The Gap within the Gap: Using Longitudinal Data to Understand Income Gaps in Educational Outcomes

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February 2016

In the US, gaps in educational achievement between high-income and low-income children have been rising for decades. Much of the research documenting these gaps focuses on contemporaneous measures of economic disadvantage, which understate the persistent disadvantage experienced by a subset of children. Using school administrative data from the state of Michigan, we create measures of persistent disadvantage, as proxied by repeated eligibility for subsidized meals. We show that traditional measures of contemporaneous disadvantage understate the achievement gap between children growing up in chronic disadvantage and those having never experienced poverty. Approximately one in four students in our sample who are ever economically disadvantaged are disadvantaged in every year between kindergarten and 8th grade. These children have significantly worse education outcomes, scoring 0.94 standard deviations below never-poor children on standardized tests. The gap based on persistent disadvantage is comparable to that estimated by Reardon (2011) between individuals with family income in the 90th percentile to those with income in the 10th percentile, while the test score gap measured using contemporaneous measures approximates the 90/50 test score gap.

Keywords: Achievement Gaps, Chronic Poverty, Education Inequality

[1] We thank our partners at the Michigan Department of Education (MDE) and Michigan's Center for Educational Performance and Information (CEPI) for providing the data used in these analyses, especially Erika Bolig, Thomas Howell, and Venessa Keesler. We would also like to thank Mónica Hernandez, Amy Schwartz, and seminar participants at the University of Chicago for providing helpful comments. The Institute of Education Sciences, U.S. Department of Education provided support through Grants R305E100008 and R305B110001. This research uses data structured and maintained by the Michigan Consortium for Educational Research (MCER). MCER data are modified for analysis using rules governed by MCER and are not identical to data collected and maintained by MDE and CEPI. Results, information and opinions are the authors' and do not reflect the views or positions of MDE or CEPI. Direct correspondence to kmichelm@umich.edu.

Gaps in educational achievement between high-income and low-income children are growing. The poverty gap in standardized test scores is 40% larger today than it was 25 years ago and is twice as large as the black-white gap (Reardon 2011). These scores are an early predictor of gaps in educational attainment and income in adulthood: a one-standard deviation difference in test scores in grade school corresponds to a five percentage point difference in college attendance and a nine percent difference in earnings at age 28 (Chetty, Friedman, and Rockoff, 2011).

There is a long literature on the link between family resources in childhood and education outcomes (see Duncan and Brooks-Gunn 1997 or Duncan and Murnane 2011 for a review). Much of this literature relies on contemporaneous measures of economic disadvantage, comparing outcomes for children who are currently poor and currently not poor. Studies using longitudinal information on family resources document larger achievement deficits for the persistently disadvantaged relative to those who are transitorily disadvantaged (e.g. Dahl and Lochner 2012; Duncan, Brooks-Gunn and Klebanov 1994; Haveman, Wolfe, Spaulding 1991; Ku and Plotnick 2003; NICHD 2005; Wolfe et al. 1996;). The findings of these studies are powerful, but the longitudinal datasets they use do not describe recent birth cohorts and suffer from non-response and attrition, which are growing more common in household surveys (Meyer, Mok, and Sullivan 2015; Meyer Nittag 2015).

We expand on this literature to assess whether similar patterns emerge for a recent cohort of 8th graders using administrative data that provide longitudinal information on the entire population of students within the Michigan public school system. These data present several advantages over survey data. They contain the entire population of students within the Michigan public school system, reducing concerns of sampling bias and survey attrition. Since these

datasets are administrative, they do not suffer from non-response bias or attrition (other than that created by exit from the public school system). The large sample size (each cohort is roughly 100,000 students) also allows for precise estimation of how the timing and duration of disadvantage are associated with test score gaps, which is more challenging in survey data based on smaller samples.

We rely on measures of subsidized meal eligibility as a proxy for economic disadvantage, which includes students living in households below 185% of the federal poverty line. Throughout, we refer to these students as economically disadvantaged or low-income interchangeably to refer to those who were eligible for subsidized meals. All state administrative systems now contain this information, in part because the federal government requires states to report the number of children eligible for subsidized meals. This measure is widely used by education researchers as a proxy for poverty. In recent years, subsidized meal eligible students comprised nearly half of the student population nationwide, while the share living below the poverty line was less than a quarter of all children.

Investigating methods to identify the most disadvantaged students within this broad definition is of great importance to researchers and policymakers alike. Researchers often use subsidized meal eligibility as a control variable, to identify a subgroup when evaluating a program, or to calculate "value-added" measures of teacher and school quality. More precise measurement of economic disadvantage will improve the quality of these analyses. Using information on a student's past eligibility for subsidized meals is one way to differentiate the intermittent or transitorily disadvantaged from the persistently disadvantaged. To our knowledge, no study has leveraged the longitudinal nature of these data systems to construct measures of the

persistence of economic disadvantage to examine the relationship between the duration of disadvantage and education outcomes.

Incorporating longitudinal information on subsidized meal eligibility, we find that 60% of 8th graders claim subsidized meals at least once between kindergarten and 8th grade. This large share of the student population is quite heterogeneous, with some students cycling on and off eligibility throughout grade school and others eligible every year. Persistently disadvantaged children are quite different from children who are only temporarily disadvantaged. They are more likely to be black or Hispanic and to attend schools in urban areas. And, as we will show, they score substantially lower on standardized tests than both their transitorily disadvantaged and never disadvantaged peers.

Achievement gaps measured using contemporaneous disadvantage mask the heterogeneity within both the high-income and low-income populations: a subset of those in the "high-income" group at the time of assessment were low-income in a prior year, while a subset of those eligible for subsidized meals in a given year were actually eligible every year. Both of these factors lead to an underestimation of the achievement gap between the most advantaged and least advantaged students when relying on contemporaneous measures alone. Chronically disadvantaged students score a quarter of a standard deviation below those transitorily disadvantaged, and nearly a full standard deviation below those never-poor on standardized tests. This is 35% wider than the gap measured using contemporaneous measures. These score differences between the temporarily and chronically disadvantaged persist even after controlling for differences in demographics, school quality, and prior achievement. This implies that differences in observed characteristics alone cannot explain why persistently disadvantaged students perform worse on standardized tests than those who are never poor or only transitorily

disadvantaged. While we lack information on individual-level family income, we provide suggestive evidence that the persistently disadvantaged are worse off not only due to the duration of time spent in economic disadvantage, but also due to the absolute level of resources available at each age compared to the transitorily disadvantaged.

II. Prior Literature: Family Resources and Child Outcomes

A long literature examines the relationship between family resources and child outcomes (for an overview, see Duncan and Brooks-Gunn 1997; Duncan, Magnuson, Kalil, and Ziol-Guest 2012; Duncan and Murnane 2011; or Mayer 1997). Identifying which specific factors affect child outcomes has been more challenging to determine. Children growing up in low-income households face a host of challenges such as family instability, mental and physical health issues, stress, and poor housing quality. Research using policy changes in income transfer programs has suggested a causal link between family income and child outcomes (Dahl and Lochner 2012; Duncan, Morris, Rodrigues 2011). Family income is also correlated with other factors that have been shown to affect child outcomes such as parental education and occupation, single parenthood (Sandefur, McLanahan, and Wojtkiewicz 1992), parental mental health (Petterson and Albers 2001), and neighborhood quality (Chetty, Hendren, Katz, Forthcoming; Ludwig and Kling 2007).

