Contextual Origins of Black-White Educational Disparities in the 21st Century

Katherine Michelmore
Syracuse University

Peter Rich
Cornell University

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Correspondence:

Peter Rich, Cornell University, Department of Policy Analysis and Management, 186 Martha van Rensselaer Hall, Ithaca, NY, 14850. Phone: 607-255-0219. Email: peter.rich@cornell.edu.

Katherine Michelmore, Syracuse University, Department of Public Administration and International Affairs, Maxwell School of Citizenship and Public Affairs. 426 Eggers Hall, Syracuse, NY 13244. Phone: 315-443-9039. Email: kmmichel@syr.edu.

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Black-white educational inequality is a perennial problem in the United States. Today, black children on average are 8 percentage points less likely to graduate high school, 8 percentage points less likely to enter college, and perform 0.85 standard deviations lower on 8th grade standardized math exams than their white counterparts (Murnane 2013; Ma, Pender, and Welch 2016; de Brey et al. 2019). Although these racial educational disparities narrowed somewhat over the past half century, they remain large and consequential, extending into a broad array of black-white differences in employment, income, health, and wealth in adulthood (Johnson 2019).

How much do black-white education gaps reflect racial differences in childhood context? Scholars have long sought to understand the role family socioeconomic status (SES) plays in racial educational inequality, and to determine whether neighborhoods and schools close or widen these gaps over time (Reardon, Robinson-Cimpian, and Weathers 2014; Chetty et al. 2018; von Hippel, Workman, and Downey 2018; Reardon et al. 2019). This research considers racially unequal schooling outcomes as part of a multi-generational process in which resource disparities carry from one generation to the next, influencing the home context in which children are raised and the school and neighborhood quality their families can access (Alexander, Entwistle, and Olson 2014; DeLuca, Clampet-Lundquist, and Edin 2016; Sharkey 2013). A multi-generational perspective also accounts for historic roots of black-white inequality: racial differences in family income and local environment, produced through centuries of racially exclusive policy, maintain their inertia even in ostensibly race-neutral policy environments where institutionalized prejudice is no longer widely endorsed (Bonilla-Silva 1996; Conley 1999; Krysan and Crowder 2017).

Slowing the inertia of historical racial inequalities is a pressing challenge in the 21st century, yet identifying where to implement interventions remains contested. Conventional

wisdom established by Coleman et al. (1966) suggests that family context, rather than schooling conditions, is the central current through which educational inequalities persist (Jencks et al. 1972). Recent scholarship further emphasizes neighborhood context as a source of (im)mobility beyond the family (Chetty et al. 2014, 2018), with one study suggesting that the negative effect of growing up in poor communities far outweighs the influence of attending impoverished schools (Wodtke and Parbst 2017). Arguments about the limited impact of schools are difficult to square with alternative evidence showing that school settings are consequential for student outcomes (Hanushek and Rivkin 2009; Logan, Minca, and Adar 2012; Carlson and Cowen 2015; Jennings et al. 2015; Reardon et al 2019), and that the expansion of educational opportunity produces educational gains for disadvantaged children (Jackson, Johnson, and Persico 2015; Lafortune, Rothstein, and Schanzenbach 2018; Johnson 2019).

Our goal in this study is to understand how much racial inequality in education outcomes can be accounted for by racial inequality in family, school, and neighborhood context during childhood. A broad data collection effort over the past two decades makes answering this classic sociological question possible with a new level of precision. School districts and states across the U.S. now periodically record student administrative information, providing detailed information about each student's school and classroom, residential location, standardized test score, grade promotion, and degree completion. Scholars have leveraged these data to analyze the effect of schools, teachers, and administrative policies on a wide array of student outcomes (Jacob 2005; Rivkin, Hanushek, and, Kain 2005; Lauen and Gaddis 2013; Jennings et al. 2015; Rich and Jennings 2015; Michelmore and Dynarski 2017).

Despite their advantages and prevalence in policy-oriented research, administrative datasets have not been used to disentangle the roles of family, school, and neighborhood contexts

in persistent black-white educational inequality. A limitation—which we address in this study—is that school administrators do not routinely collect information about family income, parental education, and household composition. Instead, they report a single indicator for whether a student receives free or reduced price lunch under the National School Lunch Program (Harwell and LeBeau 2010; Domina et al. 2018). When used cross-sectionally (a common practice in education research), this variable provides a coarse binary measure of family economic disadvantage. We address this concern by utilizing students' longitudinal history of subsidized meal receipt, adapting insights from scholarship on permanent income and poverty trajectories.

Using individual student administrative records provided by the Michigan Department of Education (MDE) for all students since 2002, we reveal a profound distinction between the social contexts white and black children inherit—a distinction that is partially hidden by cross-sectional measures. Long-term differences in social context explain more than half of the black-white achievement gap and reveal a black net advantage in high school completion and college entry. Further, our findings suggest school context, much more than neighborhood disadvantage, plays a key role in 21st century black-white inequality.

Background

A. Multi-generational dimensions of black-white educational inequality

Racial inequality in education is evident as early as kindergarten, when the average white student scores between .40 and 1.34 standard deviations higher than the average black student on standardized exams (see Quinn 2015 [pp.123] for a recent review). It is difficult to truly isolate race from SES effects when explaining educational gaps because both domains intersect, bound by historical processes. Nonetheless, it is common practice to measure raw black-white gaps and

then to observe how they change after controlling for family SES, income, wealth, or social class (Conley 1999; Condron 2009). This exercise has produced the striking finding that the black-white kindergarten gap is mostly explained by racial differences in family SES. Murnane et al. (2006), for instance, find that adjusting for family SES reduces the kindergarten black-white gap in math scores by 68 percent and in reading scores by 73 percent. Fryer and Levitt (2006) estimate that family SES accounts for 86 percent of the math gap and 130 percent of the reading gap—a reversal in which black kindergarten students, controlling for SES, outperform their white peers by .12 standard deviations (see also Quinn 2015).

The fact that large testing gaps by SES are evident by age five—and explain most or all of the black-white gap—underscores the importance of family resources in children's cognitive and social development during their first years of life (Carneiro and Heckman 2002; Magnuson and Waldfogel 2005). Family SES is thought to affect children early on through their access to nutrition, healthcare, and learning materials, as well as the types of everyday vocabulary, aspirations, and stress to which children are exposed (Brooks-Gunn and Duncan 1997; Magnuson and Duncan 2006). As children grow, family SES influences stability in home life as well as the time parents invest in their children's educational experiences and decisions (Haveman, Wolfe, and Spaulding 1991; Alexander, Entwisle, and Horsey 1997). Children from higher SES backgrounds learn from their parents how to negotiate opportunities and obstacles they face in school, challenging authority and vocalizing needs. In contrast, children from lower SES backgrounds more often defer to authority and to institutional arrangements that may exclude them from opportunities (Lareau 2011). Thus, throughout childhood, family SES shapes educational outcomes and complicates the promise of public education to provide equal opportunity for all students (Jencks et al. 1972).

Beyond test scores, a number of studies have shown that higher high school graduation rates among white versus black students can be completely explained or reversed by controlling for SES (Rumberger 1983; Haveman and Wolfe 1994; Rumberger 1995; Merolla 2013). The "black net advantage" these studies find corresponds with similar work showing black rates of college entry exceeding white rates after accounting for differences in family background (Hauser 1983; Alexander, Holupa, and Pallas 1987; Bennett and Xie 2003; Merolla 2018). However, conclusions about the size of the black net advantage in high school graduation and college entry vary according to the measure of family SES used, and whether school and neighborhood conditions are considered. Moreover, insights from this literature have not been updated to include cohorts entering Kindergarten after 1992. Children in the 21st century arguably face unique circumstances—following welfare reform in 1996, as well as the rise of school accountability and public school choice marshalled by the 2001 *No Child Left Behind Act*—that warrant renewed attention to the contextual origins of black-white educational outcomes.

B. Racial educational gaps: the role of schools and neighborhoods

Families with higher incomes typically pay to live in more affluent neighborhoods where the level of achievement and resources in local public schools is higher and where exposure to criminal and environmental hazards is lower (Owens 2016; Manduca and Sampson 2019). Thus, variation in contexts reflects the resources and choices made by those children's families (Sampson 2008). Although families are the primary site in the reproduction of inequality, secondary school and neighborhood environments play some independent role in their transition to adulthood. Differences in the opportunities, institutional processes, quality of amenities, and peer

composition, for instance, have been shown to influence educational and adulthood outcomes (Chetty et al. 2016; Chetty et al. 2014).

Racial gaps in test score achievement illustrate the potential independent effects of schools. SES explains most or all of black-white achievement gaps in kindergarten, but racial differences grow as students progress through school (Fryer and Levitt 2006; Murnane et al. 2006; Reardon et al. 2014; von Hippel et al. 2018). One explanation for this trend could be racial bias in academic tracking and discipline that penalizes black students, even in high-achieving educational settings (Tyson 2011; Lewis-McCoy 2015; Lewis and Diamond 2015). Another, broader explanation is that black and white students attend segregated schooling contexts (Rumberger 1995; Condron 2009; Logan et al. 2012). As a result, black children are exposed to mostly- or all-black schools with higher rates of economically disadvantaged and lower achieving peers, served by teachers with less instructional experience (Mickelson 2002; Hanushek and Rivkin 2009; Reardon et al. 2019).

Beyond academic achievement, schools influence a wide range of salient transition points into adulthood, including high school degree completion and college attainment (Jennings et al. 2015; Altonji and Mansfield 2018). These outcomes are correlated with test scores because children's educational aspirations are sensitive to feedback they receive throughout their grade progression (Alexander et al. 1997). Early test scores provide information students incorporate sequentially into their decisions. Administrators, teachers, counselors, and peers may influence how students incorporate that information into their educational and extracurricular pathways (Deming 2011). We thus expect school context to affect high school graduation and college entry, even after accounting for initial SES-based achievement gaps in kindergarten.

Neighborhoods are another contextual factor long thought to shape children's educational outcomes. Children growing up in neighborhoods with concentrated disadvantage fare considerably worse on measures of academic achievement, income mobility, incarceration, and teen pregnancy (Leventhal and Brooks-Gunn 2000; Harding 2003; Sampson, Sharkey, and Raudenbush 2008; Wodtke 2013; Sharkey and Faber 2014; Alvarado 2018; Manduca and Sampson 2019). Moreover, the duration of childhood spent in these neighborhoods is proportionally related to negative life outcomes (Chetty, Hendren, and Katz 2016)—including a lower rate of high school graduation (Harding 2003; Wodtke, Harding, and Elwert 2011, 2016). Net of SES, black children are more likely than white children to populate disadvantaged neighborhoods for longer periods of time (Quillian 2003; Timberlake 2007), which may explain why recent research finds a negative relationship between metropolitan residential segregation and black educational attainment (Quillian 2014).

Given the strong correlation between local neighborhood and school characteristics, scholars are unresolved on how much each of these environmental features independently affect children's outcomes (Cook et al. 2002). One analysis proposes that schools have very little effect on test achievement after accounting for neighborhood poverty (Wodtke and Parbst 2017), while results from other studies suggest that schools—and in particular the instructional quality and peer composition of schools attended over time—play a considerable role in academic achievement (Carlson and Cowen 2015; Halpern-Manners 2016; Langenkamp and Carbonaro 2018; Reardon et al. 2019). We contribute to this debate by incorporating measures of both school and neighborhood quality throughout childhood in our evaluation of the black-white gaps—and by considering not only educational achievement, but also high school completion and college entry.

C. A longitudinal approach to childhood socioeconomic disadvantage

Prior research on the origins of black-white inequality have relied on large national surveys—such as the High School and Beyond Survey or the Educational Longitudinal Study—that include a rich cross-sectional array of family background measures, most notably parental education and employment, income, and family structure (Rumberger 1995). However, recent educational research has gravitated toward student administrative datasets because they provide annual updates on student progress and standardized test scores for a full population of students—which are valuable for evaluating school and teacher quality and have adequate sample power for analyzing the effects of state and local school district policy reforms.

The black net advantage found in previous decades has not been reproduced in studies using student administrative data. In an analysis of Massachusetts student data, for instance, Murnane (2013) showed that after accounting for the only available indicator of family income—student receipt of subsidized meals—black-white gaps in high school graduation were only partially reduced. Conclusions from Murnane (2013) suggest that net of SES status, white students still hold an advantage over black students. We do not know to what extent this deviation from the prior literature is an artifact of poor measures of SES or of changes in the dynamics of educational inequalities in the 21st century. This concern is particularly important as more research uses administrative datasets to evaluate the effect of local policies on racial and SES gaps—gaps that may be incorrectly measured by masking durational dynamics of student disadvantage (Michelmore and Dynarski 2017).

To address this measurement issue, we draw insights from poverty scholarship showing that duration is a critical aspect for consideration: children growing up in chronic versus short-term disadvantage have more negative outcomes on a wide range of educational and adult

outcomes (Guo 1998; Shuey and Wilson 2008; Ratcliffe 2015). When we ignore duration, we miss a particularly vulnerable portion of the population. Using the Panel Study of Income Dynamics (PSID), for example, Ratcliffe and McKernan (2010) estimate that while more than one-third of adults (37 percent) spent at least one childhood year living below the poverty threshold, the majority had only brief or intermittent spells, while only 10 percent were persistently poor, spending more than half of their childhood in poverty (see also Bane and Ellwood 1983).

A longitudinal measurement strategy improves upon single point-in-time estimates of SES by incorporating the cumulative impact family educational and financial resources have over extended periods of time. In Fryer and Levitt's (2006) analysis, for instance, the authors find that white students outperform black students on 3rd grade test scores by a difference of 0.34 standard deviations after accounting for a cross-sectional measure of family SES. Rothstein and Wozny (2013) reproduce these findings, but show that using a measure of permanent (multi-year average) income yields a residual black-white achievement gap of just 0.15 standard deviations. Rothstein and Wozny's (2013) findings coincide with other studies showing that single-year estimates of family income introduce measurement bias, either from income volatility (Hardy 2014) or from variation in long-term earnings slopes (Solon 1992; Mazumder 2005).

We adapt these methodological lessons to our study of student administrative data. As Michelmore and Dynarski (2017) note, a cross-sectional measure of student socioeconomic disadvantage—based on a binary indicator of federal subsidized meal receipt—conflates current with chronic disadvantage and conflates students who are not currently disadvantaged with students who never experience disadvantage. These conflation errors are consequential: the achievement gap is 40 percent wider when comparing students who were never disadvantaged throughout grade school to those who were always disadvantaged, relative to the gap when using

a cross-sectional measure of disadvantage (Michelmore and Dynarski 2017). In addition, measures of disadvantage at a single point in time fail to capture the possibility that the timing of disadvantage has heterogeneous effects. It has long been theorized, for instance, that early childhood disadvantage may have a greater impact on later life outcomes than disadvantage experienced at older ages due to the nature of children's brain development (see Carneiro and Heckman 2002; Duncan and Magnuson 2011; Duncan, Magnuson, and Votruba-Drzal 2014; Hair et al. 2015). Finally, lacking information on detailed measures of family income, a longitudinal binary indicator for subsidized meal certification may also serve as a proxy for the depth of disadvantage a child experiences throughout childhood (Michelmore and Dynarski 2017). A child who certifies for subsidized meals every year likely experiences lower *permanent* family income than a child who certifies for subsidized meals in a single year.

A trajectory approach can help differentiate between both temporal and durational components of socioeconomic disadvantage, distinguishing between experiencing disadvantage in early childhood but not later childhood and experiencing disadvantage throughout childhood. Previous research applying this trajectory approach to panel survey data has uncovered heterogeneity in high school completion according to trajectory of poverty, with chronically poor children experiencing the lowest high school completion rates (Wagmiller et al. 2006; Lee 2014). These studies reveal stark differences in poverty trajectories by race, but they do not directly evaluate the extent to which these differences account for black-white gaps in education outcomes. Further, both studies rely on national panel survey data from the PSID and NLSY 1979, which have small, nationally dispersed samples with limited information about the academic and peer context of the schools children attend.

We expect that racial group differences in exposure to chronic versus short-term spells of socioeconomic disadvantage could account for racial differences in educational outcomes through a couple of mechanisms. First, black and white students may experience different trajectories of disadvantage in ways not fully captured by point-in-time measures of family income. Failure to include measures of longitudinal disadvantage will result in omitted variable bias, whereby compositional differences in longitudinal disadvantage between black and white students will be absorbed by race indicators, mechanically over-attributing differences in black-white education outcomes to racial differences rather than differences in SES. Second, longitudinal disadvantage may be differentially associated with high school completion for disadvantaged white students and disadvantaged black students. That is, the experience of persistent or recurrent disadvantage may differ for white and black students in ways that substantially shape education outcomes.

