitive skills will lead to the accumulation in the achievement difference. The accumulated achievement difference may seem to be small in magnitude; however, it is obtained from a hypothetical setting, under which we assume the two children are exactly the same at the beginning but just differ one standard deviation in non-cognitive skills. In real life, which I will show later, as the differences in non-cognitive skills are more significant across different groups, the accumulated difference can be greater.

Non-cognitive Skills and the Growing SES-based Achievement Gap

To assess my hypothesis that non-cognitive skills is an important factor to the persistent and widening SES-based achievement difference, I first examine whether and how non-cognitive skills may channel family SES's effects on achievement growth rate by comparing Model B and Model C for math and reading achievement respectively. Table III-7 summarizes the percent of

change in the family SES coefficient after we include non-cognitive skills in the model (comparing Models B and C). Estimates of the association between family SES and the growth rate are reduced by from 13 to 30 percent in the math achievement model, and from 8 to 25 percent in the reading achievement model.

I also conducted a counterfactual analysis to gauge more formally the impact of non-cognitive skills on the achievement difference across different SES groups over time. To keep the results simple and clear, I focus on the achievement difference between the children from the top 20% of the family SES distribution (high SES) and those from the bottom 20% (low SES). Figure III-3 and Figure III-4 presents the results and show the extent to which the mean difference between high and low SES groups in non-cognitive skills at baseline contribute to the difference in their math and reading achievement from kindergarten and fifth grade. The observed point values are derived by evaluating the full model for the focal group at that group's mean covariate values. This simply uses the group's own properties to generate an expected achievement score in math or reading test at each time point. The counterfactual scores for the low SES group are a form of statistical experimentation. In this instance, I apply the high-SES group's mean non-cognitive skills, but keep other background variables and measures at the mean level of the low SES group, and predict their outcome under this alternative non-cognitive skills scenario. By doing this, I explore a "what if" counterfactual: What if everything else about the low SES group remains the same, but instead of having the non-cognitive averages observed for them, they have high SES groups' average? How would that affect their development trajectory and the achievement difference as children progress through school? This artificial exercise will allow us to better evaluate the extent to which non-cognitive skills will influence the SES-based achievement difference in early school years.

As Figure III-5 shows, after substituting high SES group's non-cognitive skills into the low SES group's achievement prediction, both the math and reading growth trajectories for low SES group shift upward. It also shows that the slopes of the trajectory for low SES group increase, suggesting an elevated learning rate in the counterfactual setting. These two changes shrink the achievement difference between high and low SES groups over time. As Figure III-6 shows, the differences in math and reading test score between the two groups drop by 12 to 16 percent from kindergarten to fifth grade if low SES children have the similar non-cognitive skills as high SES children. To achieve similar amount of changes for math achievement test without changing the non-cognitive skills, we need to increase family's SES by at least one standard deviation. For reading achievement test, we need to increase family's SES by one to three standard deviations.

Discussion and Conclusion

Non-cognitive skills is a significant factor in children's trajectory of development in educational achievement. As shown by this study, it positively affects children's growth rate in both math and reading achievement throughout kindergarten to fifth grade. At the same time, non-cognitive skills are not distributed randomly, and children from higher SES families are equipped with better non-cognitive skills. This SES stratification in non-cognitive skills sorts children into different growth trajectories and contributes to the cumulated achievement difference across different SES groups as children progress through school. A counterfactual analysis suggests that difference in non-cognitive skills between high (top 20%) and low (bottom 20%) SES groups accounts for 12 to 16 percent of difference in the two groups' achievement difference in the early school years.

Findings from this study contribute to the literature in several ways. First, few studies have examined the association between non-cognitive skills and children's educational achievement from a longitudinal and developmental perspective. Studies from multiple disciplines have shown that non-cognitive skills are strong predictor of and have long-lasting effects on achievement and success (e.g. Heckman 2006; Duckworth & Seligman 2005, 2006; Claessens, Duncan & Engel 2009). Findings from this study not only support these arguments, but extend the current literature by showing that non-cognitive skills also affect children's developmental trajectory. Results from this study suggest the importance of examining non-cognitive skills' role in children's achievement from a longitudinal and developmental perspective in future studies in this area.

Second, studies have suggested that the achievement differences across children from different SES groups persist and widen as they progress through school. Existing literature that has sought to explain a growing achievement difference focuses on evaluating and comparing school versus family effects as two major sets of explanatory factors (Downey, von Hippel, and Broh 2004; Cheadle 2008, 2011; Potter and Roksa 2013). Results from the present study broaden the question and show that non-cognitive skills are also an important driver of the persistent and widening SES-based achievement difference over the early school years. Understanding the more nuanced relationship between non-cognitive skills and the characteristics of school and families and the processes operating within them, all of which could influence the persistent and widening SES-based achievement difference is an important area for future research. For example, it is plausible that non-cognitive skills can be shaped and cultivated both by families and at school. Thus, it will be interesting for future studies to examine how and to what extent school versus family will influence children's non-cognitive skills.

This study also provides policy implications. Specifically, it corroborates the suggestion from the Perry School study that early intervention on non-cognitive skills is beneficial to the development of children from less privileged background. Moreover, the counterfactual analysis in this study suggests that to eliminate the SES stratification in children's non-cognitive skills will boost the growth of children from disadvantaged background, and thus help reducing the growing achievement gap as children progress through school.

In addition, this study raises several questions for the future research. Firstly, I just focus on a sample of children from kindergarten to fifth grade, which is the early stage of the formal education career. However, whether and to what extent non-cognitive skills affect one's development in achievement in the later education years, such as during junior and senior high school, remains unknown. It is possible that non-cognitive skills will be differentially relevant in the years after elementary schooling. As suggested by the findings in this study, the magnitude of the association between non-cognitive skills and the rate of change in test score improvement decrease from kindergarten to fifth grade. Does this suggest that non-cognitive skills are more important when a child is younger? This is an interesting scientific question deserves attention for future studies but beyond the scope of the present one.

In addition, as discussed earlier, I adopt a path-dependent cumulative process model by allowing the non-cognitive skills to change over time in this study. However, the more detailed mechanisms of such a path-dependency process, the potential factors that drive the change of non-cognitive skills, and the corresponding effects are not addressed by here. For example, it is possible that achievement, which itself is determined by past non-cognitive skills, has feedback effects on children's future non-cognitive skills. This reciprocal and dynamic relationship between non-cognitive skills and achievement, if it exists, could be a mechanism underlying the

cumulative achievement advantage. Specifically, children with better non-cognitive skills may experience faster achievement trajectories, which in turn, further improve their non-cognitive skills. By this process, children who are at an advantaged starting point beget much better than their peers with a disadvantaged starting point. This interesting question needs more detailed and thorough analysis in the future.

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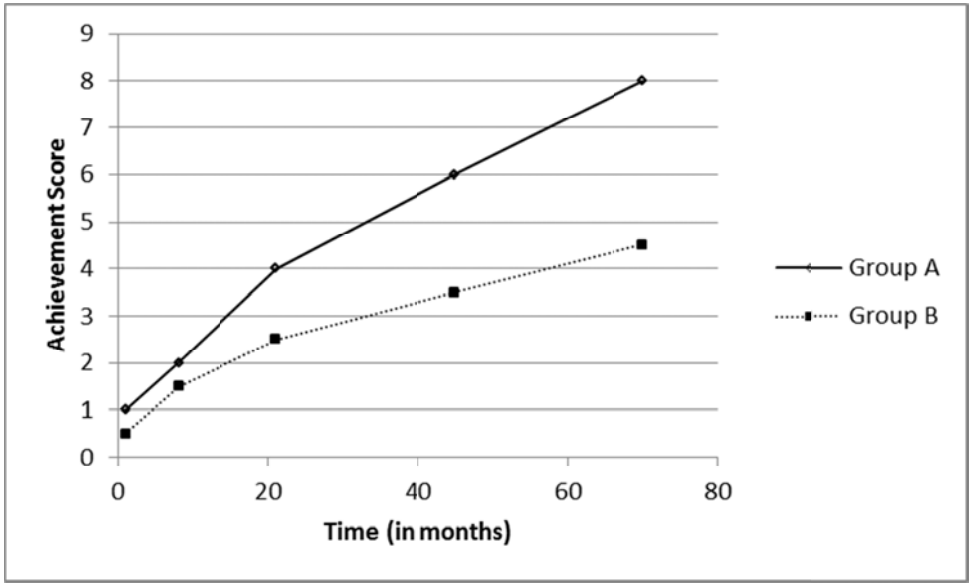


Figure III-1 Cumulative Achievement Advantage

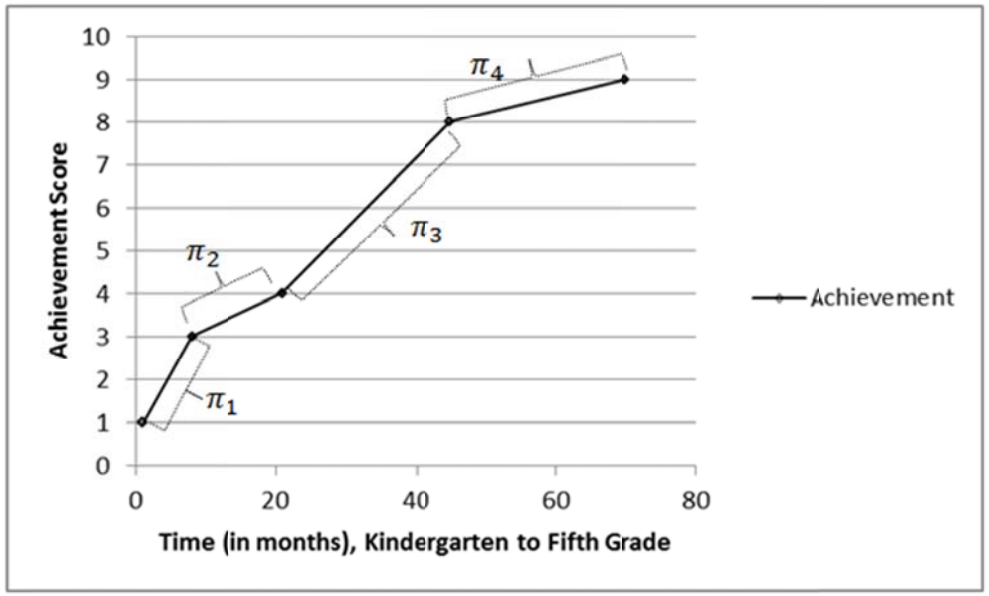


Figure III-2 Piecewise Growth Curve Model of Children's Achievement

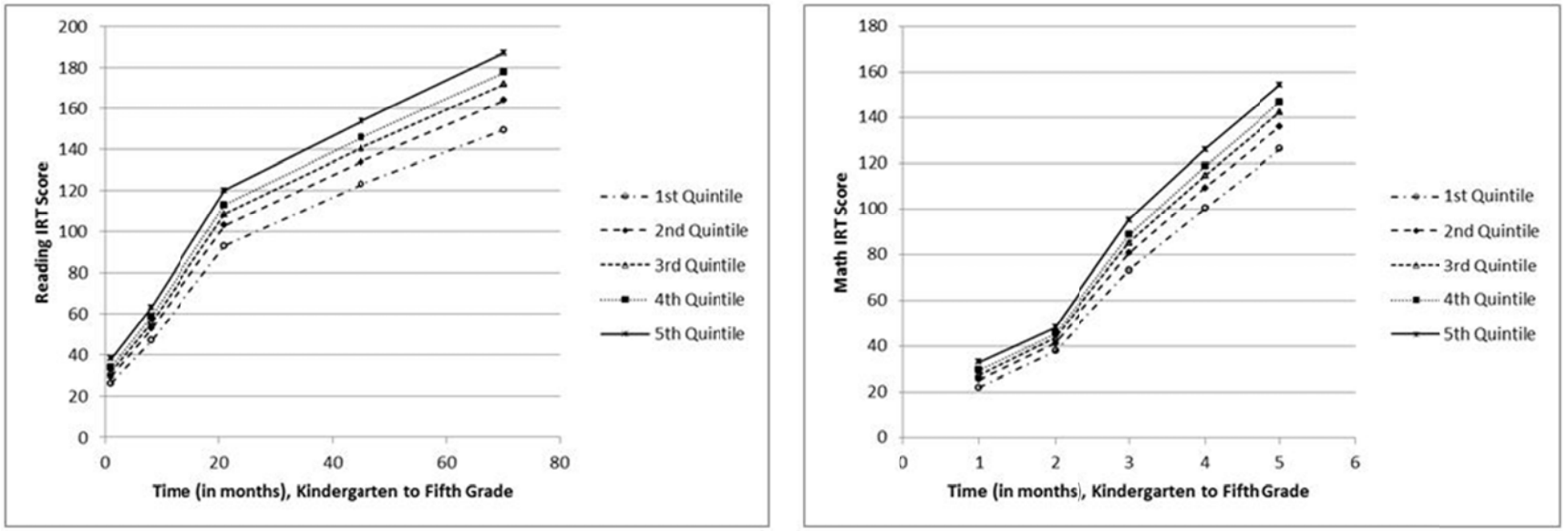


Figure III-3 Achievement and Family SES (from ECLS-K Kindergarten Fall to Fifth Grade, Unadjusted)

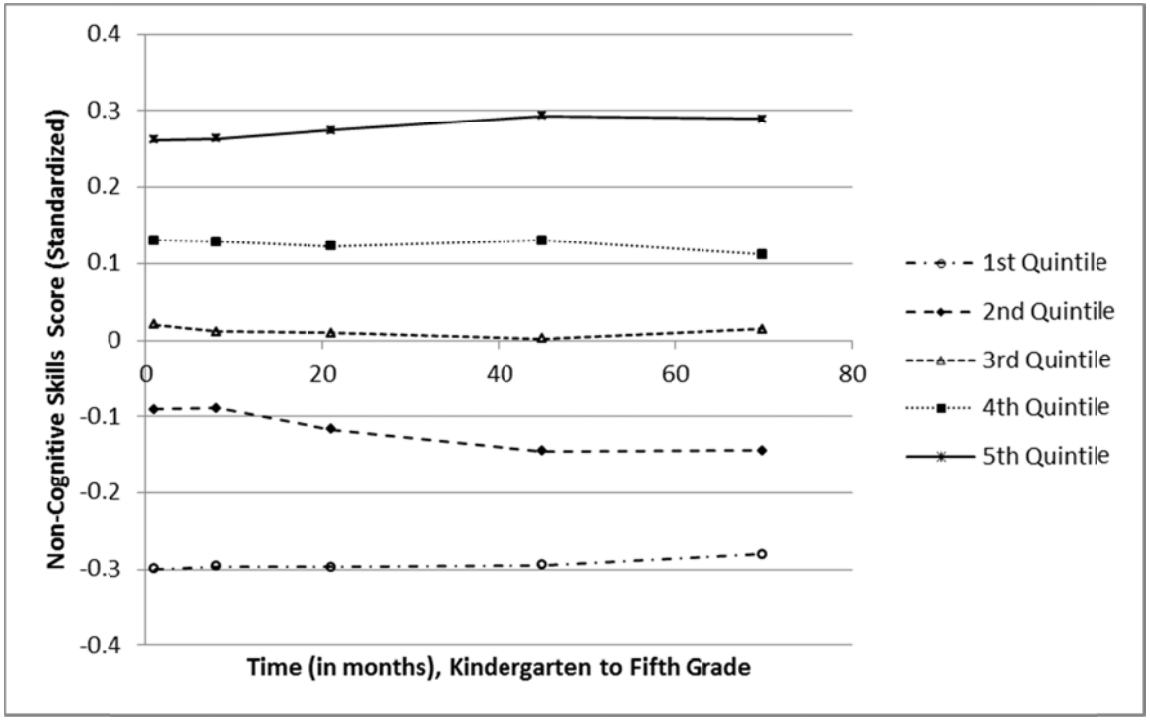
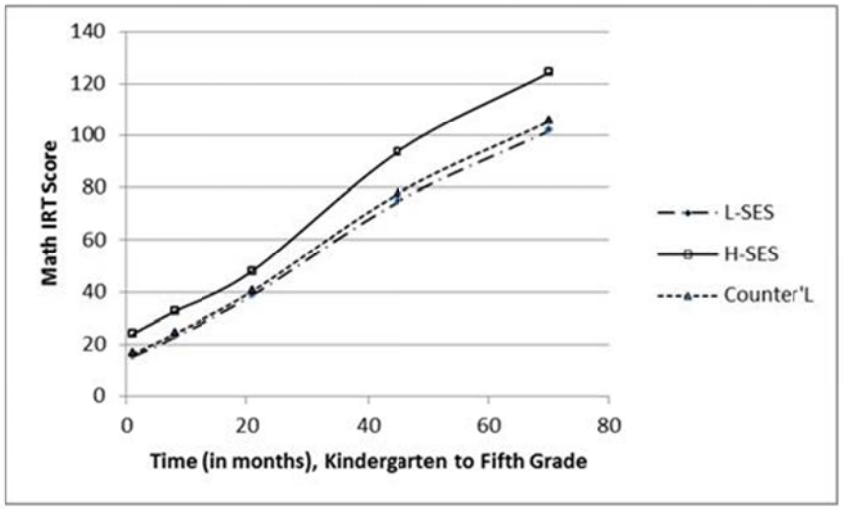


Figure III-4 Standardized Non-Cognitive Skills and Family SES (from ECLS-K Kindergarten Fall to Fifth Grade, Unadjusted)



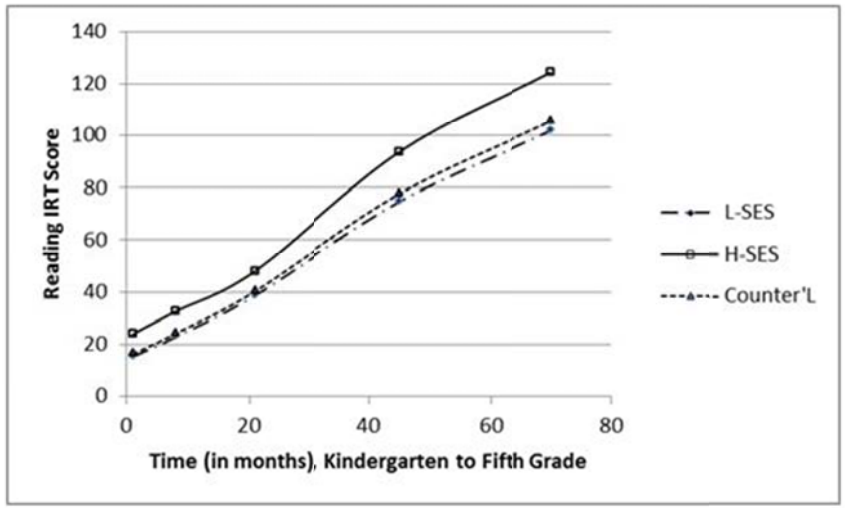


Figure III-5 Counterfactual Analysis Results

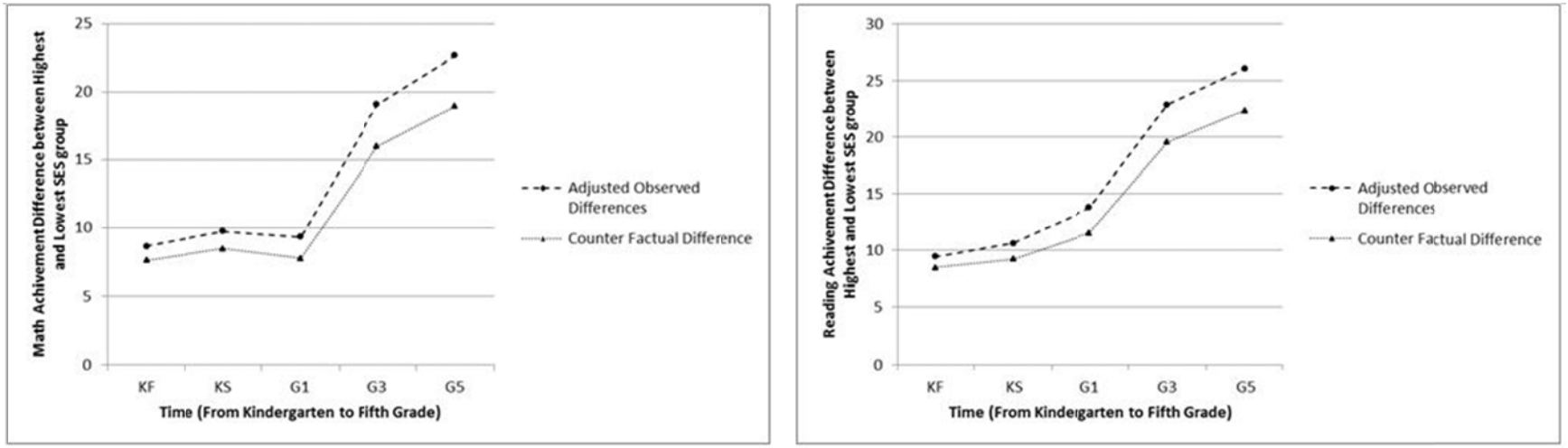


Figure III-6 Changes in Achievement Differences

Table III-1 Observations and Missing Data on Dependent and Independent Variables

	Wave 1 to 2	Wave 2 to 3	Wave 3 to 4	Wave 4 to 5	
Average of Months between Waves	7.16	13.05	24.76	24.24	
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Achievement					
Math Test	12355	14178	11353	9285	7831
Reading Test	12373	13715	11184	9235	7830
Non-cognitive Skills					
Teacher Rated Social Rating Scale	13325	13929	10728	8075	7590
Demographic Background					
Age in Months upon Entry into Kindergarten	12624				
Gender (Female =1)	14844				
Race	14808				
Immigrant Generation	14624				
Intact Family	12648				
SES (measured at baseline)	14106				
Second-time Kindergartener (=1)	14836				
Language at Home (English = 1)	14000				
Number of Siblings	12648				
Parenting and Home Environment					
log(Number of Books at Home)	13922				
Stimulating Activities (Standardized)	13981				
Communication (Standardized)	10582				
Extracurricular Activities (Standardized)	14857				
Help with Homework (Standardized)	10277				
Sample Size					
Size of Analytical Sample for Math Scores	14583[a]				
Size of Analytical Sample for Reading Scores	14478[a]				
Total Sample Size ** (N)	14857[a]				