Much of the work relating family resources to child outcomes relies on contemporaneous, rather than longitudinal, measures of income. This is surprising, given the large literature documenting the chronic nature of poverty in the United States (Ashworth, Hill, Walker 1994;

Bane and Ellwood 1986; Cellini, McKernan, Ratcliffe 2008).[2] It is plausible that children growing up chronically poor face more severe challenges than children who experience poverty intermittently. Still, even using a single year of family income to assess the income-based achievement gap suggests large differences between low-income and high-income students. Reardon (2011) uses multiple surveys to show that gaps between poor and richer children have grown over time. For recent years, he estimates that the math test score gap between students with family income in the 90th percentile and those in the 10th percentile is around one standard deviation.

A smaller body of research exploits longitudinal data to show that racial and socioeconomic gaps emerge by the time children enter kindergarten (Duncan and Magnuson 2011; Fryer and Levitt 2004; Magnuson and Duncan 2006) and have lasting effects into adulthood (Heckman et al., 2010). Some studies have examined the relationship between the duration and timing of disadvantage and child outcomes (Duncan, Brooks-Gunn, Klebanov 1994; Duncan et al. 2012; Haveman et al 1991; Ku and Plotnick 2003; Peters and Mullis 1997; Petterson and Albers 2001; Smith, Brooks-Gunn, Klebanov 1997; Wolfe et al. 1996) using various measures of disadvantage such as family income or welfare receipt. They find that persistently disadvantaged children have worse test scores, more behavioral problems, and, as adults, have less schooling and lower wages. Examining IQ and behavioral problems, Duncan and coauthors (1994) conclude that the effect of persistent poverty is up to 80% higher than that of transitory poverty. Chronically poor children inherently spend more years in poverty than intermittently poor children. Whether the duration of the poverty spell itself or differences in

[2] Duncan and Rodgers (1988) find that while incidence of chronic poverty in childhood was relatively uncommon among children in the PSID in the late 1960s and 1970s, approximately half of all children experienced economic hardship at some point during childhood.

permanent family income or unobserved characteristics drive differences in outcomes between these groups is an open question.

The longitudinal studies discussed above rely on data from surveys such as the Panel Study of Income Dynamics (PSID) and the National Longitudinal Survey of Youth (NLSY). These datasets include multiple measures of income over a child's lifetime that allow researchers to identify those who are persistently disadvantaged. They are also rich in other family background characteristics such as marital status transitions, receipt of welfare, and parental occupation. But they also suffer from response bias and sample attrition, which is likely to be correlated with disadvantage. Recent studies have documented a decline in the quality of household survey data relative to administrative data, raising concerns about the validity of self-reported income information (Meyer, Mok, and Sullivan 2015; Meyer and Nittag 2015). In particular, Meyer, Mok, and Sullivan (2015) report that more than half of welfare dollars reported in administrative data are not reported in survey data, which potentially leads to biased estimates in assessing who receives government transfers and their correlates with child outcomes.

A large literature now makes use of administrative data held by states to conduct educational research (Dynarski and Berends, 2015). These datasets lack the detailed income data on the PSID and NLSY. But they are large, covering the universe of public school students in each state and contain comprehensive information on students' test scores and educational attainment. They can also be used to track students longitudinally, since each child is assigned a unique identifier that, in many states (including Michigan) stays with a student through college. Since these administrative datasets lack detailed measures of parental income, eligibility for subsidized school meals is the only available measure of family income. This proxy for poverty,

discussed in detail below, is used widely by education researchers (see, for example, papers in the volume edited by Dynarski and Berends 2015 such as Papay, Murnane, and Willett 2015). To our knowledge, no study has leveraged the longitudinal nature of these data systems to construct measures of the persistence of economic disadvantage to examine the relationship between the duration of disadvantage and education outcomes.

III. The National School Lunch Program

III.A. Background on NSLP

The National School Lunch Program (NSLP) is an 11 billion dollar federal program delivering meals to 31 million students across the country as of 2012 (Food and Nutrition Services 2012). The program, which was established in the 1946 National School Lunch Act, authorizes subsidies that allow students to receive free or reduced price lunch. Eligibility for subsidized lunch is widely used as an indicator of financial need. Policymakers and researchers rely on it to target low-income students for policy interventions or evaluations. On the policy side, local education agencies define school poverty levels as the share of children eligible for subsidized meals and make Title I allocation decisions based on those levels (U.S. Department of Education 2012). Many other programs such as teacher loan forgiveness are based on the fraction of students eligible for subsidized meals in their school.[3]

[3] Schools also receive federal reimbursement for each student eligible for subsidized lunches, which are approximately $3 per student eligible for a free lunch as of the 2014-15 school year (Food and Nutrition Services 2015).

Students can claim eligibility for free or reduced-price meals in one of two ways: by filling out paperwork with their school reporting household income or through direct certification based on receipt of other federal means-tested benefits. Under the first method, monthly household income must be below 185% of the federal poverty guidelines in order to receive a reduced-price meal, and 130% of the federal poverty guidelines for a free meal.[4] In 2015, a family of four must have annual earnings below $31,525 for free meals and $44,863 to qualify for reduced-price meals.[5]

Rather than proving family income, students can become directly certified for subsidized meals if they receive benefits from another means-tested federal program such as food stamps (SNAP), the supplemental food subsidy for women, infants and children (WIC), welfare (TANF), or if they reside in a household with foster children. In these cases, students do not have to fill out paperwork with their schools, as eligibility is determined directly through these other programs. Students who are directly certified for subsidized meals tend to have lower income than those who become eligible by filling out an application, as the income thresholds for many of these programs is below 185% of the poverty threshold. Food stamps, for instance, require household income to be below 130% of poverty (U.S. Department of Education 2012).[6] Once

[4] NSLP uses the federal poverty guidelines, which differ slightly from the federal poverty threshold in that they do not distinguish between the ages of individuals residing in the household. The federal poverty threshold has different settings depending on whether the additional family members are children or not, while the guidelines make no such distinction. See http://aspe.hhs.gov/poverty-guidelines for more information.

[5] In the 48 contiguous states. Separate guidelines are established for Alaska and Hawaii. See http://aspe.hhs.gov/poverty-guidelines for details.

[6] The income threshold for WIC is 185% of poverty, see http://www.fns.usda.gov/wic/wic-income-eligibility-guidelines for details. The income thresholds for TANF vary by state, but more than half of states require monthly income to be below $795 per month ($9,540 a year, which is well below the poverty threshold for a family of three) for a single parent of two children in 2012 (Falk 2014). Michigan required monthly income to be less than $814 for a single parent with two children as of 2012. There are no explicit income requirements for foster care.

students have gained eligibility for NSLP through either of these methods, they are eligible for the entire school year and up to 30 days of the next school year (USDA 2015).