Data and Research Design

Our study employs student administrative data from MDE that contain information on all students in the Michigan public school system since the 2002-03 school year. This data system has several advantages: it is large, containing the full population of students attending public schools in Michigan; it follows students over time so long as they remain in the state; and it is not subject to attrition or response bias, which is more common in survey data.

We proxy for family SES using certification for subsidized meals. Children certify for subsidized meals either by proving their household income is below 185 percent of the federal poverty threshold in a given month at the start of the school year or, for students who receive other means-tested benefits such as food stamps, through direct certification.[1] Usage of this measure as

[1] Beginning in 2011, students in Michigan could also become eligible for subsidized meals through the Community Eligibility Provision (CEP), which allows schools or districts to provide free meals to all students if at least 30

a proxy for socioeconomic disadvantage has been critiqued in the past due to measurement error concerns (Harwell and LeBeau 2010). However, Domina et al. (2018) show that subsidized meal certification has more predictive power for measuring student achievement than an income-based measure of poverty from tax return data.

A key advantage of the MDE data over national survey data is that they allow us to identify and account for variation in the academic and peer composition of the schools that children attend—both at a point in time, as well as over time. We combine this information with characteristics of the neighborhoods where students lived by merging tract-level Census and American Community Survey data produced by the National Historical Geographic Information System (Manson et al. 2018) to geocoded student home addresses from Kindergarten through 8th grade. Thus, our analysis simultaneously incorporates longitudinal information on family, school, and neighborhood context.

We restrict our sample to black and white 8th graders who turned age five by October 1st of the 2002-03 and 2003-04 school years. Very few students drop out prior to completing 8th grade[2], allowing us to capture the full population of public school students at the point just before some begin to select out of additional education. In so doing, we reduce the threat of positive selection in the various educational outcomes outlined below. Given our focus on comparability of point-in-time versus longitudinal contextual measures, we retain students with all nine consecutive years of data in Kindergarten through 8th grade—a 20 percent reduction in sample size.[3] This decision does not influence the general conclusions of the analysis, but allows us to develop several

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percent of their student body was directly certified for subsidized meals. For this reason, we focus our analysis on cohorts who completed 8th grade before or just at the beginning of this policy change.

[2] Beginning in 2010, the state of Michigan allowed students to legally drop out at age 16 only with parent or guardian permission (McGrath 2010).

[3] Students do not have to make timely progress over these nine years, so long as they are observed in a public school in each of the nine years.

specifications of the timing and duration of disadvantage for a balanced panel of students.[4] We also exclude students missing demographic information or school information in 8th grade, which represents less than 1 percent of the longitudinal sample. Accounting for these restrictions, our analytical sample includes 133,170 white and black students from the two cohorts.

We evaluate black-white gaps in several educational outcomes of interest. For simplicity, our main analysis uses high school graduation as the outcome of interest. We then illustrate the robustness of these findings to several other important education outcomes: 8th and 11th grade standardized math test scores, persistence to 11th grade, college enrollment, and 4-year college enrollment. We measure high school graduation within five years of completing 8th grade to avoid excluding students who repeat a grade, and to align with standard practices in other studies of high school graduation (Heckman and LaFontaine 2010).[5] Based on our sample and definition, we estimate a five-year high school graduation rate of 85 percent, and we find large disparities by race—88 percent of white students graduate, compared to 75 percent of black students.[6]

Our analysis unfolds in three stages. First, we evaluate racial differences in socioeconomic disadvantage using a growth-based trajectory model (GBTM) analysis (Jones and Nagin 2013). This data-driven approach groups students according to the timing and duration of their certification for federally subsidized lunch between kindergarten and eighth grade. The second stage of the study incorporates these disadvantage trajectories into a formal regression and

[4] In robustness checks, we relax this sample restriction to include any student who ever attended a Michigan public school in the years our cohorts attended first through eighth grade, and re-calculate the trajectories of disadvantage using the growth-based trajectory models discussed below. Results are substantively similar.

[5] We consider a student to have graduated from high school if they do so in the expected year of graduation based on their 8th grade school year, or one year following expected high school graduation. Very few students take six or more years to complete high school. Conclusions did not change when we alternatively analyzed four-year graduation rates, though the rates were lower. Students earning a GED are not included in our measure.

[6] We estimate a four-year graduation rate of 76.5 in Michigan, similar to state-level rates reported in Balfanz et al. (2010) and slightly higher than their reported national average of 75 percent. Graduation rates grew slightly in Michigan during the 2000s, but at a lower rate than the average state.

decomposition analysis of the black-white gap in high school degree attainment. Finally, we test the robustness of our main findings to several other important education outcomes. In an online appendix, we also present results from alternative longitudinal specifications of family socioeconomic disadvantage, where we find that all models that incorporate measures of the duration of socioeconomic disadvantage experienced throughout childhood improve upon cross-sectional measures of disadvantage.

Part I. Analyzing racial differences in socioeconomic disadvantage

A. Measuring socioeconomic disadvantage

Across nine years of observations, there are 512 mathematically unique sequences of student subsidized meal eligibility. Although we observe nearly all (501) of these sequences in the Michigan data, most students can be grouped together into categories of recognizable patterns, which we define as trajectories of student disadvantage. Following advice on best practices (Warren et al. 2015), we make judgments about how to categorically classify student experience by drawing from both empirical and theoretical insights, and we test for potential bias in our substantive conclusions.

To arrive at the preferred specification, we run a series of growth based trajectory models (GBTM) with 3, 4, 5, 6, or 7 trajectory categories.[7] The model fit statistics for each trajectory classification are reported in Appendix Table 1.[8] We highlight the 5-category model here due to its model fit and because it differentiates students who transition into disadvantage in early

[7] We use the "traj" command in Stata developed by Jones and Nagin (2013). We chose our preferred model by comparing fit statistics and selecting on efficiency (a lower BIC score), clear differentiation between categories (a higher entropy score), and utility (no fewer than 5 percent of the sample in a category) (Wagmiller et al. 2006; Warren et al. 2015).

[8] We also used latent curve analysis (LCA) and latent growth curve analysis (LCGA) methods to define trajectories, but found they were less likely to converge across nine years of data and, when they did converge, did not produce a clear theoretical advantage over the categorical groupings from the GBTM models.

childhood versus late childhood, which we think is important given the large literature on the effects of poverty in early childhood (e.g. Duncan et al. 1998; Hair et al. 2015). Figure 1 presents a trajectory plot for these five categories, a stylized representation of the common patterns of socioeconomic disadvantage experienced by students in Michigan.[9] The 5-category model clearly defines a group of students who persistently received subsidized meals (approximately 30 percent of the sample), and a group of students who persistently did not receive subsidized meals (approximately 45 percent of the sample) throughout grade school. Remaining students spent some, but not all years receiving subsidized meals. In the 5-category model, we characterize these students as early transitioners (7 percent of the sample), late transitioners (7 percent of the sample), and recurrent recipients (11 percent of the sample).

[Figure 1 about here]

Figure 2 presents a sequence plot of subsidized meal claiming among students in each of these categories.[10] Among students in the never disadvantaged category, the majority never certify for subsidized meals, while a minority spend one year receiving subsidized meals.[11] On average, these students certify for subsidized meals in 0.10 out of 9 years. In contrast, among students in the persistently disadvantaged category, the majority certify for subsidized meals in every year. On average, students in the persistent disadvantage category spend 8.6 of their 9 years certifying for subsidized meals. Notably, for both of these categories, the GBTM modeling includes students who do not cleanly fit into the "never" and "always" categorizations, but spend the vast majority of their years either certifying or not certifying. Our conclusions are substantively similar when

[9] The 4-category GBTM model had similar fit statistics; a corresponding trajectory plot for the 4-category GBTM model is presented in Appendix Figure 1.
[10] A corresponding sequence plot for the 4-category GBTM model is presented in Appendix Figure 2.
[11] For simplicity, we refer to these students as "never" disadvantaged, although some students do, in fact, experience disadvantage in one of the nine years observed.

we generate our own categorization in which student disadvantage never changes in the "never" and "always" categories, though the GBTM 5-category model has better fit statistics and better predictive power (see Appendix Table 2).

[Figure 2 about here]

Students in the remaining three categories spend some, but not all years receiving subsidized meals. Both late transitioners and early transitioners have similar patterns in that they are not eligible for subsidized meals initially, but become eligible at some point in elementary school, and for the most part remain eligible through the ninth year of data. The main difference between the early and late transitioners is *when* they become eligible, which also leads to large differences in the total number of years receiving subsidized meals. Early transitioners spend about 6 years receiving subsidized meals, while late transitioners certify for subsidized meals for about 3 of the 9 years.

The final category, students who recurrently certify for subsidized meals, is comprised of a heterogeneous group. About half of the students in this category were initially certified for subsidized meals in the first year, but became ineligible in a later year; while the other half of the group was not initially certified for subsidized meals, but became eligible in a subsequent year. In contrast to the early and late transitioners, many students in the recurrent category have years in the middle grades where they do not certify for subsidized meals, but many of them become certified again later. One key unifying characteristic of these students is that they appear to have relatively volatile patterns of subsidized meal claiming over the course of grade school.[12] In total,

[12] One limitation the trajectory approach cannot overcome is distinguishing between those children experiencing large swings in family income from those who experience minor fluctuations above or below the 185 percent poverty threshold—an issue we explore in the appendix.

students in the recurrently disadvantaged trajectory certify for subsidized meals for about 5 of the 9 years.

The trajectory specification shown in Figures 1 and 2 is similar to those from prior work on trajectories of disadvantage, with one exception. Using longitudinal data from national samples, Lee (2014) and Wagmiller et al. (2006) find a subset of children who transition out of poverty during childhood. A "transition off" category did not clearly emerge in Michigan using the 5-category GBTM model. There are very few students who experience a transition off, and they are mostly in the recurrent trajectory category. One explanation for the infrequency of transitions off may be that subsidized meal certification can trigger based on one month of low family income, rather than annual income that may be less sensitive to temporary downturns. In addition, subsidized meal eligibility has a higher income threshold than poverty, inclusive of many families who may earn income above the 100 percent poverty line but never above the 185 percent mark. In an online appendix, we investigate this issue with a validity check using the PSID. We find that the distribution of disadvantage across a wide range of variables—income, wealth, debt, parental education, unemployment, marital status, family size, and homeownership—corresponds to the categories of disadvantage we forefront in our main analysis. We also replicated our analysis using an entirely theory-driven definition of trajectories—a five-category specification that includes a "transition off" category—and found that it did not change our overall conclusions but produced inferior fit statistics.[13]

Table 1 presents a descriptive portrait of Michigan student characteristics for each trajectory category. Never disadvantaged students clearly stand out from their less-advantaged peers: they score .41 standard deviations above the statewide average on 8th grade math tests, they

[13] Sequence plots from the theory-driven specification are provided in Appendix Figure 3.

have a 94 percent five-year graduation rate, nearly 80 percent of them enroll in college within 2 years of expected high school completion date, and about half attend a 4-year institution within 2 years of expected high school completion date.

[Table 1 about here]

Never disadvantaged students also attend schools where the vast majority of their peers are white and the average student scores 0.20 standard deviations above the statewide average. Approximately one-third of their peers receive subsidized meals, and only 17 percent of their peers were persistently disadvantaged throughout grade school. Never disadvantaged students rarely attend a low performing school (3 percent of their years), as measured by the fraction of years they attend a school ranked in the bottom quintile of test scores statewide. They also reside in neighborhoods with low rates of poverty and unemployment, and high shares of adults with college degrees and working in professional occupations. The median income in their census tract is about $65,000.[14]

In contrast, persistently disadvantaged students perform nearly half of a standard deviation below the statewide average, and 0.86 standard deviations below their never-disadvantaged peers. Less than three-quarters finish high school within five years of starting, and only 16 percent enroll in a 4-year institution within two years of their expected high school completion date. They also attend schools disproportionately in urban areas, with high concentrations of students of color, and where their average peer scores 0.25 standard deviations below the statewide average.

[14] Neighborhood controls come from 2010 Census and 2008-2012 ACS measures. We selected a range of variables considered by the neighborhood effects literature to associate with concentrated disadvantage (Sampson, Sharkey, and Raudenbush 2008) in addition to median income. Cross-sectional measures are reported in 8th grade. We measure the fraction of years spent in bottom-quintile-disadvantage census tract by using principal component analysis to construct an index of advantage each year. The bottom quintile of the distribution is measured relative to all Michigan tracts. We do not use time-varying neighborhood data, so variation within students over time in this measure is contingent on residential mobility. On average, there are 58 students in our sample from each census tract.

Approximately two-thirds of their peers receive subsidized meals, and nearly half of their peers are persistently disadvantaged—almost three times the exposure to persistently disadvantaged peers as never-disadvantaged students. Neighborhood poverty rates are more than double those of never-disadvantaged students, and median income is $40,000.

Students in the other three categories fall somewhere between the never disadvantaged and the persistently disadvantaged. Late transitioners exhibit school and neighborhood characteristics most closely aligned with never-disadvantaged students, while the early and recurrent transitioners appear more similar to the persistently disadvantaged.

Overall, this descriptive evidence lends conceptual validity to our five-trajectory categorization of disadvantage. Children who fall into the never disadvantaged category are distinctly advantaged compared to students with any experience of disadvantage. On the other hand, the persistently disadvantaged students also stand out in their experiences compared not only to the never disadvantaged, but also compared to their peers who experience more intermittent spells of disadvantage.

B. Race and socioeconomic disadvantage

We next turn to a descriptive analysis of black and white gaps in educational outcomes and in contextual disadvantage. Table 2 summarizes educational outcomes overall and by race, revealing an observed white advantage across every measure of achievement (8^{th} and 11^{th} grade test scores) and attainment, including 11^{th} grade persistence, high school completion, and college entry. Table 2 also shows that close to 80 percent of black students received subsidized lunch in 8^{th} grade, compared to just 37 percent of white students. Black children are also more likely than white children to attend urban and predominantly black schools with a higher proportion of

economically disadvantaged and underperforming classmates–and they live in neighborhoods with higher rates of poverty, unemployment and public assistance, lower educational attainment, and a lower median income than the average white student.

[Table 2 about here]

The cross-sectional comparison of individual disadvantage conceals an important longitudinal difference between black and white student experiences. We calculate, for instance, a 2.15 ratio of black to white socioeconomic disadvantage using subsidized meal receipt in 8th grade. Adopting the 5-category trajectory model defined above, however, we find that nearly 60 percent of black students fall into the persistently disadvantaged category, compared to less than 20 percent of white students—a 3.24 ratio of black to white *persistent* disadvantage. We also find that black students are far less likely to never experience disadvantage (12 percent compared to more than 50 percent of white students), and that they are more likely to be recurrently disadvantaged (16 percent compared to 9 percent of white students). Similar shares of black and white students transition into disadvantage at an early age (7-9 percent), and white students are slightly more likely to transition into disadvantage later in childhood (8 percent) compared to black students (5 percent).

Taking a longitudinal approach to measuring socioeconomic disadvantage also reveals stark differences in schooling experiences, both by race and socioeconomic disadvantage. In Table 3, we present school peer context in a cross tabulation of individual student trajectories (row) by race (columns). The first row indicates that white, never-disadvantaged students attend schools with 17 percent persistently disadvantaged peers, 60 percent never disadvantaged peers, and an average 8th grade math score of .21 standard deviations above the statewide average. Reading down the rows (within the column for white students), we see a gradient in which persistently-

disadvantaged students attend schools with roughly twice as many persistently disadvantaged peers—and they attend schools performing 0.20 standard deviations lower in math achievement—than never-disadvantaged students.

[Table 3 about here]

Table 3 also illustrates stark differences by race. Never-disadvantaged black students, for instance, attend schools with 30 percent exposure to persistently-disadvantaged peers, compared to 17 percent exposure among never-disadvantaged white students. These patterns are consistent with Pattillo (1999), who showed that middle- -income black families are disproportionately exposed to contextual poverty due to institutionalized and informal dynamics of racial residential segregation.

Part II. Contextual origins of the black-white high school attainment gap

We next incorporate longitudinal measures of socioeconomic disadvantage to evaluate black-white gaps in high school completion. We present a series of results from logistic regression models and decomposition analyses before extending our analysis to a wider range of educational outcomes. For comparison, we provide results using both the 5-category trajectory of disadvantage scheme defined above as well as the more common point-in-time approach, which uses a single year of subsidized meal certification (8^{th} grade) to proxy for socioeconomic disadvantage.