**Restricted to students who did not change school between kindergarten and fifth grade.
(a) With missing values on independent variables imputed. (b) Wave 1 is at Kindergarten Fall, Wave 2 is at Kindergarten Spring, Wave 3 is at First Grade Spring, Wave 4 is at Third Grade Spring, Wave 5 is at Fifth Grade Spring

Table III-2 Description of Social Demographic and Background Variables

Demographic Controls	
Age in Months upon Entry into Kindergarten	Children's age in months at their entry to kindergarten
Gender (Male =1)	Female is coded as 1. Male is the reference group
Race	White is the reference group.
Immigrant Generation	Non-immigrant is the reference group
Intact Family	Whether child lives in a family with both mother and father. Non-intact family is the reference group (coded as 0).
SES	SES Index from ELS. It is constructed based on mother's and father's education, mother's and father's occupation, and family income
Second-time Kindergartener (=1)	Whether a child was a second-time kindergartener. First-time kindergartener is the reference group (coded as 0)
Language at Home (English = 1)	Language the children speak at home. English Speaking at home is the reference group (coded as 0)
Number of Siblings	Child's number of siblings a child has. This is a time-varying variable updated at each wave
Parenting and Home Environment	
Stimulating Activities (Standardized)	Averaged frequency (within person) of stimulating activities at home, such as reading books, telling stories, singing songs, etc.. It is standardized across the sample
log(Number of Books at Home)	Natural logarithm of the number of books at home
Communication (Standardized)	A composite measurement of how much parents listen to and help with children's problem, know their friends, and are patient with their children. It is standardized across the sample.
Extracurricular Activities (Standardized)	Diversity of recreational activities by counts of different types of activities such as going to the museum, concert, zoo, etc.. It is standardized across the sample.
Help with Homework (Standardized)	Frequency that parents help with their children's homework. It is standardized across the sample

Table III-3 Descriptive Statistic of Demographic, Parenting and Home Environment Variables

Variable		Mean	SD
A. Math IRT Score			
	Kindergarten Fall	20.06	7.37
	Kindergarten Spring	27.80	8.84
	First Grade	43.59	9.05
	Third Grade	85.40	17.60
	Fifth Grade	114.86	20.89
B. Reading IRT Score			
	Kindergarten Fall	22.58	8.51
	Kindergarten Spring	32.44	10.41
	First Grade	56.14	13.66
	Third Grade	108.43	19.83
	Fifth Grade	140.59	22.70
C. Demographic Background			
Age in Months upon Entry into Kindergarten		68.43	4.47
Gender (Female =1)		0.49	0.50
Race			
	Black	0.14	
	Hispanic	0.17	
	Asian	0.06	
	Other	0.05	
Immigrant Generation (%)			
	1st	0.00	
	2nd	0.43	
Intact Family (=1) (%)		0.77	
SES Composite Measurement		0.03	0.80
Second-time Kindergartener (=1) (%)		0.19	
Language at Home (English = 1) (%)		0.87	
Number of Siblings		1.46	1.17
D. Parenting and Home Environment			
	log(Number of Books at Home)	4.12	0.98
	Stimulating Activities (Standardized)	0.00	1
	Communication (Standardized)	0.00	1
	Extracurricular Activities (Standardized)	0.00	1
	Help with Homework (Standardized)	0.00	1
E. Non-Cognitive Skills Scores (Standardized)			
	Kindergarten Fall	0.00	1
	Kindergarten Spring	0.00	1
	First Grade	0.00	1

Third Grade	0.00	1
Fifth Grade	0.00	1
(Continued)		
F. Time Interval (in month)		
Kindergarten Fall - Kindergarten Spring	7.13	0.77
Kindergarten Spring - First Grade	13.01	0.65
First Grade - Third Grade	24.77	0.64
Third Grade - Fifth Grade	24.22	0.69
Sample Size (N)	14857	

Table III-4 Non-cognitive skills and Development in Mathematic Ability, Kindergarten Fall to Fifth Grade

	Model A		Model B		Model C		Model D	
	coef	sig	coef	sig	coef	sig	coef	sig
Initial points, First Day of Kindergarten								
Intercept	-3.687	***	-4.899	***	-9.429	***	-5.675	***
	(0.957)		(0.918)		(0.980)		(0.955)	
Family SES			2.770	***	1.984	***	1.791	***
			(0.080)		(0.085)		(0.083)	
Lagged Non-cognitive Skills							1.869	***
							0.058	
Monthly Growth, Kindergarten Fall to Spring								
Intercept	1.158	***	1.149	***	1.113		1.245	
	(0.100)		(0.100)		(0.110)		(0.111)	
Family SES			0.049	***	0.018	~	0.012	
			(0.009)		(0.010)		(0.010)	
Lagged Non-cognitive Skills							0.069	***
							0.007	
Monthly Growth, Kindergarten Spring to 1st Grade Spring								
Intercept	1.785	***	1.787	***	1.817	***	1.880	***
	(0.068)		(0.068)		(0.075)		(0.075)	
Family SES			-0.013	*	-0.011	~	-0.015	*
			(0.006		(0.007		(0.007)	
Lagged Non-cognitive Skills							0.039	***
							0.005	

Monthly Growth, 1st Grade Spring to 3rd Grade Spring								
Intercept	1.747	***	1.718	***	1.602	***	1.754	***
	(0.077)		(0.075)		(0.081)		(0.079)	
(Continued)								
Family SES			0.139	***	0.082	***	0.072	***
			(0.007)		(0.007)		(0.007)	
Lagged Non-cognitive Skills							0.104	***
							0.005	
Monthly Growth, 3rd Grade Spring to 5th Grade Spring								
Intercept	1.653	***	1.648	***	0.033	***	1.583	***
	(0.074)		(0.074)		(0.007)		(0.081)	
Family SES			0.059	***	0.033	***	0.029	***
			(0.006)		(0.007)		(0.007)	
Lagged Non-cognitive Skills							0.046	***
							(0.005)	

Note: (a) Model A is the null model, where only age upon entry of kindergarten and gender is included in the multilevel model as covariates. Model B is specified similarly to Model A with further inclusion of family SES as a covariate. Model C include all the control variables on demographic and family characteristics. Model D is the full model, which adds measurements on non-cognitive skills into modeling. (b) Lagged Non-cognitive Skills is the non-cognitive skills measured at the beginning of each period. (c) ~ ≤ 0.1,* ≤ 0.05, ** ≤ 0.01, *** ≤ 0.005

Table III-5 Non-cognitive skills and Development in Reading Ability, Kindergarten Fall to Fifth Grade

	Model A		Model B		Model C		Model D	
	coef	sig	coef	sig	coef	sig	coef	sig
Initial points, First Day of Kindergarten								
Intercept	2.811	*	1.621		-4.464	***	-1.066	
	(1.115)		(1.073)		(1.161)		(1.146)	
Family SES			3.172	***	2.310	***	2.146	***
			(0.094)		(0.101)		(0.099)	
Lagged Non-cognitive Skills							1.760	***
							0.070	
Monthly Growth, Kindergarten Fall to Spring								
Intercept	1.413	***	1.394	***	1.293	*	1.486	**
	(0.121)		(0.121)		(0.134)		(0.134)	
Family SES			0.066	***	0.036	***	0.027	*
			(0.011)		(0.012)		(0.012)	
Lagged Non-cognitive Skills							0.102	***
							0.008	
Monthly Growth, Kindergarten Spring to 1st Grade Spring								
Intercept	2.016	***	1.997	***	1.901	***	2.092	***
	(0.101)		(0.100)		(0.110)		(0.110)	
Family SES			0.080	***	0.036	***	0.031	***
			(0.009)		(0.012)		(0.010)	
Lagged Non-cognitive Skills							0.117	***
							0.007	

Monthly Growth, 1st Grade Spring to 3rd Grade Spring								
Intercept	2.095	***	2.069	***	2.005	***	2.118	***
	(0.089)		(0.088)		(0.095)		(0.094)	
(Continued)								
Family SES			0.118	***	0.065	***	0.057	***
			(0.008)		(0.008)		(0.008)	
Lagged Non-cognitive Skills							0.077	***
							(0.006)	
Monthly Growth, 3rd Grade Spring to 5th Grade Spring								
Intercept	1.463	***	1.458	***	1.371	***	1.400	***
	(0.088)		(0.088)		(0.097)		(0.097)	
Family SES			0.052	***	0.032	***	0.029	***
			(0.007)		(0.009)		(0.009)	
Lagged Non-cognitive Skills							0.030	***
							(0.006)	

Note: (a) Model A is the null model, where only age upon entry of kindergarten and gender is included in the multilevel model as covariates. Model B is specified similarly to Model A with further inclusion of family SES as a covariate. Model C include all the control variables on demographic and family characteristics. Model D is the full model, which adds measurements on non-cognitive skills into modeling. (b) Lagged Non-cognitive Skills is the non-cognitive skills measured at the beginning of each period. (c) ~ ≤ 0.1,* ≤ 0.05, ** ≤ 0.01, *** ≤ 0.005

Table III-6 Extent to which Non-cognitive Skills Explain Variances of Growth Rates (Child Level)

	Variance			Changes in Variance (%)		
	Model A	Model C	Model D	A vs. C	C vs. D	A vs. D
IRT Scores on reading test						
Monthly growth, kindergarten fall to spring	0.45	0.40	0.34	9.90	14.55	23.01
Monthly growth, kindergarten spring to 1st grade spring	0.33	0.32	0.29	4.18	8.24	12.07
Monthly growth, 1st grade spring to 3rd grade spring	0.23	0.22	0.21	5.41	5.11	10.25
Monthly growth, 3rd grade spring to 5th grade spring	0.20	0.19	0.19	2.63	3.25	5.80
IRT Scores on math test						
Monthly growth, kindergarten fall to spring	0.21	0.19	0.17	9.00	14.20	21.92
Monthly growth, kindergarten spring to 1st grade spring	0.12	0.11	0.10	4.06	7.84	11.58
Monthly growth, 1st grade spring to 3rd grade spring	0.17	0.15	0.14	7.46	7.30	14.21
Monthly growth, 3rd grade spring to 5th grade spring	0.13	0.12	0.12	2.87	3.83	6.59

Model A is the null model, where only age upon entry of kindergarten and gender are included in the multilevel model as covariates. Model C include all the control variables on demographic and family characteristics. Model D is the full model, which extends Model C by adding measurements on non-cognitive skills into modeling.

Table III-7 Extent to which Non-cognitive Skills to Explain Family SES's effects on Monthly Growth Rate (%)

	Math IRT Score	Reading IRT Score
Monthly growth, kindergarten fall to spring	-32.740	-25.912
Monthly growth, kindergarten spring to 1st grade spring	-31.619	-13.387
Monthly growth, 1st grade spring to 3rd grade spring	-12.022	-11.360
Monthly growth, 3rd grade spring to 5th grade spring	-13.027	-8.204

Appendix Table 5 Pairwise Correlation between Family SES Composite Measurement across Waves

	Kindergarten Fall	1st Grade	3rd Grade	5th Grade
Kindergarten Fall	1.00			
	(0.00)			
1st Grade	0.89	1.00		
	(0.00)	(0.00)		
3rd Grade	0.86	0.93	1.00	
	(0.00)	(0.00)	(0.00)	
5th Grade	0.85	0.92	0.95	1.00
	(0.00)	(0.00)	(0.00)	(0.00)

Appendix Table 6 Construction of Home Environment and Parenting Measurements

Items Name	Measured Wave
In-home Activities	KS,G1,G3,G5
Telling stories to child	
Sing songs with child	
Help child to do arts and crafts	
Involved child in household chores, like cooking, cleaning, setting the table, or caring for pets	
Play games or do puzzles with child	
Talk about nature or do science projects	
Communications	First Grade
Even if I am really busy, I make time to listen to child.	
I discourage child from talking about his/her worries because it upsets him/her	
I encourage child to talk about his/her troubles	
I encourage child to tell me about his/her friends and activities	
When I lose my patience with child's questions and demands, I just don't listen to child anymore.	
Help with Homework	First grade
During this school year, how often did you help him/her with homework?	
Books at home	Kindergarten Fall, 1st grade, 3rd grade
Extracurricular Activities	Kindergarten Fall, 3rd Grade
I. In the past month, has anyone In your family done the following things with child?	
Gone to a play, concert, or other live shows	
Visited an art gallery, museum, or historical site	
Visited a zoo, aquarium, or petting farm	
Attended an athletic or sporting event in which child was not a player	
II. Outside of school hours in the past year, has child participated in the following activities?	
Dance lessons?	
Organized athletic activities, like basketball, soccer, baseball, or gymnastics?	
Organized clubs or recreational programs like scouts?	
Music lessons, for example, piano, instrumental music or singing lessons?	
Art classes or lessons, for example, painting, drawing, sculpturing?	
Organized performing arts programs, such as children's choirs, dance programs, or theater performances?	

Appendix Table 7 Non-cognitive Skills and Math Ability Growth

	Modl A			Model B			Model C			Model D		
	Coef.	SE	sig	Coef.	SE	sig	Coef.	SE	sig	Coef.	SE	sig
Initial points, first day of kindergarten 1998												
Intercept	-3.687	0.957	***	-4.899	0.918	***	-9.429	0.980	***	-5.675	0.955	***
Month	0.339	0.014	***	0.354	0.013	***	0.376	0.013	***	0.333	0.013	***
Gender (Female = 1)	0.024	0.116		0.048	0.112		-0.380	0.111	***	-1.059	0.109	***
Race												
Black							-1.068	0.204	***	-0.784	0.199	***
Hispanic							-1.553	0.196	***	-1.484	0.189	***
Asian							1.950	0.291	***	1.594	0.282	***
Other							-1.227	0.268	***	-1.023	0.260	***
Number of Siblings							-0.403	0.049	***	-0.415	0.047	***
Home Language (Non-English = 1)							0.572	0.236	*	0.666	0.229	***
Immigrant Status												
1st gen							-3.011	0.883	***	-2.796	0.851	***
2nd-gen							0.106	0.140		0.174	0.135	
Intact Family (=1)							0.608	0.145	***	0.267	0.141	~
Family SES				2.770	0.080	***	1.984	0.085	***	1.791	0.083	***
Second-time Kindergartener							-1.900	0.165	***	-1.438	0.159	***
Stimulating Activities (Standardized)							-0.122	0.057	*	-0.165	0.055	***
log(Number of Books at Home)							0.856	0.075	***	0.740	0.073	***
Extracurricular Activities (Standardized)							1.064	0.068	***	0.916	0.066	***
Help with Homework (Standardized)							-0.566	0.056	***	-0.529	0.054	***
Communication with Children (Standardized)							0.082	0.059		0.001	0.007	
Non-cognitive Skills (T = KF)										1.869	0.058	***
Points gained per month, kindergarten 1998-99												
Intercept	1.158	0.100	***	1.149	0.100	***	1.113	0.110	***	1.245	0.111	***
Month	0.000	0.001		0.000	0.001		-0.001	0.001		-0.002	0.001	

Gender (Female = 1)		-0.020	0.012		-0.020	0.012		-0.029	0.012	*	-0.054	0.013	***
Race													
	Black							-0.176	0.023	***	-0.163	0.023	***
	Hispanic							-0.061	0.022	***	-0.058	0.022	**
	Asian							0.031	0.033		0.018	0.033	
	Other							0.002	0.030		0.007	0.030	
Number of Siblings								0.007	0.006		0.006	0.006	
Home Language (Non-English = 1)								-0.011	0.027		-0.008	0.027	
Immigrant Status													
	1st gen							-0.061	0.099		-0.049	0.098	
	2nd-gen							0.007	0.016		0.011	0.016	
Intact Family (=1)								-0.029	0.016	~	-0.041	0.016	*
Family SES					0.049	0.009	***	0.018	0.010	~	0.012	0.010	
Stimulating Activities (Standardized)								0.000	0.006		-0.002	0.006	
log(Number of Books at Home)								0.035	0.009	***	0.030	0.009	***
Extracurricular Activities (Standardized)								0.018	0.008	*	0.012	0.008	
Help with Homework (Standardized)								-0.012	0.006	~	-0.010	0.006	
Communication with Children (Standardized)								0.005	0.007		0.001	0.007	
Non-cognitive Skills (T = KF)											0.069	0.007	***
Points gained per month, kindergarten 1998-99													
Intercept		1.785	0.068	***	1.787	0.068	***	1.817	0.075	***	1.880	0.075	***
Month		-0.008	0.001	***	-0.008	0.001	***	-0.009	0.001	***	-0.009	0.001	***
Gender (Female = 1)		-0.022	0.008	**	-0.022	0.008	**	-0.023	0.009	**	-0.036	0.009	***
Race													
	Black							-0.051	0.016	***	-0.041	0.016	*
	Hispanic							0.019	0.016		0.018	0.016	
	Asian							-0.060	0.022	**	-0.067	0.022	***
	Other							-0.047	0.021	*	-0.042	0.021	*
Number of Siblings								0.011	0.004	***	0.010	0.004	***

Home Language (Non-English = 1)								-0.051	0.018	***	-0.049	0.018	**
Immigrant Status													
	1st gen							0.014	0.063		0.010	0.063	
	2nd-gen							-0.009	0.012		-0.008	0.012	
Intact Family (=1)								-0.007	0.011		-0.013	0.011	
Family SES					-0.013	0.006	*	-0.011	0.007		-0.015	0.007	*
Stimulating Activities (Standardized)								-0.015	0.005	***	-0.015	0.005	***
log(Number of Books at Home)								0.007	0.006		0.005	0.006	
Extracurricular Activities (Standardized)								0.004	0.005		-0.001	0.005	
Help with Homework (Standardized)								0.011	0.004	**	0.013	0.004	***
Communication with Children (Standardized)								0.007	0.005		0.005	0.005	
Non-cognitive Skills (T = KS) Points gained per month, second and third grade 2000-2002											0.039	0.005	***
Intercept		1.747	0.077	***	1.718	0.075	***	1.602	0.081	***	1.754	0.079	***
Month		-0.001	0.001		0.000	0.001		-0.001	0.001		-0.003	0.001	*
Gender (Female = 1)		-0.103	0.009	***	-0.105	0.009	***	-0.128	0.009	***	-0.165	0.009	***
Race													
	Black							-0.196	0.018	***	-0.175	0.018	***
	Hispanic							-0.068	0.017	***	-0.073	0.016	***
	Asian							0.071	0.023	***	0.049	0.023	*
	Other							-0.074	0.022	***	-0.059	0.022	**
Number of Siblings								-0.015	0.004	***	-0.016	0.004	***
Home Language (Non-English = 1)								-0.039	0.019	*	-0.026	0.019	
Immigrant Status													
	1st gen							-0.132	0.074	~	-0.139	0.072	~
	2nd-gen							0.001	0.013		0.005	0.013	
Intact Family (=1)								0.039	0.012	***	0.016	0.012	
Family SES					0.139	0.007	***	0.082	0.007	***	0.072	0.007	***
Stimulating Activities (Standardized)								-0.017	0.005	***	-0.018	0.005	***

log(Number of Books at Home)								0.056	0.006	***	0.049	0.006	***
Extracurricular Activities (Standardized)								0.043	0.005	***	0.035	0.005	***
Help with Homework (Standardized)								-0.036	0.005	***	-0.031	0.005	***
Communication with Children (Standardized)								0.009	0.005	~	0.005	0.005	
Non-cognitive Skills (T = G1)											0.104	0.005	***
Points gained per month, third grade to fifth grade 2002-2004													
Intercept	1.653	0.074	***	1.648	0.074	***	1.538	0.081	***	1.583	0.081	***	
Month	-0.006	0.001	***	-0.006	0.001	***	-0.006	0.001	***	-0.007	0.001	***	
Gender (Female = 1)	-0.034	0.009	***	-0.034	0.009	***	-0.048	0.009	***	-0.065	0.009	***	
Race													
Black							-0.082	0.019	***	-0.071	0.019	***	
Hispanic							0.008	0.017		0.007	0.016		
Asian							0.094	0.023	***	0.082	0.023	***	
Other							0.008	0.022		0.013	0.022		
Number of Siblings							-0.006	0.004		-0.006	0.004		
Home Language (Non-English = 1)							-0.023	0.019		-0.018	0.019		
Immigrant Status													
1st gen							-0.013	0.076		-0.004	0.075		
2nd-gen							0.021	0.014		0.021	0.014		
Intact Family (=1)							0.002	0.013		-0.009	0.013		
Family SES				0.059	0.006	***	0.033	0.007	***	0.029	0.007	***	
Stimulating Activities (Standardized)							-0.010	0.005	~	-0.010	0.005	~	
log(Number of Books at Home)							0.032	0.006	***	0.029	0.006	***	
Extracurricular Activities (Standardized)							0.022	0.005	***	0.019	0.005	***	
Help with Homework (Standardized)							-0.011	0.005	*	-0.009	0.005	*	
Communication with Children (Standardized)							-0.005	0.005		-0.008	0.005	~	
Non-cognitive Skills (T = G3)										0.046	0.005	***	