In recent years, nearly half of all school children received subsidized meals (see Figure 1). Over the last decade, the growth in the share of children receiving subsidized meals has outpaced the growth in the share of children living below the poverty line. Subsidized meal eligibility is now a worse proxy for poverty than it was at the start of the 21st century. This is in part due to the growth in the share of children living in households with income below 185% of the federal poverty line, as illustrated by the dashed grey line (calculated from the Survey of Income and Program Participation from 2001 through 2008). There is also evidence that take-up of subsidized meals among the eligible population has increased over the last decade. Comparing the share of children living in households with income below 185% of poverty to the share of children receiving subsidized meals indicates that eligible students were less likely to claim subsidized meals at the start of the 21st century than in more recent years. Part of the widening of the gap between the share of children residing in poverty and the share of children receiving subsidized meals appears to be due to an increase in the take-up of subsidized lunch among students meeting the income criteria over the last decade.

III.B. Measurement and misclassification of subsidized meal eligibility

While subsidized lunch eligibility is a convenient way to approximate poverty, the measure itself is not without limitations. Students eligible for subsidized meals typically have family income below 185% of the federal poverty guidelines, but estimates suggest that some students have income above this threshold[7] (Newman and Ralston 2006), raising concerns regarding the

[7] This is partially an issue of defining income. Subsidized meal eligibility is determined by *household* income, while the Census definition of poverty uses *family* income, which only includes the income of individuals residing in the

validity of this measure for approximating socioeconomic status (Harwell and LeBeau 2010; Hauser 1994; Kurki, Boyle, and Aladjem 2004; Randolph and Prejean-Harris 2014). This is in part due to the method of determining eligibility. Eligibility for subsidized meals is determined by monthly income, but once students are certified, they maintain their eligibility for the entire calendar year, even if household income increases over the course of the year. This tends to result in a larger share of the population obtaining eligibility for subsidized meals than if eligibility were determined based on annual income (Cruse and Powers 2006).

As with any means-tested benefit program, less than full take-up and the potential for misclassification affect who is categorized as economically disadvantaged. A long literature demonstrates that take-up in social welfare programs is both incomplete and correlated with attributes that determine social outcomes (Currie 2004). Participation in subsidized meals is likely subject to similar bias. Older students may be particularly unlikely to take up eligibility, if they fear the judgment of their peers. We illustrate this for students in Michigan in figure X, which shows the share of students claiming subsidized meals by grade for both the 2004-05 school year as well as the 2014-15 school year. The drop-off in claiming is less pronounced in recent years than it was ten years ago, but there is still a 10 percentage point drop in claiming between 7th grade and 12th grade. Part of this decline certainly comes from differential drop-out rates, with disadvantaged students more likely to drop out of high school before reaching 12th grade than students who were not eligible for subsidized meals, but the decline in claiming is apparent even before students are of the age to drop out of high school.

household who are related by blood or marriage. Household income includes any individual residing in the household, regardless of relation.

Using data from the Survey of Income and Program Participation (SIPP) panels from 2001 to 2008, we found that approximately 20% of children age 5 to 17 who reported receiving a subsidized meal had family income above 185% of poverty in that month. On the other hand, we found that approximately 25% of children with family income below 185% of poverty did not report receiving subsidized meals. This could be a reporting error, where individuals do not report receiving a subsidized meal to the SIPP but do in fact receive the subsidy, or an under-claiming issue, where some students do not claim subsidized meals when their family income renders them eligible. This also presents an advantage of using administrative data rather than survey data, as eligibility is reported by the school and not subject to underreporting bias. Using several years of information on subsidized meal eligibility will also reduce concerns that individuals are falsely claiming benefits, as we expect students who are persistently eligible for subsidized meals are not claiming the subsidy in error.

IV. Data and Method

In Michigan, administrative data allow for the tracking of students from kindergarten through 12th grade so long as students remain in the Michigan public school system. Our data come from the Michigan Center for Educational Performance and Information (CEPI), and contain information on all students in the Michigan public school systems since the 2002-2003 school year. In our analysis, we focus on the cohorts of students who were in 8th grade between the 2010-2011 and the 2012-2013 school years, which allows us to observe students from kindergarten through 8th grade and evaluate their subsidized meal eligibility throughout grade school.[8] We further restrict the sample to 8th graders who were in the Michigan public school

[8] Results are quite similar if we focus on an earlier cohort, e.g. those in 8th grade during the 2009-10 school year. See appendix table 1. Patterns are also quite similar if we analyze students in other grades, see appendix table 2.

system in 7th grade in order to control for prior achievement, but we make no further restrictions on how many years students must be present in the Michigan public school system.[9] Approximately 76% of 8th graders in these cohorts were observed in the Michigan public school system for the full nine years. In all analyses, we include an indicator for whether a student was missing in at least one year of the data to allow these students to have a separate correlation with 8th grade math test scores.[10] Results are quite similar if we restrict the sample to individuals present for all nine years between kindergarten and 8th grade (see appendix table 3).

The administrative databases we use include the Single Record Student Database (SRSD), the Michigan Student Data System (MSDS), which replaced the SRSD in 2010, and the Michigan Educational Assessment Program (MEAP) database. The SRSD and MSDS provide information on student demographics such as race, gender, subsidized meal eligibility, special education status, limited English proficiency (LEP) status, and migrant status.

IV.A. Dependent variable

The MEAP database provides assessment data on the Michigan Educational Assessment Program tests, the state standardized tests that are required of all public school students. MEAP examinations are administered from grades 3 through 8 and again in 11th grade. We focus on math test scores in this analysis although patterns are quite similar for other subject areas. We

[9] See Data appendix for full explanation of restrictions.
[10] Students who were missing in at least one year typically scored about 0.06 standard deviation below students present for all nine years.

standardize test scores by grade and year for the entire population of students in the state of Michigan; all measurements of test scores can be interpreted as standard deviations and reflect a given student's performance relative to their academic peers in Michigan public schools in that year.

IV. B. Independent variables

We create several measures of economic disadvantage based on contemporaneous and longitudinal subsidized meal eligibility. Our first measure is based on 8th grade eligibility for subsidized meals, ignoring any prior eligibility. Based on this measure, we categorize students as either "currently disadvantaged" or "not currently disadvantaged". We also create a measure that separates the free-lunch eligible students from the reduced-price lunch eligible students, still focusing only on 8th grade eligibility.