A. How does family, school, and neighborhood context account for the black-white high school attainment gap?

We begin with a logistic regression analysis evaluating the relationship between family socioeconomic disadvantage and high school completion. In sequential models, we control for

demographic (gender, Michigan nativity and migrant status), school (percent receiving subsidized meals; proportion of peers persistently disadvantaged; proportion white, pupil-teacher ratio, 8th grade average math test scores, excluding the focal student), and neighborhood (poverty rate, unemployment rate, proportion on welfare, proportion female-headed household, proportion with less than a high school diploma, percent with a college degree, proportion in professional occupations, proportion under 18, median household income) characteristics. Importantly, to account for duration of exposure to contextual disadvantage, we also include a measure for the fraction of years between Kindergarten and 8th grade that students attended low-performing schools (with peer performance in the bottom quintile of the state) and a similar measure for the fraction of years students lived in a highly disadvantaged census tract.[15]

Table 4 presents selected marginal effect coefficients from the logistic regression models (each panel-column represents a separate regression) for black and white students separately. Panel A contains models using 8th grade subsidized meal certification to proxy for disadvantage, while Panel B uses the five trajectories of disadvantage.

[Table 4 about here]

We find large gaps in high school completion by trajectory of disadvantage for both black and white students in our baseline model. The trajectories of disadvantage imply that persistently-disadvantaged students are more than 20 percentage points less likely to complete high school compared to their never-disadvantaged peers. We also find statistically significant differences *within* the population of students who are ever disadvantaged for both black and white students. Persistently disadvantaged students are significantly less likely to complete high school within five years than any of their other ever-disadvantaged peers, whose high school completion is between

[15] Tables 1 and 2 summarize these variables, which we describe with greater detail in an online appendix.

4 and 15 percentage points lower than their never-disadvantaged peers. The cross-sectional specification, in contrast, conceals variation among all students observed receiving subsidized meals in 8th grade. Black and white students who were disadvantaged in 8th grade were 15-16 percentage points less likely to complete high school within five years compared to students who were not disadvantaged in 8th grade; the gap between the persistently and never disadvantaged is about 30 percent wider among white students, and 45 percent wider for black students.

Adding controls for other demographic characteristics in Model 2 of Table 4 does little to reduce gaps by socioeconomic disadvantage in high school completion. Controlling for school characteristics (Model 3) reduces the never versus persistent disadvantage gap in high school completion for both black and white students, but gaps between other disadvantaged groups and never-disadvantaged students remain relatively unchanged for white students, and marginally reduced for black students. Finally, the addition of neighborhood characteristics in Model 4 does little to change gaps in high school completion between ever-disadvantaged and never-disadvantaged students, most likely due to a correlation between school and neighborhood characteristics.[16]

Model 5 includes additional controls for 8th grade achievement, school mobility, and residential mobility. The number of school switches between kindergarten and eighth grade, as well as the number of residential moves (i.e. observed changes in student census block), may also mediate the relationship between disadvantage and high school attainment, as school disruptions have been shown to negatively affect student achievement, particularly among black and Hispanic

[16] Models including neighborhood but not school characteristics (not shown) have less explanatory value than those presented in Model 3, implying that schools play a larger role than neighborhoods in high school completion (which we explore further below). Results are substantively similar with a linear probability specification (see Appendix Table 3) and with estimates that include school and neighborhood fixed effects, rather than controls for school and neighborhood characteristics.

students (Xu, Hannaway, and D'Souza 2009). Indeed, adding these controls significantly reduces gaps in high school attainment across the four categories of disadvantage, with more pronounced reductions among the persistently disadvantaged, where the gap shrinks to about half of its magnitude in the unconditional models for both black and white students. However, even with the full range of controls, the gap between the persistently and never disadvantaged remains about 30 percent wider than the cross-sectional gap among white students, and more than 70 percent wider than the cross-sectional gap among black students. Thus, including a wide range of controls measured in 8th grade does not replace the value added to the models by measuring student socioeconomic disadvantage longitudinally.

Figure 3 illustrates how the black-white gap is affected by a trajectory approach to measuring disadvantage compared to a point-in-time approach, and whether differences are mitigated by the inclusion of demographic, school, and neighborhood characteristics.

[Figure 3 about here]

The top row of Figure 3 depicts the total black-white gap when no other covariates are included (this is effectively a difference of means), which is approximately a 13-percentage point gap in 5-year high school completion between black and white students. The second row, corresponding to Model 1 from Table 4, shows that simply controlling for student disadvantage shrinks the black-white gap considerably. Using the 8th grade cross-sectional measure, the gap is cut roughly in half; using the trajectory approach, the gap is reduced to only one quarter of the unconditioned gap. The inclusion of additional student demographic information has no additive effect on the estimated black-white gap. However, we see in the fourth and fifth rows that, by accounting for differences in the schools attended by white and black students and the neighborhoods in which students reside, the black-white high school attainment gap reduces to

nearly negligible levels. In the trajectory approach, the black-white gap is reversed, revealing that black students are marginally *more* likely to complete high school relative to their white peers, after controlling for differences in trajectory of disadvantage, school, and neighborhood characteristics.

The sixth row in Figure 3 reveals that adding controls for student mobility and 8th grade test score achievement further widens the net black advantage in high school graduation, up to nearly 4 percentage points over white students. Test scores and mobility are often conceptualized as the primary outcome of interest in studies of family SES, schools, and neighborhoods, so we interpret these models with caution. That is, test scores and mobility may be mediators through which contextual factors influence high school graduation. Indeed, coefficients for disadvantage presented in Table 4 decline between Models 4 and 5 with the inclusion of these controls, implying that part of the correlation between family background and high school graduation is channeled through academic achievement and mobility. Controlling for racial group differences in these additional dimensions complicates how we delineate between family SES, school, and neighborhood effects on the black-white graduation gap—an issue we discuss further below.

We highlight two critical conclusions emerging from Figure 3. First, using a trajectory measure of disadvantage rather than a cross-sectional measure carries substantial, statistically significant, and theoretically important consequences for conclusions about black-white gaps in high school attainment. Typical analyses ignoring student longitudinal disadvantage *underestimate* the role of socioeconomic background on educational attainment, and *overestimate* other differences associated with student race. Second, and relatedly, we see that the two primary dimensions through which racial inequality is expressed is through racial differences in trajectory

membership (i.e., black students have much higher proportions in the persistently-disadvantaged category; see Table 2) and through the types of schools that students attend.

B. Decomposition of the black-white gap in high school completion

The sequentially nested models presented in Table 4 and Figure 3 reveal total net explanatory power, but they are not well suited for quantifying the relative importance that families, schools, and neighborhoods have on black-white inequality. We next present a Fairlie (2005) decomposition of our regression results. Intuitively, this approach quantifies the difference between the observed gap and what we would observe if, for instance, the average black student attended schools with the same characteristics as the average white student. In practice, this exercise is performed for all covariates from a given model simultaneously, allowing us to compare how much of the racial gap is explained by mean racial group differences in family, demographic, school, and neighborhood characteristics (often referred to as the "explained" portion of the gap).[17]

[Table 5 about here]

Results, presented in Table 5, illustrate the strength of a trajectory approach to measuring disadvantage. In Model 1, receiving subsidized meals in 8th grade explains 57 percent of the black-white gap in high school completion. Using the trajectory approach instead of the point-in-time approach increases the share explained to 77 percent. Differences in the share of black and white students that are persistently versus never disadvantaged alone explains 88 percent of the gap in high school completion among black and white students in Michigan.[18]

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[17] The Fairlie decomposition also allows us to observe the effects of racial heterogeneity in effects (i.e. black-white differences in regression coefficients from models estimated in Table 4). Differences in coefficients explained only about 7 percent of the black-white gap overall, while the compositional differences we present in Table 5 explain over 100 percent of the gap.

[18] The total explanatory contribution of trajectory categories in Table 5 is the sum of all reported positive and negative values—which accounts for the contribution of black-white compositional differences to the black-white

Demographic characteristics add little to our understanding of black-white gaps in high school completion, but school and neighborhood characteristics do explain a sizeable remainder of the gap.[19] There are competing arguments about the relative importance of schools compared to neighborhoods in educational outcomes (Carlson and Cowen 2015; Wodtke and Parbst 2017), and Table 5 provides two new pieces of evidence for consideration. First, our conclusions about the relative importance of school and neighborhood characteristics on high school graduation depend on our measure of family disadvantage. In the cross-sectional specification, Model 4 estimates that schools and neighborhoods account for 51 percent and 7 percent of the black-white graduation gap, respectively. In contrast, the trajectory of disadvantage approach—which explains a greater share of the total gap—estimates that schools and neighborhoods account for 40 and 3 percent of the black-white graduation gap. Aside from the issue of sensitivity to measurement of family socioeconomic disadvantage, we find it particularly remarkable that schools account for a substantially higher share of the graduation gap than neighborhoods, even though we include a rich vector of neighborhood characteristics in 8th grade and a measure of the fraction of years children spent in highly-disadvantaged tracts since Kindergarten. Our sensitivity tests using school and neighborhood fixed effects (Appendix Table 3) reveal that even after accounting for unobserved time-invariant characteristics not measured in Table 5 (such as average crime level, environmental hazard, or social disorder), schools continue to explain more of the black-white graduation gap. This evidence suggests that schools may be the primary mechanism through which neighborhood effects influence educational outcomes, given the fact that where students live so

graduation gap. In Model 1 of the trajectory model, for instance, these values sum to .770. In Model 4, values for the trajectory categories sum to .626. A similar summation can be used to describe the total contribution of school characteristics. For brevity, we report only this summed share for neighborhood characteristics (full results available by request).

[19] All school-level measures apply a "leave one out" rule in which the focal student's characteristics are excluded from the school average. This choice turns out to be inconsequential to the results presented, but is nonetheless conceptually important.

closely influence the schools they attend. This finding warrants additional attention that is better suited to tease out the influence of selection as well as the cross-distribution of students from similar neighborhoods attending different schools (and vice versa).

Another insight to emerge from Table 5 is the extent to which the relationship between family socioeconomic disadvantage on high school graduation gaps is channeled through selection into neighborhoods and schools. Once again, how this is measured depends on whether we incorporate longitudinal information about student subsidized meal receipt. In the trajectory model specification, the share of the black-white gap explained by disadvantage (Model 1) reduces from 77 percent to 63 percent once neighborhood and school characteristics are included (Model 4). We interpret the 14 percentage point reduction as an indirect school and neighborhood selection effect, whereby family SES shapes children's contextual exposure, which in turn affects their likelihood of completing high school. The remaining explanatory power of schools and neighborhoods implies a direct correlation between these contexts and the black-white gap, net of family SES.

Model 5 presents results from a comprehensive model including controls for 8th grade test scores and student mobility. Black-white differences in these characteristics combined account for half of the racial gap in graduation. However, we argue that as mediators, the inclusion of these variables is most valuable for understanding how they change the estimated relative influence of the other contextual variables included in Model 4. Comparing values from Model 4 and Model 5 in the trajectory of disadvantage column, for example, reveals that 43 percent of the black-white graduation gap is directly related to black and white differences in trajectory of disadvantage, compared to 63 percent in the absence of these controls. Subtracting these two values, we estimate that about 20 percent of the black-white gap comes from the indirect role family resources play in student mobility and test scores. A similar exercise reveals that about two thirds of the school

effect in Model 4 operates through its relationship to mobility and test scores. Neighborhood effects appear to operate entirely through these mechanisms. Nonetheless, we note that even after controlling for individual student mobility and achievement, there remains an important distinction between cross-sectional and trajectory-based measures of disadvantage. The partial (direct) correlation of family background using simple 8th grade scores explains just 31 percent of the black-white gap, hiding the explanatory power of persistently disadvantaged students—which directly explains 43 percent of the black-white gap.

C. Are conclusions sensitive to longitudinal specifications of disadvantage?

The advantage of the trajectory approach is that it incorporates longitudinal information about family socioeconomic background—consistent with a "permanent income" measurement approach that avoids sensitivity to point-in-time household volatility. This approach also raises questions about whether the conclusions are sensitive to alternative specifications of longitudinal disadvantage. We explore this issue in the appendix, and find that across seven alternative specifications (comparable to Model 4 in Table 5), longitudinal measures of disadvantage account for between 105 and 106.9 percent of the black-white graduation gap, while a cross-sectional approach accounts for 102.4 percent of the gap (see Appendix Table 4). Across the longitudinal models, school characteristics explain 35 to 42 percent of the gap, and neighborhood characteristics explain between 0 and 3 percent of the gap. Thus, conclusions about the black-white gap and about the relative share explained by differences in school and neighborhood characteristics are generally similar. Moreover, all of the longitudinal specifications produce better fit statistics than the cross-sectional approach, providing further evidence that incorporating all nine years of data improves measurement.

The model with the best fit was one that specified disadvantage in a non-parametric way (a set of indicators for disadvantage for one to nine years), suggesting that accounting for the duration of disadvantage is of utmost importance in explaining black-white gaps in high school attainment. After controlling for the duration of disadvantage, we found little evidence of variation in the effect of timing of disadvantage, but these data may not be well-suited to answer this question, since few of our students transition off of disadvantage once they become disadvantaged.

Part III. Assessing black-white gaps in other education outcomes

In this final section, we test whether our findings extend to black-white gaps in other critical education outcomes. We measure 11^{th} grade persistence—an intermediary step preceding graduation—using a binary measure of whether a student is observed in 11^{th} grade within three years of enrolling in 9^{th} grade for the first time. The MDE dataset also includes linkages to the National Student Clearinghouse, a repository of college enrollment information allowing us to evaluate 1) whether students enroll in any college, and 2) whether students enroll in a four-year college or university within 2 years of their expected (4-year) high school completion. Finally, we also examine 8^{th} (for our full population sample) and 11^{th} (for the subset of sample children who persist through spring of their 11^{th} grade year) grade standardized test scores.

In Table 6, we present results from decomposition analyses, similar to those presented in Table 5. Each row of Table 6 represents a separate decomposition exercise. Column 1 indicates the total black-white gap for each outcome, column 2 indicates the share of that gap explained by socioeconomic disadvantage (either cross-sectional or longitudinal), columns 3 through 5 indicate the share explained by student, school, and neighborhood characteristics, respectively, and the final column indicates the total share of the gap explained by the covariates. For this analysis, we

use Model 4 from Table 5, which excludes student mobility and achievement. For each outcome, we conduct separate decompositions using the cross-sectional measure of disadvantage and the trajectories of disadvantage.

[Table 6 about here]

Across all of the outcomes we examined, we find a very consistent pattern: trajectories of disadvantage explain a larger share of the black-white gap than the cross-sectional measures of disadvantage. Though the actual share of the gap explained varies by outcome, we find remarkably consistent evidence that trajectories of disadvantage explain about 40-50 percent more of the variation in the outcome of interest than a point-in-time measure alone. The added share of the gap explained by trajectories of disadvantage typically only results in a small increase in the total share of the gap explained by all covariates. This is because adding longitudinal measures of disadvantage results in a reduction of the share of the gap explained by school and neighborhood characteristics.

For both 8th and 11th grade math test scores, we find that black students score, on average, about three-quarters of a standard deviation below their white peers. In contrast to the attainment outcomes we examine, the decomposition exercise indicates we can explain only about 50-60 percent of the total black-white achievement gap in either the cross-sectional or longitudinal models of disadvantage. Still, we find that the longitudinal measures of disadvantage explain about 50 percent more of the variation in test scores than the cross-sectional measure alone, and this increase is generally paired with a decline in the share of the gap explained by school or neighborhood characteristics.

In contrast, the estimation models more than explain the black-white gap in persistence to 11th grade, high school completion, college enrollment, and 4-year college enrollment by family

SES, student, school, and neighborhood characteristics. Similar to our main results for high school graduation, for each of the other attainment outcomes we also find that longitudinal measures of disadvantage explain a much larger share of the black-white gap than a cross-sectional measure alone.

This exercise indicates that using longitudinal measures of disadvantage out-perform cross-sectional measures on a wide variety of outcomes, which has broad implications for measuring socioeconomic and racial gaps in educational outcomes using administrative data. Furthermore, Table 6 demonstrates that the "net black advantage" found in high school graduation represents a broader trend of black disadvantage in educational attainment—corresponding to scholarship from previous decades that until now has not been documented in the 21st century. Within each educational attainment variable, we find that the relative importance of socioeconomic disadvantage is greatest in predicting racial differences in college enrollment, which is plausible given the cost burden to accessing higher education that many parents help children navigate. In contrast, schools and neighborhoods provide more explanatory power to black-white gaps in 11th grade persistence than to any other category, suggesting possibly that early high school dropout is especially vulnerable to institutional and peer influences that play less of a role in other educational choices.

Discussion

Our analysis of student administrative data in Michigan reveals a stark divide in the social origins of black and white children coming of age in the beginning of the 21st century—and the toll this divide takes on educational inequality. In fact, we demonstrate that were black and white children to have equal experiences of family socioeconomic disadvantage, school context, and

neighborhood characteristics, black students would graduate high school and attend college at *higher* rates than white students. Achievement gaps by race would still persist, but would shrink to half of their current levels. In short, black-white educational inequality is reproduced by profound differences in the contextual (dis)advantages black and white children inherit.