Note: (a) Model A is the null model, where only age upon entry of kindergarten and gender is included in the multilevel model as covariates. Model B is specified similarly to Model A with further inclusion of family SES as a covariate. Model C include all the control variables on demographic and family characteristics. Model D is the full model, which adds measurements on non-cognitive skills into modeling. (b) T indicates the time that non-cognitive skills being measured. KF= Kindergarten Fall, KS= Kindergarten Spring, G1= First Grade, G3= Third Grade. (c) ~ 0.1,* 0.05, ** 0.01, *** 0.005

Appendix Table 8 Non-cognitive Skills and Reading Ability Growth

	Modl A			Model B			Model C			Model D		
	Coef.	SE	sig	Coef.	SE	sig	Coef.	SE	sig	Coef.	SE	sig
Initial points, first day of kindergarten 1998												
Intercept	2.811	1.115	*	1.621	1.073		-4.464	1.161	***	-1.066	1.146	
Month	0.273	0.016	***	0.287	0.015	***	0.316	0.015	***	0.277	0.015	***
Gender (Female = 1)	1.341	0.135	***	1.364	0.131	***	0.906	0.130	***	0.268	0.130	*
Race												
Black							0.295	0.245		0.576	0.241	*
Hispanic							-1.060	0.232	***	-1.001	0.227	***
Asian							2.897	0.345	***	2.566	0.339	***
Other							-0.161	0.318		-0.014	0.312	
Number of Siblings							-0.825	0.058	***	-0.839	0.057	***
Home Language (Non-English = 1)							0.929	0.281	***	1.035	0.276	***
Immigrant Status												
1st gen							-2.963	1.036	***	-2.740	1.016	**
2nd-gen							0.293	0.164	~	0.369	0.161	*
Intact Family (=1)							0.777	0.171	***	0.460	0.168	**
Family SES				3.172	0.094	***	2.310	0.101	***	2.146	0.099	***
Second-time Kindergartener							-1.660	0.202	***	-1.228	0.197	***
Stimulating Activities (Standardized)							-0.096	0.066		-0.141	0.065	*
log(Number of Books at Home)							1.023	0.089	***	0.920	0.087	***
Extracurricular Activities (Standardized)							1.069	0.080	***	0.935	0.079	***
Help with Homework (Standardized)							-0.624	0.066	***	-0.590	0.065	***
Communication with Children (Standardized)							0.099	0.069		0.018	0.068	
Non-cognitive Skills (T = KF)										1.760	0.070	***
Points gained per month, kindergarten 1998-99												
Intercept	1.413	0.121	***	1.394	0.121	***	1.293	0.134	***	1.486	0.134	***
Month	-0.001	0.002		-0.001	0.002		-0.001	0.002		-0.003	0.002	

Gender (Female = 1)		0.086	0.015	***	0.086	0.015	***	0.077	0.015	***	0.040	0.015	**
Race													
	Black							-0.104	0.029	***	-0.085	0.029	***
	Hispanic							0.008	0.027		0.011	0.027	
	Asian							0.172	0.040	***	0.150	0.040	***
	Other							0.018	0.037		0.027	0.037	
Number of Siblings								-0.007	0.007		-0.008	0.007	
Home Language (Non-English = 1)								-0.041	0.033		-0.039	0.033	
Immigrant Status													
	1st gen							-0.054	0.118		-0.040	0.118	
	2nd-gen							0.002	0.019		0.008	0.019	
Intact Family (=1)								0.031	0.020		0.014	0.020	
Family SES					0.066	0.011	***	0.036	0.012	***	0.027	0.012	*
Stimulating Activities (Standardized)								-0.001	0.008		-0.004	0.008	
log(Number of Books at Home)								0.034	0.010	***	0.027	0.010	**
Extracurricular Activities (Standardized)								0.015	0.009	~	0.006	0.009	
Help with Homework (Standardized)								-0.018	0.008	*	-0.016	0.008	*
Communication with Children (Standardized)								0.034	0.008	***	0.030	0.008	***
Non-cognitive Skills (T = KF)											0.102	0.008	***
Points gained per month, kindergarten 1998-99													
Intercept		2.016	0.101	***	1.997	0.100	***	1.901	0.110	***	2.092	0.110	***
Month		-0.003	0.001	*	-0.003	0.001	*	-0.004	0.001	**	-0.006	0.001	***
Gender (Female = 1)		0.040	0.012	***	0.041	0.012	***	0.024	0.013	~	-0.016	0.013	
Race													
	Black							-0.078	0.024	***	-0.049	0.024	*
	Hispanic							-0.057	0.023	*	-0.058	0.023	***
	Asian							0.023	0.033		0.000	0.032	
	Other							-0.051	0.031	~	-0.034	0.031	
Number of Siblings								-0.006	0.005		-0.007	0.005	

Home Language (Non-English = 1)								-0.027	0.027		-0.019	0.027	
Immigrant Status													
	1st gen							-0.056	0.093		-0.066	0.092	
	2nd-gen							-0.001	0.018		0.001	0.018	
Intact Family (=1)								0.024	0.017		0.003	0.017	
Family SES					0.080	0.009	***	0.041	0.010	***	0.031	0.010	***
Stimulating Activities (Standardized)								-0.019	0.007	**	-0.020	0.007	***
log(Number of Books at Home)								0.044	0.009	***	0.038	0.009	***
Extracurricular Activities (Standardized)								0.036	0.007	***	0.023	0.007	***
Help with Homework (Standardized)								-0.024	0.006	***	-0.020	0.006	***
Communication with Children (Standardized)								0.016	0.007	*	0.011	0.007	~
Non-cognitive Skills (T = KS)											0.117	0.007	***
Points gained per month, second and third grade 2000-2002													
Intercept		2.095	0.089	***	2.069	0.088	***	2.005	0.095	***	2.118	0.094	***
Month		-0.001	0.001		0.000	0.001		-0.001	0.001		-0.002	0.001	*
Gender (Female = 1)		0.044	0.011	***	0.042	0.011	***	0.020	0.011	~	-0.007	0.011	
Race													
	Black							-0.227	0.021	***	-0.211	0.021	***
	Hispanic							-0.058	0.019	***	-0.061	0.019	***
	Asian							-0.115	0.027	***	-0.130	0.027	***
	Other							-0.149	0.026	***	-0.137	0.026	***
Number of Siblings								-0.024	0.005	***	-0.025	0.005	***
Home Language (Non-English = 1)								0.004	0.022		0.014	0.022	
Immigrant Status													
	1st gen							-0.093	0.087		-0.102	0.086	
	2nd-gen							-0.009	0.016		-0.006	0.016	
Intact Family (=1)								0.006	0.015		-0.011	0.015	
Family SES					0.118	0.008	***	0.065	0.008	***	0.057	0.008	***
Stimulating Activities (Standardized)								-0.013	0.006	*	-0.014	0.006	*

log(Number of Books at Home)								0.053	0.008	***	0.048	0.007	***
Extracurricular Activities (Standardized)								0.044	0.006	***	0.038	0.006	***
Help with Homework (Standardized)								-0.021	0.006	***	-0.017	0.005	***
Communication with Children (Standardized)								0.010	0.006	~	0.007	0.006	
Non-cognitive Skills (T = G1)											0.077	0.006	***
Points gained per month, third grade to fifth grade 2002-2004													
Intercept		1.463	0.088	***	1.458	0.088	***	1.371	0.097	***	1.400	0.097	***
Month		-0.002	0.001		-0.002	0.001		-0.002	0.001	~	-0.003	0.001	*
Gender (Female = 1)		-0.016	0.011		-0.016	0.011		-0.026	0.011	*	-0.037	0.011	***
Race													
	Black							-0.044	0.022	*	-0.038	0.022	~
	Hispanic							0.004	0.020		0.004	0.020	
	Asian							0.045	0.027	~	0.038	0.027	
	Other							-0.024	0.027		-0.021	0.026	
Number of Siblings								-0.008	0.005	~	-0.008	0.005	~
Home Language (Non-English = 1)								0.008	0.023		0.011	0.023	
Immigrant Status													
	1st gen							-0.149	0.091		-0.143	0.091	
	2nd-gen							0.001	0.016		0.002	0.016	
Intact Family (=1)								-0.017	0.015		-0.024	0.015	
Family SES					0.052	0.007	***	0.032	0.009	***	0.029	0.009	***
Stimulating Activities (Standardized)								-0.021	0.007	***	-0.021	0.006	***
log(Number of Books at Home)								0.031	0.008	***	0.030	0.008	***
Extracurricular Activities (Standardized)								0.012	0.006	~	0.009	0.006	
Help with Homework (Standardized)								-0.012	0.006	*	-0.011	0.006	*
Communication with Children (Standardized)								-0.007	0.006		-0.009	0.006	
Non-cognitive Skills (T = G3)											0.030	0.006	***

Note: (a) Model A is the null model, where only age upon entry of kindergarten and gender is included in the multilevel model as covariates. Model B is specified similarly to Model A with further inclusion of family SES as a covariate. Model C include all the control variables on demographic and family characteristics. Model D is the full model, which adds measurements on non-cognitive skills into modeling. (b) T indicates the time that non-cognitive skills being measured. KF= Kindergarten Fall, KS= Kindergarten Spring, G1= First Grade, G3= Third Grade. (c) ~ 0.1,* 0.05, ** 0.01, *** 0.005

Appendix Table 9 Sensitivity Analysis: Non-cognitive Skills and Math Ability Growth (Comparison of Two Samples)

		Analytical Sample			Change School Sample		
		Coef.	SE	sig	Coef.	SE	sig
Initial points, first day of kindergarten 1998							
Intercept		-7.607	0.947	***	-8.519	1.404	***
Month		0.355	0.012	***	0.363	0.018	***
Gender (Female = 1)		-0.995	0.112	***	-0.837	0.168	***
Race							
	Black	-0.674	0.180	***	-0.539	0.250	*
	Hispanic	-1.400	0.184	***	-1.154	0.265	***
	Asian	1.829	0.277	***	2.110	0.421	***
	Other	-1.428	0.241	***	-0.925	0.372	*
Number of Siblings		-0.466	0.048	***	-0.495	0.070	***
Home Language (Non-English = 1)		0.659	0.230	***	0.825	0.329	*
Immigrant Status							
	1st gen	-2.642	0.869	***	-2.662	0.986	**
	2nd-gen	0.336	0.135	*	-0.052	0.203	
Intact Family (=1)		0.332	0.143	*	0.552	0.202	**
Family SES		2.119	0.081	***	1.862	0.120	***
Second-time Kindergartener		-1.479	0.144	***	-1.491	0.217	***
Stimulating Activities (Standardized)		-0.198	0.058	***	-0.239	0.092	**
log(Number of Books at Home)		0.833	0.074	***	0.738	0.109	***
Extracurricular Activities (Standardized)		1.027	0.065	***	1.075	0.102	***
Help with Homework (Standardized)		-0.504	0.055	***	-0.470	0.082	***
Communication with Children (Standardized)		0.011	0.058		0.093	0.087	
Non-cognitive Skills (T = KF)		1.743	0.057	***	1.639	0.085	***
Points gained per month, kindergarten 1998-99							
Intercept		1.024	0.110	***	1.126	0.174	***
Month		0.001	0.001		-0.001	0.002	

Gender (Female = 1)		-0.045	0.013	***	-0.065	0.021	***
Race							
	Black	-0.176	0.021	***	-0.121	0.031	***
	Hispanic	-0.059	0.021	**	-0.055	0.033	~
	Asian	0.020	0.033		-0.085	0.053	
	Other	0.015	0.028		-0.108	0.047	*
Number of Siblings		0.006	0.006		0.002	0.009	
Home Language (Non-English = 1)		0.006	0.027		0.017	0.042	
Immigrant Status							
	1st gen	-0.073	0.101		-0.098	0.117	
	2nd-gen	-0.001	0.016		-0.019	0.026	
Intact Family (=1)		-0.033	0.017	*	0.034	0.025	
Family SES		0.013	0.009		0.039	0.015	**
Stimulating Activities (Standardized)		-0.003	0.007		-0.022	0.011	~
log(Number of Books at Home)		0.028	0.009	***	0.026	0.014	~
Extracurricular Activities (Standardized)		0.011	0.008		0.019	0.012	
Help with Homework (Standardized)		-0.006	0.006		0.008	0.010	
Communication with Children (Standardized)		0.005	0.007		-0.018	0.011	
Non-cognitive Skills (T = KF)		0.061	0.007	***	0.080	0.010	***
Points gained per month, first grade 1999-2000							
Intercept		1.873	0.074	***	1.817	0.111	***
Month		-0.009	0.001	***	-0.008	0.001	***
Gender (Female = 1)		-0.036	0.009	***	-0.044	0.014	***
Race							
	Black	-0.058	0.015	***	-0.050	0.021	*
	Hispanic	0.018	0.015		0.008	0.022	
	Asian	-0.071	0.022	***	-0.056	0.033	~
	Other	-0.068	0.019	***	-0.011	0.031	
Number of Siblings		0.012	0.004	***	0.002	0.006	

Home Language (Non-English = 1)		-0.062	0.018	***	-0.048	0.025	~
Immigrant Status							
	1st gen	0.026	0.064		-0.157	0.075	*
	2nd-gen	-0.017	0.012		-0.003	0.018	
Intact Family (=1)		-0.011	0.012		-0.008	0.017	
Family SES		-0.021	0.006	***	-0.019	0.010	*
Stimulating Activities (Standardized)		-0.018	0.005	***	-0.001	0.008	
log(Number of Books at Home)		0.008	0.006		-0.004	0.009	
Extracurricular Activities (Standardized)		-0.001	0.005		0.002	0.008	
Help with Homework (Standardized)		0.013	0.004	***	0.017	0.007	*
Communication with Children (Standardized)		0.006	0.005		0.007	0.007	
Non-cognitive Skills (T = KS)		0.036	0.004	***	0.046	0.007	***
Points gained per month, second and third grade 2000-2002							
Intercept		1.696	0.079	***	1.972	0.108	***
Month		-0.002	0.001	*	-0.006	0.001	***
Gender (Female = 1)		-0.167	0.009	***	-0.164	0.013	***
Race							
	Black	-0.175	0.016	***	-0.140	0.020	***
	Hispanic	-0.068	0.016	***	-0.052	0.021	*
	Asian	0.056	0.022	**	0.049	0.031	
	Other	-0.097	0.020	***	-0.074	0.030	*
Number of Siblings		-0.017	0.004	***	-0.021	0.005	***
Home Language (Non-English = 1)		-0.031	0.019	~	-0.008	0.024	
Immigrant Status							
	1st gen	-0.117	0.073		-0.087	0.072	
	2nd-gen	0.020	0.013		0.005	0.017	
Intact Family (=1)		0.023	0.012	~	0.015	0.016	
Family SES		0.080	0.007	***	0.101	0.009	***
Stimulating Activities (Standardized)		-0.021	0.005	***	-0.024	0.007	***

log(Number of Books at Home)		0.058	0.006	***	0.056	0.009	***
Extracurricular Activities (Standardized)		0.038	0.005	***	0.045	0.008	***
Help with Homework (Standardized)		-0.031	0.005	***	-0.022	0.006	***
Communication with Children (Standardized)		0.006	0.005		-0.009	0.007	
Non-cognitive Skills (T = G1)		0.101	0.005	***	0.103	0.007	***
Points gained per month, third grade to fifth grade 2002-2004							
Intercept		1.566	0.080	***	1.678	0.127	***
Month		-0.007	0.001	***	-0.007	0.002	***
Gender (Female = 1)		-0.063	0.010	***	-0.083	0.015	***
Race							
	Black	-0.086	0.017	***	-0.098	0.025	***
	Hispanic	0.006	0.016		-0.004	0.024	
	Asian	0.086	0.022	***	0.074	0.034	*
	Other	-0.002	0.020		-0.032	0.036	
Number of Siblings		-0.007	0.004	~	-0.017	0.006	**
Home Language (Non-English = 1)		-0.023	0.019		-0.042	0.027	
Immigrant Status							
	1st gen	-0.025	0.077		-0.149	0.087	~
	2nd-gen	0.020	0.014		0.020	0.021	
Intact Family (=1)		-0.013	0.013		0.012	0.019	
Family SES		0.037	0.007	***	0.054	0.011	***
Stimulating Activities (Standardized)		-0.008	0.006		-0.005	0.009	
log(Number of Books at Home)		0.035	0.006	***	0.019	0.010	~
Extracurricular Activities (Standardized)		0.017	0.005	***	0.021	0.009	*
Help with Homework (Standardized)		-0.008	0.005	~	-0.014	0.007	~
Communication with Children (Standardized)		-0.007	0.005		0.000	0.008	
Non-cognitive Skills (T = G3)		0.042	0.005	***	0.040	0.008	***

Note: (a) Models used in the sensitivity analysis is specified the same as the Model D (full model) in the main analysis. The sensitivity analysis is applied on two samples separately. The first sample is the analytical sample in the main text analysis,

which refers to the children who do not change school during kindergarten to fifth grade. The second sample is the children who changed school during kindergarten to fifth grade, who are not excluded from the analytical sample. To make the results comparable across these two samples, there are only two level (within children and between children) specified in the multilevel model in the sensitivity analysis. (b) T indicates the time that non-cognitive skills being measured. KF= Kindergarten Fall, KS= Kindergarten Spring, G1= First Grade, G3= Third Grade (c) ~ 0.1,* 0.05, ** 0.01, *** 0.005

Appendix Table 10 Sensitivity Analysis: Non-cognitive Skills and Reading Ability Growth (Comparison of Two Samples)

		Analytical Sample			Change School Sample		
		Coef.	SE	sig	Coef.	SE	sig
Initial points, first day of kindergarten 1998							
Intercept		-3.158	1.142	**	-4.837	1.744	**
Month		0.296	0.015	***	0.324	0.023	***
Gender (Female = 1)		0.293	0.134	*	0.129	0.208	
Race							
	Black	0.973	0.216	***	0.631	0.308	*
	Hispanic	-0.802	0.221	***	-0.814	0.328	*
	Asian	3.062	0.334	***	3.429	0.521	***
	Other	-0.515	0.289	~	-0.903	0.459	*
Number of Siblings		-0.915	0.058	***	-0.875	0.087	***
Home Language (Non-English = 1)		1.238	0.280	***	1.087	0.411	**
Immigrant Status							
	1st gen	-2.419	1.046	*	-2.657	1.217	*
	2nd-gen	0.654	0.162	***	0.226	0.250	
Intact Family (=1)		0.544	0.173	***	0.686	0.250	**
Family SES		2.581	0.097	***	2.333	0.148	***
Second-time Kindergartener		-1.249	0.180	***	-1.376	0.277	***
Stimulating Activities (Standardized)		-0.172	0.070	*	-0.245	0.114	*
log(Number of Books at Home)		1.009	0.089	***	0.944	0.135	***
Extracurricular Activities (Standardized)		1.072	0.078	***	1.263	0.126	***
Help with Homework (Standardized)		-0.546	0.066	***	-0.403	0.102	***
Communication with Children (Standardized)		0.040	0.070		0.127	0.108	
Non-cognitive Skills (T = KF)		1.693	0.069	***	1.597	0.105	***
Points gained per month, kindergarten 1998-99							
Intercept		1.333	0.135	***	1.785	0.213	***
Month		-0.001	0.002		-0.007	0.003	*

Gender (Female = 1)		0.052	0.016	***	0.037	0.026	
Race							
	Black	-0.089	0.026	***	-0.044	0.038	
	Hispanic	0.030	0.026		0.061	0.041	
	Asian	0.198	0.040	***	0.141	0.065	*
	Other	0.060	0.034	~	-0.010	0.057	
Number of Siblings		-0.010	0.007		-0.021	0.011	*
Home Language (Non-English = 1)		-0.024	0.034		-0.024	0.052	
Immigrant Status							
	1st gen	-0.023	0.123		-0.116	0.142	
	2nd-gen	-0.001	0.019		-0.094	0.031	***
Intact Family (=1)		0.017	0.020		0.063	0.031	*
Family SES		0.027	0.012	*	0.035	0.018	~
Stimulating Activities (Standardized)		-0.017	0.008	*	-0.019	0.014	
log(Number of Books at Home)		0.023	0.011	*	0.011	0.017	
Extracurricular Activities (Standardized)		0.007	0.009		0.006	0.015	
Help with Homework (Standardized)		-0.009	0.008		-0.023	0.013	~
Communication with Children (Standardized)		0.032	0.008	***	-0.014	0.013	
Non-cognitive Skills (T = KF)		0.091	0.008	***	0.080	0.013	***
Points gained per month, first grade 1999-2000							
Intercept		2.048	0.109	***	1.655	0.165	***
Month		-0.006	0.001	***	-0.002	0.002	
Gender (Female = 1)		-0.008	0.013		0.012	0.020	
Race							
	Black	-0.096	0.022	***	-0.023	0.030	
	Hispanic	-0.088	0.022	***	-0.003	0.032	
	Asian	-0.015	0.032		0.124	0.049	**
	Other	-0.117	0.028	***	0.016	0.045	
Number of Siblings		-0.003	0.005		-0.013	0.008	