We compare these two contemporaneous measures of subsidized meal eligibility to measures based on persistent eligibility. We construct three categories based on eligibility for subsidized meals between kindergarten and 8th grade.[11] The first category consists of students who were eligible for subsidized meals at least once but not every year between kindergarten and 8th grade; we term these students "transitorily disadvantaged". The second category includes students who were eligible for subsidized meals in every year they attended Michigan public schools between kindergarten and 8th grade; we consider these students "persistently disadvantaged".[12] We compare these groups to students who never experienced economic disadvantage between

[11] In robustness checks, we also create measures based on kindergarten through 5th grade eligibility, 3rd through 8th grade eligibility, and 5th through 8th grade eligibility. See appendix figure 1 and appendix table 2.
[12] In order to be considered 'persistently poor', students must be present in the dataset for all nine years. Students who were not present for all nine years and had at least one year of subsidized meal eligibility will automatically be considered 'transitorily poor'. Results are not sensitive to this decision: similar results are found when restricting the entire sample to individuals observed for the full nine years (see Appendix Table 3).

kindergarten and 8th grade, the "never disadvantaged". In some analyses, we further differentiate disadvantaged students by the total number of years spent in subsidized meal eligibility as well as the timing of disadvantage to further illustrate how test score gaps vary based on when and how long a student is disadvantaged.

IV.C. Outline of Analysis

Our analysis proceeds as follows. We first compare demographic and school characteristics of 8th graders between the 2010-2011 and 2012-2013 school year using our contemporaneous and persistent measures of disadvantage. We then use life table methods to illustrate the chronic nature of disadvantage among those students who become disadvantaged at an early grade. This method allows us to calculate the probability of escaping subsidized meal eligibility each year after the initial eligibility year, providing a descriptive picture of how many years students are eligible for subsidized meals. We then evaluate test score gaps using our longitudinal and contemporaneous measures of economic disadvantage (persistently disadvantaged, transitorily disadvantaged, and currently disadvantaged). We present these trends unconditionally as well as through OLS regression analysis, testing whether measures of persistent disadvantage add explanatory power in predicting 8th grade test scores even after controlling for student and school characteristics.

We conduct a number of sensitivity tests to evaluate how estimates change based on the duration and timing of disadvantage and what these results mean for the interpretation of the achievement gap. There are several reasons why we might expect persistently disadvantaged students to perform worse on standardized tests compared to their transitorily disadvantaged peers. Persistently disadvantaged students inherently spend more years eligible for subsidized

meals than their transitorily disadvantaged peers. The difference in duration itself might account for achievement gaps. On the other hand, persistently disadvantaged students might have lower permanent family income than transitorily disadvantaged students and would have lower achievement even if the duration of disadvantage were similar between the two groups. As a test of these two hypotheses, we examine 3rd grade math test scores among this same cohort to test whether test score gaps are evident even before the persistently disadvantaged experience nine full years of subsidized meal eligibility. If we observe no difference in 3rd grade math test scores between those disadvantaged for four years compared to those disadvantaged for nine years, this will provide evidence that the duration of disadvantage affects the achievement gap. On the other hand, if we observe differences in 3rd grade test scores among those who will eventually experience nine years of disadvantage compared to those who ultimately experience fewer years, this will provide evidence that persistently disadvantaged students have fewer resources than the transitorily disadvantaged that are not explicitly due to the difference in the number of years spent in disadvantage.

V. Descriptive Results

V.A. Who is Disadvantaged?

Nearly 60% of all 8th graders in the 2011-2013 school years were eligible for subsidized meals at least once between kindergarten and 8th grade (see table 1). The average 8th grader ever experiencing economic disadvantage was eligible for more than six years, or about 70% of their total grade school years. Of those who were ever disadvantaged, nearly one in four 8th graders were eligible every year they were in Michigan public schools up through 8th grade. The

remaining 75% of those ever disadvantaged experienced spells averaging five years, or approximately 60% of their total time in grade school.

Ever Disadvantaged vs. Never Disadvantaged

Demographically, there are substantial differences between students who ever experienced economic disadvantage in childhood compared to those who were never disadvantaged. Of those who were never disadvantaged between kindergarten and 8th grade, nearly 90% were white. In contrast, only 60% of those who were ever disadvantaged were white. Those students who had ever been disadvantaged by 8th grade were six times more likely to be black and four times more likely to be Hispanic compared to those who were never disadvantaged. Low-income students were also much more likely to be in urban schools and attend schools where more than half of their peers were eligible for free or reduced price meals. While we lack individual-level information on household income, we do have information from the American Community Survey (ACS) on median household income in the zip code where students live. Using this measure, the never-poor population lives in a zip code where the median household income is approximately $63,000 (2014$), while those who were ever disadvantaged live in places with a median household income of about $46,000.

Persistently Disadvantaged vs. Transitorily Disadvantaged

We also find substantial differences *within* the population of students who were ever disadvantaged. While the persistently disadvantaged were eligible for subsidized meals every year between kindergarten and 8th grade (by definition), the transitorily disadvantaged were eligible for approximately 5 years, or 60% of the time. There are also substantial racial differences between these two groups. More than half of the population of students who were

persistently disadvantaged were black or Hispanic (51%), compared to only 32% of those who were transitorily disadvantaged. The persistently disadvantaged also live in areas with lower median household income compared to the transitorily disadvantaged-- $41,000 compared to $48,000, respectively. The persistently disadvantaged are more concentrated in urban areas, while the transitorily disadvantaged are more concentrated in suburban areas. Those who were persistently disadvantaged attended schools with a higher concentration of students eligible for subsidized meals than those who were transitorily disadvantaged. 14% of 8th graders who were persistently disadvantaged attended schools where more than 90% of the student population was also disadvantaged, compared to 4% of those who were transitorily disadvantaged.

Contemporaneous Disadvantage

These trends in persistent disadvantage present a different picture than that based on disadvantage in 8th grade alone. Nearly half of 8th graders were eligible for free or reduced price lunch in 2011-2013, understating the share of 8th graders who ever experience disadvantage by about 20%. While 53% of 8th graders were not disadvantaged in 8th grade, one in five of those students were disadvantaged in a prior year. Despite this, the currently disadvantaged look quite similar to the sample of 8th graders who were ever disadvantaged—they spent about seven years in eligibility, compared to six among the ever disadvantaged, which represents almost 80% of their school years. 8th graders eligible for free lunch, who represent about 85% of all students on subsidized meals, spent slightly more of their years in economic hardship than the larger group eligible for any subsidized meal—82% of the time compared to 80% of the time, respectively.

V.B. What do Survey Data Reveal about Persistent vs. Transitory Disadvantage?

Lacking information on other family background characteristics such as family income, parental education, and family structure, we have little other information on how the persistently disadvantaged differ from the transitorily disadvantaged and the never disadvantaged. We can, however, turn to nationally-representative survey data to compare family characteristics of those growing up in economically disadvantaged households to those growing up in more affluent households to determine potential correlates with chronic disadvantage that could also affect achievement.

In analysis using the Early Childhood Longitudinal Survey, Kindergarten Class of 1998-1999 (ECLS-K), we determined that approximately half of 8th graders in 2006-2007 were ever eligible for subsidized meals and about 10% of 8th graders were eligible in each survey wave of the ECLS-K (see appendix table 4). These estimates are somewhat lower than in our Michigan data, potentially reflecting sample attrition or under-reporting in the ECLS-K. Similar to patterns in Michigan, persistently disadvantaged students in the ECLS-K were much more likely to be a racial or ethnic minority (73% compared to 46% among transitorily disadvantaged and 11% among the never disadvantaged). They were also much less likely to live with both parents at the start of the survey (51% compared to 65% among the transitorily disadvantaged and 91% among the never disadvantaged) and much less likely to have a parent with any college experience (29% compared to 56% among the transitorily disadvantaged and 85% among the never disadvantaged). Their average family income was around $18,000, while the transitorily disadvantaged had family income of $31,000 and family income for the never disadvantaged was around $71,000. All of these factors have previously been linked to adverse outcomes for children, further illustrating that chronically disadvantaged children face a host of other challenges that likely contribute to the income-based achievement gap.