We also show that systemic differences in the types of schools black and white children attend—net of their socioeconomic disadvantage—accounts for much more of observed racial inequality than the neighborhoods where children live. Given substantial attention to the importance of neighborhoods in the stratification literature—including a recent study suggesting that schools contribute very little, net of neighborhood disadvantage (Wodtke and Parbst 2017), we consider this to be an important and surprising finding. School and neighborhood contexts are no doubt correlated (Carlson and Cowen 2015), but our results suggest that when school context is measured thoroughly to include peer academic achievement and nuanced measures of student disadvantage, it may account for a large share of what is typically labeled neighborhood effects. This finding holds even with a wide range of census variables measuring neighborhood disadvantage in detail in 8th grade along with a long-term measure of student disadvantage from Kindergarten through 8th grade. Alternative fixed-effects specifications absorbing all school and neighborhood time-invariant characteristics in 8th grade lead to the same conclusion about the greater importance of school characteristics.

The insights from our study emerge in part because we leverage the *longitudinal* strengths of student administrative data to capture nine years of student socioeconomic disadvantage, school context, and neighborhood context. This contribution of the study—an improvement in measurement—is one we hope scholars will widely adopt. We demonstrate that using longitudinal information about student subsidized meal receipt yields valuable explanatory power. In baseline

models, for instance, we show that a cross-sectional measure of subsidized meal receipt in 8th grade accounts for 57 percent of the black-white high school graduation gap, compared to 77 percent when measuring student subsidized meal receipt across all years since kindergarten. This insight not only influences our conclusions about racial educational inequality, but also changes how we interpret the importance of schools and neighborhoods in more elaborate statistical models.

Our argument echoes the call for measuring permanent income in the stratification literature, even when educational administrative data provides only binary annual measures of student status. We recommend that users of student administrative data take full advantage of each student's personal history of subsidized meal eligibility. Here, we highlighted a trajectory analysis for its conceptual use in our study, but found that even an interval measure of the fraction of years observed receiving subsidized meals performed much better than a cross-sectional measure of meal receipt in 8th grade—and can be defined using simpler methodological tools.

In addition to the three main findings highlighted above, our study also uncovers a number of insights that we hope scholars will explore in contexts beyond Michigan. We show, for instance, that more than half of white students in Michigan public schools will never certify for subsidized meals between kindergarten and 8th grade, a pattern experienced by only one in ten black children. In contrast, while only one in five white children will consistently certify for subsidized meals between kindergarten and 8th grade, more than half of black children are persistently disadvantaged throughout childhood. We also showed that differences in trajectories of disadvantage between black and white students correlate with large differences in the types of schools that disadvantaged and non-disadvantaged students attend, as well as the neighborhoods in which they grow up. Relative to the average white student in the state, black students attend schools with three times as many always disadvantaged peers, and where their peers score one-half of a standard deviation

below the peers of white students on 8th grade standardized math tests. These gaps remain when comparing by race within trajectory. Within each trajectory of disadvantage, black students attend schools with, on average, twice as many always disadvantaged peers as comparable white students.

Notably, our decomposition analysis reveals that differences in trajectories of family socioeconomic disadvantage between black and white students is the most salient explanatory factor for gaps in every educational outcome in our study, yet this effect is only partially mediated by schools and neighborhoods. Including measures of these secondary contexts as controls reduces the share of the black-white high school graduation gap explained by socioeconomic disadvantage from 77 percent to 63 percent. Thus, family background play a strong role in student outcomes beyond the ability to buy into high performing schools and neighborhoods, adding to evidence that resources and selectivity are only a small aspect of inter-generational investment.

Despite the fact that longitudinal measures of disadvantage alone explain most of the black-white graduation and college entry gaps, we are careful here not to conclude that our findings settle the debate of which matters more, "race versus class." The dramatic racial differences in SES background shown in our study reflect a historical consequence of anti-black exclusion (and pro-white inclusion) in both state-sanctioned institutional practices and the informal social processes of daily life. It is therefore particularly striking that accounting for family, school, and neighborhood more than erases black-white gaps in educational attainment. Translating this statistical exercise into efficacious social policy, however, would require a major intervention. Where to begin? Our finding that the relative importance of racial differences in the schools children attend, independent of student trajectories of socioeconomic disadvantage, lends support to an array of policies aiming to integrate schools. Bussing and magnet school programs are still used (though this has become less frequent), and there may be promise in the adoption of

neighborhood-based or income-based integration programs (Carlson et al. 2019) or in the insistence on racial balance in charter school enrollment (Potter and Quick 2018). These strategies may also need to attend to inequality-generating mechanisms within integrated schools (Lewis and Diamond 2016).

A housing or place-based approach to addressing black-white educational inequality may also be effective, in part because neighborhood and school conditions are so closely related. However, evaluating the trade-offs between a focus on schools versus neighborhoods requires additional scholarship. While our study admittedly lacks a strong causal identification method, the fact that our decomposition revealed an overpowering importance of schools over neighborhoods across all educational outcomes suggests that the relevance of schools cannot be easily dismissed. Additional work analyzing the relative effects of neighborhoods versus schools should, at the very least, adopt more robust measures of school peer composition, test performance, and institutional environment.

Our study is not without other limitations. Because it is the only measure available, we rely on subsidized meal certification as a single proxy for family SES known to be imprecise (Harwell and LeBeau 2010). Ancillary analyses for a subset of PSID children with records of federal lunch receipt suggests there is some mismatch between claiming of subsidized meals and reported annual family income, with about 14 percent of students receiving subsidized meals when their family income is above the income threshold for the program, and an additional 8 percent of low-income individuals not reporting receipt of subsidized meals (see Appendix Table 5). This mismatch is likely present in the Michigan data as well, though without income information to validate, we do not know the exact magnitude of this concern. This issue is further complicated by the fact that subsidized meal certification is based on a month of family income, while many surveys (including

the PSID) evaluate income on an annual basis. Still, recent research has also found that subsidized meal certification provides predictive power in understanding student achievement, and thus should not be treated as uninformative (Domina et al. 2018).

Barring concerns over the validity of the subsidized meal measure, we cannot causally link trajectories of disadvantage with educational outcomes. That is, we cannot definitively explain *why* some children who experience disadvantage throughout childhood are less likely to graduate or attend college than children who intermittently cycle in and out of disadvantage. One explanation may be that trajectories capture real fluctuations in family status that, over time, translate to educational outcomes. Alternatively, it is possible that a measure of persistent disadvantage includes a sizeable proportion of families in "deep poverty" with especially low income—never approaching the 185 percent poverty rate threshold—that has acute effects on student educational outcomes. Families with slightly higher incomes may experience changes in status, but it is possible that average level of income matters much more than the changes above or below an arbitrary threshold. Thus our trajectory approach should be interpreted as correlational rather than implying a direct causal link between trajectories of disadvantage in childhood and education outcomes; and while it improves upon a limited binary variable, the longitudinal approach leaves additional questions unanswered that warrant the need for additional detailed information about family background.

Despite these limitations, our analyses shed light on the importance of incorporating longitudinal information on students' socioeconomic disadvantage in measuring income and race-based gaps in education outcomes. Future work should examine whether these findings hold in other geographic contexts, and among different racial/ethnic groups. The state of Michigan is large and somewhat representative of the country as a whole, but has much smaller Hispanic and Asian

populations, precluding us from conducting similar analyses on other race and ethnicity-based gaps.

Finally, we hope our study motivates the use of longitudinal student information in the analysis of educational policy. Prior findings from the field of childhood poverty research have shown that attention to the timing and duration of disadvantage reveals critical differences in childhood contexts. Our study adapted this knowledge in a public education setting, where an increasing availability of student administrative data provides new opportunities to evaluate how social contexts shape student outcomes. A longitudinal approach can be used in this format to better understand racial and socioeconomic gaps, even when information on family background is limited. Researchers should adopt this this first-order insight when they evaluate the causal impacts of policy interventions on educational inequality.

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Table 1: Characteristics of Michigan students, by trajectory of socioeconomic disadvantage

	Trajectory of socioeconomic disadvantage				
	Never	Recurrent	Persistent	Late transition	Early transition
Student educational outcomes					
8th grade standardized math scores	.413	-.204	-.445	-.043	-.264
11th grade standardized math scores	.376	-.152	-.395	-.030	-.215
Persists to 11th grade	.955	.836	.724	.892	.824
Graduated from high school within 5 years	.940	.816	.721	.867	.799
Enrolled in college within 2 years of expected HS graduation	.793	.545	.425	.614	.505
Enrolled in 4-year college within 2 years of expected HS graduation	.513	.237	.156	.291	.215
Student characteristics in 8th grade					
Certified for subsidized meals	.040	.355	1.000	.852	1.000
Female	.507	.521	.521	.508	.511
Michigan Native	.905	.898	.894	.935	.922
School characteristics					
Urbanicity					
City	.130	.268	.388	.158	.214
Suburb	.502	.362	.328	.458	.430
Town/Rural	.368	.370	.284	.385	.356
School racial composition					
White	.817	.652	.540	.767	.686
Black	.080	.243	.335	.137	.214
Hispanic	.042	.057	.079	.048	.054
School-level pupil-teacher ratio	19.57	18.97	18.59	19.41	19.08
School-level proportion on subsidized meals	.345	.528	.642	.449	.530
School-level percent persistently disadvantaged	.174	.331	.456	.240	.306
School-level average 8th grade math test score	.215	-.089	-.240	.036	-.079
Fraction of years spent in a low-performing school (K-8th grade)	.029	.205	.331	.080	.167
Census tract characteristics					
Poverty rate	.099	.182	.248	.135	.176
Unemployment rate	.102	.147	.179	.124	.145
Proportion receiving public assistance	.025	.045	.063	.033	.043
Proportion female-headed households	.246	.324	.368	.287	.322
Proportion with less than a high school diploma	.082	.129	.169	.107	.130
Proportion with a college degree	.315	.206	.164	.233	.198
Proportion in professional occupation	.383	.292	.253	.320	.289
Proportion under 18	.243	.245	.258	.240	.244
Median income (2012$)	65,607	47,661	40,061	54,237	47,781
Fraction of years spent in disadvantaged census tract (K-8th grade)	.032	.258	.435	.103	.225
Student mobility					
Number of school moves (K-8th grade)	2.82	3.50	3.88	3.11	3.53
Number of census block moves (K-8th grade)	2.09	2.93	3.45	2.65	3.14
Observations	67,465	15,670	40,752	10,251	10,867

Source: Michigan Department of Education (MDE), National Center for Education Statistics' Common Core of Data (CCD), the 2010 Census, and the 2008-12 American Community Survey (ACS).

Note: Sample restricted to students who turned 5 by October 1st of 2002 or 2003 (N=145,005). Student socioeconomic disadvantage is a binary indicator equal to one when a student certifies for subsidized meals; trajectories of disadvantage describe subsidized meal certification from Kindergarten through 8th grade. School characteristics come from the CCD and from aggregated MDE data based on the school of attendance in 8th grade. The fraction of years spent in a low-performing school is based on the performance level of the school a child attended in spring of each year from Kindergartern through 8th grade; low-performing schools are in the bottom quintile of 3th-8th grade schoolwide average test scores within year (normed within Michigan). Census tract characteristics come from the 2010 Census and 2008-12 ACS, matched to student's residential address in 8th grade. The fraction of years in a disadvantaged census tract are based on where children lived each year from Kindergarten through 8th grade; disadvantaged census tracts are neighborhoods in the bottom quintile of a composite index of neighborhood advantage (normed within Michigan), constructed using principal component analysis (see online appendix).

Table 2: Characteristics of Michigan students, by race

	All students	White	Black
Student educational outcomes			
8th grade standardized math scores	.022	.171	-.556
11th grade standardized math scores	.067	.198	-.560
Persists to 11th grade	.863	.900	.734
Graduated from high school within 5 years	.849	.878	.748
Enrolled in college within 2 years of expected HS graduation	.629	.666	.499
Enrolled in 4-year college within 2 years of expected HS graduation	.345	.381	.216
Student characteristics in 8th grade			
Race/Ethnicity			
White	.724	1	0
Black	.195	0	1
Hispanic	.049	0	0
Female	.513	.512	.512
Michigan Native	.905	.916	.942
Socioeconomic disadvantage			
Cross-sectional disadvantage			
Certified for subsidized meals in 8th grade	.468	.372	.799
Trajectory of socioeconomic disadvantage			
Never disadvantaged	.465	.574	.115
Recurrently disadvantaged	.108	.094	.157
Persistently disadvantaged	.281	.182	.588
Late transition to disadvantage	.071	.080	.046
Early transition to disadvantage	.075	.070	.094
School characteristics			
Urbanicity			
City	.226	.123	.566
Suburb	.430	.448	.375
Town/Rural	.345	.429	.059
School racial composition			
White	.708	.832	.286
Black	.183	.071	.621
Hispanic	.055	.045	.050
School-level pupil-teacher ratio	19.18	19.43	18.30
School-level proportion on subsidized meals	.469	.404	.697
School-level percent persistently disadvantaged	.286	.218	.505
School-level average 8th grade math test score	.026	.120	-.365
Fraction of years spent in a low-performing school (K-8th grade)	.147	.046	.508
Census tract characteristics			
Poverty rate	.158	.122	.284
Unemployment rate	.133	.112	.213
Proportion receiving public assistance	.040	.030	.073
Proportion female-headed households	.297	.257	.445
Proportion with less than a high school diploma	.117	.099	.168
Proportion with a college degree	.246	.264	.179
Proportion in professional occupation	.325	.343	.261
Proportion under 18	.247	.242	.261
Median income (2012$)	54,349	58,824	38,546
Fraction of years spent in disadvantaged census tract (K-8th grade)	.189	.065	.623
Student mobility			
Number of school moves (K-8th grade)	3.27	3.05	4.06
Number of census block moves (K-8th grade)	2.68	2.46	3.48
Observations	145,005	104,951	28,219

Source: MDE, CCD, Census, and 2008-12 ACS.

Table 3. Characteristics of school peers in 8th grade, by race and trajectory of socioeconomic disadvantage

	Characteristics of schools attended by white students			Characteristics of schools attended by black students		
Student trajectory of socioeconomic disadvantage	Proportion persistently disadvantaged	Proportion never disadvantaged	Mean 8th grade math score	Proportion persistently disadvantaged	Proportion never disadvantaged	Mean 8th grade math score
Never disadvantaged	.167	.605	.218	.292	.432	.030
Recurrently disadvantaged	.260	.458	.022	.490	.208	-.357
Persistently disadvantaged	.345	.381	-.063	.586	.149	-.465
Late transition to disadvantage	.216	.509	.071	.392	.279	-.215
Early transition to disadvantage	.258	.451	-.001	.445	.222	-.318
Overall	.220	.530	.120	.516	.203	-.365

Source: MDE.

Note: N=133,170 students (black and white only). All differences between black and white students statistically significant at the p<.001 level.