Home Language (Non-English = 1)		-0.025	0.027		-0.024	0.052	
Immigrant Status							
	1st gen	-0.074	0.094		-0.116	0.142	
	2nd-gen	-0.001	0.018		-0.094	0.031	***
Intact Family (=1)		0.011	0.017		0.063	0.031	*
Family SES		0.037	0.009	***	0.035	0.018	~
Stimulating Activities (Standardized)		-0.028	0.008	***	-0.019	0.014	
log(Number of Books at Home)		0.049	0.009	***	0.011	0.017	
Extracurricular Activities (Standardized)		0.030	0.007	***	0.006	0.015	
Help with Homework (Standardized)		-0.011	0.006	~	-0.023	0.013	~
Communication with Children (Standardized)		0.012	0.007	~	-0.014	0.013	
Non-cognitive Skills (T = KS)		0.105	0.007	***	0.080	0.013	***
Points gained per month, second and third grade 2000-2002							
Intercept		2.073	0.094	***	2.433	0.129	***
Month		-0.006	0.001	***	-0.002	0.002	
Gender (Female = 1)		-0.008	0.013		0.012	0.020	
Race							
	Black	-0.096	0.022	***	-0.023	0.030	
	Hispanic	-0.088	0.022	***	-0.003	0.032	
	Asian	-0.015	0.032		0.124	0.049	**
	Other	-0.117	0.028	***	0.016	0.045	
Number of Siblings		-0.003	0.005		-0.013	0.008	
Home Language (Non-English = 1)		-0.025	0.027		0.038	0.038	
Immigrant Status							
	1st gen	-0.074	0.094		-0.160	0.109	
	2nd-gen	-0.001	0.018		-0.023	0.026	
Intact Family (=1)		0.011	0.017		0.035	0.024	
Family SES		0.037	0.009	***	0.046	0.014	***
Stimulating Activities (Standardized)		-0.028	0.008	***	-0.027	0.012	*

log(Number of Books at Home)		0.049	0.009	***	0.046	0.013	***
Extracurricular Activities (Standardized)		0.030	0.007	***	0.026	0.012	*
Help with Homework (Standardized)		-0.011	0.006	~	0.005	0.010	
Communication with Children (Standardized)		0.012	0.007	~	0.020	0.010	~
Non-cognitive Skills (T = G1)		0.105	0.007	***	0.116	0.010	***
Points gained per month, third grade to fifth grade 2002-2004							
Intercept		1.356	0.096	***	1.436	0.149	***
Month		-0.002	0.001	~	-0.002	0.002	
Gender (Female = 1)		-0.007	0.011		-0.016	0.018	
Race							
	Black	-0.224	0.020	***	-0.090	0.029	***
	Hispanic	-0.072	0.018	***	0.012	0.028	
	Asian	-0.145	0.026	***	-0.007	0.040	
	Other	-0.194	0.024	***	0.036	0.042	
Number of Siblings		-0.025	0.005	***	-0.014	0.007	~
Home Language (Non-English = 1)		0.012	0.022		-0.053	0.032	~
Immigrant Status							
	1st gen	-0.069	0.087		-0.045	0.103	
	2nd-gen	-0.002	0.016		-0.018	0.024	
Intact Family (=1)		0.000	0.015		0.001	0.022	
Family SES		0.068	0.008	***	0.067	0.013	***
Stimulating Activities (Standardized)		-0.018	0.006	**	-0.009	0.011	
log(Number of Books at Home)		0.052	0.008	***	0.017	0.011	
Extracurricular Activities (Standardized)		0.042	0.006	***	0.000	0.010	
Help with Homework (Standardized)		-0.020	0.005	***	-0.012	0.009	
Communication with Children (Standardized)		0.008	0.006		-0.008	0.009	
Non-cognitive Skills (T = G3)		0.070	0.006	***	0.019	0.009	*

Note: (a) Models used in the sensitivity analysis is specified the same as the Model D (full model) in the main analysis. The sensitivity analysis is applied on two samples separately. The first sample is the analytical sample in the main text analysis,

which refers to the children who do not change school during kindergarten to fifth grade. The second sample is the children who changed school during kindergarten to fifth grade, who are not excluded from the analytical sample. To make the results comparable across these two samples, there are only two level (within children and between children) specified in the multilevel model in the sensitivity analysis. (b) T indicates the time that non-cognitive skills being measured. KF= Kindergarten Fall, KS= Kindergarten Spring, G1= First Grade, G3= Third Grade (c) ~ 0.1,* 0.05, ** 0.01, *** 0.005

Appendix Table 11 Family SES and Gains in Math Achievement during First Grade

	Coef.	SE	sig	Coef.	SE	sig
Assessment Interval [a]	0.730	0.106	***	0.730	0.106	***
Month	-0.109	0.014	***	-0.109	0.014	***
Gender	-0.280	0.116	*	-0.270	0.116	*
Race						
Black	-0.692	0.224	***	-0.702	0.224	***
Hispanic	0.076	0.213		0.083	0.213	
Asian	-0.784	0.315	*	-0.829	0.315	**
Other	-0.674	0.284	*	-0.675	0.284	*
Number of Siblings	0.157	0.051	***	0.170	0.051	***
Home Language (Non-English = 1)	-0.867	0.255	***	-0.919	0.256	***
Immigrant Status						
1st gen	0.333	0.858		0.372	0.858	
2nd-gen	-0.038	0.171		-0.029	0.171	
Intact Family (=1)	-0.083	0.155		-0.136	0.155	
Family SES						
SES Composite (Linear)	-0.121	0.094				
Quintile Categories (1st Quintile as the Reference)						
2nd Quintile				-0.103	0.204	
3rd Quintile				0.323	0.213	
4th Quintile				0.406	0.220	
5th Quintile				-0.200	0.237	
Second-time Kindergartener	-0.206	0.199		-0.193	0.199	
Stimulating Activities (Standardized)	-0.187	0.070	**	-0.182	0.070	**
log(Number of Books at Home)	0.052	0.081		0.023	0.081	
Extracurricular Activities (Standardized)	0.045	0.068		0.035	0.068	
Help with Homework (Standardized)	0.170	0.059	***	0.170	0.059	***
Communication with Children (Standardized)	0.110	0.062	~	0.101	0.062	
Intercept	14.243	1.748	***	14.376	1.745	***

(a) Assessment Interval measures the months between the mathematic test in Kindergarten Spring and that in First Grade. (b) ~ 0.1,* 0.05, ** 0.01, *** 0.005

Chapter IV. Can Non-cognitive skills Compensate for Background Disadvantage? -- The Moderation of Non-cognitive Skills on Family SES and Achievement during Early Childhood and Early Adolescence

Introduction

Over the past several decades, it has been established that family SES is significantly associated with a child's educational attainment and achievement (Entwisle, Alexander, and Olson 2012; Sewell and Hauser 1975). The positive SES gradient in educational achievement, usually measured by standardized achievement test scores and GPAs, is observed as early as children enter kindergarten, and persists into their later educational career, such as in middle school (Alexander, Entwisle, and Olson 2001, 2007; Lee and Burkam 2002; Mayer 1997; Reardon 2011). This positive relationship between SES and children's academic achievement has been under the spotlight of sociological studies for long. It is claimed that higher SES families have more economic, social and cultural capital to mobilize, which helps their children to achieve academic success. (e.g., Bourdieu and Passeron 1990; Lamont and Lareau 1988; Mayer 1997; Sewell and Hauser 1975).

Existing scholarship examining the relationship between family SES and education outcomes implicitly assumes that family SES's effects on education achievement are independent from other factors. In other words, it is assumed that family level socioeconomic resources affect achievement the same way for all children, regardless of the individual level differences in child characteristics. However, this may not be true. This article investigates whether and how children's traits in non-cognitive skills, such as motivation, self-control, attention and etc., will moderate family SES's effects on education achievement.

Sociological explorations of the importance of non-cognitive skills to social attainment date back to the Wisconsin model of status attainment (Hauser, Tsai, and Sewell 1983; Sewell, Haller, and Portes 1969). More recently, scholars have shown that non-cognitive skills, such as self-control, conscientiousness, etc., are significantly related to one's education attainment, labor market outcomes, and health (Almlund et al. 2011; Cunha and Heckman 2008; Heckman et al. 2010). Early childhood skills such as attention, perseverance and self-regulation, in particular, are shown to predict children's achievement in school (Claessens, Duncan, and Engel 2009; Duncan et al. 2007; Hsin and Xie 2014; Hsin and Yu 2012).

As is suggested by the resource substitution theory (Ross and Mirowsky 2006), the existence of multiple resources can make outcomes less dependent on the presence of any specific resources. Non-cognitive skills, given their critical role in social attainment process, may weaken the strength of the ties between other influential factors, such as family SES, and one's social outcomes. For instance, past studies have suggested that the Big Five personality traits, which are commonly used to measure non-cognitive skills, would moderate family SES's effects on one's occupation (Shanahan et al. 2014). Unfortunately, to my best knowledge, few studies have investigated whether and how non-cognitive skills modify family SES's effects on education achievement during one's early life course before adulthood. It is likely that the presence of better non-cognitive skills would lessen the effects of family's resources in financial, cultural and social capital on children's achievement in school. In other words, better non-cognitive skills would protect lower SES children from the academic disadvantage due to their family background.

To fully understand whether and how non-cognitive skills moderate the effects of family SES on achievement, we need to consider the potential variation by developmental stages.

Although children spend most of their childhood and adolescence time in school, early childhood and adolescence are two distinct developmental periods and differ in many ways. Which factors influence kindergarteners' development and how that influence works change as children grow up from being young children to young adolescents (Duncan et al. 1998; Heckman 2006). Thus, answers to whether and how non-cognitive skills modify the effects of family SES on achievement may be different during childhood than during adolescence. In this study, I use a longitudinal design to account for the potential time-variation between two developmental stages.

This study applies an interactive and longitudinal perspective to examine the classical sociological issue of the relationship between family SES and education achievement, and in particular how the effects of family SES on achievement vary by children's non-cognitive skills. Using data from Early Child Longitudinal Survey-Kindergarten (ECLS-K), I investigate how family SES effects on children's achievement are moderated by children's non-cognitive skills during two developmental stages: early childhood and early adolescence.

To answer this empirical question, two methodological challenges arise: (1) family SES, children's non-cognitive skills and other covariates vary over time; (2) non-cognitive skills, the proposed moderator of family SES effects on achievement, are themselves influenced by early family SES and can mediate previous SES's effects on achievement. Because of these two challenges, the conventional regression method in sociology is insufficient and will yield biased estimates. I thus use Structural Nested Mean Models in my analysis to address these methodological challenges.

The results reveal that better non-cognitive skills are associated with lower effects of family SES on children's achievement during both developmental stages of early childhood and early adolescence. This paper advances scholarship on SES and education achievement by

uncovering that family SES's effects on children's achievement are not homogeneous but vary with children's non-cognitive skills. Results suggest that programs that improve low SES children's non-cognitive skills have the potential to reduce SES-based education inequality – that is, better non-cognitive skills could help make up for disadvantages in academic achievement that owe to low family socioeconomic resources. This study highlights the importance of considering how family-level factors interact with individual-level characteristics to shape the education inequality and the broader stratification process in future sociological studies.

Non-cognitive Skills and Children's Education Achievement

Different from cognitive skills like IQ and grades, non-cognitive skills, also known as socio-emotional skills, refer to one's social psychological traits in attitudes and behaviors. As early as in 1970s, social psychological factors have been shown to play an important role in the stratification process (Hauser et al. 1983; Sewell et al. 1969; Sewell and Hauser 1975). By analyzing a sample of young farm-reared men in Wisconsin, Sewell and colleagues found that social psychological positions such as educational and occupational aspiration at youth are significantly associated with young adults' educational and occupational attainment (Sewell et al. 1969; Sewell and Hauser 1972).

The importance of the non-cognitive skills to stratification, and to educational attainment in particular, has gained renewed interest in the past decade and recent research has extended the early work of Wisconsin studies both in terms of measurements and data. First, scholars have gone beyond educational and occupational aspiration to incorporate measurements of non-cognitive skills such as motivation, self-discipline (Duckworth and Seligman 2005), self-esteem and locus of control (Heckman, Stixrud, and Urzua 2006), and Big Five personality inventory (neuroticism, extraversion, openness, agreeableness, and conscientiousness) (Borghans et al.

2008) in their analyses. Recent studies have also expanded the kinds of datasets used to estimate the association between non-cognitive skills and achievement. Datasets used include school samples (Duckworth and Seligman 2005, 2006), district samples (Alexander, Entwisle, and Dauber 1993; Entwisle et al. 2012), national surveys (Heckman 2006), and international datasets (Almlund et al. 2011; Duncan et al. 2007; Zhou, Main, and Wang 2010).

These more recent studies consistently show that non-cognitive skills are important to one's academic performance in school and educational attainment. Among the set of diverse non-cognitive skills, attention, motivation and conscientiousness (such as perseverance and self-control), are the ones most robustly associated with education achievement in childhood and adolescence. These non-cognitive skills are found to predict achievement even after controlling for family background and cognition. Interpersonal skills, such as getting along well with others, are also shown to correlate with educational attainment and achievement.

For example, in a sample of American middle school students, Duckworth and colleagues found that eighth graders' self-discipline is critical to their academic success and predicts the subsequent academic success more robustly than do measures of cognitive ability such as IQ (Duckworth and Seligman 2005, 2006). They also found that the changes in students' self-control predict the subsequent grade changes (Duckworth, Tsukayama, and May 2010). Children's socio-emotional skills at school entry, measured by their behaviors in classroom and their temperament/disposition in "leadership" or "involvement", are found to substantially affect education in a random sample of Baltimore children (Alexander et al. 1993; Entwisle et al. 2012). More involved children are likely to be enthusiastic and adaptable, and have better first-grade academic outcomes and higher educational attainment at age 22 (Entwisle et al. 2012). In the same sample, first graders' non-cognitive skills such as attention, following the rules and

behaving well in school are shown to have short-term and lasting effects on their subsequent academic achievement (Alexander et al. 1993). Evidence for the significance of self-control to education is also found in other countries. For example, in a sample of Chinese primary school children, effortful control predicts grades after controlling for the baseline grades (Zhou et al. 2010).

Studies based on national representative survey data also corroborate the significance of non-cognitive skills to academic achievement in school. For instance, Duncan and colleagues conducted analyses on national representative data from six countries, including the Early Childhood Longitudinal Study- Kindergarten (ECLS-K), and showed that pre-school attention skills are consistently associated with third grade and fifth grade academic outcomes (Claessens et al. 2009; Duncan et al. 2007). In a sample of while male children from National Longitudinal Survey of Youth 79 (NLSY 79), Cunha and Heckman (2008) found that non-cognitive traits in anxiety, antisociality, interpersonal skills, headstrongness and concentration significantly influence white male children's development of cognitive ability from childhood to adolescence. Using prospective data from National Education Longitudinal Study (NELS), Llsera found that high school students with better social skills and work habits have higher educational attainment ten years after even controlling for non-cognitive skills (Lleras 2008).

Non-cognitive Skills, Family SES and Education Achievement

Compared with the association between non-cognitive skills and achievement, the relationship between non-cognitive skills and family SES, as well as the role of non-cognitive skills in explaining SES education inequality, is heavily under-investigated (Evans and Rosenbaum 2008; Farkas 2003).

The first role of non-cognitive skills in accounting for the SES achievement difference is as mediators, where non-cognitive skills are influenced by family SES, and mediate family SES's effects on education by positively affecting academic achievement (Table IV-1). Lareau is perhaps among the pioneers who hinted that family SES would affect children's education achievement by influencing children's non-cognitive skills. According to her ethnographic observations, parenting practices differ by social classes. In contrast to poor and working class parents, who let their children grow "naturally," middle- and upper-class parents carefully and consistently cultivate their children's non-cognitive skills such as initiative, independence, and interpersonal skills by carefully structuring their children's leisure time, engaging their children in extensive communications and so on. These non-cognitive skills would in turn promote middle- and upper- class children's academic development in school, and contribute to their academic advantage over their lower-SES peers in school (Lareau 2011).

Though not many quantitative studies to date have examined the relationship between non-cognitive skills and family SES, existing findings all suggest a positive association between them. For example, in a national representative sample of kindergarten students, non-cognitive skills, including motivation, self-control, attention, interpersonal skills and etc., are found to differ by SES as early as upon the entry into kindergarten (Reardon and Portilla 2014), and this SES difference persists into fifth grade (Liu 2016). Other studies on smaller samples also suggest that lower-SES children do worse in self-control and attention. For example, with less economic resources, parents from lower SES background are found to be less responsive, warmth to their children, which hurt children's development in effortful control (Kiff et al. 2012). It is (Dilworth-Bart 2012) also suggested that lower-SES children score lower in attention and

inhibitory control as their parents have less cultural and social capital to provide them an encouraging and stimulating home environment to promote the formation of these skills.

Even fewer studies have directly investigated whether non-cognitive skills mediate family SES's effects on achievement, but all provide a confirmative answer. Lleras (2008) used data from NELS to analyze the relationship between family SES, non-cognitive skills and achievement in high school students and found that non-cognitive skills and behaviors in high school explain a substantial portion of the socioeconomic difference in educational attainment. In a prospective sample of White rural children, Evans and Rosenbaum (2008) showed that 9-year-old's self-regulation is positively related with family income, and mediates family income's effects on school grades at age 13. They also replicated the analyses in a nationally representative sample and found that self-regulation mediates the prospective relationship between early-childhood family income and children's 5th grade achievement after controlling for a diverse set of characteristics of the children, family, and parental investment, including children's cognitive skills. They concluded that socio-emotional skills form an important explanatory mechanism for the income-achievement gap, and should be give more recognition to narrow the achievement gap (Evans and Rosenbaum 2008). Studies on national representative ECLS-K data have also yielded similar findings. For example, Hsin and Xie's (2012) found that non-cognitive skills, such as attention, interpersonal skills, motivation, and self-control, are positively associated with family SES from kindergarten to fifth grade, and non-cognitive skills moderately mediate the effects of family SES on achievement during this period. Using the same data, Liu (2016) found that these socioemotional skills also mediate family SES's effects on achievement growth, measured by monthly gains in math and reading test scores, during early school years.

Non-cognitive Skills as Moderators on Family SES's Effects on Achievement

Most past studies assume that SES affects achievement independently from other factors, and that effects of SES are homogeneous. In contrast, I argue that non-cognitive skills can moderate family SES's effects on achievement (Table IV-1). In other words, family-level socioeconomic resources are likely to interact with individual-level characteristics to affect children's education achievement, and family SES's effects on achievement vary by the level of children's non-cognitive skills.

According to the resource substitution theory, the existence of multiple resources can make outcomes less dependent on the presence of any specific resource, and the presence of one type of resource may fill a gap due to the absence of another. In other words, the effects of different resources on the outcome are interdependent, and an increase (or decrease) in one particular resource can decrease (or increase) the size of the alternative resource's effects on the outcome (Ross and Mirowsky 2006, 2011). As non-cognitive skills and family SES both matter for children's education, it is plausible that they are exchangeable resources to children's achievement. The presence of better non-cognitive skills may make achievement less dependent on family-level socioeconomic resources.

For example, a child who has fostered a high motivation in learning and a well-developed self-control may know how to make better use of the time and learning resources both in school and at home or community. Thus, this child's academic achievement may be more determined by his/her own attitudes, efforts and behaviors, and less by his/her family background. Similarly, a child with strong perseverance will make consistent efforts regardless of their surroundings even in face of adversities. In this case, persistence benefits low SES children's academic development by making up for the academic disadvantage they may otherwise suffer due to their family's lack of resources. In contrast, a child lacking self-control and good attitudes to academic

studies may need more material investment in education from his/her family to obtain academic success. In such case, family's socioeconomic resources are more important for education. In short, family's socioeconomic resources and children's non-cognitive skills may be substitutable to affect achievement, and family SES's effects on education achievement are likely to be smaller among children with better non-cognitive skills.

The above speculation is supported both by real life examples and scientific evidence. As a matter of fact, there are plenty of anecdotes in our society where children coming from humble background achieve success and upward mobility by their own efforts and through positive traits such as perseverance, conscientiousness, motivation and self-control. Scientific studies also hint the possibility that non-cognitive skills may make up for shortcomings in family's socioeconomic resources. For instance, in the Perry School Intervention Study, a group of students from disadvantaged background were selected to participate in an intervention program fostering non-cognitive skills such as planning, executing plans, and reviewing their work. Follow-up studies showed that these students not only improved in their cognitive ability, but also became more successful than their peers from similar background in terms of socioeconomic attainment in later life (Heckman et al. 2010).