V.C. How does the duration of disadvantage differ by grade of onset?

The majority of ever- disadvantaged 8th graders become eligible for subsidized meals by the time they enter 1st grade. Early disadvantage is also correlated with the duration of disadvantage, as we illustrate in figure 2. We created a duration measure by identifying the first grade in which a student became eligible for subsidized meals, following them for consecutive years until they first become ineligible. We present the survival rate of subsidized meal eligibility for the first spell of disadvantage a student experiences between kindergarten and 8th grade, limiting the sample to students who first became eligible for subsidized meals in 2006.[13]

Figure 2 illustrates the chronic nature of disadvantage, particularly among students who first experience economic disadvantage at a young age. Among children who first became eligible in kindergarten, 93% were still eligible one year later. After four years, 80% of students whose spell began in kindergarten were still eligible; half were still eligible eight years after the initial spell began. In contrast, the one-year survival rate among students who first became eligible in 4th grade is 83%. Though we find a large difference in the duration of spells between those who first became eligible in kindergarten and those who became eligible in 4th grade, the duration dependence of disadvantage is still quite high among this population—half of the students who first became eligible in 4th grade were still eligible four years later.

VI. Results: Achievement Gaps by Economic Disadvantage

VI.A. Raw Score Differences

[13] This sample restriction allows us to identify differences in survival rates by grade of entry without concern of conflating grade of entry with year of entry. This is of particular concern during this time period because of the Great Recession, which likely affected the duration of poverty spells. Appendix Figure 1 shows survival rates in subsidized meal eligibility by calendar year of onset, pooling all grades.

Given the historical racial achievement gap, the large demographic differences between disadvantaged and non-poor students suggest that we should expect large divergences in their academic achievement as well. Measured the conventional way, using only contemporaneous measures of disadvantage, the 8th grade math test score gap between those currently disadvantaged and not currently disadvantaged was 0.69 standard deviations (see Table 2). One in five of those students who were not eligible for subsidized meals in 8th grade had been eligible in a previous year, which leads to an underestimation of the test score gap between the most advantaged students and the least advantaged. Differentiating between those who were eligible for a free meal rather than a reduced-price meal, we estimate a slightly wider test score gap of 0.74 standard deviations between those who were not eligible and those who were eligible for a free meal in 8th grade. The gap between the free-meal eligible and the reduced-price meal eligible itself is one-third of a standard deviation, illustrating the heterogeneity within the subsidized meal population itself.

While we do find a larger gap in math standardized test scores using the more restrictive contemporaneous definition of free-lunch eligible students, the gap measured using these contemporaneous measures obscures the much larger gap between those persistently disadvantaged throughout grade school and those who never experience economic disadvantage. Incorporating longitudinal measures, the test score gap between the never disadvantaged and the persistently disadvantaged is 35% wider than that measured using only contemporaneous information, at nearly a full standard deviation. While three-quarters of students cycle on and off eligibility throughout grade school, one in four ever-disadvantaged students are persistently disadvantaged. These students scored a quarter of a standard deviation below the transitorily

disadvantaged students on their 8th grade standardized math tests, which itself is one third of the gap between those currently disadvantaged and not currently disadvantaged in 8th grade.

VI.B. Regression-Adjusted Score Differences by Persistent Disadvantage

We have established that test score gaps between low-income and higher-income students are much wider if we compare students who are persistently disadvantaged and those who are never disadvantaged than relying on contemporaneous measures alone. It remains an empirical question whether these differences are in part explained by differences in demographic characteristics, differences in schools that students attend, and where they live. Students who are persistently disadvantaged, for instance, are much more likely to be from an ethnic or racial minority and are much more likely to attend schools with a high concentration of other disadvantaged students even compared to their transitorily disadvantaged peers. These differences may be driving the divergent estimates between contemporaneous and longitudinal measures of the achievement gap. In other words, these raw gaps may be contaminated by omitted-variable bias, with demographics and geography correlated with both persistent disadvantage and test scores.

We test this empirically by estimating conditional test score gaps that control for individual characteristics, school fixed effects, and median household income at the zip code level. Table 3 presents results. In Panel A, we measure disadvantage based on 8th grade subsidized lunch eligibility, dichotomizing students into "currently disadvantaged" and "not currently disadvantaged" groups. In Panel B, we split the "currently disadvantaged" category into two groups: those who are eligible for free lunch and those who are eligible for a reduced-

price lunch.[14] In Panel C, we introduce our measures of the persistence of disadvantage, differentiating between those who were never disadvantaged between kindergarten and 8th grade (the reference group), those who were transitorily disadvantaged, and those who were persistently disadvantaged. In all regressions, we cluster the standard errors at the school level to adjust for correlation in test scores among students who attend the same school.

Each column/panel combination in table 3 represents a separate regression. Column 1 includes only the measures of disadvantage, column 2 adds demographic characteristics such as race and gender, column 3 adds school fixed effects, column 4 adds controls for median household income at the zip code level, and column 5 includes controls for prior-year math test scores. With no controls in the model, we estimate an 8th grade math test score gap of 0.69 standard deviations between those eligible for a subsidized meal and those not eligible in 8th grade. Differentiating between the free and the reduced-price meal students in Panel B, we estimate a slightly larger test score gap between the free-lunch eligible and the ineligible of 0.74 standard deviations, replicating the gaps presented in Table 2. Using our measures of the persistence of disadvantage (Panel C), we estimate a test score gap of 0.70 standard deviations between the never disadvantaged and the transitorily disadvantaged, and 0.94 standard deviations between the persistently disadvantaged and the never poor.

In column 2, we include student demographic characteristics. Table 1 indicated that there are substantial racial differences between students who are transitorily disadvantaged, persistently disadvantaged, and never disadvantaged. Part of the overall test score gap could be explained by differences in race and gender among the transitorily disadvantaged, persistently

[14] We also conducted a separate analysis where we excluded 8th graders who were ever reduced-price lunch eligible, see Appendix Table 5.

disadvantaged, and the never disadvantaged. Including these controls, along with interactions of race and gender, reduces the test score gap using both contemporaneous and persistent measures of disadvantage (column 2). The gap between those currently eligible for subsidized meals and those who are not remains about a half of a standard deviation (0.55), while the gap between the never disadvantaged and the persistently disadvantaged is still nearly 40% larger than the gap based on contemporaneous eligibility.