Table 4. Marginal effects from logistic regression models estimating 5-year high school degree completion by race and socioeconomic disadvantage, measured cross-sectionally and by trajectory

	Panel A. Cross-sectional socioeconomic disadvantage									
	White students					Black students				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Cross-sectional measure of disadvantage										
Disadvantaged in 8th grade	-.158	-.158	-.133	-.128	-.090	-.148	-.149	-.108	-.105	-.068
	(.002)	(.002)	(.002)	(.002)	(.002)	(.005)	(.005)	(.006)	(.006)	(.007)
Demographics		X	X	X	X		X	X	X	X
School Characteristics			X	X	X			X	X	X
Neighborhood Characteristics				X	X				X	X
Student mobility					X					X
8th grade math test score					X					X
ll	-36,155	-35,925	-34,404	-34,283	-32,630	-15,645	-15,441	-13,849	-13,807	-13,192
AIC	72,315	71,860	68,828	68,606	65,305	31,294	30,892	27,717	27,655	26,430
BIC	72,334	71,908	68,923	68,797	65,525	31,310	30,933	27,799	27,818	26,618
Pseudo R-squared	0.071	0.077	0.086	0.090	0.134	0.018	0.031	0.053	0.055	0.097
Observations	104,951	104,951	104,951	104,951	104,951	28,219	28,219	28,219	28,219	28,219

	Panel B. Trajectory of socioeconomic disadvantage									
	White students					Black students				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Trajectory of socioeconomic disadvantage										
Never disadvantaged (reference)										
Recurrently disadvantaged	-.108	-.109	-.095	-.090	-.064	-.142	-.142	-.119	-.118	-.089
	(.004)	(.004)	(.004)	(.004)	(.003)	(.008)	(.008)	(.009)	(.009)	(.010)
Persistently disadvantaged	-.207	-.207	-.177	-.172	-.115	-.224	-.226	-.173	-.171	-.118
	(.003)	(.003)	(.004)	(.004)	(.003)	(.006)	(.006)	(.008)	(.008)	(.009)
Late transition to disadvantage	-.074	-.073	-.067	-.065	-.048	-.041	-.040	-.038	-.038	-.027
	(.004)	(.004)	(.004)	(.004)	(.004)	(.010)	(.010)	(.012)	(.013)	(.014)
Early transition to disadvantage	-.142	-.142	-.125	-.121	-.084	-.128	-.126	-.111	-.111	-.076
	(.005)	(.005)	(.005)	(.005)	(.004)	(.009)	(.009)	(.011)	(.011)	(.012)
Demographics		X	X	X	X		X	X	X	X
School Characteristics			X	X	X			X	X	X
Neighborhood Characteristics				X	X				X	X
Student mobility					X					X
8th grade math test score					X					X
ll	-35,825	-35,586	-34,245	-34,150	-32,633	-15,421	-15,207	-13,761	-13,724	-13,157
AIC	71,660	71,187	68,517	68,347	65,318	30,852	30,430	27,548	27,495	26,365
BIC	71,707	71,264	68,641	68,566	65,566	30,893	30,496	27,654	27,683	26,578
Pseudo R-squared	0.079	0.085	0.091	0.093	0.133	0.033	0.046	0.059	0.061	0.100
Observations	104,951	104,951	104,951	104,951	104,951	28,219	28,219	28,219	28,219	28,219

Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Note: Disadvantaged students are those who certify for subsidized meals. Cross-sectional measures of disadvantage (Panel A) uses only information about subsidized meals as reported in students' 8th grade year, while disadvantage trajectories (Panel B) describe patterns of disadvantage observed across all years from Kindergarten through 8th grade. Demographic characteristics include gender, Michigan native, kindergarten cohort year. School characteristics include share of school receiving subsidized meals, share of school persistently disadvantaged, share of school that is white, pupil to teacher ratio, average 8th grade math standardized test score (by cohort), and the fraction of years in a low-performing school. Neighborhood characteristics measured at the census tract level include poverty rate, unemployment rate, proportion on welfare, proportion female-headed household, proportion with less than a high school diploma, proportion with a college degree, proportion in professional occupations, proportion under 18, median household income measured, and the fraction of years in disadvantaged neighborhood. See Table 1 for additional covariate details.

Table 5. Decomposition of the black-white high school completion gap, by measure of socioeconomic disadvantage

	Cross-sectional disadvantage			Trajectory of disadvantage		
	(1)	(4)	(5)	(1)	(4)	(5)
Proportion of gap explained by covariates						
Cross-sectional measure of disadvantage						
Disadvantage in 8th grade	.571	.450	.314			
Trajectory of socioeconomic disadvantage						
Recurrently disadvantage				-.015	.020	.013
Persistently disadvantage				.881	.667	.459
Late transition to disadvantage				-.063	-.049	-.034
Early transition to disadvantage				-.030	-.012	-.005
Student characteristics		-.004	.004		.005	.013
School characteristics		.510	.183		.397	.131
Neighborhood characteristics		.068	-.005		.029	-.035
Residential and school mobility						
Number of school moves			.182			.167
Number of residential moves			.061			.058
8th grade math test score			.400			.390
Share explained	.571	1.024	1.139	.772	1.057	1.156
Share unexplained	.429	-.024	-.139	.228	-.057	-.156

Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Notes: N=133,170 students (black and white only). Results from Fairlie decompositions of logistic regession models 1, 4, and 5 from Table 4. A pooled model of white and black students is used as the weighting group. In unadjusted models, the black mean high school completion is .75 and white mean high school completion is .88; thus the initial gap is -.13. Random ordering of coefficients used.

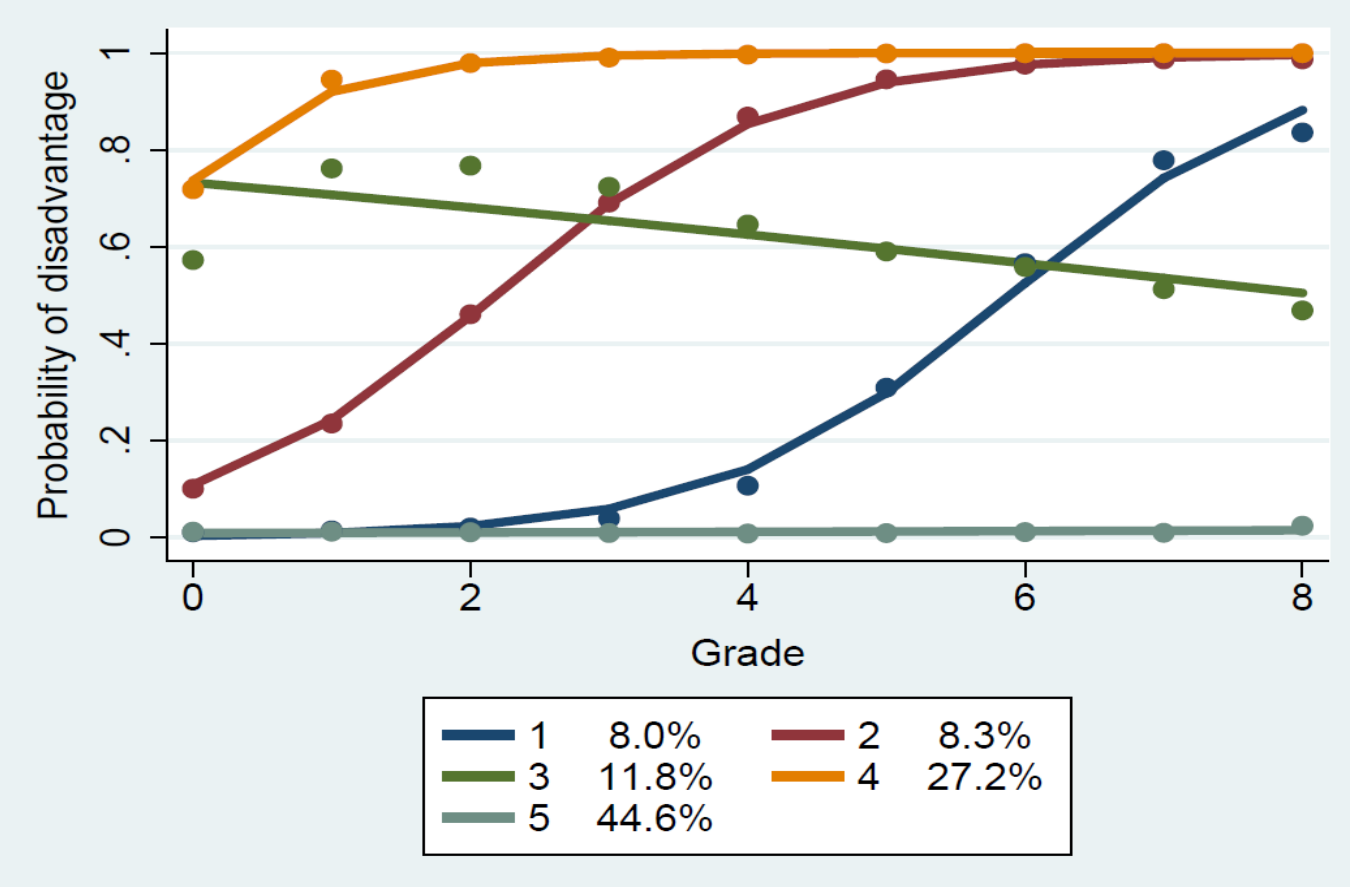
Table 6. Selected results from decomposition of black-white gaps in education outcomes, by specification of socioeconomic disadvantage

		Proportion of black-white gap explained by racial compositional differences				
	Black-white gap in outcome	Socioeconomic disadvantage	Student Characteristics	School Characteristics	Neighborhood Characteristics	Total
8th grade standardized math test score	-0.71					
Cross-sectional disadvantage		.212	.003	.263	.056	.534
Trajectory of disadvantage		.308	.003	.233	.034	.578
11th grade standardized math test score	-0.75					
Cross-sectional disadvantage		.179	.002	.248	.072	.502
Trajectory of disadvantage		.255	.002	.226	.056	.539
Persists to 11th grade	-0.17					
Cross-sectional disadvantage		.311	-.013	.516	.171	.984
Trajectory of disadvantage		.495	-.003	.415	.109	1.015
5-year high school completion	-0.13					
Cross-sectional disadvantage		.450	-.004	.510	.068	1.024
Trajectory of disadvantage		.626	.005	.397	.029	1.057
College enrollment	-0.17					
Cross-sectional disadvantage		.548	.003	.459	.079	1.088
Trajectory of disadvantage		.832	.003	.303	.000	1.137
4-year college enrollment	-0.16					
Cross-sectional disadvantage		.506	-.009	.348	.173	1.018
Trajectory of disadvantage		.756	-.015	.220	.098	1.059

Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Note: N=133,170 students (black and white only). Selected results from decompositions (by row) similar to those presented in Model 4 of Table 5. Black-white gaps in continuous educational outcomes (8th and 11th grade test scores) are estimated with linear regressions and decomposed using the Oaxaca method; the remaining four outcomes are binary measures of educational attainment, estimated with logistic regressions and decomposed using the Fairlie method.

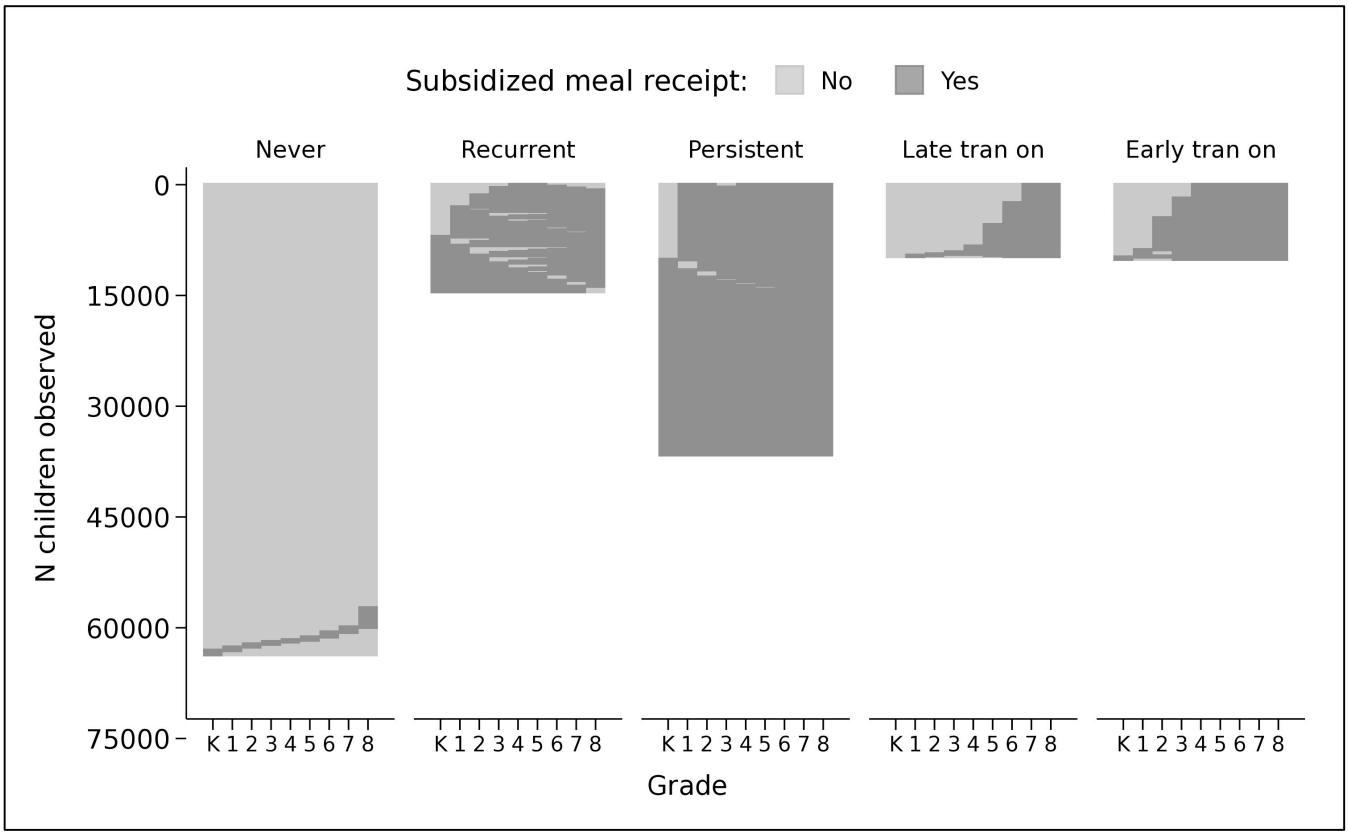
Figure 1. Probability of socioeconomic disadvantage, by growth based trajectory model category



Source: Michigan Department of Education (MDE).

Note: Sample restricted to students who turned 5 by October 1st of 2002 or 2003 (N=145,005). Trajectories of socioeconomic disadvantage, based on nine years (x-axis) of subsidized meal receipt records, are estimated with GBTM 5-category model (order 11111). The y-axis represents the mean of students receiving subsidized meals.

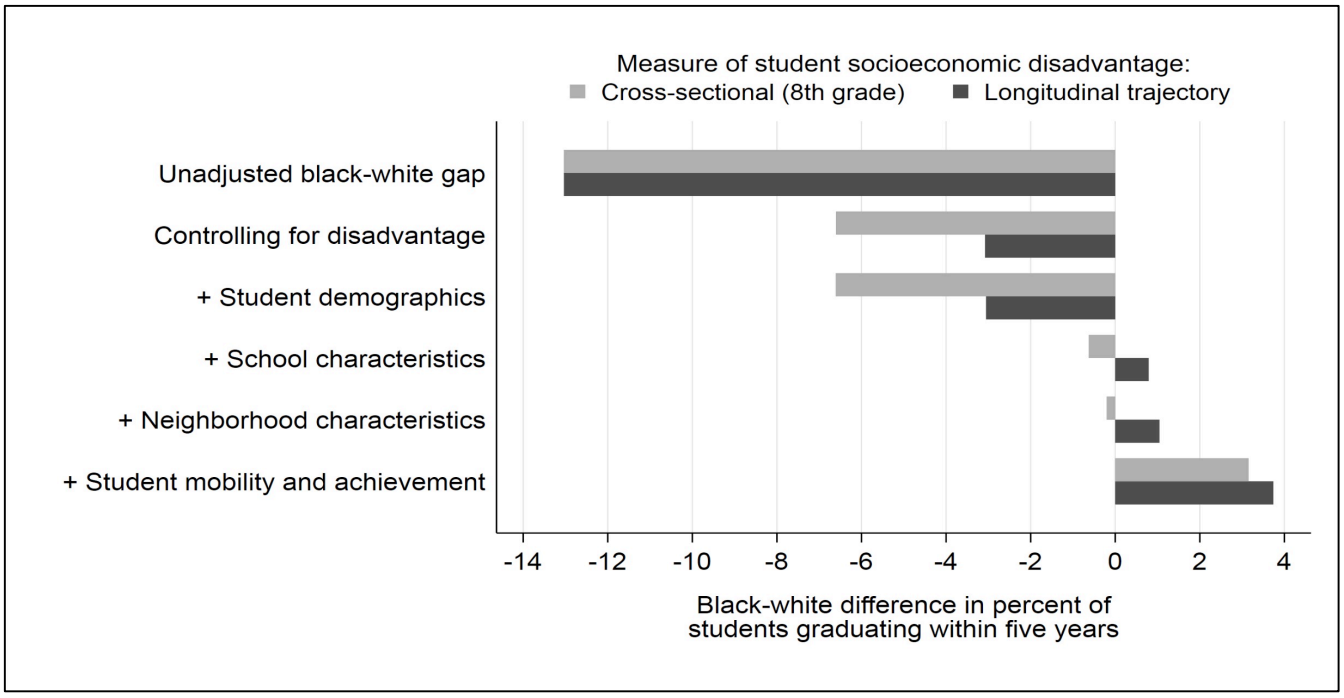
Figure 2. Sequence plot from growth based trajectory model



Source: Michigan Department of Education (MDE).

Note: N=145,005 students. The x-axis denotes the grade, ranging from kindergarten through 8th grade; the y-axis represents the number of students observed. The trajectories of socioeconomic disadvantage, based on nine years of subsidized meal receipt records, are estimated with the GBTM 5-category model (order 11111) shown in Figure 1.