To date, two studies have specifically examined the interaction between non-cognitive skills and family SES in social status attainment process, and both of them focused the period of late adolescents and young adulthood. The first one is by Shanahan and colleagues, where they used data from National Longitudinal Study of Adolescent Health Survey (Add Health) to examine whether non-cognitive skills are stronger predictors of attainments at lower levels of family SES. They measure non-cognitive skills by the Big Five personality traits, and family SES by parents' education. Results from this study showed that being less neurotic, more

agreeable, extroverted, conscientious, and imaginative can weaken the effects of family background on young adults' education attainment, hourly wages and occupation. In other words, non-cognitive skills are more important to lower-SES children's status attainment. Damian and colleagues (2015) replicated the above study by using data from Project Talent, a large U.S. representative sample of high school students. They also found some evidence that the association between adolescents' family SES and their attainment in adulthood, including education attainment, annual income, and occupation prestige, is weakened by Big Five personality traits. Nevertheless, they pointed out that non-cognitive skills can only compensate the SES disadvantage in status attainment process to a limited extent, and do not lead to a full "catch-up" effect. (Damian et al. 2015)

Taken together, past studies suggest that SES's effects on social attainment are moderated by one's non-cognitive skills, and better non-cognitive skills would weaken SES's effects on social outcomes. Unfortunately, both of the two studies analyzed a sample of adolescents and young adults, and examined the interaction between family SES and non-cognitive skills in affecting status attainment; whether and how non-cognitive skills moderate SES's effects on school achievement in early life course remains unknown.

Moderated Effects in a Longitudinal Setting and Methodological Challenges

The evolving role of non-cognitive skills over life course is another important factor to consider. Children spend a good amount of time in school, from early childhood to adolescence. However, scholars in child development widely argue that childhood and adolescence are two different developmental periods, with their own distinct features. Thus, the role of non-cognitive skills in explaining the association between SES and achievement may change over time. As is conjectured by the "sensitivity hypothesis", there are sensitive periods in the life course when

skills are more or less malleable to environmental influences. (Borghans et al. 2008) Previous studies have supported this hypothesis. For example, it is shown that the effects of family's economic resources on children's development are more significant during early childhood than later, and children's wellbeing is more susceptible to their surroundings when they are younger (Brooks-Gunn and Duncan 1997; Duncan et al. 1998; Duncan, Brooks-Gunn, and Klebanov 1994; Duncan, Ziol-Guest, and Kalil 2010; Heckman 2006). Hsin and Xie (2012) found that the effects of family SES on non-cognitive skills' development grow over time, and non-cognitive skills' role as mediators of SES's effects on achievement start off weakly and increase over the life-course.

To account for the potential time-variation when examining whether and how non-cognitive skills moderate family SES's effects on achievement, I take a longitudinal perspective in this study and examine the focal question during two developmental stages of early childhood and early adolescence. I use Figure IV-1 to present the conceptual framework of this study. In Figure IV-1, D represents the demographic background variables, which are time invariant (for example, age upon the entry of kindergarten, gender, and race). C_0 and C_5 represent all the time-varying covariates measured at kindergarten entry and fifth grade (for example, family structure, number of siblings, etc.). NC_0 and NC_5 are non-cognitive skills measured at kindergarten entry and fifth grade, respectively. SES_1 and SES_8 are family SES measured at first grade and eighth grade. Y_8 is children's math or reading achievement in early adolescence, measured at 8^{th} grade. As shown in the graph, this study focuses on two developmental stages: (1) early childhood, here specified as the period around kindergarten to first grade, and (2) early adolescence, here specified as the period from around fifth to eighth grade.

Nevertheless, solving the problem in a longitudinal setting is not as simple as it may seem to be. Conventional regression method in sociology is insufficient as it only gives unbiased estimates when the moderator variable and the moderated variable are independent of each other. In other words, conventional regression will only be proper under the assumption that non-cognitive skills are independent of family SES. However, the assumption of independence is not the met in the current longitudinal framework. As has been discussed, family SES influences the development of non-cognitive skills, and non-cognitive skills mediate SES's effects on achievement. Thus, non-cognitive skills will be both a mediator and moderator of family SES's effects on achievement. In this specific study, non-cognitive skills measured in early adolescence, while moderating adolescence family SES's effects on achievement, are also affected by early childhood family SES and mediate its effects on achievement (Figure IV-1). As family SES is relatively stable over time, non-cognitive skills and family SES measured in early adolescence will not be independent from each other. This makes conventional method inappropriate to estimate the how non-cognitive skills will moderate family SES's effects on achievement over time. I will formally discuss this methodological challenge in more detail in the method section below.

Methods

In this section, I first quickly review the conceptual model and the scientific questions of this article. Then, I discuss the model specification and why conventional regression method is insufficient to provide unbiased estimates. Third, I introduce the structure nested mean model (SNMM), and explicate how it helps to overcome the limitations of the conventional methods. Stylized Figure IV-1 shows the conceptual model used to design the statistical models that follow. The central focus of this study is to estimate: whether and how family SES's direct

effects[15] on achievement in early adolescence depend on children's evolving non-cognitive skills during two developmental stages: early childhood and early adolescence (the direct effects during early childhood is termed as μ_1, and that during early adolescence is termed as μ_2). As is shown in the figure, within each of the two developmental stages, the moderator non-cognitive skills are measured prior to family SES. Specifically, during early childhood, non-cognitive skills are measured upon entry to kindergarten and family SES is measured at first grade; during early adolescence, non-cognitive skills are measured at fifth grade, and family SES is measured at eighth grade. By this design, I avoid the problem that family SES will affect the moderator non-cognitive skills within each period as non-cognitive skills are measured before family SES. However, this design does not break the relationship between early childhood family SES (measured at 1st grade) and early adolescence non-cognitive skills (measured at 5th grade), which propose the major challenge to the estimation.

Model Specification and Problems of Conventional Methods in a Longitudinal Setting

I specify a linear model to address the conceptual question described in Figure IV-1 (Equation (1)).

$$E(Y_8|NC_0, SES_1, NC_5, SES_8, C_0, C_5, D) = \beta_0 + \beta_1 NC_0 + \underbrace{(\beta_2 + \beta_3 NC_0)SES_1}_{\mu_1} + \beta_4 NC_5 + \underbrace{(\beta_5 + \beta_6 NC_5)SES_8}_{\mu_2} + C_0 + C_5 + D \quad (1)$$

In the equation, NC_0 and NC_5 are time-varying non-cognitive skills measured during early childhood at kindergarten entry and early adolescence at 5th grade, which are potential moderators of family SES effects on achievement. C_0 and C_5 are time-varying demographic control variables, such as parents' marital status, employment, during two focal developmental

[15] Formal discussion and definition of direct effects and moderated effects is provided in the Appendix A.

stages. D is the time-invariant demographic control variables such as race, gender and so on. SES_1 is family SES in early childhood (measured at first grade), and SES_8 is family SES in early adolescence (measured at 8th grade). $(\beta_2 + \beta_3 NC_0)SES_1$ (μ_1) and $(\beta_5 + \beta_6 NC_5)SES_8$ (μ_2) correspond to family SES's direct effects on achievement during early childhood and early adolescence respectively. Thus, β_2 and β_5 are the average direct effects of family SES during two developmental stages. β_3 and β_6 measure how family SES effects on achievement vary for children with different prior non-cognitive skills during each period.

However, estimates of this model (Equation (1)) by conventional regression in sociology are problematic for causal interpretation for two reasons (Figure IV-2) as we directly condition on time-varying variables such as non-cognitive skills. First, it gives rise to the problem of over-control of intermediate pathways. As discussed earlier, non-cognitive skills during adolescence (NC_5) is an intermediate variable as it is influenced by previous family SES in early childhood and can mediate its effects on achievement. Thus the part of μ_1 in Equation (1), which involving parameters β_2 and β_3, fail to capture the effect of early childhood family SES (SES_1) on young adolescence achievement (Y_8) that operates through children's non-cognitive skills during early adolescence (NC_5). This violates the definition of the direct and moderated direct effects of family SES (see Appendix A), and fails to answer the focal research question of this study. Second, conditioning on early adolescence non-cognitive skills (NC_5) also introduces the collider-stratification bias. As shown in Figure IV-2, conditioning on NC_5 induces an association between prior early childhood family SES (SES_1) and unobserved determinants of Y_8, which yields biased estimates (Elwert and Winship 2014; Greenland 2003; Pearl 1995, 2003).

Similar problems arise with directly controlling for other non-focal time-varying covariates such as parents' employment status, family structure, marital status, and so on. As

illustrated by Figure IV-2, these characteristics in early adolescence (e.g. C_5) are affected by previous family SES in early childhood (e.g. SES_1) and can mediate its effects on later achievement at 8th grade. Moreover, these covariates can also confound early adolescence family SES's effects on achievement (e.g. C_5 confounds SES_8's effects on achievement). Specifically, as these covariates during early adolescence are measured at 5th grade, they are likely to affect early adolescence family SES which is measured at 8th grade. Thus, including the non-focal time-varying covariates directly into the conventional regression model will introduce problems such as over-control and collider bias as well.

In sum, these complicated methodological issues pose challenge to investigate how non-cognitive skills moderate family SES's effects on achievement in a longitudinal setting. Thus, to answer the questions in this study, alternative methods are necessary.

Estimation with Structural Nested Mean Model

I use Structure Nested Mean Model (SNMM) to tackle both methodological problems raised above. By and large, Structural Nested Mean Model is similar to conventional regression in specification, with a major distinction that time-varying moderator such as non-cognitive skills are residualized by previous family SES and non-cognitive skills. In below, I will use the focal variable of non-cognitive skills as an example to illustrate how SNMM can help to overcome the problems of over control and collider bias in the longitudinal setting.

In general, SNMM formally relates family SES's direct effects (μ_1 and μ_2) to the conditional mean of the potential outcomes (Robins 1994), which is important to estimating these effects in the regression context. It decomposes the conditional expectation of the outcomes into several additive terms including the average direct effects of family SES, the moderated family SES's direct effects, and a set of "nuisance" functions which capture the association of

the moderators with the outcome (Almirall, Ten Have, and S. A. Murphy 2010; Almirall et al. 2013; Robins 1994, 1999, 2000; Wodtke, Geoffrey T., Felix Elwert 2016).

In the form of an equation, SNMM is summarized by equation (2)

$$E\big(Y_8(SES_1, SES_8)\big|NC_0, NC_5(SES_1)\big) =$$

$$\beta_0 + \epsilon_1(NC_0) + \mu_1(NC_0, SES_1) + \epsilon_2\big(NC_0, SES_1, NC_5(SES_1)\big) + \mu_2(NC_5(SES_1), SES_8) \quad (2)$$

$$\epsilon_1(NC_0) = E(Y_8(0,0)|NC_0) - E\big(Y_8(0,0)\big) \quad (3)$$

$$\epsilon_2\big(NC_0, SES_1, NC_5(SES_1)\big) = E\big(Y_8(SES_1, 0)\big|NC_0, NC_5(SES_1)\big) - E(Y_8(SES_1, 0)|NC_0) \quad (4)$$

In Equation (2), the intercept $\beta_0 = E(Y_8(0,0))$ is the grand mean of achievement with family SES in early childhood and early adolescence equal to zero, which is the reference value. Functions of $\mu_1(NC_0, SES_1)$ and $\mu_2(NC_5(SES_1), SES_8)$ (detailed formal definition is in Appendix A), capture the direct and the focal moderated direct causal effects. $\epsilon_1(NC_0)$, defined by Equation (3), is the association between early childhood non-cognitive skills (NC_0) and the achievement in 8th grade, had the child spent both his/her early childhood and adolescence in a family with SES equal to 0. $\epsilon_2\big(NC_0, SES_1, NC_5(SES_1)\big)$, as defined by Equation(4), is the association between early adolescence non-cognitive skills (NC_5) and achievement at 8th grade had the children with non-cognitive skills $NC_5(SES_1)$ spent early childhood in a family with SES equal to SES_1 and then early adolescence in a family with SES equal to 0. In the Structure Nested Mean Model, the functions of $\epsilon_1$and ϵ_2 are designed to capture the associational effects of the intermediate time-varying variables (e.g. non-cognitive skills) on the final outcome (e.g. 8th grade achievement), and are thus called "nuisance" functions. Intuitively, replacing the time-varying variables by the nuisance functions in the model will break the linkage between prior treatment (e.g. early childhood family SES, SES_1) and following intermediate variable (e.g. early adolescence non-cognitive skills, NC_5) (as shown in Figure IV-2 and Figure IV-3), and thus

solve the problem of over-control and collider bias by directly conditioning on these variables (e.g. NC_5).

Implementing SNMM in regression involves two stage of regression analysis, which is also termed as Regression-with-Residuals (RWR) (Almirall, Ten Have, and S. A. Murphy 2010; Almirall et al. 2013). In the first stage of regression, we model each of the time-varying covariates conditional on the observed past and obtain the estimated residuals[16], which are the nuisance functions. For instance, I regress the non-cognitive skills in early childhood on itself, and non-cognitive skills in adolescence on prior family SES and non-cognitive skills in early childhood (Equation (5)-(6)). Based on the regression, I obtain the residuals (Equation (7)-(8)). The residuals are the nuisance parts to be included in the SNMM.

$$E(NC_0) = \alpha_0 \quad (5)$$

$$E(NC_5|NC_0, SES_1) = \gamma_0 + \gamma_1 NC_0 + \gamma_2 SES_1 \quad (6)$$

$$NC_0^r = NC_0 - \hat{E}(NC_0) \quad (7)$$

$$NC_5^r = NC_5 - \hat{E}(NC_5) \quad (8)$$

The second stage is to regress the final outcome of achievement on two family SES measurements, interactions between non-cognitive skills and family SES, and the residualized non-cognitive skills to obtain the estimates. The model is specified following Equation (2). That is, I estimate a model as below:

$$\begin{aligned} &E(Y_8|NC_0, SES_1, NC_5, SES_8) \\ &\quad = \beta_0 + \underbrace{\eta_1 NC_0^r}_{\epsilon_1} + \underbrace{\beta_1 SES_1 + \beta_2 SES_1 * NC_0}_{\mu_1} + \underbrace{\eta_2 NC_5^r}_{\epsilon_2} \\ &\quad + \underbrace{\beta_3 SES_8 + \beta_4 SES_8 * NC_5}_{\mu_2} \quad (9) \end{aligned}$$

[16] The baseline time-varying covariates will regress on themselves as there is no observed past.

The β_k coefficients in Equation (9) are the estimated average direct effects of family SES on achievement and how these effects are moderated by children's non-cognitive skills in two developmental stages respectively. The η_k coefficients represent the association between non-cognitive skills and the final outcome of the achievement in early adolescence. In this study, η_1 can be interpreted as the main effects of early childhood non-cognitive skills on achievement; η_2 can be interpreted as the main effects of early adolescence non-cognitive skills on achievement. Different from conventional regression methods (Equation (1)), this two-stage Regression-with-Residual (RWR) replaces non-cognitive skills (NC_k) with the residualized non-cognitive skills (NC_k^r). The residualized non-cognitive skills (NC_k^r) serve as the nuisance functions in the SNMM. It breaks down the pathway between non-cognitive skills and previous family SES, thus eliminate the problem of over-control and collider bias.

I use RWR in this study to overcome the methodological problems raised by conditioning on time-varying variables. To better deal with other non-focal time-varying covariates, I use the approach of Covariate-Adjusted Regression-with-Residuals (CA-RWR) introduced by Wodtke and Almirall's recent work (2015). Specifically, in the first stage, I estimate the residuals of focal variable of non-cognitive skills and all other non-focal time-varying covariates or confounders by Equation (10) to (17).

$$E(NC_0) = \alpha_0 \quad (10)$$

$$E(C_0) = \alpha_1 \quad (11)$$

$$E(NC_5|C_0, NC_0, SES_1) = \gamma_0 + \gamma_1 C_0 + \gamma_2 NC_0 + \gamma_3 SES_1 \quad (12)$$

$$E(C_5|C_0, NC_0, SES_1) = \eta_0 + \eta_1 C_0 + \eta_2 NC_0 + \eta_3 SES_1 \quad (13)$$

$$\hat{\delta}(NC_0) = NC_0 - \hat{E}(NC_0) \quad (14)$$

$$\hat{\delta}(C_0) = C_0 - \hat{E}(C_0) \quad (15)$$

$$\hat{\delta}(NC_5) = NC_5 - \hat{E}(NC_5|C_0, NC_0, SES_1) \quad (16)$$

$$\hat{\delta}(C_5) = C_5 - \hat{E}(C_5|C_0, NC_0, SES_1) \quad (17)$$

In the second stage, I estimate the SNMM specified as Equation (18).

$$E(Y_8|NC_0, C_0, SES_1, NC_5, C_5, SES_8)$$
$$= \beta_0 + \eta_1\hat{\delta}(NC_0) + \beta_1 SES_1 + \beta_2 SES_1 * NC_0 + \eta_2\hat{\delta}(NC_5) + \beta_3 SES_8 + \beta_4 SES_8$$
$$* NC_5 + \beta_5\hat{\delta}(C_0) + \beta_6 SES_1 * NC_0 + \beta_7\hat{\delta}(C_5) + \beta_8 SES_8 * C_5 \quad (18)$$

There are three assumptions to estimate the SNMM model with observed data (Almirall, Ten Have, and S. a. Murphy 2010; Robins 1994; Wodtke, Geoffrey T., Felix Elwert 2016). The first is that the ***mean of "nuisance" function equal to zero, conditional on the past***. This assumption is about the specification of the nuisance functions. To test the robustness of the results, I tried extensive specifications of the nuisance functions in the sensitivity analysis. The second assumption is ***consistency***. Specifically, it states that the observed outcome is consistent with one of the conceptualized potential outcomes. The third assumption is ***sequential ignorability***. It states that: $Y_8(SES_1, SES_8) \perp SES_1|NC_0$ and $Y_8(SES_1, SES_8) \perp SES_8|NC_0, SES_1, NC_5$. In words, it assumes that at each time point, there exist no unobserved variables that directly affect selection into different family SES and the outcome achievement, other than prior measured covariates and prior family SES, as shown in Figure IV-2. Though sequential ignorability is met by design in experimental studies, where treatment can be randomly assigned at each time point, it requires data on all the potential predictors of family SES and achievement to satisfy in an observation study like this. I thus conduct a sensitivity analysis to assess how the potential violations of these this assumption may change the results. The results are presented in the appendix and will be discussed in the following results section.

Data and Measures

To assess my research questions, I use data from Early Childhood Longitudinal Studies, Kindergarten Class of 1998-99 (ECLS-K), a nationally representative study designed to assess social-group differences in U.S. children's social-emotional and cognitive development. The survey, conducted by the National Center for Education Statistics (NCES), used a three-stage stratified sampling procedure in following a group of selected children from school entry through 8th grade. Data were collected from children and their families, teachers, and schools on children's cognitive, social, emotional, and physical development. In addition, information was included on children's home environment, home educational activities, school environment, classroom environment, classroom curriculum, and teacher qualifications. The analytic sample in this article is restricted to children who took the assessment of math or reading ability in 8th grade. This yields a sample of 9224 for children who were assessed via a math test, and 9165 for children who were assessed via a reading test.

Table IV-2 summarizes the descriptive statistics for the variables used in this study. The dependent variable is achievement measured by children's math and reading test scores in 8th grade, when they were around 13-14 years old. I used the standardized math and reading scores provided by ECLS-K. These standardized scores measure how children did in terms of mathematic or reading ability compared with their peers. The standardized score has a mean of 50 and a standard deviation around 10.

Time-Varying Covariates

Family SES. Family SES is measured with an index constructed by NCES. This is a composite measurement based on mother and father's education, occupations, and family income, with each component equally weighted. It is further standardized with a mean of 0 and a standard

deviation of 1 across the sample being surveyed (NCES 2002). In this study, I use family SES at when first grade to measure SES in early childhood and family SES at 8th grade to measure SES in early adolescence. I choose using a composite measurement of SES over using several separate measurements on multiple dimensions of family's SES because the composite measurement facilitates the quantitative analysis of how non-cognitive skills may moderate SES's effects on achievement[17].

Non-cognitive Skills. I follow the convention in this field (Claessens et al. 2009; Hsin and Yu 2012) and measure non-cognitive skills based on ECLS-K Social Rating Scale as provided by children's teacher. This scale is adapted from the Social Skills Rating System (Gresham and Elliott 1990), and is designed to capture children's socioemotional skills such as self-control, motivation, attention, and etc.. At each wave of the survey, teachers were asked to use a frequency scale to report how often students exhibit a certain social skill or behavior (1 = never to 4 = very often), from which the ECLS constructed five SRS scales[18]: Approaches to Learning, Self-Control, Interpersonal Skills, Externalizing Problem Behaviors, and Internalizing Problem Behaviors. In this analysis, non-cognitive skills are measured using an unweighted averaged composite[19] of scales for Approaches to Learning, Self-Control, and Interpersonal Skills that is standardized across the analytical sample at each time point to ease interpretation. This standardized composite measurement measures children's behaviors and traits such as attentiveness, persistence, organization, ability to control behaviors, and skills in expressing

[17] If we use several measurements on different aspects of family SES, it will make the model and computation very complicated as there will be interaction between each of these aspects and the non-cognitive skills, as well as the interactions between each of these aspects with other time-varying covariates.
[18] There are 24 items in total for SRS in kindergarten and first grade waves, and 26 items in third grade and fifth grade wave.
[19] I conduct a Confirmatory Factor Analysis to examine the validity of such construct. The RMSEA for the model is 0.063 (with a 90% confidence interval 0.061 to 0.064), and the CFI is 0.962. Conventionally, a RMSEA less than 0.1 and CFI greater than 0.9 suggest a well fitted model.

emotions, forming and maintaining a good relationship with others[20]. Early childhood non-cognitive skills are those measured at entry to kindergarten, and early adolescence non-cognitive skills are measured at 5th grade by the survey.