Regardless of how we define the low-income sample (using contemporaneous or persistent disadvantage), we can account for about half of the test score gap between low-income and higher-income students by controlling for student characteristics and school fixed effects (column 3). This implies that some of the income-based gap in math test scores is driven by across-school differences, suggesting that low-income students attend lower-quality schools than higher-income students. After controlling for school fixed effects, income-based test score gaps are reduced by about half, but are still highly significant and remain between 0.39 and 0.55 standard deviations between the higher-income and low-income students. In contrast to the findings in Fryer and Levitt (2004) that much of the black-white test score gap can be attributed to differences in the quality of schools that blacks and whites attend, our findings suggest that there is a substantial income-based test score gap *within* schools.[15] Fryer and Levitt (2004) find that the black-white test score gap shrinks by more than two-thirds once including school fixed effects. Our results shrink by approximately half after including school fixed effects. This implies that we cannot completely explain the income-based test score gap by controlling for the

[15] Our own estimation of the black-white test score gap in Michigan is presented in Appendix Table 6.

quality of schools that low-income and higher-income students attend. This is true of both the contemporaneous measures and the persistence of disadvantage measures.

While we lack individual measures of household income in our data, we can test whether household income at the zip code level accounts for some of the income-based achievement gap generated using subsidized meal eligibility. It might be the case that a continuous measure of income at the zip code level (median household income) better approximates achievement gaps than a binary proxy for income at the individual level (subsidized meal eligibility). In column 4 of table 3, we control for the median household income at the zip code level using data from the ACS five year average from 2010-2014.[16] Including this control does very little to change the coefficients on our measures of disadvantage in either the contemporaneous disadvantage context or the persistent disadvantage context. While we do find a positive correlation between median household income and math test scores (not shown), the coefficient was quite small: a $1,000 increase in median household income at the zip code level was associated with a 0.003 standard deviation increase in math test scores. Persistent disadvantage remains a strong predictor of 8th grade math test scores even after controlling for median household income.

Researchers conducting studies of program effects using administrative data typically include lagged test scores as a summary statistic for demographics (Angrist et al. *Forthcoming*). Do lagged scores indeed control for differences in disadvantage? We examine this question in column 5 of table 3, which adds 7th grade math scores as a control. We find that there are still unexplained differences between low-income and higher-income children once we control for

[16] In an alternative specification, we included zip code fixed effects, which produced very similar results to those presented here. Results not shown but available upon request.

lagged test scores, and that these unexplained differences are particularly large when we compare the persistently disadvantaged with those who are never disadvantaged.

Results from our regression analysis indicate that while student and school characteristics reduce the income-based test score gap measured using either contemporaneous or longitudinal measures of disadvantage, the math test score gap between the persistently disadvantaged and the never disadvantaged remains larger than the math test score gap measured between the currently disadvantaged and the not currently disadvantaged. This suggests that differences in observed student and school characteristics cannot account for the differences in income-based test score gaps measured using longitudinal measures of disadvantage compared to contemporaneous measures. In fact, these controls explain virtually none of the differences between the contemporaneous measures and the longitudinal measures—the test score gap measured using the longitudinal disadvantage remains 40% larger than the gap using contemporaneous disadvantage after controlling for student characteristics, school fixed effects, median household income in the zip code, and prior test scores. These results have implications for practitioners as well as researchers. Practitioners cannot identify the most disadvantaged students using only contemporaneous disadvantage—even with information on prior test scores and average income in the area. Persistent poverty measures help identify the most disadvantaged students for targeting resources. Using persistent poverty can also help researchers who wish to estimate heterogeneity in treatment effects within the disadvantaged population. Our results suggest that persistent disadvantage provides explanatory power in predicting test scores, even after controlling for other correlates of socioeconomic status. We next conduct a number of sensitivity analyses to illustrate the robustness of these findings.

VII. Sensitivity Analyses

VII.A. Does prior disadvantage convey information beyond prior test scores and current disadvantage?

Thus far, we have compared test score gaps using contemporaneous and persistent disadvantage in separate models, comparing coefficients across models. In this next section, we test whether our measures of disadvantage contribute additional explanatory power above and beyond information conveyed through current economic disadvantage and prior test scores. We do this by regressing math test scores on measures of current disadvantage, subsequently adding controls for prior test scores and prior economic disadvantage in the same regression. This allows us to explicitly test whether prior disadvantage can explain some of the variation in 8th grade math test scores above and beyond what can be explained by current poverty and prior test scores.

Results are presented in table 4, where each column represents a different regression. The first two columns replicate results from table 3. Column 1 presents results of regressing current math test scores on a measure for current economic disadvantage. Column 2 includes controls for student characteristics, school fixed effects, median household income by zip code, and prior test scores. Column 3 adds controls for past disadvantage. The coefficients on these three terms (currently disadvantaged, transitorily disadvantaged, and persistently disadvantaged) can be estimated simultaneously because they are not mutually exclusive categories. All of the persistently disadvantaged students are also currently disadvantaged, while the transitorily disadvantaged students may or may not be currently disadvantaged.[17] The reference group, once again, is the subgroup of 8th graders who were never disadvantaged between kindergarten and 8th

[17] 74% of the transitorily poor students are poor in 8th grade, while 26% were poor in an earlier grade but not 8th grade.

grade. Comparing across columns 1 and 2 (replicated from table 3) indicate how much of the contemporaneous income-based achievement gap can be explained by prior test scores. Column 3 tests whether adding controls for prior disadvantage conveys further information beyond that of prior test scores. If the association between 8th grade test scores and prior disadvantage was fully captured by 7th grade test scores and disadvantage in 8th grade, we would expect the coefficients on the transitorily disadvantaged and persistently disadvantaged indicators to be zero.

Columns 1 and 2 replicate results from Table 3: the income-based math test score gap is approximately 0.69 of a standard deviation with no controls in the model and approximately 0.10 standard deviations with all controls and prior test scores included. Adding controls for prior disadvantage (column 3), we still find that the transitorily disadvantaged and the persistently disadvantaged score significantly lower on math tests than those disadvantaged in 8th grade alone, even after controlling for prior test scores. In comparing columns 2 and 3, much of the achievement gap between the currently disadvantaged and the not currently disadvantaged is driven by the persistently disadvantaged. Those who were disadvantaged only in 8th grade scored 0.03 standard deviations below those never disadvantaged, while those who were persistently disadvantaged scored an additional 0.10 standard deviations below the never disadvantaged even after controlling for 7th grade test scores. This implies that controls for persistent economic disadvantage still contribute explanatory power above and beyond that of current disadvantage and prior test scores.

VII. B. How do test score gaps change with each additional year of disadvantage?

We have shown that those who are economically disadvantaged persistently from kindergarten through 8th grade perform worse on standardized tests than those who are disadvantaged for only some of the years between kindergarten and 8th grade. To further understand how test scores vary with each additional year of disadvantage, we next use a number of non-parametric specifications of disadvantage to estimate how test score gaps change with each additional year. We implement models unconditionally as well as conditional on student and school characteristics to illustrate how the income-based test score gap is mediated by these controls.