Figure 3. Black-white gaps in high school degree completion by regression model, with socioeconomic disadvantage measured cross-sectionally and by trajectory



Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Note: N=133,170 students (black and white only). Each row of results reports the difference in black and white predicted percent graduating high school within five years. The top row reports an unadjusted black-white gap of 13.04 percent (see also Table 2); each additional row corresponds to regression models 1-5 reported in Table 4.

Contextual Origins of Black-White Educational Disparities in the 21st Century

Online Appendix

A. Variables

Educational outcome measures

8th grade math score: 8th grade math test score is standardized at the grade and year level, with mean zero and standard deviation of one. It represents a student's score relative to the average 8th grader in the state in that year.

11th grade math score (conditional on persistence): 11th grade math test score is standardized at the grade and year level, with mean zero and standard deviation of one. It represents a student's score relative to the average 11th grader in the state in that year. This value is missing for all students who do not enroll in public schools in 11th grade within three years of entering 9th grade.

11th grade persistence: 11th grade persistence is a binary outcome representing whether a student has persisted in school through 11th grade, as measured by whether they have a valid 11th grade test score and report ever being in 11th grade in the Michigan Student Data System (MSDS).

High school graduation (within five years): High school graduation is a binary outcome set to one if a student completes a high school diploma (not GED) within five years of starting high school, or one year beyond the expected high school graduation year. This outcome is assessed regardless of whether a student persists through 11th grade (i.e. it is non-missing for all students in the main sample).

College enrollment: College enrollment is a binary outcome set to one if a student enrolls in any postsecondary institution covered in the National Student Clearinghouse (NSC) data by the second fall following expected high school graduation. This outcome is non-missing for all students in the main sample.

Four-year college enrollment: Four-year college enrollment is a binary indicator set to one if a student enrolls in any four-year institution covered in the NSC data by the second fall following expected high school graduation. This outcome is non-missing for all students in the main sample.

Demographic control variables and academic achievement

The Michigan Department of Education (MDE) administrative data includes few measures of demographic characteristics. We include a binary indicator for whether the student is female, corresponding to 1 for female students, and 0 otherwise. We also include an indicator for whether the student was born in the state of Michigan (1=yes, 0=no) and whether the student was a migrant (1=yes, 0=no).

School characteristics

We obtain school characteristics from the Common Core of Data (CCD) "Public School Universe" file published online by the National Center for Education Statistics, as well as by collapsing the data to the school-grade-year level and taking the mean for some outcomes. All school characteristics are measured for the student's 8th grade school in which they spent the most time. From the CCD, we obtain information on the percent of the school certified for subsidized meals (a continuous measure ranging from 0 to 1), the share of the school that is comprised of white students (a continuous measure ranging from 0 to 1), and the pupil-teacher ratio.

We calculate the average peer 8th grade math score by collapsing the data to the school-grade-year level and employing the "leave one out" technique to leave out the focal student when calculating peer achievement. By collapsing student level data to the school level, we also create a measure of the share of individuals in a student's 8th grade school who are persistently disadvantaged, measured as the share of 8th graders who certified for subsidized meals in every year between kindergarten and 8th grade.

To capture a longitudinal measure of school quality, we also create a measure for the fraction of years a student spends in a bottom-quintile performing school. This measure is created by collapsing student-level test score data measured in 3rd through 8th grade to the school-year level and creating quintiles of average scores in each year statewide. Matching students to schools in each year, we create a measure for the share of years spent in a bottom-quintile performing school by dividing the number of years in a bottom-quintile performing school by the total number of years a student is present in the Michigan public schools and matches to the school-year level file. Some students do not merge to the school-year file in early grades because their schools do not have any students taking the standardized math test, which is administered in each grade between 3rd and 8th grade. The average student in our sample matches to the school-year file in 8.56 of the 9 years they are observed in the data; more than 80 percent of students match to the file in all years. Matching at the school-by-year level allows students to move across schools over time, so this measure captures both disadvantage through moving across low-performing schools, as well as disadvantage through remaining in a low-performing school over time.

Neighborhood characteristics

We obtain neighborhood characteristics from the 2008-12 pooled American Community Survey (ACS) and the 2010 decennial Census. We selected a number of variables used in scholarship on neighborhood effects to measure local context, including: percent of persons in poverty, percent of the civilian workforce (age 16 and up) who are unemployed, percent of households receiving public assistance, percent of households headed by females, percent of 25 year olds with less than a high school diploma, percent of 25 year olds with a college degree or more, percent of the civilian workforce in professional occupations, percent of persons under age 18, and the median household income. We use a student's 8th grade census tract to merge on this information. We also create a measure for the fraction of years spent in a disadvantaged census tract by constructing a composite index variable of neighborhood advantage, identifying the bottom

quintile of census tracts across all years (relative to all tracts in Michigan), counting the number of years a child resided in a bottom quintile performing tract, and then dividing that count by the total number of years in the data. We use time-invariant contextual data to measure neighborhoods, so variation within students over time in their exposure to neighborhood disadvantage comes from residential mobility between census tracts.

Residential and school mobility

Residential mobility is a count of the number of times a student's census block changes between Kindergarten and 8th grade, based on annually updated geocoded addresses. We are unable to measure mobility prior to public school enrollment, nor can we identify moves between housing units with the same census block.

School mobility is a count of the number of years a student attends a different school than the prior consecutive year between Kindergarten and 8th grade.

B. Alternative measures of socioeconomic disadvantage

We use longitudinal information about student subsidized meal receipt to create measures of student socioeconomic disadvantage. The main analysis foregrounds a comparison between the cross-sectional model measuring disadvantage in 8th grade with a 5-category growth-based trajectory model (GBTM), developed following Jones and Nagin (2013). We also created seven alternative measures of disadvantage to test the robustness of our findings. Appendix Table 2 summarizes the results of these tests.

Using the GBTM method, we create a 4-category model of trajectories of disadvantage (C in Appendix Table 2), which had similar efficiency as the 5-category model. A depiction of these trajectories can be found in Appendix Figures 1 and 2. The 4-category model is similar to the 5-category model in that it identifies students who were persistently disadvantaged (36 percent) and persistently not-disadvantaged (45 percent). Students who fell in between these two groups either experienced disadvantage recurrently throughout grade school (9 percent), or transitioned onto disadvantage at some point in grade school (10 percent).

We also created a "theory-driven" categorization of disadvantage (D in Appendix Table 2), with five categories of trajectories based on previous literature regarding the importance of timing and duration of disadvantage: never disadvantaged, always disadvantaged[1], episodically disadvantaged, transition on to disadvantage, and transition off of disadvantage. Never and always disadvantaged students are those who never or always certify for subsidized meals in each of the nine years, respectively. Those who transition onto disadvantage are those that did not initially certify for subsidized meals in kindergarten, but did by 8th grade. The transition off category includes students who initially certified for subsidized meals in kindergarten but not in 8th grade, and episodically disadvantaged students includes all students who did not fit easily into

[1] We also include students who were not disadvantaged in kindergarten, but were disadvantaged in all grades between first through eighth grade. Some students may not receive subsidized meals in kindergarten if they do not attend a full-day kindergarten program.

one of the other four categories. This last group of students experienced intermittent spells of disadvantage throughout grade school. Appendix Figure 3 provides a sequence plot for the theory-driven trajectory categorization of disadvantage.

We next developed a timing measure of disadvantage (E in Appendix Table 2) by creating three indicators for whether a student was disadvantaged in an early (kindergarten through 2nd grade), middle (3rd through 5th), or late (6th through 8th) grade. These categories are not mutually exclusive, such that students who were disadvantaged in all grades would have each indicator set to 1; students who were never disadvantaged would have each indicator set to zero.

We created two measures to identify the duration of disadvantage that a student experienced between kindergarten and 8th grade—one is a simple interval measure ranging from 0 to 9 corresponding to the total number of years disadvantaged in those years (F in Appendix Table 2). The second measure consisted of 10 mutually-exclusive indicators, ranging from 0 to 9, corresponding to students who were disadvantaged each number of years (I in Appendix Table 2). An individual experiencing nine consecutive years of socioeconomic disadvantage, for instance, would have the "9" indicator set to 1, and all other indicators set to zero. This allows for a more flexible functional form in identifying the relationship between duration of disadvantage and high school completion.

We combine the timing and duration measures described above to create a timing-duration measure of disadvantage that includes an interval measure of the number of years of disadvantage between kindergarten and 8th grade (ranging from 0 to 9) as well as the three indicators for disadvantaged in an early, middle or late grade (G in Appendix Table 2). This structure allows us to test whether, controlling for the total number of years of disadvantage, the timing of disadvantage matters.

Finally, building on a measure created by Lee (2014), we create a "transitions" measure of disadvantage (H in Appendix Table 2) that includes four mutually-exclusive categories: never disadvantaged (=1 if never disadvantaged; 0 otherwise), persistently disadvantaged (=1 if disadvantaged at least once between kindergarten and 2nd grade, 3rd and 5th grade, and 6th and 8th grade; 0 otherwise), moving in to disadvantage (=1 if not disadvantaged in kindergarten through 5th grade but disadvantaged at least once between 6th and 8th grade; 0 otherwise) and moving out of disadvantage (=1 if disadvantaged in kindergarten through 2nd grade or 3rd through 5th grade but not in 6th through 8th grade; 0 otherwise).

Regression and decomposition analysis using alternative specifications of disadvantage

In Appendix Table 2, we provide selected regression coefficients and fit statistics for each of the nine specifications of disadvantage. The models presented here match the specifications in Model 4 from Table 4, which depicts race-specific regressions illustrating SES- and race-based gaps in high school completion, controlling for student demographics, school, and neighborhood characteristics. Notably, each of the eight longitudinal specifications improve upon the cross-sectional specification of disadvantage in terms of AIC and BIC. The specification that is most efficient for both black and white students is the non-parametric specification (I) of total number of years of disadvantage.

Some specifications allow us to investigate the relative importance of timing versus duration of disadvantage in predicting socioeconomic status-based gaps in high school completion. Our timing specification (specification E) indicates that for white students, being disadvantaged in 6th through 8th grade is associated with the lowest high school graduation rate. Black students, on the other hand, have lowest graduation rates when they are economically disadvantaged in kindergarten through 2nd grade. Adding duration to the model (specification G), we find a similar pattern among white students—disadvantage experienced in 6th through 8th grade is associated with a 7.2 percentage point reduction in the likelihood of graduating from high school, while disadvantage experienced during earlier grades is associated with 1.3-2.8 percentage points lower graduation rates. Black students, on the other hand, exhibit an entirely different pattern. After controlling for the total number of years of disadvantage, we find no differentiation between being disadvantaged in kindergarten through 2nd grade, 3rd through 5th grade, or 6th through 8th grade. Disadvantage in each age range is associated with roughly a 1.5-2 percentage point decline in likelihood of graduating from high school, holding total number of years disadvantaged constant.

We find a similar pattern when we characterize students' disadvantage into four mutually exclusive categories (specification H): never disadvantaged, persistently disadvantaged, moving in to disadvantage, and moving out of disadvantage. White students who move in to disadvantage have lower graduation rates than white students who were disadvantaged early in grade school but not later (moving out). Black students, on the other hand, have similar reductions in likelihood of completing high school regardless of whether they move into (5.7 percentage points) or out of (5.2 percentage points) disadvantage. For both black and white students, being persistently disadvantaged is associated with a 17 percentage point decline in the likelihood of completing high school. This may provide evidence of racial heterogeneity in the relative importance of the timing of disadvantage, which may be a fruitful direction for future research. We note, however, that administrative data do not provide measures of socioeconomic disadvantage in early childhood (before entering kindergarten), a period theorized to be particularly influential on development and educational outcomes.

Appendix Table 4 provides a comparison of selected decomposition results from the cross-sectional and GBTM 5-category models along with decomposition results from the seven alternative specifications of disadvantage. Each longitudinal specification of disadvantage produces decomposition results that lead to similar conclusions about the black-white gap in high school completion. Compared to the cross-sectional model, which estimates a 45 percent contribution of family disadvantage to the black-white graduation gap, all other models estimate that between 60 and 72 percent of the gap is explained by the timing and/or duration of socioeconomic disadvantage. The cross-sectional model over-estimates the role of all other covariates and explains in total 102 percent of the black-white gap—about 3 to 4 percentage points lower than any of the alternative longitudinal specifications. These findings lend further support to the value of taking a longitudinal approach to evaluating racial and socioeconomic inequality in education.

C. Validation exercise

Our main analysis employs a trajectory approach to maximize information about family background given only one available variable in the administrative dataset—student subsidized meal receipt. Here we turn to the Panel Study of Income Dynamics (PSID) to validate our trajectory strategy. The PSID is a nationally-representative dataset that began in 1968 with a sample of 4,800 black and white families. Original respondents and their progeny have been followed every year through 1997 and every other year thereafter. Unlike the Michigan Department of Education (MDE) dataset, the PSID has a relatively small, nationally dispersed sample and it does not contain detailed longitudinal information about school context. Although not well suited for a comprehensive analysis of black-white gaps in high school graduation, the PSID does have longitudinal information about income, employment, wealth, marital status, educational attainment, and household composition.

We limit our PSID analysis to a sample of black and white children who descend from the original 1968 sample and who turned age 5 by October 1st in all even numbered years from 1972 to 1998. This age cutoff approximates entry into Kindergarten. We use data collected by PSID in the spring of the subsequent year and every other year thereafter (in odd numbered years).[2] We restrict our sample to individuals consistently present in the data from age 5 through 13, spanning the same total number of years (nine) as observed in Michigan (K-8th grade). In total, the PSID sample includes 3,175 black and white children distributed nationally, representing 14 kindergarten cohorts.[3]

Our goal is to observe characteristics of PSID children who belong to trajectories of socioeconomic disadvantage that match the same trajectories used in the main analysis. To do so, we first calculate eligibility of subsidized meal status using the household income to poverty ratio variable provided by the PSID. PSID children in households with a ratio higher than 1.85 within a given year are coded as ineligible for subsidized meals, while those below 1.85 are coded as eligible. We code children's subsidized meal status in each of five observed ages (5, 7, 9, 11, 13), which we use to construct trajectories of socioeconomic disadvantage.

We highlight two key differences between PSID and MDE trajectories of disadvantage. First, PSID trajectories are based on eligibility (using annual income) rather than receipt of subsidized meals. It has been shown elsewhere that some students should be receiving meals but do not claim them (Harwell and LeBeau 2010; Domina et al. 2018). To explore this issue, we draw on the Child Development Supplement of the PSID, where we can observe reported subsidized meal receipt in three data waves for a subsample of children. Appendix Table 5 shows

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[2] There are 256 PSID children turning age 5 in 2002 whom we could compare directly with students in the MDE analysis. Summary statistics are noisily estimated for this small, nationally dispersed sample. Because our goal is to evaluate the validity of trajectory categories, we choose to instead prioritize sample power by maximizing the inclusion of many PSID kindergarten cohorts. This decision may mask variation between cohorts—a fruitful direction for future research.

[3] PSID data collection is available every other year beginning in spring of 1997. We maintain an every-other-year observation pattern in the years prior to 1997 for consistency. We observe children in ages 6 through 14 (typically grades 1 through 9) based on their age as of October 1st. This is one year older than the observations of K through 8th grade students observed in the MDE dataset. We use even ages for the PSID so that we can report graduation within five years of entering high school. Using a different cohort of children observable at odd ages requires we report graduation within 4 or 6 years of entering high school.

that roughly 4 in 5 PSID children are both eligible for and receive subsidized school meals. About 8 percent of children are eligible but do not receive meals, and another 14 percent receive meals but are ineligible to do so. A second difference is that in the PSID we observe only five waves of student subsidized meal status, compared to nine waves in the MDE dataset—an artifact of the PSID's every-other-year data collection process beginning in 1997. This difference makes it impossible to construct the 5-category trajectories in the PSID using a data-driven GBTM approach. Instead, we assign PSID children to trajectories using a post-hoc coding scheme we developed after observing the sequence plot emerging from the GBTM analysis foregrounded in the study (see Figure 2). We provide a sequence plot for PSID children in Appendix Figure 4 for comparison.