Other Covariates. Other time varying covariates include: number of siblings, intact family (living with both parents = 1), mother is full-time employed (=1), father is full-time employed (=1), marital status of resident parents (married=1). As discussed above, these time-varying covariates are not the main focus of the current study, but I include them in my models because they may work as time-varying confounders in the relationship between family SES, non-cognitive skills, and achievement.

Time-Invariant Covariates

As shown in Table IV-2, I also include demographic and other background information as time-invariant control variables. These include: child's age in months when they entered kindergarten, gender (female = 1), race, whether the child is a second time kindergartener (second time = 1), immigrant generation (native =0 as the reference), language spoken at home (Non-English = 1), mother's age at birth, mother's marital status at birth (married = 0).

Missing values are assumed to be missing at random (Allison 2002; Little and Rubin 2014). The magnitude of missing values differed across variables in the same wave as well as across waves for the same variable, and Table IV-1 presents the observations and missing patterns of the sample. I use multiple imputation strategy[21] to deal with the missing covariates.

[20] A more detailed description of the constructed non-cognitive skills measurement is available in Appendix C.
[21] I use the ICE command in STATA (Royston, 2007) to deal with the imputation.

Five data sets were imputed, using all the covariates in the analysis[22]. The results presented in the main text are based on the analysis on one of the five computed datasets.

Analysis and Results

Descriptive Statistics

Table IV-2 presents the descriptive statistics of all the variables used in this study. Figure IV-4 shows the descriptive relationship between family SES and achievement by children's non-cognitive skills during two developmental stages: early childhood (left part) and early adolescence (right part). This graph is plotted based on the observed data without any controls, and non-cognitive skills are categorized into three groups: high, medium and low. Specifically, the upper left graph depicts the relationship between family SES and mathematic achievement in 8th grade (which is the outcome variable in this study) by children's non-cognitive skills in early childhood; the bottom left graph depicts the relationship between family SES and reading achievement in 8th grade by non-cognitive skills in early childhood; the upper right graph depicts the relationship between family SES and mathematic achievement by non-cognitive skills in early adolescence; and the right bottom graph depicts of the relationship between family SES and reading achievement by non-cognitive skills in early adolescence. As we can tell from these four graphs, the relationship between family SES and achievement differs across children with different levels of non-cognitive skills. As is suggested by the variation in the slope of the line, the association between family SES and achievement is weaker among children with higher non-cognitive skills, and this is true for both mathematic and reading achievement and during both developmental stages of early childhood and early adolescence.

[22] As will be discussed later in the sensitivity analysis, I repeat the analysis over all the five imputed data sets, the results are consistent and stable, with only slight difference in the estimates. I am thus presenting one set of the results in the main text here.

Non-cognitive Skills as a Mediator

Table IV-3 describes how non-cognitive skills serve as a mediator of previous family SES's effects on achievement. The results come from traditional regression method. In Model A and B, the outcome is mathematic test scores at 8th grade. Model A is the regression model with all the control variables but non-cognitive skills at 5th grade, and Model B is the full model with the non-cognitive skills at 5th grade. Model C and D is specified similarly to the first two models, but with the outcome as the reading test scores at 8th grade. As is suggested by the results, after including non-cognitive skills, family SES's effects on math and reading achievement decrease. This suggest that non-cognitive skills at 5th grade is a mediator of 1st grade family SES's effects on achievement. Thus, as discussed in method section, traditional regression methods will be insufficient[23] to answer the question that whether and how non-cognitive skills will moderate family SES's effects on achievement during adolescence, or how non-cognitive skills at 5th grade will moderate 8th grade family SES's effects on achievement. Thus, I analyze the moderated effects of family SES by using Structural Nested Mean Model (SNMM). The results and the discussion are presented in the following section.

Moderated Family SES's effects by SNMM

Mathematic Achievement

Table IV-4 presents the results from the SNMM, or regression-with-residual model (the full results table is in Appendix E). The coefficients before family SES represent the direct effects of family SES on 8th grade achievement during either early childhood or early adolescence. The coefficients before non-cognitive skills show the direct main effects of non-

[23] For robustness check, I also estimate the model using conventional regression. The results are summarized in Appendix F. Though the estimates of regression is not appropriate for causal interpretation, they are consistent with the results from SNMM, suggesting the robustness of the findings in this study.

cognitive skills on achievement. The interaction term between family SES and non-cognitive skills tell whether and how family SES's direct effects on achievement are moderated by non-cognitive skills within each of the two focal developmental stages.

Model 1 in Table IV-4 presents the estimates from the analysis with mathematic achievement as the outcome. As is shown, early-childhood family SES has a significant positive direct effect on later mathematic achievement in early adolescence, holding early-adolescence family SES constant. One standard deviation increase in early-childhood family SES increases later achievement in mathematics by 1.27 points. The main effects of early childhood non-cognitive skills are also significant. The size of the effect is larger than that of family SES, as one standard deviation increase in non-cognitive skills will increase achievement by 2 points.

Moreover, the significant coefficients before the interaction between family SES and non-cognitive skills during early childhood suggest that family SES's effects vary across children with different prior non-cognitive skills. Specifically, as the interaction is negative ($\beta = -0.23$, $p<0.05$), it means that higher non-cognitive skills can substantially reduce the effects of family SES on achievement during this developmental period. One standard deviation increase in non-cognitive skills could lower family SES effects by 0.23 point, or around 18 percent of the total family SES effect, which is notable. Compared with the effect of other variables (Table in Appendix E), the magnitude of the moderation is also noteworthy. For example, the moderation effect is about 40 percent of the effect size of mother's unemployment on achievement during the same period of early childhood. Figure IV-5 (a) shows the moderated early-childhood family SES effects in a graph. The x-axis is children's non-cognitive skills, and the y axis is the effects of early-childhood family SES on math achievement. As we can tell from the graph, during early-childhood, SES's effects on later math achievement decrease as

children's non-cognitive skills increase. This also suggests that non-cognitive skills benefit lower-SES children's achievement the most, and less for the higher-SES children.

During the period of early adolescence, family SES effects on achievement are also significantly positive. As suggested by the lower part in Model 1, Table IV-4, a one standard deviation increase in family SES during this period will improve achievement in math by 2.79 points. Non-cognitive skills' effects on achievement during this period are also significantly positive. One standard deviation increase in non-cognitive skills will increase achievement by 1.62 points. Compared to early childhood, it seems that during early adolescence, non-cognitive skills' effects become smaller where family SES's effects get bigger.

More importantly, the effects of family SES on later mathematic achievement are moderated by non-cognitive skills during this developmental period as well. The negative and significant coefficient of the interaction term in the model suggests that family SES effects are greater for children with lower non-cognitive skills and smaller for those with higher non-cognitive skills. In particular, a one standard deviation improvement in non-cognitive skills will reduce family SES effects on achievement by 0.42 points, which is about 15 percent of SES's original effects. Figure IV-5 (b) visualizes the moderated SES effect on math achievement during early adolescence, and shows that the effects of family SES on math achievement are smaller for children with better non-cognitive skills during early adolescence.

Reading Achievement

Model 2 in Table IV-4 presents the results for reading achievement, and the results are similar to those for mathematic achievement. First, during the period of early childhood, both family SES and non-cognitive skills affect later achievement. One standard deviation improvement in early childhood family SES is associated with a 2.26 point improvement in

reading achievement, and one standard deviation increase in non-cognitive skills is associated with 1.71 point increase. Furthermore, the coefficient of the interaction between family SES and non-cognitive skills is negative and marginally significant (β=-0.2, p<0.1), implying that non-cognitive skills moderate family SES effects on reading achievement in this developmental period. One standard deviation increase in non-cognitive skills will reduce the effects of SES on achievement by 10 percent. I use Figure IV-5 (c) to visualize the moderated SES effects. As non-cognitive skills increase, the effects of early-childhood family SES on reading achievement decrease. Similar as previous, this can be interpreted as that non-cognitive skills' positive effects on reading achievement is stronger for children from lower-SES families.

Second, during the period of early adolescence, family SES and non-cognitive skills' effects on reading achievement are also positive and significant. As is shown in Table IV-4 Model 2, one standard deviation increase in family SES will result in a 2.6 point increase in reading achievement, and same increase in non-cognitive skills will improve reading achievement by 1.54 points. As is hypothesized, the size of SES effects varies by children's non-cognitive skills, and the reading achievement of children with higher non-cognitive skills is less impacted by their family SES. Specifically, one standard deviation increase in non-cognitive skills will reduce family SES's effects by 0.37, which is around 14 percent of SES's direct effects. The above moderation by non-cognitive skills on SES's effects on reading achievement during early adolescence is shown by Figure IV-5 (d).

In sum, during both developmental periods of early childhood and early adolescence, family SES and non-cognitive skills affects math and reading achievement positively, while at the same time, non-cognitive skills moderate family SES effects, such that family SES's effects on achievement are weaker among children with higher non-cognitive skills. In other words,

non-cognitive skills will compensate family's SES to affect achievement in school. This implies that better non-cognitive skills will help loser-SES children to obtain academic success by protecting them from the academic disadvantage associated with their family background.

Sensitivity Analysis

As aforementioned, the results from the SNMM are valid and unbiased under two assumptions: (1) the model specification (nuisance and the causal model) of the SNMM are correct (2) there are no unobserved confounding variables that will influence family SES and achievement at the same time. These two assumptions are strong, and failure to meet them may render the estimates and inference invalid. Thus, I conduct further sensitivity analyses to test the robustness of the reported results. Results from sensitivity analyses are included in the appendix.

First, I focused on the assumptions on the model specifications. Specifically, I experimented with a variety of model specifications for both the causal model and nuisance functions. Details are discussed in Appendix B with Appendix Table 12 summarizing the results. Results from these models suggest that the reported estimates are robust.

Second, I conducted sensitivity analyses to check for the assumptions of unobserved confounders. To test how the robustness of the results are influenced by the unobserved confounding variables affecting both family SES and the achievement in early adolescence, I measure and include an extensive set of confounders in the analysis. Moreover, I also formally investigated the robustness of the results to hypothetical unobserved confounding. I discussed details about this formal analysis in Appendix C. In short, the current results hold even when the confounding measures are very large.

Third, I explored the importance of missing data. To assess the sensitivity of the results to the missing data, I constructed 5 data sets by different multiple imputation, and replicate the

main analysis over all the five imputed data sets. I also tested the models by using other strategies such as the list wise deletion method. The results from these analyses follow similar patterns to the ones presented in this paper, and only differ very slightly in the coefficient estimates. These analyses[24] indicate that results presented in the main text are stable under different procedures for handling missing data.

Discussion and Conclusion

The connection between family background and children's educational achievement is a central topic to stratification and education scholarship in sociology and general social sciences. Family SES, an overall summary of family's socioeconomic characteristics, has long been shown a significant predictor of children's achievement. Though myriad studies have developed around whether and how family translates its socioeconomic resources into children's educational achievement, very few studies have carefully investigated whether the effects of family-level socioeconomic resources on achievement are moderated by children's characteristics, such as non-cognitive skills, and whether the moderation effects vary across children's developmental stages.

Adopting an interactive and longitudinal perspective, this study asks the above questions and analyzes the interplay between family SES effects and children's non-cognitive skills in affecting education achievement during two developmental stages: early childhood and early adolescence. Capitalizing on recent methodological developments, this study finds that non-cognitive skills can moderate family SES effects on subsequent achievement. Specifically, during both developmental stages of early childhood and early adolescence, family SES's effects on achievement are significantly weaker among children with higher non-cognitive skills.

[24] Available upon request.

Results from this study suggest that non-cognitive skills would compensate shortcomings in family's socioeconomic resources in academic success for children from lower SES background. However, as shown by this and other studies (Hsin and Yu 2012; Liu 2016; Reardon and Portilla 2014), without any intervention, children from lower SES families are more likely to be the ones with lower non-cognitive skills; they therefore suffer a double jeopardy from shortages in both family resources and non-cognitive skills, which can amplify their academic disadvantage compared to their peers from higher SES families. These implications thus highlight the importance and the potential benefits of enhancing non-cognitive skills for low SES children to reduce the SES-based achievement inequality. In addition, as non-cognitive skills are critical to education and moderate family SES's effects on achievement during both periods of early childhood and early adolescence, it will be beneficial to start intervening on improving low SES children's non-cognitive skills in their early childhood.

This study is not without caveats. First, though ECLS-K data enables me to study the proposed question in a longitudinal setting, it does not have any information on children's educational attainment beyond 8th grade. Thus, I am not able to test whether non-cognitive skills will moderate family SES effects on educational achievement in other periods of development, such as late adolescence or early adulthood, or on other outcomes, such as college graduation or young adults educational attainment. Second, the two key factors in this study are children's non-cognitive skills and family SES. Though I have included many other covariates capturing family characteristics in the analysis, they are not of focal interest. As mentioned earlier, family SES effects on achievement can also be moderated by other factors as well. Thus, it would be interesting to examine how other characteristics of children will modify the effects of family socioeconomic resources in the process of education attainment in the future. Third, I use a

composite measurement of family SES to facilitate the statistical examination of the focal question in this study. As family SES is a multi-dimensional concept, including multiple tangible and intangible resources, future studies can delve more into questions like what the specific types of resources' effects are that non-cognitive skills can moderate.

Despite these limitations, this study contributes to the current literature and expands our understanding of stratification and education in several ways. First, though it has been shared by scholars that family SES (Coleman et al. 1966; Sewell and Hauser 1975) and non-cognitive skills are both critical to children's achievement (e.g. Almlund, Heckman, Duckworth, & Kautz, 2011; Duckworth & Seligman, 2006; Heckman, 2006), few studies have considered whether non-cognitive skills and family SES will interact to affect education. Results from this current study advance our understanding by showing that non-cognitive skills can moderate family SES effects on achievement, with higher non-cognitive skills reducing SES's effects on achievement during early childhood and early adolescence.

Second, this study highlights the value of bringing an interactive and longitudinal perspective in future stratification studies, and consider how individual-level characteristics would moderate the effects of family-level characteristics in social attainment process and the reproduction of inequality over life course. Many past studies in sociology implicitly assume that family characteristics, such as SES, would work independently to affect children's development. But the results in this study suggest that children's individual differences can change the ways in which family SES affects their development in early life. It is thus reasonable to speculate that other family level factors such as family structure, divorce, parents unemployment and etc., would also interact with children's characteristics to affect their social outcomes in later life such as risk behavior in adolescence, education attainment and income in adulthood. Therefore, future

studies may pay closer attention to examine these multiplicative combinations of family characteristics and individual characteristics in affecting children's development and in shaping the formation of inequality.

This study also suggests the need for methodological advancement in sociology. As discussed in this study, estimating moderation effects by individual characteristics in a longitudinal setting presents many methodological challenges, most centrally because individual characteristic is a potential moderator of family-level factors while are also influenced by family. Thus, traditional regression method is insufficient to yields causal estimates and new methods are required. In this study, I use Structural Nested Mean Models to overcome the methodological challenges (Almirall, Ten Have, and S. A. Murphy 2010; Almirall et al. 2013; Wodtke and Almirall 2015). However, this method is not without limitation. For an example, it allows us examining the moderated effects of one single measurement of family characteristics, such as a composite SES, in the model; but it becomes much more complicated once we want to estimate how individual characters will moderate several family level characteristics at the same time. This and other limitations and challenges call for methodological advancement in sociology to facilitate research on the stratification process in a longitudinal setting.

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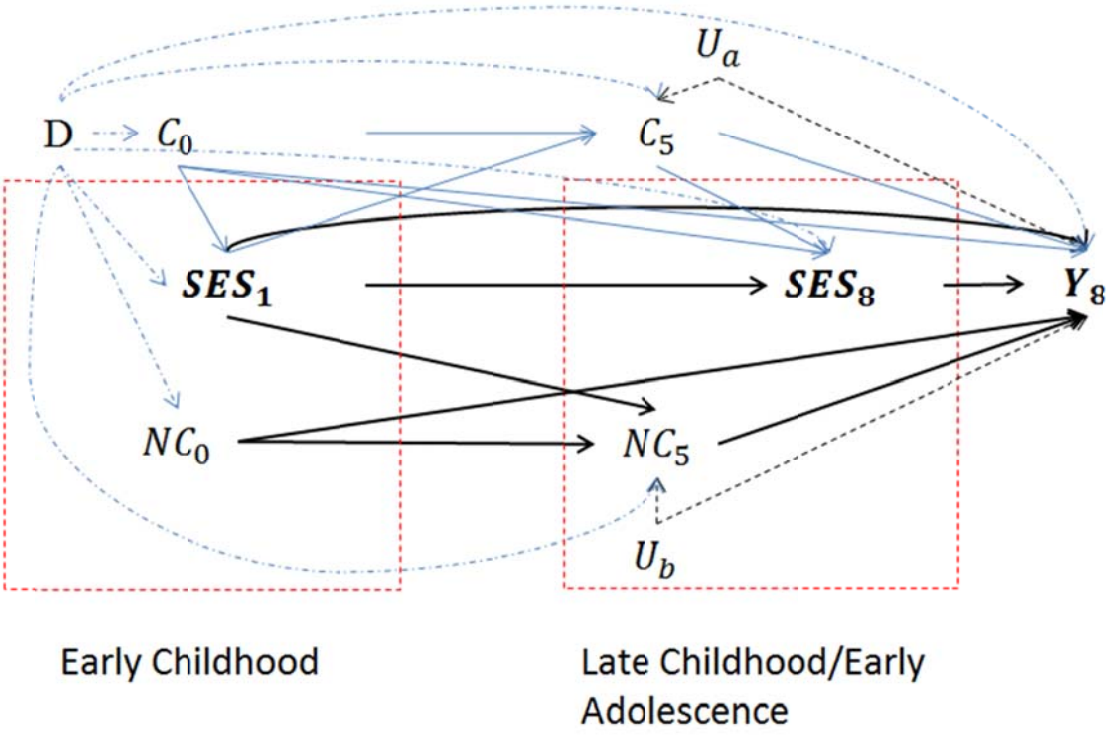
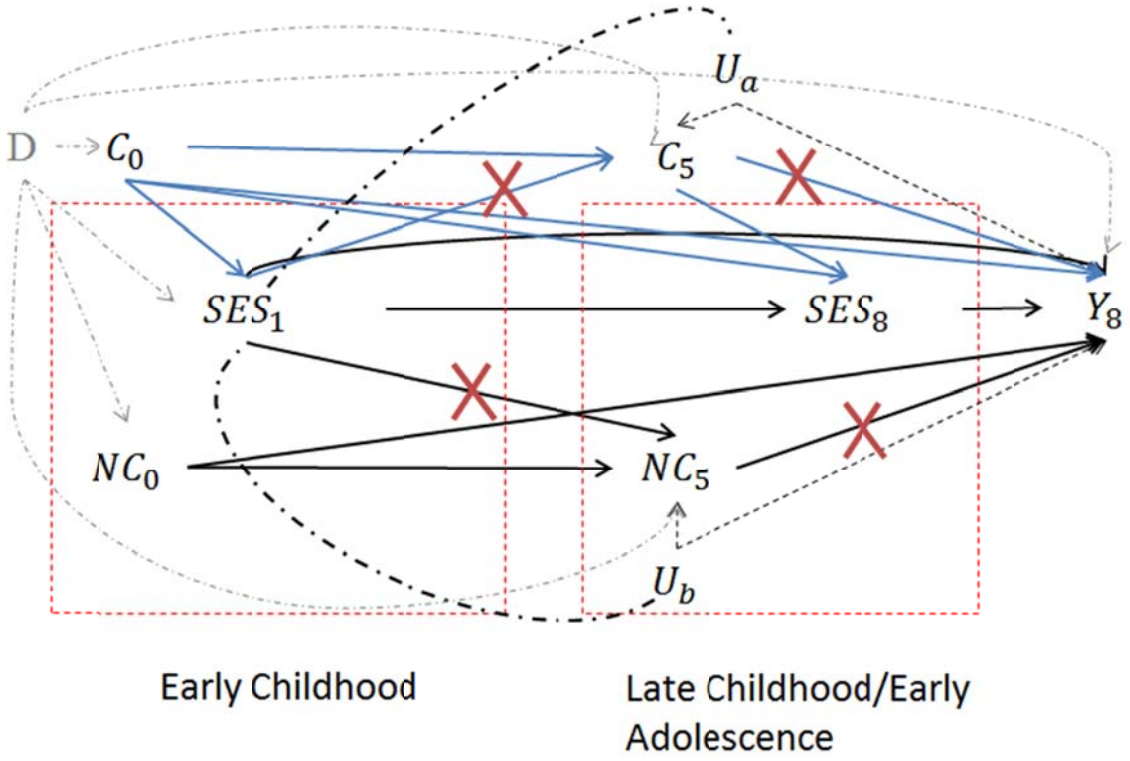
Figure IV-1 Conceptual Framework: Causal Relationship between Pre-treatment time-invariant Covariates, Time-Varying Treatments, Moderators, Confounders, and Outcome: Selection on Prior Confounders and Potential Moderators



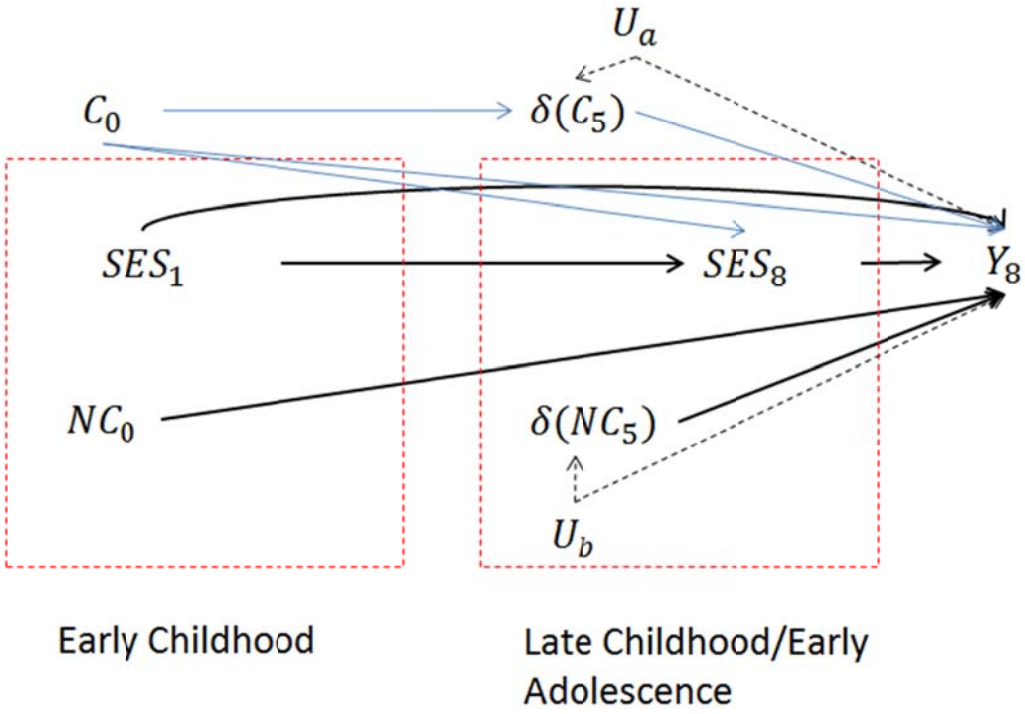
Note: (1) SES_1 and SES_8 are family SES at two time points (1st Grade and 8th Grade). (2) Y_8 is students' achievement in 8th Grade. (3) C_0 and C_5 are pre-SES time-varying confounders at Kindergarten and 5th Grade respectively. (4) NC_0 and NC_5 are non-cognitive skills measured at kindergarten entry and fifth grade and are focal prior SES moderators. (5) U_a and U_b represents unobserved factors. (6) D are the time-invariant demographic and background covariates.