Figure 3 illustrates math test score gaps based on the number of years of economic disadvantage experienced between kindergarten and 8th grade. This is measured by regressing math test scores on a set of indicators for the number of years a student was economically disadvantaged between kindergarten and 8th grade, with students who were never disadvantaged serving as the reference category. The coefficients on these indicators are plotted in figure 3. Each line represents a separate regression, with each point in the line corresponding to a coefficient on a separate indicator for the number of years of disadvantage. The black line represents the income-based math test score gap by number of years of economic disadvantage, not including any other controls in the model. Individuals who were disadvantaged for one year between kindergarten and 8th grade have math test scores that are 0.35 standard deviations below those of students who were never disadvantaged between kindergarten and 8th grade. With each additional year of economic disadvantage, the gap widens by about 0.08 standard deviations such that individuals who were disadvantaged for every year between kindergarten and 8th grade perform 0.89 standard deviations below those who were never disadvantaged. This is strikingly linear between one and nine years of economic disadvantage. Adding controls for student and

school characteristics shifts the whole curve downward, but the slope of the curve remains remarkably consistent with the addition of student characteristics and school fixed effects.

VII. C. Are persistently disadvantaged students poorer than transitorily disadvantaged students?

Figure 3 implies that each additional year of disadvantage is associated with a wider test score gap. It remains unclear whether persistently disadvantaged students experience the same level of income as transitorily disadvantaged students but for a longer period of time, or whether persistently disadvantaged students have lower permanent income compared to transitorily disadvantaged students. We are unable to explicitly answer this question with our data, but we can provide some suggestive evidence that persistently disadvantaged students are worse off than transitorily disadvantaged students for other reasons than just the duration of disadvantage. Because we have panel data on these individuals, we can compare 3rd grade math test scores to 8th grade math test scores for the same cohort of students based on the number of years they are ultimately disadvantaged. If we find differences among those disadvantaged for nine years even in 3rd grade—before they experience nine full years of disadvantage—this will provide suggestive evidence that the persistently disadvantaged have different traits than the transitorily disadvantaged.

We present evidence of this in figure 4, which plots 3rd and 8th grade math test score gaps for the same cohort of students by the ultimate number of years a student is economically disadvantaged between kindergarten and 8th grade. All test score gaps are measured relative to those who were never disadvantaged between kindergarten and 8th grade. While there is a level difference in the test score gap between 3rd grade and 8th grade, implying that disadvantaged students fall further behind the never-disadvantaged between their 3rd and 8th grade tests, the

slopes of the two lines are parallel. This indicates that there were differences in test scores between students who were ultimately disadvantaged for nine years and those disadvantaged for six or seven years even in 3rd grade—before they actually experienced nine years of disadvantage. These differences are significant, as indicated by the 95% confidence intervals in dashed grey. This suggests that the persistently disadvantaged have different traits—whether it be lower permanent family income, worse neighborhood conditions, poorer health—than the transitorily disadvantaged that is independent of the actual duration of time spent eligible for subsidized meals.

Supporting this claim, data from the ECLS-K indicate that income as a percent of poverty monotonically falls in all waves with each additional year spent eligible for subsidized meals (see appendix figure 4). Children who are never eligible for subsidized meals have income around 200% of poverty in all waves of the ECLS-K from kindergarten through 8th grade. Children eligible for subsidized meals in all waves, on the other hand, have family income below 150% of poverty in all years. This provides further evidence that the persistently disadvantaged not only spent more years in subsidized meal eligibility, they also have lower family income in each of those years compared to their peers who are eligible intermittently.

VII.C. How do test score gaps vary by the timing of disadvantage?

While figures 3 and 4 illustrate that each additional year of disadvantage is associated with a wider test score gap, they do not provide information on whether the *timing* of disadvantage is an important component of the math test score gap. Previous research has suggested that income matters more when children are young (Heckman et al. 2010; Duncan, Morris, Rodrigues 2011); we might expect that experiencing disadvantage at a young age is

associated with wider test score gaps than being disadvantaged at an older age. We test this next by regressing 8th grade math test scores on a full set of lagged indicators for whether a student was eligible for subsidized meals in the current grade as well as any of the prior eight years. These are not mutually exclusive indicators—students who were disadvantaged in each grade will have the full set of indicators set to one. Those who were disadvantaged in some of the grades but not all grades will have indicators set to one in the years of disadvantage, and zero in all other years. Individuals who were never disadvantaged will have all indicators set to zero.

Figure 5 illustrates how past eligibility for subsidized meals affects the 8th grade math test score gap between disadvantaged and non-disadvantaged students (see appendix table 7 for regression estimates). Each line represents a separate regression with different controls included in the models. Each line plots the coefficients on the set of indicators, which represent the 8th grade math test score gap between individuals eligible for subsidized meals in a given time period relative to their peers who were not eligible in that time period. For instance, controlling for eligibility in other years, those who were eligible for subsidized meals eight years prior (when they were in kindergarten) scored 0.14 standard deviations below their peers who were not eligible for subsidized meals then. 8th graders who were disadvantaged in the current year scored 0.18 standard deviations below their peers who were not disadvantaged that year. Aside from the larger coefficients on eligibility for subsidized meals in kindergarten and in 8th grade, there is little variation in the size of the coefficients on subsidized meal eligibility in all intermediate grades.

Results from figure 5 suggest that the largest contributions to the 8th grade math test score gap between the persistently disadvantaged and the never disadvantaged come from individuals who were eligible for subsidized meals in early grades (e.g. kindergarten) and in the grades

nearest the assessment year (e.g. 7th and 8th grade). This is not entirely surprising given the chronic nature of disadvantage among this population—those who are eligible for subsidized meals in kindergarten are least likely to exit than those who are eligible only in later grades. The fact that the coefficient on disadvantage in kindergarten is larger than for the other grades reflects the fact that those who were disadvantaged in kindergarten are least likely to escape disadvantage. Beyond this early-onset effect (being disadvantaged in kindergarten) and recency effect (being disadvantaged in the year of the assessment), we find little evidence that being disadvantaged in 1st grade has a differential effect on 8th grade math test scores than being disadvantaged in 6th grade.

VIII. Discussion and Conclusion

As of the 2012-2013 school year, nearly 60% of Michigan public school students experienced economic hardship at some point between kindergarten and 8th grade. Among those students, we identified a subgroup who were disadvantaged in each year from kindergarten through 8th grade. Those who were persistently disadvantaged throughout grade school performed nearly one standard deviation below students who were never disadvantaged on standardized math tests. This is fully 35% larger than the 8th grade math test score gap estimated using contemporaneous measures of disadvantage. While more than half of the income-based test score gap can be explained by student characteristics, the quality of schools they attend, and median household income of their residential zip code, the test score gap measured using longitudinal measures of disadvantage remains nearly 35-40% larger than the gap measured using contemporaneous disadvantage. In other words, observed characteristics do little to explain why the income-based test score gap is wider when using measures of persistent disadvantage than when relying on contemporaneous measures alone.