We proceed with a descriptive analysis examining characteristics of PSID children separately for each trajectory of socioeconomic disadvantage. Appendix Figure 5 presents box plots showing the distribution of family income to poverty ratios. A horizontal bar at 1.85 represents the threshold for subsidized meal eligibility. Each box depicts the 25^{th}-75^{th} percentile levels of the family income to poverty ratio (i.e. the interquartile range, or IQR), with the median represented by a horizontal bar. Vertical lines below and above each IQR box represent the 5^{th} to 25^{th} percentile and the 75^{th} to 95^{th} percentile, respectively. Not surprisingly, the IQR for the never disadvantaged children is well above the subsidized lunch threshold line, while the IQR for the persistently disadvantaged children is stable and always below the threshold. Notably, the recurrently disadvantage group features a distribution of children with a median income to poverty ratio near the subsidized meal threshold across all ages except 14, where the ratio shifts slightly higher. The early- and late-transition groups display distributions that cross from above to below the 185 percent poverty threshold. Because the income to poverty ratio is used to define disadvantage, the overall picture to emerge from Appendix Figure 5 is mechanical. However, we note that for the never disadvantaged trajectory group, the IQR of family income to poverty ratios are considerably higher than the other groups, and there is a tall upper tail. We conclude from this observation that the never disadvantaged group, while heterogeneous, has substantially higher incomes on average across all observed ages.

Appendix Table 6 further explores differences across trajectories of socioeconomic disadvantage. Across a wide range of variables, persistently disadvantaged children are substantially worse off than other trajectory groups, while never disadvantaged children are substantially better off—a finding in parallel with the trajectory characteristics explored in Table 1 of the main analysis. Here we highlight that persistently disadvantaged children have lower rates of high school completion (64 percent) and are also much less likely to enroll in college by age 19 (26 percent) than even early transitioners (35 percent). Eighty-four percent of never-disadvantaged children graduate from high school and more than two-thirds (69.4%) enroll in college—more than two and half times the share of persistently disadvantaged children who do so. As expected, the trajectories of disadvantage also map onto household income, wealth, homeownership, and unemployment. One of the most common alternative measures for family socioeconomic status is parental education level, and we see in Appendix Table 6 that about one in twenty persistently disadvantaged children have a college-educated parent, compared to one in ten among late-transitioners and one in two among never disadvantaged. The never-disadvantaged trajectory has the highest rate of marriage and the largest average number of adults in the home, accompanied with the fewest number of children.

Finally, Appendix Table 6 reveals that the racial differences in disadvantage we observe in Michigan are also present in the PSID's national sample. We estimate that only 11 percent of

white children are persistently disadvantaged compared to 52 percent of black children. Conversely, 65 percent of white children are never disadvantaged compared to just 24 percent of black children. Membership in recurrent, early transition, and late transition trajectories of socioeconomic disadvantage are approximately similar by race. How these racial differences in exposure to persistent disadvantage correlate with neighborhood and especially school characteristics is a question we are unable to address using the PSID, highlighting once again the value of using student administrative data for our primary analysis. Nonetheless, the descriptive validation exercise shown here lends conceptual support to our longitudinal use of subsidized meal receipt in MDE data to approximate student socioeconomic background.

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Appendix Table 1. Model fit statistics for GBTM models with Michigan student data across nine waves

Panel A. Number of categories

	Number of categories				
GBTM analysis	3	4	5	6	7
Smallest % trajectory membership	18.35	7.82	6.95	5.73	3.07
Entropy	0.92	0.93	0.90	0.82	0.82
AIC	-485022.56	-468046.29	-462044.77	-455842.67	-455512.35
BIC (n observations)	-485071.22	-468113.20	-462129.92	-455946.07	-455633.99
BIC (n subjects)	-485062.43	-468101.11	-462114.54	-455927.39	-455612.02
Preferred model			X		

Panel B. Order specification

	Number of categories			
GBTM analysis	5	5	5	5
Order	11111	01111	02222	03333
Smallest % trajectory membership	6.95	8.37	7.52	4.74
Entropy	0.902	0.898	0.900	0.850
AIC	-462044.77	-461971.12	-457392.73	-458382.23
BIC (n observations)	-462129.92	-462050.19	-457496.13	-458509.96
BIC (n subjects)	-462114.54	-462035.90	-457477.45	-458486.89
Preferred model	X			

Appendix Table 2. Comparison of selected marginal effect estimates and model fits statistics from various measurement specifications of socioeconomic disadvantage predicting 5-year high school completion (logit models)

	White students			Black Students		
	Model coefficients	Std Error	-ll AIC BIC R2	Model coefficients	Std Error	-ll AIC BIC R2
A. Cross-sectional (binary)						
Disadvantage in 8th grade	-.128	(.002)	-34,283	-.105	(.006)	-13,807
			68,606			27,655
			68,797			27,818
			0.090			0.055
B. GBTM trajectory (5 category)						
Never disadvantaged (reference)	-	-	-34,150	-	-	-13,724
Recurrently disadvantaged	-.090	(.004)	68,566	-.118	(.009)	27,683
Persistently disadvantaged	-.172	(.004)	68,347	-.171	(.008)	27,495
Late transition to disadvantage	-.065	(.004)	0.093	-.038	(.013)	0.061
Early transition to disadvantage	-.121	(.005)		-.111	(.011)	
C. GBTM trajectory (4 category)						
Never disadvantaged (reference)	-	-	-34,152	-	-	-13,703
Transition on disadvantage	-.079	(.003)	68,347	-.066	(.010)	27,450
Transition off disadvantage	-.078	(.004)	68,557	-.087	(.011)	27,630
Persistently disadvantaged	-.165	(.003)	0.093	-.171	(.008)	0.062
D. Theory-driven trajectories						
Never disadvantaged (references)	-	-	-33962	-	-	-13759
Always disadvantaged	-.182	(.004)	67970	-.177	(.009)	27564
Episodic	-.106	(.003)	68189	-.122	(.009)	27752
Transition on disadvantage	-.108	(.003)	0.098	-.092	(.011)	0.058
Transition off disadvantage	-.079	(.007)		-.103	(.016)	
E. Timing (indicators)						
Ever disadvantaged, KG-2nd grade	-.044	(.003)	-33,878	-.075	(.009)	-13,717
Ever disadvantaged, 3rd-5th grade	-.028	(.003)	67,800	-.071	(.011)	27,477
Ever disadvantaged, 6th-8th grade	-.084	(.003)	68,010	-.065	(.011)	27,657
			0.100			0.061
F. Duration (interval)						
Number of years of disadvantage	-.018	(.000)	-34,054	-.025	(.001)	-13,689
			68,147			27,417
			68,338			27,581
			0.096			0.063
G. Timing + Duration (indicators, interval)						
Ever disadvantaged, KG-2nd grade	-.028	(.004)	-33,861	-.024	(.012)	-13,685
Ever disadvantaged, 3rd-5th grade	-.013	(.004)	67,767	-.022	(.015)	27,416
Ever disadvantaged, 6th-8th grade	-.072	(.004)	67,987	-.014	(.015)	27,604
Number of years of disadvantage	-.005	(.001)	0.101	-.019	(.002)	0.063
H. Transitions (indicators)						
Never disadvantaged (reference)	-	-	-33,839	-	-	-13,713
Moving in to disadvantage	-.091	(.003)	67,723	-.057	(.010)	27,469
Moving out of disadvantage	-.059	(.004)	67,933	-.052	(.013)	27,649

Persistently disadvantaged	-.171	(.003)	0.101	-.171	(.008)	0.062
I. Non-Parametric Duration (indicators)						
0 years (reference)	-	-	-33,802	-	-	-13,680
1 year	-.092	(.005)	67,661	-.027	(.015)	27,416
2 years	-.058	(.005)	67,928	-.042	(.016)	27,645
3 years	-.075	(.005)	0.102	-.031	(.015)	0.064
4 years	-.092	(.006)		-.068	(.015)	
5 years	-.103	(.006)		-.091	(.014)	
6 years	-.132	(.006)		-.117	(.013)	
7 years	-.155	(.006)		-.152	(.011)	
8 years	-.174	(.005)		-.182	(.010)	
9 years	-.194	(.005)		-.185	(.009)	
Observations		104,951			28,219	

Source: MDE, CCD, 2010 Census, and 2008-12 ACS.

Appendix Table 3. Results from linear probability regressions estimating 5-year high school degree completion by race and socioeconomic disadvantage, measured cross-sectionally and by trajectory

Panel A. Cross-sectional socioeconomic disadvantage

	White students									Black students								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cross-sectional measure of disadvantage																		
Disadvantaged in 8th grade	-.158	-.158	-.135	-.133	-.101	-.136	-.136	-.130	-.086	-.148	-.150	-.097	-.095	-.050	-.106	-.110	-.094	-.051
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.006)	(.006)	(.007)	(.007)	(.007)	(.007)	(.007)	(.007)	(.007)
Demographics		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
School characteristics			X	X	X							X	X	X				
Neighborhood characteristics				X	X								X	X				
Student mobility					X				X					X				X
8th grade math test score					X				X					X				X
School fixed effects						X		X	X						X		X	X
Neighborhood fixed effects							X	X	X							X	X	X
Observations	104,951	104,951	104,951	104,951	104,951	104,951	104,951	104,951	104,951	28,219	28,219	28,219	28,219	28,219	28,219	28,219	28,219	28,219
ll	-28,728	-28,498	-26,523	-26,429	-24,874	-23,506	-24,036	-21,808	-19,695	-16,240	-16,035	-14,372	-14,328	-13743	-14598	-14605	-13409	-12801
AIC	57,460	57,006	53,065	52,897	49,794	47,021	48,082	45,509	41,289	32,484	32,080	28,763	28,695	27532	29206	29221	28215	27006
BIC	57,479	57,053	53,160	53,088	50,013	47,069	48,130	54,565	50,374	32,500	32,121	28,845	28,859	27720	29247	29262	33963	32779
Adjusted R-squared	0.054	0.058	0.066	0.068	0.096	0.138	0.115	0.146	0.180	0.019	0.033	0.055	0.057	0.0983	0.100	0.055	0.105	0.1433

Panel B. Trajectory of socioeconomic disadvantage

	White students									Black students								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Trajectory of socioeconomic disadvantage																		
Never disadvantaged (reference)																		
Recurrent	-.108	-.109	-.094	-.091	-.063	-.095	-.095	-.093	-.054	-.142	-.143	-.094	-.094	-.045	-.101	-.114	-.096	-.043
	(.003)	(.003)	(.003)	(.004)	(.004)	(.003)	(.003)	(.003)	(.003)	(.01)	(.01)	(.01)	(.01)	(0.01)	(.01)	(.011)	(.011)	(.011)
Persistent	-.207	-.207	-.182	-.181	-.137	-.190	-.192	-.184	-.126	-.224	-.226	-.150	-.149	-.077	-.162	-.179	-.149	-.075
	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.008)	(.008)	(.009)	(.009)	(0.009)	(.009)	(.01)	(.01)	(.01)
Late transition	-.074	-.073	-.065	-.064	-.042	-.065	-.064	-.062	-.036	-.041	-.041	-.022	-.024	-.001	-.032	-.019	-.023	.000
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.014)	(.014)	(.014)	(.014)	(0.014)	(.014)	(.015)	(.015)	(.015)
Early transition	-.142	-.142	-.126	-.124	-.090	-.127	-.127	-.122	-.077	-.128	-.127	-.087	-.088	-.032	-.103	-.101	-.091	-.035
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.011)	(.011)	(.012)	(.012)	(0.012)	(.011)	(.012)	(.012)	(.012)
Demographics		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
School characteristics			X	X	X							X	X	X				
Neighborhood characteristics				X	X								X	X				
Student mobility					X				X					X				X
8th grade math test score					X				X					X				X
School fixed effects						X		X	X						X		X	X
Neighborhood fixed effects							X	X	X							X	X	X
Observations	104,951	104,951	104,951	104,951	104,951	104,951	104,951	104,951	104,951	28,219	28,219	28,219	28,219	28,219	28,219	28,219	28,219	28,219
ll	-28,277	-28,038	-26,285	-26,202	-24,793	-23,026	-23,580	-21,376	-14,434	-16,045	-15,830	-14,305	-14,265	-13722.3	-14,521	-14,486	-13,346	-12,785
AIC	56,563	56,091	52,596	52,449	49,637	46,069	47,175	44,653	28,877	32,099	31,675	28,636	28,575	27497	29,058	28,988	28,097	26,979
BIC	56,611	56,168	52,720	52,669	49,885	46,145	47,252	53,737	28,918	32,140	31,741	28,742	28,763	27709	29,124	29,054	33,869	32,777
Adjusted R-squared	0.062	0.067	0.070	0.072	0.097	0.144	0.122	0.153	0.1824	0.032	0.047	0.059	0.062	0.0997	0.104	0.063	0.109	0.1443

Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Note: Disadvantaged students are those who certify for subsidized meals. Cross-sectional measures of disadvantage (Panel A) uses only information about subsidized meals as reported in students' 8th grade year, while disadvantage trajectories (Panel B) describe patterns of disadvantage observed across all years from Kindergarten through 8th grade. Demographic characteristics include gender, Michigan native, kindergarten cohort year. School characteristics include share of school receiving subsidized meals, share of school persistently disadvantaged, share of school that is white, pupil to teacher ratio, average 8th grade math standardized test score (by cohort), and the fraction of years in a low-performing school. Neighborhood characteristics measured at the census tract level include poverty rate, unemployment rate, proportion on welfare, proportion female-headed household, proportion with less than a high school diploma, proportion with a college degree, proportion in professional occupations, proportion under 18, median household income measured, and the fraction of years in disadvantaged neighborhood. See Table 1 for additional covariate details.

Appendix Table 4. Selected results from decomposition of black-white high school completion gap, by specification of socioeconomic disadvantage

	Proportion of black-white gap explained by racial compositional differences				
Disadvantage specification	Socioeconomic disadvantage	Student characteristics	School characteristics	Neighborhood characteristics	Total
A. Cross-sectional	.450	-.004	.510	.068	1.024
B. GBTM trajectory 5 category	.626	.005	.397	.029	1.057
C. GBTM trajectory 4 category	.630	.004	.395	.027	1.056
D. Theory-driven trajectory	.603	.002	.418	.029	1.051
E. Timing	.652	.016	.381	.011	1.061
F. Duration	.696	.007	.358	.004	1.065
G. Timing + Duration	.681	.007	.372	.005	1.065
H. Transitions	.643	.008	.389	.021	1.062
I. Non-Parametric Duration	.715	.001	.352	.000	1.069

Source: MDE, CCD, 2010 Census, and the 2008-12 ACS.

Note: Selected results from Fairlie decompositions (by row) that are identical to those presented in Model 4 of Table 5, except in the measurement of SES disadvantage (see Appendix Table 2 for details corresponding to row letter). Figures in the "Socioeconomic disadvantage" column represent the percent of the raw black-white gap directly attributable to black-white differences in disadvantage as specified, while "Other covariates" reports similar figures for all demographic, school, and neighborhood controls combined. The "Total" column is greater than one because in each model the black-white high school completion gap is more than fully explained by the combination of racial differences in socioeconomic disadvantange and all other covariates from Model 4.

Appendix Table 5. Comparison between reported reciept of subsidized lunch and income-based estimation of subsidized lunch eligibility, by academic year

	1996-97	2002-03	2007-08	Pooled
Subsidized meal claim status: (Column proportions)				
Not income-eligible, did not claim	0.41	0.50	0.49	0.47
Income-eligible, claimed	0.37	0.28	0.29	0.31
Income-eligible, did not claim	0.10	0.08	0.06	0.08
Not income-eligible, claimed	0.12	0.15	0.15	0.14
Total	1.00	1.00	1.00	1.00
N observations	1,863	2,526	1,433	5,822

Source: Panel Study of Income Dynamics (PSID).

Note: Sample includes all children-year records in the PSID for individuals enrolled in public schools (grades K-12) and whose subsidized lunch status is reported in the Child Development Supplement. We calculate subsidized meal eligibility based on whether the child's family income-to-poverty ratio was below or above 1.85.