Figure IV-2 Problems with Conventional Regression: Over-control and Collider Stratification from Conditioning on Time-varying Confounders and Moderators



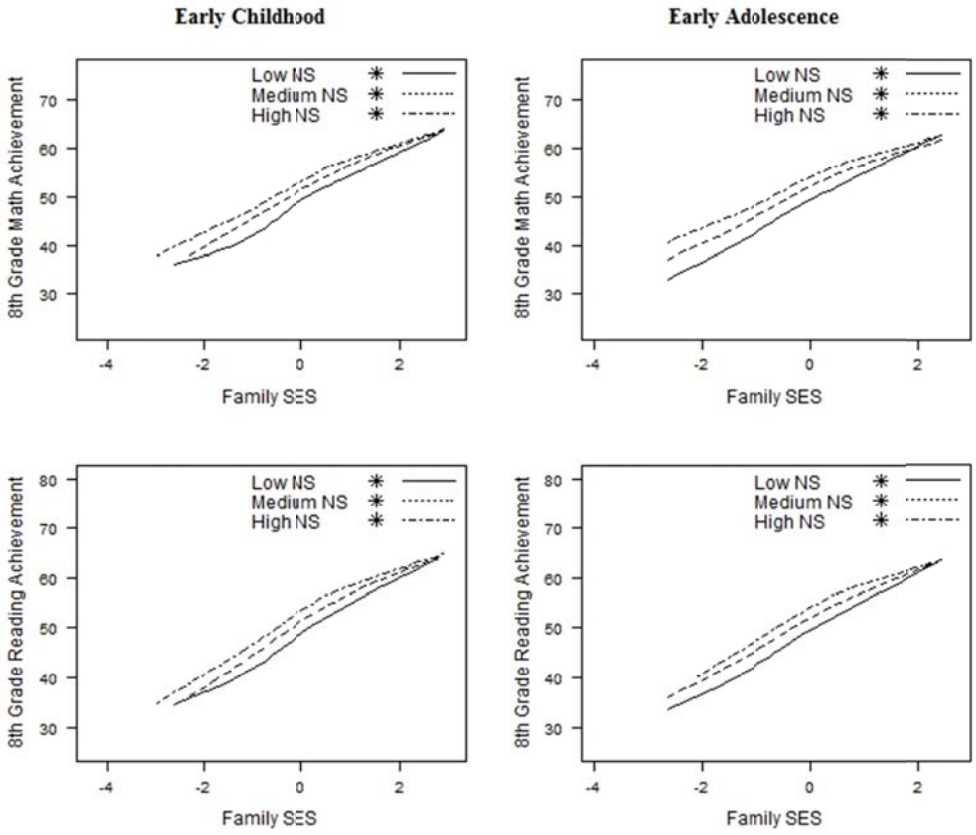
Note: (1) SES_1 and SES_8 are family SES at two time points (1st Grade and 8th Grade). (2) Y_8 is students' achievement in 8th Grade. (3) C_0 and C_5 are pre-SES time-varying confounders at Kindergarten and 5th Grade respectively. (4) NC_0 and NC_5 are non-cognitive skills measured at kindergarten entry and fifth grade and are focal prior SES moderators. (5) U_a and U_b represents unobserved factors.

Figure IV-3 Consequences of and residualizing time-varying confounders and moderators



Note: (1) SES_1 and SES_8 are family SES at two time points (1st Grade and 8th Grade). (2) Y_8 is students' achievement in 8th Grade. (3) C_0 and C_5 are pre-SES time-varying confounders at Kindergarten and 5th Grade respectively. NC_0 and NC_5 are non-cognitive skills measured at kindergarten entry and fifth grade and are focal prior SES moderators. (4) $\delta(C_5) = C_5 - \hat{E}[C_5|C_0, SES_1, NC_0]$. (5) NC_0 is prior treatment moderator at kindergarten, $\delta(NC_5) = NC_5 - \hat{E}[NC_5|NC_0, SES_1, C_0]$ (6) U_a and U_b represent unobserved factors.

Figure IV-4 Family SES and Achievement by Non-cognitive Skills in Two Developmental Stages



Note: (1) NS is short for non-cognitive skills. (2) Loess smoothed curve is used.

Figure IV-5 Family SES's Effects on Achievement and Non-cognitive Skills

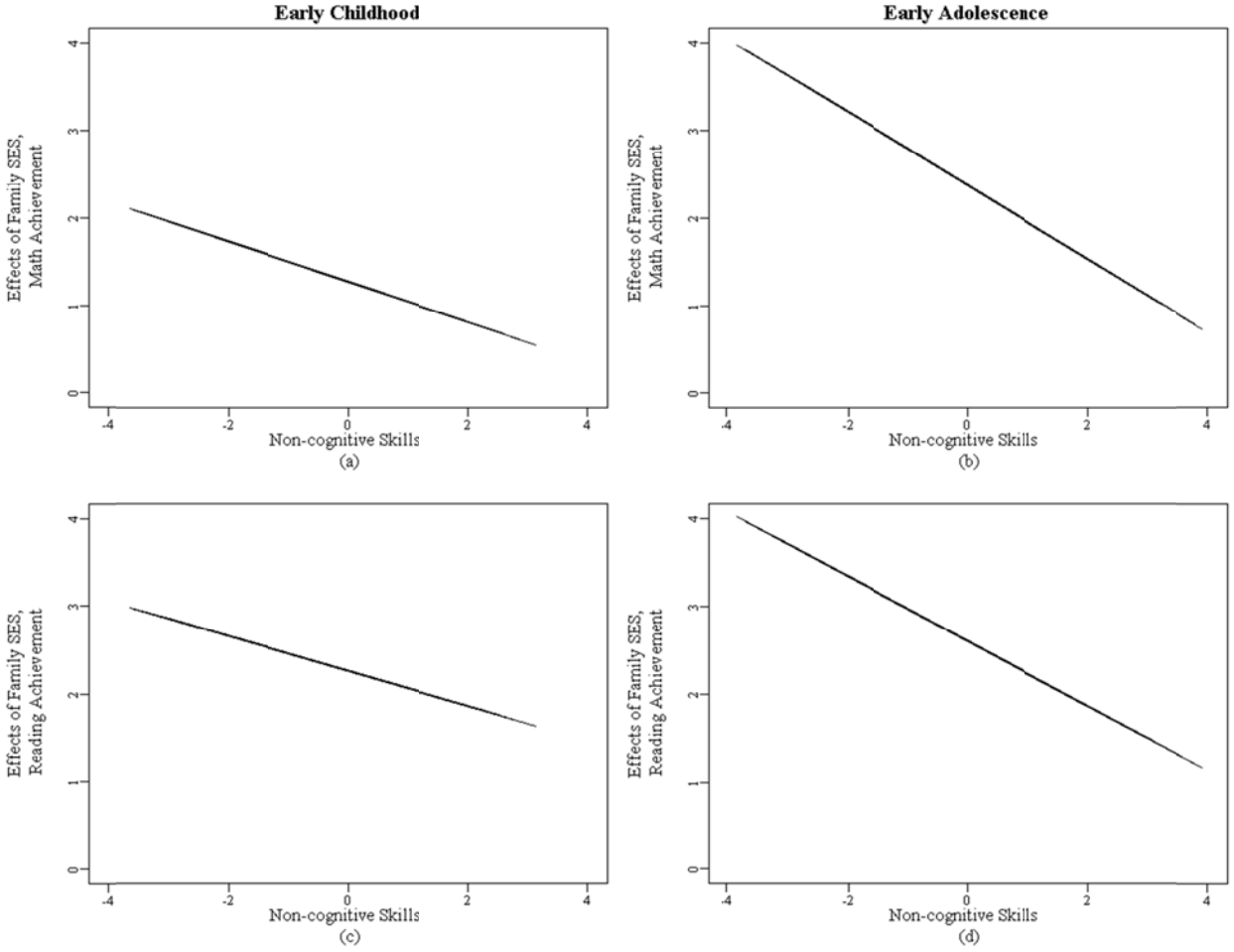


Table IV-1 Family SES, Non-Cognitive Skills and Achievement

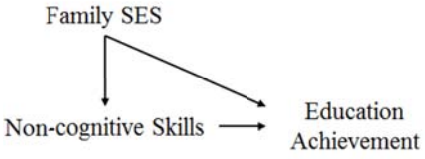
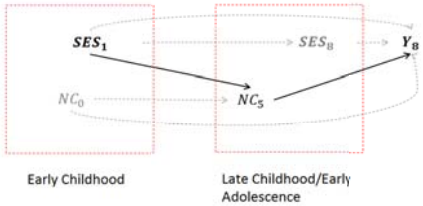
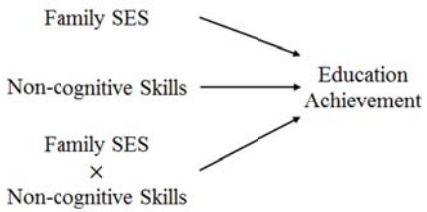
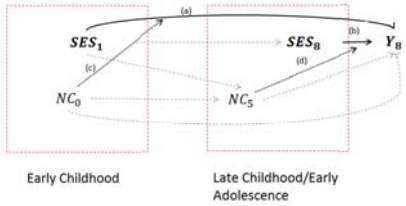
The Role of Non-Cognitive Skills	Conceptual Interpretation	Graphic Illustration	Graphic Illustration (Longitudinal Setting)	Focus of the Current Study
Mediator	A mediator is a third variable that accounts for the relation between an independent variable and a dependent variable.			No
Moderator	A moderator is a third variable that "affects the direction and/or strength of the relation" between an independent variable and a dependent variable.			Yes

Table IV-2 Descriptive Statistics of Variables

Variables	Mean	SD	% Missing
Time-invariant Covariates			
Months upon Entry of Kindergarten	68.48	4.36	8.63
Gender	0.50	0.50	0.00
Race			
Black	0.10	0.31	0.18
Hispanic	0.17	0.38	0.18
Asian	0.06	0.23	0.18
Other	0.05	0.22	0.18
Multi-kindergarten (=1)	0.15	0.36	0.08
Immigration Generation (Native as the Reference Group)			
1st Generation	0.01	0.07	1.70
2nd Generation	0.25	0.44	1.70
Language Spoken at Home	0.87	0.34	3.28
Mother's Age at Birth	29.36	5.75	14.07
Mother's Marital Status at Birth	0.76	0.43	4.11
Time-Varying Covariates			
Early Childhood			
Number of Siblings	1.46	1.15	11.97
Intact Family (=1)	0.81	0.39	11.97
Mother is Fulltime Employed (=1)	0.46	0.50	13.78
Father is Fulltime Employed (=1)	0.92	0.28	27.40
Marital Status of Resident Parent(s)	0.77	0.42	4.70
Children's Non-cognitive Skills (Standardized)	0.12	0.96	8.89
Family SES at First Grade	0.08	0.81	5.30
Early Adolescence			
Number of Siblings	1.55	1.13	7.21
Intact Family (=1)	0.78	0.41	3.84
Mother is Fulltime Employed (=1)	0.51	0.50	6.86
Father is Fulltime Employed (=1)	0.89	0.31	22.53
Marital Status of Resident Parent(s)	0.75	0.43	3.91
Children's Non-cognitive Skills (Standardized)	0.04	0.99	8.42
Family SES at 8th Grade	0.00	0.80	9.74
Math Test Score (Standardized)	51.47	9.65	0.14
Reading Test Score (Standardized)	51.57	9.81	0.78
N	9237		

Table IV-3 Family SES, Non-Cognitive Skills and Achievement in Early Adolescence

Model	Mathematic Test Score (8th Grade)				Reading Test Score (8th Grade)			
	A		B		C		D	
	Coef	Sig	Coef	Sig	Coef	Sig	Coef	Sig
Intercept	42.17	***	43.81	***	36.21	***	37.74	***
	(1.75)		(1.70)		(1.74)		(1.70)	
Family SES (1st Grade)	3.44	***	3.08	***	3.72	***	3.39	***
	(0.19)		(0.18)		(0.19)		(0.18)	
Non-Cognitive Skills (5th Grade)			2.08	***			1.91	***
			(0.09)				(0.09)	
N	9224		9224		9224		9224	
R^2	0.262		0.301		0.298		0.329	

Notes: ~p<0.10, *p<0.05,**p<0.01, and ***p<0.001

Table IV-4 Moderated Direct Effects of Family SES on 8th Grade Achievement by SNMM in Two Developmental Stages

Model	Model 1: Mathematic Test Score			Model 2: Reading Test Score		
	Coef	SE		Coef	SE	
Intercept	50.75	1.56	***	43.97	1.54	***
Early Childhood						
Family SES	1.27	0.46	***	2.26	0.45	***
Family SES # Non-Cognitive Skills	-0.23	0.12	*	-0.20	0.12	~
Early Adolescence						
Family SES	2.79	0.43	***	2.60	0.43	***
Family SES # Non-Cognitive Skills	-0.42	0.43	***	-0.37	0.12	***
N	9224			9165		

Notes: Standard errors are based on 250 bootstrap samples. ~p<0.10, *p<0.05,**p<0.01, and ***p<0.001

Appendix A : Defining Moderated SES's Effects on Achievement in a Longitudinal Setting

Stylized Figure IV-1 shows the conceptual model used to design the models that follow. The central focus of this study is to estimate: whether and how family SES effects on achievement in early adolescence depend on children's evolving non-cognitive skills during two developmental stages: early childhood and early adolescence.

To analyze the moderated effects of SES by non-cognitive skills, we first need to estimate SES's effects on achievement. Borrowing the framework of potential outcomes (Holland 1986; Rubin 1974) and treating SES as a treatment, I define SES's effects on achievement as the direct effects and the focal interest to this study is thus the moderated direct effects. The direct effect refers to the changes in achievement that is directly affected by any changes in family SES and not mediated by other covariates. Thus, the direct effects of early-childhood SES on achievement is formally defined as: $DE_{SES_1} = E(Y(ses_1, ses_8) - Y(ses_1^*, ses_8))$. The direct effects of early-adolescence SES on achievement is formally defined as: $DE_{SES_8} = E(Y(ses_1, ses_8^*) - Y(ses_1, ses_8))$. (Sobel 2008; Wang and Sobel 2013) In the equations, SES_1 and SES_8 denote children's family SES measured at first 1st grade and 8th grade respectively. Y is the early-adolescence achievement measured at 8th grade. The direct effects of early childhood family SES (DE_{SES_1}) tell us how 8th grade achievement changes if we change family SES in a child's early childhood (SES_1) from ses_1 to ses_1^* without changing the child's family SES during early adolescence. Similarly the direct effects of SES_8 (DE_{SES_8}) tell us how 8th grade achievement changes if we change family SES from ses_8 to ses_8^* during a child's adolescence without changing his/her family SES in early childhood.

The focal interest to this study is two sets of moderated direct causal effects: one is during early childhood, and the other is during early adolescence. I incorporate them into the previously defined direct effects and formally define the two sets of moderated effects as below:

$$\mu_1(NC_0, SES_1) = E(Y(ses_1, ses_8) - Y(ses_1^*, ses_8)|NC_0) \quad (1)$$

$$\mu_2(NC_5(SES_1), SES_8) = E(Y(ses_1, ses_8^*) - Y(ses_1, ses_8)|NC_0, SES_1, NC_5(SES_1)) \quad (2)$$

In Equation (1), NC_0 is the non-cognitive skills measured at kindergarten fall, which is the baseline of this survey. This equation defines the focal effects during early childhood. Specifically, it gives the direct effect of early childhood family SES on 8th grade's achievement within subgroups of prior non-cognitive skills (NC_0) at kindergarten-entry. In other words, this equation summarizes the achievement changes in 8th grade if we change a child family SES in early childhood from ses_1 to ses_1^* without changing his/her family SES during early adolescence, and how such changes in achievement vary among children with different non-cognitive skills. The second equation summarizes the focal effects during adolescence. It estimates the direct effect of family SES in early adolescence on achievement within levels of previous non-cognitive skills at 5th grade ($NC_5(SES_1)$). μ_2 captures the achievement changes in early adolescence if we change children's family SES from during their adolescence from ses_8 to ses_8^* without changing their family SES in early childhood, and how such difference depend on children's earlier non-cognitive skills measured at 5th grade (NC_5). As I have discussed earlier, non-cognitive skills can be influenced by previous family SES. Thus, in Equation (2), non-cognitive skills are expressed as a function of SES_1 by $NC_5(SES_1)$.

I further use linear function to parameterize the two sets of direct and moderated direct effects discussed above.

Early Childhood:

$$\mu_1(NC_0, SES_1) = SES_1 * (\gamma_0 + \gamma_1 NC_0) = \gamma_0 SES_1 + \gamma_1 NC_0 * SES_1 \quad (3)$$

Early Adolescence:

$$\mu_2(NC_5(SES_1), SES_8) = SES_8\big(\gamma_3 + \gamma_4 NC_5(SES_1)\big) = \gamma_3 SES_8 + \gamma_4 NC_5(SES_1) * SES_8 \quad (4)$$

In these equations, γ_0 and γ_3 are the average direct effect of family SES on achievement in early childhood (1st grade) and early adolescence (8th grade) respectively if NC_5 and NC_8 have value of mean zero. γ_1 and γ_4 are the parameters with key interest as they represent whether and how non-cognitive skills would moderate family SES's effects on achievement during the two focal developmental stages. Specifically, if $\gamma_1 = 0$ ($or\ \gamma_4 = 0$), it means non-cognitive skills does do not moderate family SES's effects on later achievement during early childhood (early adolescence). If $\gamma_1 > 0$ ($or\ \gamma_4 > 0$), it means non-cognitive skills magnify family SES's effects on achievement during early childhood (early adolescence). If $\gamma_1 < 0\ or\ (\gamma_4 < 0)$, it suggests non-cognitive skills reduce family SES's effects on achievement during early childhood (early adolescence).

Appendix B : Sensitivity Analysis on the Specification of Nuisance Functions

I investigate the sensitivity of the estimates to different specifications of the causal and nuisance functions of the Structural Nested Mean Models (SNMM). The results are presented in Table A1. Model A, B and C are focused on testing the sensitivity over different causal functions, and Model D, E, F are focused on testing on different specification of nuisance functions. W denote for the time-invariant demographic variables presented in Table 2 in the main text (e.g. gender, month upon kindergarten entry, language at home, mother's age at birth, mother's marital status at home, whether is second time kindergartener, immigrant status). C_0 and C_5 represent the time-varying variables in Table 2 and include number of siblings, family composition, mother's employment status, father's employment status, parents' marital status. C_0 are these variables measured at kindergarten entry, and C_5 are these variables measured at 5^{th} grade.