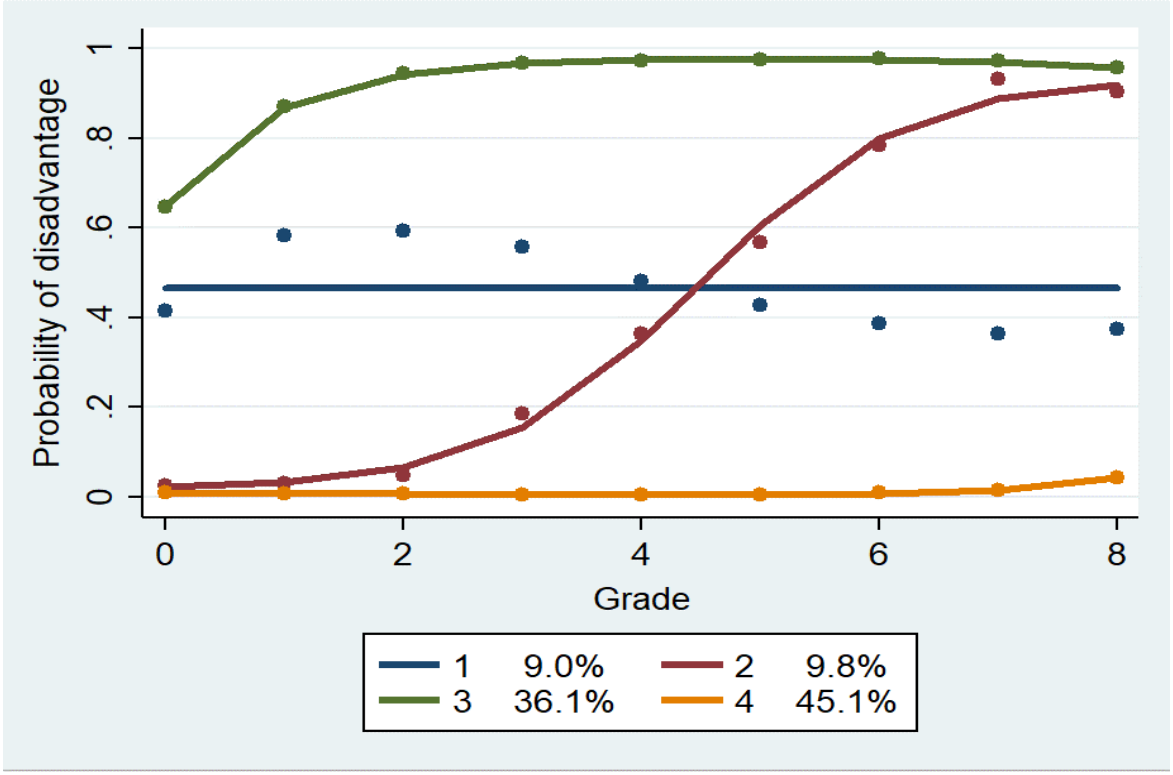
Appendix Table 6: Characteristics of individuals by trajectory of socioeconomic disadvantage from the Panel Study of Income Dynamics

	Trajectory of socioeconomic disadvantage				
	Never	Recurrent	Persistent	Late transition	Early transition
Educational outcomes					
Earn a HS degree by age 19	.841	.822	.640	.813	.718
College entry by age 19	.694	.406	.259	.382	.350
Individual characteristics					
Family income ever below 185% of poverty before age 5	.155	.602	.948	.410	.608
Female	.488	.505	.508	.447	.418
Black	.066	.126	.462	.198	.307
Household characteristics at age 13					
Eligible for subsidized school meals	.000	.205	.861	1.000	1.000
Household annual income (2012$, 1000s)	130.75	67.15	28.58	29.56	27.74
	(147.97)	(55.59)	(29.71)	(15.27)	(13.98)
Household positive wealth (2012$, 1000s)	322.62	81.35	9.28	55.86	64.91
	(1,194.69)	(318.01)	(40.73)	(115.63)	(249.53)
Household debt (2012$, 1000s)	1.88	3.47	1.52	0.69	4.44
	(15.3)	(18.23)	(5.92)	(2.5)	(34.71)
No household wealth or debt	.001	.024	.211	.002	.049
Owns home	.908	.672	.387	.751	.546
Head/spouse highest educational attainment					
Less than HS degree	.029	.131	.431	.162	.324
HS degree	.215	.475	.385	.478	.337
Some college	.284	.263	.131	.256	.280
College degree or more	.473	.131	.053	.103	.059
Unemployed head or spouse (if in labor force)	.033	.048	.143	.019	.085
Married household head	.899	.697	.410	.551	.489
Mean age of head and spouse	42.75	40.20	39.87	41.71	40.94
	(4.94)	(6.07)	(10.54)	(7.2)	(8.04)
N adults in home (including head/spouse)	2.03	1.88	1.63	1.74	1.63
	(0.42)	(0.61)	(0.83)	(0.68)	(0.68)
N children in home (including child)	2.10	2.35	2.80	2.36	2.60
	(0.82)	(1.07)	(1.65)	(1.09)	(1.22)
Observations (unweighted)	1,518	612	856	92	97
Weighted proportion (rows sum to one)	.583	.184	.177	.031	.026
Proportion among only white children	.646	.191	.113	.030	.021
Proportion among only black children	.244	.148	.519	.039	.050

Source: PSID

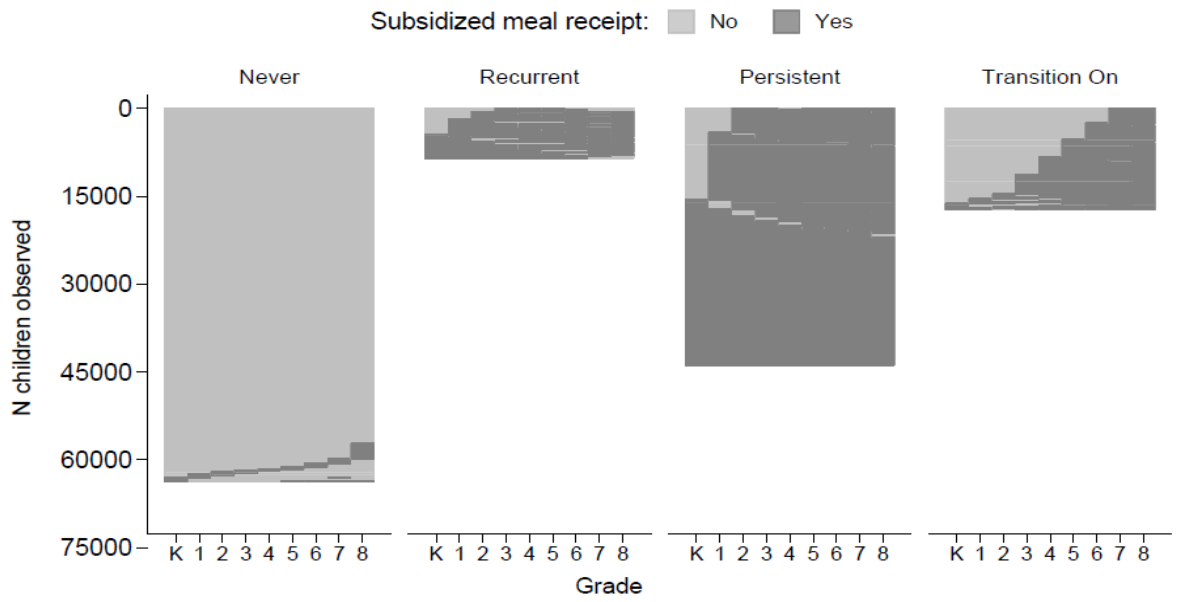
Notes: The PSID sample is restricted to black and white children who descend from the original 1968 sample and who turned age 5 by October 1st in all even numbered years from 1972 to 1998. We use data collected by PSID in the spring of the subsequent year and every other year thereafter (in odd numbered years). Trajectories of disadvantage are coded based on subsidized meal eligibility calculated from annual poverty ratios provided by the PSID. "Head/spouse highest educational attainment" is the highest level of education observed for either head or spouse. Variables for wealth and debt do not include home equity and are reported in this table only for sample children who turned age 13 by October 1st of 1989, 1999, 2001, 2003, 2005, and 2007 (n=1,317 observations). All PSID statistics are weighted with household cross-sectional frequency weights (at age 13) to account for complex survey design.

Appendix Figure 1. Trajectory plot from GBTM 4-category model



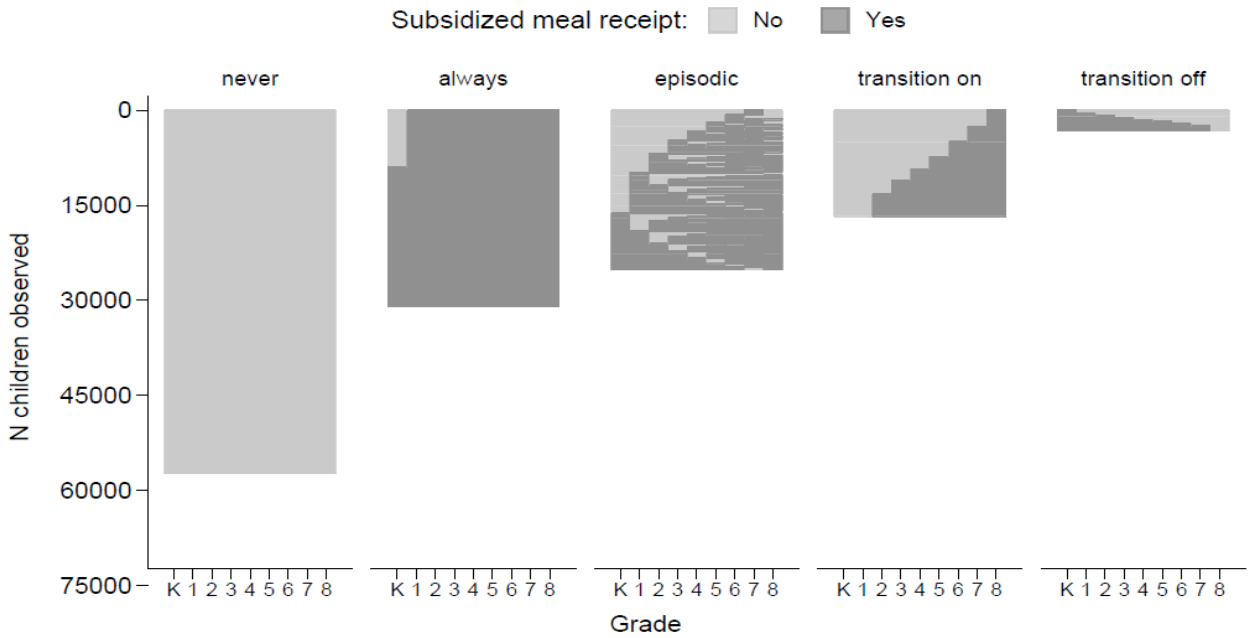
Source: Michigan Department of Education (MDE).
Note: Sample restricted to students who turned 5 by October 1st of 2002 or 2003 (N=145,005). Trajectories of socioeconomic disadvantage, based on nine years (x-axis) of subsidized meal receipt records, are estimated with GBTM 4-category model (order 0333). The y-axis represents the mean of students receiving subsidized meals.

Appendix Figure 2. Sequence plot from GBTM 4-category model



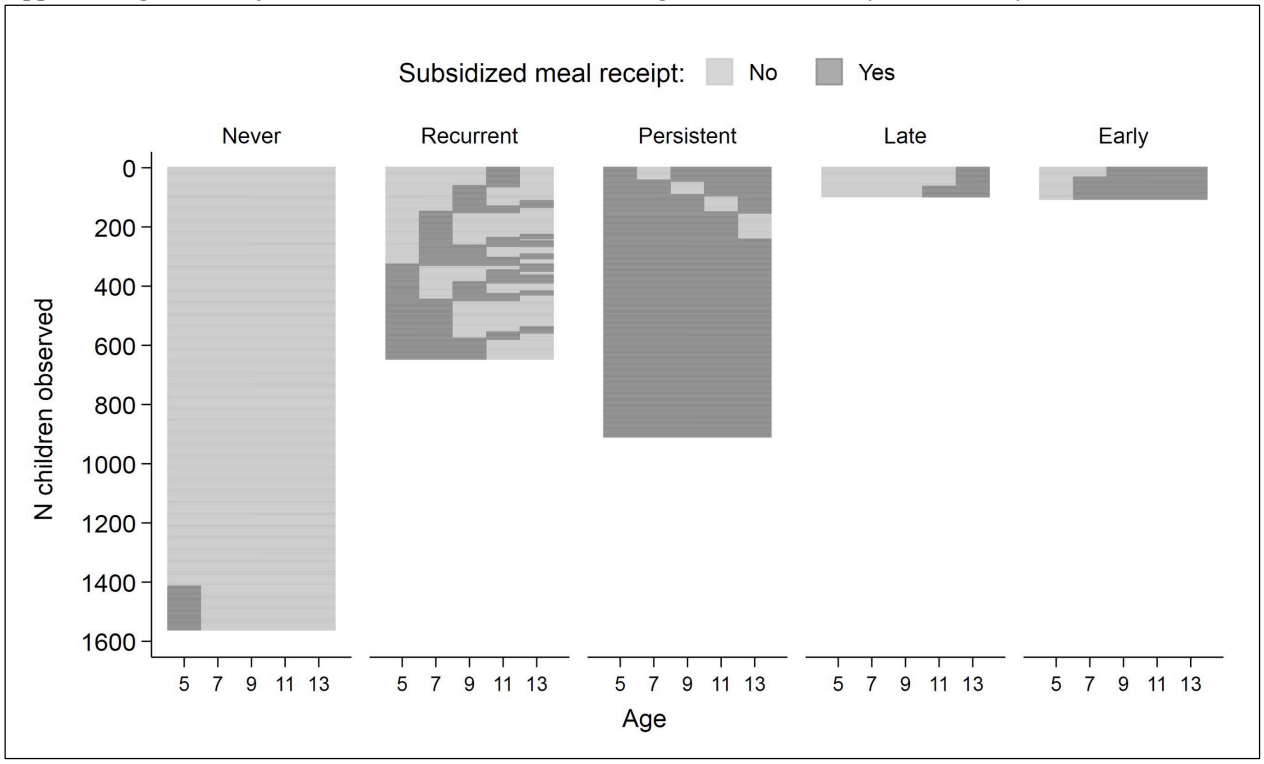
Source: Michigan Department of Education (MDE).
Note: N=145,005 students. The x-axis denotes the grade, ranging from kindergarten through 8th grade; the y-axis represents the number of students observed. The trajectories of socioeconomic disadvantage, based on nine years of subsidized meal receipt records, are estimated with the GBTM 4-category model (order 0333).

Appendix Figure 3. Sequence plot from theory-driven trajectories



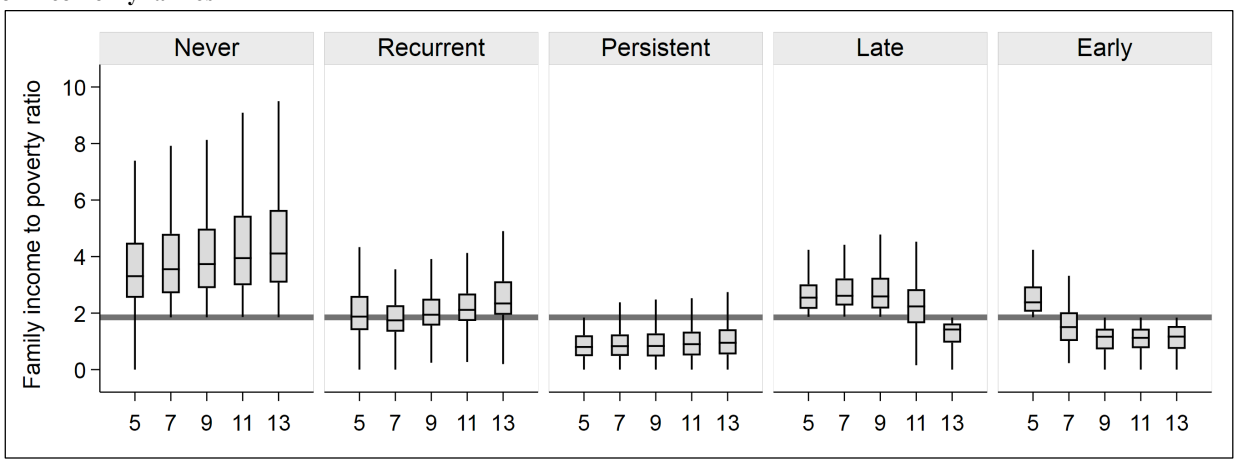
Source: Michigan Department of Education (MDE).
Note: N=145,005 students. The x-axis denotes the grade, ranging from kindergarten through 8th grade; the y-axis represents the number of students observed. The theory-driven trajectories of socioeconomic disadvantage, based on nine years of subsidized meal receipt records, were coded by authors.

Appendix Figure 4. Trajectories of socioeconomic disadvantage in the Panel Study of Income Dynamics



Source: Panel Study of Income Dynamics (PSID).
Note: The PSID sample is restricted to black and white children who descend from the original 1968 sample and who turned age 5 by October 1st in all even numbered years from 1972 to 1998. We use data collected by PSID in the spring of the subsequent year and every other year thereafter (in odd numbered years). Trajectories of disadvantage are coded based on subsidized meal eligibility calculated from annual poverty ratios provided by the PSID. Frequencies are unweighted (N=3,175).

Appendix Figure 5. Family income to poverty ratio, by age and trajectory of socioeconomic disadvantage in the Panel Study of Income Dynamics



Source: PSID.
Note: Boxplots represent the distribution of the children by family income ratio, excluding the outlier observations above the 95th or below the 5th percentile. Each box depicts the 25th-75th percentile levels, with the median represented by a horizontal bar. See Online Appendix Figure 4 for additional sample and measurement details.