Model A is the base model, where the focal interaction is only between family SES and non-cognitive skills, and only the main effects of W, C_0 and C_5 are included. Model B extend Model A by allowing family SES's effects to vary not only by prior-SES non-cognitive skills, but also other prior time-varying characteristics (C_0 and C_5). Model C further extend Model B by assuming that not only SES's effects are moderated by time-varying characteristics and non-cognitive skills, but all the time-invariant variables' effects vary across these variables. In particular, Model C is the model presented in the main text.

In Model D, the nuisance function is further specified to include the interaction term between the time-invariant variables. In Model E, the nuisance functions further include the interactions between all the variables in C_0, which is all the interactions between the variables measured at kindergarten entry. Model F further include the interactions between all the variables in C_5, which is all the interactions between variables measured at 5^{th} grade.

As we can tell from all these models, the estimates are invariant and stay quite consistent, which suggests the robustness of the analysis and the results in this study.

Appendix Table 12 Two-state estimates with different specifications of SNMM nuisance functions (1)

Model	A						B					
	Mathematic Test Score			Reading Test Score			Mathematic Test Score			Reading Test Score		
	Coef	SE		Coef	SE		Coef	SE		Coef	SE	
Intercept	50.91	1.60	***	45.19	1.63	***	50.80	1.56	***	44.00	1.45	***
Childhood												
Family SES	1.94	0.25	***	2.30	0.26	***	1.96	0.24	***	2.30	0.24	***
Family SES # Non-Cognitive Skills	-0.22	0.11	~	-0.20	0.11	~	-0.22	0.11	*	-0.20	0.10	~
Early Adolescence												
Family SES	2.37	0.24	***	2.43	0.24	***	2.37	0.24	***	2.43	0.23	***
Family SES # Non-Cognitive Skills	-0.41	0.11	***	-0.37	0.11	***	-0.41	0.11	***	-0.37	0.11	***
	main effects of W, C0, C5						main effects of W, residualized C0, residualized C5					

continued (2)

Model	C						D					
	Mathematic Test Score			Reading Test Score			Mathematic Test Score			Reading Test Score		
	Coef	SE		Coef	SE		Coef	SE		Coef	SE	
Intercept	50.75	1.44	***	43.97	1.54	***	64.50	10.05	***	46.71	10.40	***
Childhood												
Family SES	1.27	0.46	**	2.26	0.45	***	1.34	0.44	**	2.37	0.46	***
Family SES # Non-Cognitive Skills	-0.23	0.12	*	-0.20	0.12	~	-0.24	0.13	~	-0.22	0.10	*
Early Adolescence												
Family SES	2.79	0.43	***	2.60	0.43	***	2.70	0.44	***	2.54	0.46	***
Family SES # Non-Cognitive Skills	-0.42	0.43	***	-0.37	0.12	***	-0.42	0.13	***	-0.38	0.12	***
	B+ interaction between W and C0, C5						C+ interaction between elements of W					

continued (3)

Model	E						F					
	Mathematic Test Score			Reading Test Score			Mathematic Test Score			Reading Test Score		
	Coef	SE		Coef	SE		Coef	SE		Coef	SE	
Intercept	64.48	10.48	***	46.10	9.79	***	63.41	10.85	***	45.69	10.48	***
Childhood												
Family SES	1.64	0.50	***	2.41	0.53	***	1.69	0.53	***	2.26	0.50	***
Family SES # Non-Cognitive Skills	-0.24	0.11	*	-0.22	0.12	~	-0.24	0.12	*	-0.22	0.11	*
Early Adolescence												
Family SES	2.70	0.45	***	2.50	0.48	***	2.67	0.48	***	2.71	0.44	***
Family SES # Non-Cognitive Skills	-0.42	0.12	***	-0.37	0.13	**	-0.41	0.12	***	-0.36	0.13	**
	D+ all two-way interactions of elements within C0						E+ all two-way interactions of elements within C5					

Notes: Standard errors are based on 250 bootstrap samples. ~p<0.10, *p<0.05,**p<0.01, and ***p<0.001

Appendix C : Sensitivity Analysis on the Assumption of Unobserved Confounders

In this section, I implement a formal sensitivity analysis to test the robustness of the estimates to unobserved confounding, which is a violation of the sequential ignorability assumption. This may occur when there are unmeasured variables which influence both family SES and the achievement test scores.

Following Sharkey and Elwert (2011); Wodtke, Elwert, and Harding (forthcoming), I conduct a sensitivity analysis for time-varying family SES that models bias due to unobserved confounding as a function of potential outcomes (Brumback et al. 2004; Robins 1999, 2000). Specifically, I use a selection function to summarize the relationship between observed and counterfactual outcomes and then to compute bias-adjusted effect estimates. If inferences about the family SES's effects on achievement do not change across a range of substantively reasonable confounding scenarios, as defined by different values of the selection function, I conclude that the results are robust to unobserved confounding.

In the first step of the analysis, I specified a selection function: $s(\alpha, \alpha') = (\alpha - \alpha')\alpha$, where α is a sensitivity parameter specifying the magnitude of bias due to unobserved confounding. As I estimate a linear SNMM in this study, I chose a linear model for unmeasured confounding correspondingly. In the model, $\alpha = 0$ implies no unobserved confounding of family SES. $\alpha > 0$ implies the type of confounding that children from lower SES families have lower SES achievement regardless of their family SES; and children from higher family SES have higher achievement regardless of their family SES. $\alpha < 0$ implies the type of confounding that children from lower SES families have higher SES achievement regardless of their family SES; and children from higher family SES have lower achievement regardless of their family SES. The selection function constrains the magnitude of hypothetical unobserved confounding to be the same across levels of observed covariates and moderators for computational simplicity. As this study sets in a longitudinal setting, I specified two selection functions (E1 is for the period of early childhood, E2 is for the early adolescence):

$$s_0(\alpha_0, \alpha_0') = (\alpha_0 - \alpha_0') \qquad (E1)$$

$$s_5(\alpha_5, \alpha_5') = (\alpha_5 - \alpha_5') \qquad (E2)$$

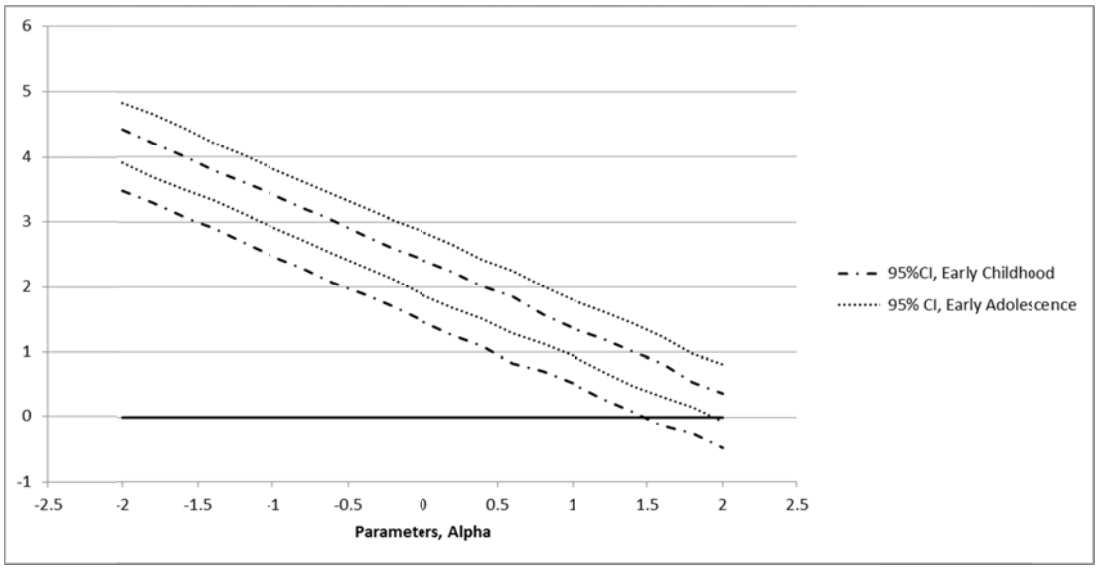
In the second step, I adjust the estimate for the average treatment effect of family SES in the time-varying context based on the above selection function (E1 and E2). First, I caudated the bias by equation:

$$B = \sum_{t=0}^{t=5} \int_{A_t' min}^{A_t' max} (A_t - A_t')\alpha_t P(A_t') \qquad (E3).$$

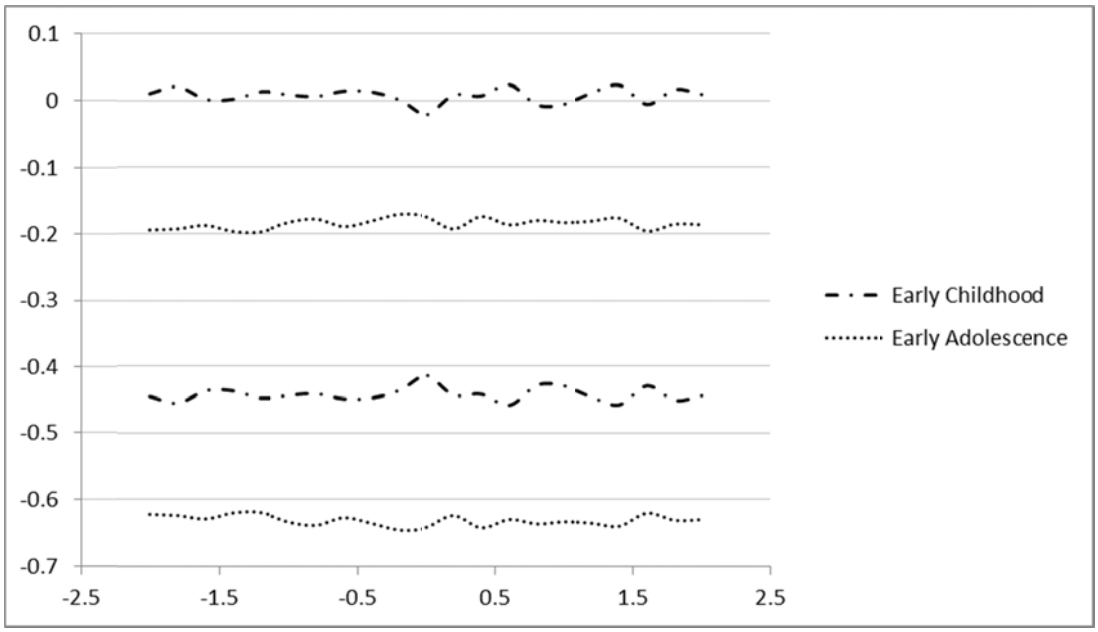
In this equation, A and A' denote particular values of family SES. $P(A')$ can be obtained by the density function of family SES, which I obtained through kernel modeling. The bias defined in E3 account for the total bias accumulated across developmental periods of early childhood and early adolescence. Second, I subtract the bias term from the observed outcome Y, and obtain a bias-adjusted outcome $Y^a = Y - B$. Next, I refit the SNMM using the adjusted outcomes, and this tiles bias-adjusted estimates for the effects of family SES on achievement. Selecting a range of plausible values for the sensitivity parameter α and estimating the bias-adjusted effects of each of these values allow me to assess the robustness of the results to different degrees of unobserved confounding.

Figure A1and A3 show the results from this sensitivity analysis for the effects of family SES's effects on math (A1) and reading achievement (A3) during childhood and adolescent respectively. Figure A2 and A4 shows the results from this sensitivity analysis for the non-cognitive skills moderated effects of family SES on math (A2) and reading (A4) achievement during childhood and adolescent respectively. The parameter α is presented on the x-axis. $\alpha = 0$ means there is no unobserved confounding variable, and $|\alpha| = 1$ means unobserved variables are assumed to confound the effect of family SES's effects on achievement to the same extent as all observed covariates already controlled in the analysis. Following Wodtke, Elwert and Harding's work (forthcoming), I judge values of $|\alpha| > 1$ to be implausible unobserved confounding scenarios given that I have adjusted a large and relevant set of observed confounders, though I still reported the results in the graph.

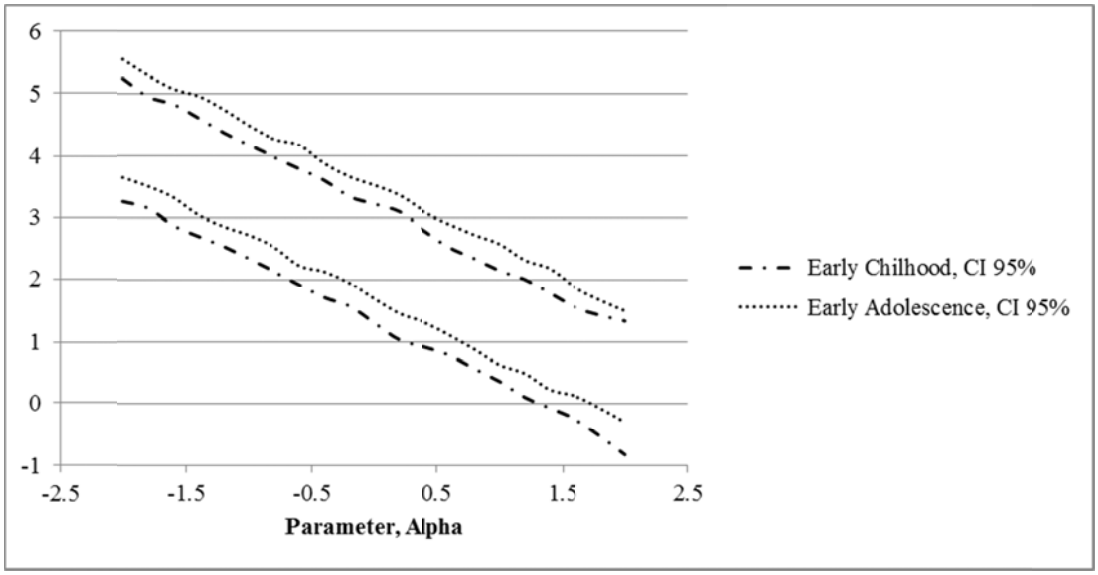
As suggested by these plots, the estimates and the main substantive conclusions are robust to unobserved confounding. Across a wide range of values of α, the direct effects of family SES on math and reading achievement during childhood and adolescence are both significant. In addition, these effects are moderated by children's non-cognitive skills during both two focal developmental stages, and better non-cognitive skills will reduce family SES's effects on achievement.



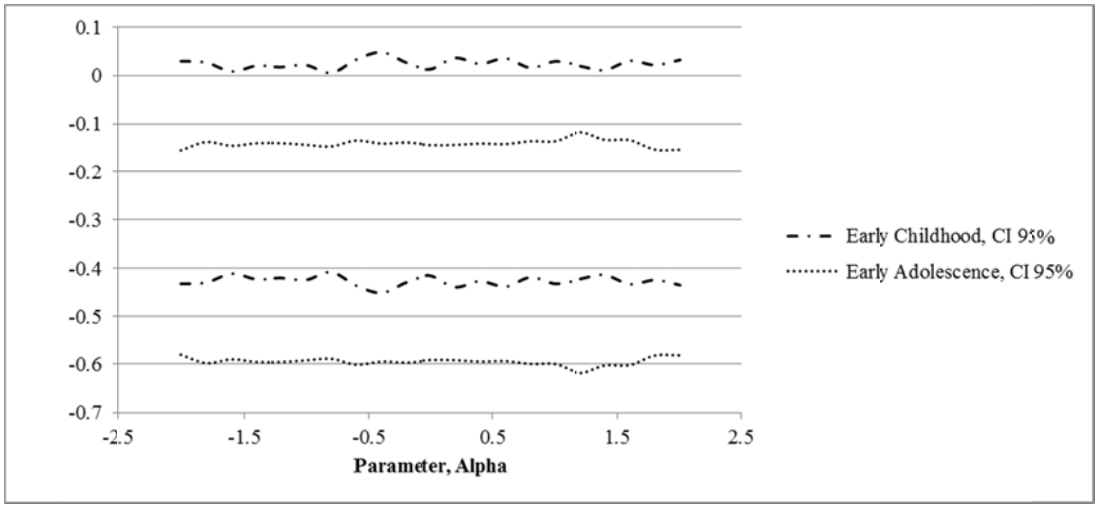
Appendix Figure 1. Sensitivity Analyses for Effects of Family SES on Children's Mathematic Achievement under Various Assumptions about the Strengths of Unobserved Confounding Variables



Appendix Figure 2. Sensitivity Analyses for Moderated Effects of Family SES on Children's Mathematic Achievement (Interaction between Family SES and Non-cognitive Skills) under Various Assumptions about the Strengths of Unobserved Confounding Variable



Appendix Figure 3. Sensitivity Analyses for Effects of Family SES on Children's Reading Achievement under Various Assumptions about the Strengths of Unobserved Confounding Variables



Appendix Figure 4. Sensitivity Analyses for Moderated Effects of Family SES on Children's Reading Achievement (Interaction between Family SES and Non-cognitive Skills) under Various Assumptions about the Strengths of Unobserved Confounding Variable

Appendix D : Detailed Description of Non-cognitive Skills Measurement[25]

Non-cognitive skills measurements used in this study are constructed based on the **Approaches to Learning**, the **Self-Control**, and the **Interpersonal Skills**, which are offered in ECLS-K's Teacher SRS.

The **Approaches to Learning** Scale measures behaviors that affect the ease with which children can benefit from the learning environment. IT includes six items that rate the child's attentiveness, task persistence, eagerness to learn, learning independence, flexibility, and organization.

The **Self-Control** Scale has four items that indicate the child's ability to control behavior by respecting the property rights of others, controlling temper, accepting peer ideas for group activities, and responding appropriately to pressure from peers.

The five **Interpersonal Skills** items rate the child's skill in forming and maintaining friendships, getting along with people who are different, comforting or helping other children, expressing feelings, ideas and opinions in positive ways, and showing sensitivity to the feelings of others.

[25] From ECLS-K user guide.

Appendix E : Full Results Table from SNMM

Appendix Table 13 Results from SNMM[26]

	Math			Reading		
	Coef.	Std. Err.	Sig	Coef.	Std. Err.	Sig
Intercept	50.75	1.69	***	43.97	1.52	***
Early Childhood						
Family SES	1.27	0.43	**	2.26	0.47	***
Non-cognitive Skills	2.00	0.09	***	1.71	0.09	***
Family SES # Non-Cognitive Skills	-0.23	0.11	*	-0.20	0.11	~
Number of Siblings	-0.30	0.07	***	-0.68	0.08	***
Intact Family	0.76	0.52		0.34	0.47	
Mother is Unemployed	-0.57	0.18	***	-0.78	0.18	***
Father is Unemployed	0.05	0.30		-0.24	0.30	
Mother is married	0.39	0.48		0.72	0.44	
Early Adolescence						
Family SES	2.79	0.42	***	2.60	0.48	***
Non-cognitive Skills	1.62	0.09	***	1.54	0.10	***
Family SES # Non-Cognitive Skills	-0.42	0.12	***	-0.37	0.11	***
Number of Siblings	-0.09	0.14		-0.23	0.16	
Intact Family	-0.72	0.54		-1.01	0.44	*
Mother is Unemployed	-0.29	0.19		-0.35	0.20	~
Father is Unemployed	-0.27	0.30		-0.30	0.29	
Mother is married	0.84	0.52		0.87	0.46	~
Time-invariant Controls						
Months upon entry to school	0.00	0.02		0.07	0.02	***
Gender (Male=1)	-2.56	0.19	***	0.56	0.17	***
Race						
Black	-3.77	0.30	***	-3.74	0.30	***
Hispanic	-1.49	0.30	***	-2.02	0.29	***
Asian	2.16	0.46	***	0.71	0.41	~
Other	-1.49	0.39	***	-1.83	0.39	***
Multi-time Kindergartener	-0.89	0.26	***	-0.56	0.26	*

[26] Due to the space limitation, I do not show the estimates of interaction between residualized control variables and family SES.

Language at Home (English =0)	-0.06	0.37		0.40	0.34	
Mother's Age	0.05	0.02	**	0.09	0.02	***
Mother is Married at birth	0.74	0.26	**	0.46	0.25	~

Standard errors are based on 250 bootstrap samples. ~p<0.10, *p<0.05,**p<0.01, and ***p<0.001

Appendix F: Comparing Results from Regression and SNMM

Appendix Table 14 Conventional Regression and SNMM

	Math						Reading					
	Regular Regress			SNMM			Regular Regression			SNMM		
	Coef	SE	sig	Coef	SE	sig	Coef	SE	sig	Coef	SE	sig
Intercept	51.28	1.54	***	50.75	1.56	***	45.54	1.54	***	43.97	1.54	***
Early Childhood												
Family SES	1.69	0.24	***	1.27	0.46	***	2.06	0.24	***	2.26	0.45	***
Non-Cognitive Skills	1.46	0.09	***	2.00	0.09	***	1.20	0.10	***	1.71	0.09	***
Family SES # Non-Cognitive Skills	-0.22	0.11	~	-0.23	0.12	*	-0.20	0.11	~	-0.20	0.12	~
Early Adolescence												
Family SES	2.37	0.24	***	2.79	0.43	***	2.43	0.24	***	2.60	0.43	***
Non-Cognitive Skills	1.62	0.09	***	1.62	0.09	***	1.53	0.09	***	1.54	0.1	***
Family SES # Non-Cognitive Skills	-0.41	0.11	***	-0.42	0.43	***	-0.37	0.11	***	-0.37	0.12	***
N	9224						9165					