In measuring the achievement gap by total number of years of economic disadvantage, we find that the relationship between the number of years in disadvantage and the size of the achievement gap is strikingly linear up through nine years of disadvantage. That is, with each additional year of disadvantage we find a steady increase in the size of the achievement gap. When comparing test scores of persistently disadvantaged students in 3rd grade to those in 8th grade, we find evidence that students who go on to experience nine years of disadvantage between kindergarten and 8th grade perform significantly worse on their 3rd grade math tests than students who were transitorily disadvantaged. This implies that the persistently disadvantaged are economically worse off than the transitorily disadvantaged beyond just the number of years they spend in economic hardship. These findings reiterate the point that relying on contemporaneous measures of economic disadvantage alone to measure test score gaps understate the much wider achievement gap between the most advantaged and the least advantaged students.

Our analysis is restricted to students in the state of Michigan—a state that, over the last decade experienced a declining population, a bankruptcy in its largest city, and higher unemployment and child poverty rates than the national average. However, Michigan experienced a similar rate of subsidized meal eligibility as the national rate. Further, our results are comparable in magnitude to test score gaps assessed using family income among nationally-representative samples.[18] Our estimates of math test score gaps between the never poor and the persistently poor are comparable to those estimated by Reardon (2011) between individuals with family income in the 90th percentile to those with income in the 10th percentile. Using only

[18] Appendix Figure 4 illustrates that the number of 8th graders eligible for subsidized meals in the Michigan public school system very closely matches the number of 8th graders with family income below 185% of poverty in the American Community Survey, lending validation for our data.

contemporaneous eligibility for free or reduced-price lunch in 8th grade, our assessment of the math test score gap is comparable to the 90/50 or the 50/10 income-based gap in math test scores estimated by Reardon (2011).

These findings have implications for how researchers interpret the marker of free or reduced-price lunch as a proxy for poverty. While contemporaneous measures of eligibility approximate the population of students who ever experience economic hardship between kindergarten and 8th grade, they do not capture the extent of disadvantage experienced by a subgroup of the population who are persistently disadvantaged. Examining only contemporaneous measures of disadvantage also ignores the fact that some students who were not poor in 8th grade did experience disadvantage at some point in the past. Both of these factors lead to an underestimation of the test score gap between the most advantaged and the least advantaged students. As we have shown, incorporating information on prior disadvantage allows for distinguishing between students who are transitorily disadvantaged from those who are persistently disadvantaged and this has implications for the income-based achievement gap. While the level differences in test score gaps between using longitudinal disadvantage and contemporaneous disadvantage are substantially attenuated once controlling for student and school characteristics, the math test score gap between the persistently disadvantaged and the never disadvantaged remains nearly 40% larger than that measured using contemporaneous disadvantage alone. Demographic and school characteristics alone cannot explain the differences in test scores between those who are disadvantaged in any given year and those who are persistently disadvantaged throughout grade school.

These results suggest that efforts to close income-based gaps in achievement should focus on the subset of low-income students that are persistently disadvantaged. These students tend to

become eligible for subsidized school meals early in childhood, often by the time they enter 1st grade, and are likely to remain eligible throughout grade school. Those who first become disadvantaged by the time they enter kindergarten are least likely to escape poverty compared to their counterparts who become disadvantaged in later grades. They score significantly lower on standardized tests than those who were never poor as well as those who were transitorily disadvantaged during grade school. In future work using this longitudinal measure of disadvantage we will assess whether these gaps exist in other states, whether they persist into secondary and post-secondary schooling outcomes, and how these measures are associated with other markers of disadvantage using nationally-representative survey data.

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Table 1. The Michigan Context: Characteristics of 8th graders by economic disadvantage, 2011-2013 cohort

			Persistence measures			Contemporaneous measures		
	All 8th graders	Never disadvantaged	Ever Disadvantaged	Persistently Disadvantaged	Transitorily Disadvantaged	Currently free or reduced-price lunch	Currently free lunch	Not currently disadvantaged
Share of total sample	1.00	0.41	0.59	0.14	0.45	0.47	0.41	0.53
Share of ever disadvantaged			1.00	0.24	0.76			
Ever poor	0.59	0.00	1.00	1.00	1.00	1.00	1.00	0.22
Number of years poor	3.59	0.00	6.10	9.00	5.18	6.75	6.94	0.75
Proportion of years poor	0.42	0.00	0.72	1.00	0.63	0.80	0.82	0.09
Female	0.49	0.49	0.50	0.51	0.49	0.50	0.50	0.49
White	0.72	0.88	0.60	0.46	0.64	0.59	0.49	0.86
Black	0.19	0.05	0.29	0.39	0.26	0.29	0.37	0.07
Hispanic	0.05	0.02	0.08	0.12	0.07	0.08	0.10	0.02
Characteristics of home zip code								
Median household income (2014$)	53,146	62,986	46,257	41,104	47,889	45,224	44,363	60,224
Characteristics of school in 8th grade								
Urban	0.17	0.07	0.24	0.36	0.19	0.26	0.39	0.09
Suburban	0.48	0.58	0.41	0.33	0.45	0.41	0.33	0.54
Rural/Town	0.35	0.35	0.35	0.30	0.37	0.33	0.28	0.36
White	0.72	0.82	0.65	0.54	0.69	0.63	0.54	0.80
Black	0.17	0.08	0.24	0.33	0.20	0.25	0.35	0.10
Hispanic	0.06	0.04	0.07	0.09	0.06	0.07	0.08	0.04
Fraction of school eligible for subsidized meal	0.46	0.34	0.56	0.65	0.52	0.58	0.59	0.36
50-75% of school on subsidized meals	0.28	0.18	0.35	0.38	0.34	0.36	0.29	0.21
75-90% of school on subsidized meals	0.10	0.01	0.16	0.23	0.13	0.17	0.19	0.03
over 90% of school on subsidized meals	0.04	0.00	0.07	0.14	0.04	0.09	0.14	0.00
Number of observations	328,159	134,979	193,180	46,361	146,819	155,262	134,333	172,897

Source : Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013. Median household income from the American Community Survey 5-year averages 2010-2014.

Table 2. The gap within the gap: Math test score gaps vary greatly by definition of disadvantage, 8th graders in 2011-2013

Contemporaneous poverty measures	Test score gap
Currently disadvantaged vs. not currently disadvantaged	0.69
Free vs. not currently disadvantaged	0.74
Free vs. reduced	0.33
Persistent poverty measures	
Never disadvantaged vs. transitorily disadvantaged	0.70
Never disadvantaged vs. persistently disadvantaged	0.94
Persistently disadvantaged vs. transitorily disadvantaged	0.23

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.
Notes: Math test scores standardized by grade and year. Persistently poor refers to students who were eligible for subsidized meals for every year between kindergarten and 8th grade. Transitorily poor refers to students who were eligible for subsidized meals in at least one year, but not every year they attended Michigan public schools.

Table 3. Do math test score gaps persist after controlling for observable characteristics? OLS regressions using different measures of disadvantage, 8th graders in 2011-2013

	No controls	+ Demographic controls	+ School FE	+ Zip code controls	+ Prior test scores
Panel A. Current poverty					
Currently disadvantaged	-0.694	-0.551	-0.393	-0.389	-0.095
	(0.019)	(0.015)	(0.004)	(0.004)	(0.002)
Not currently disadvantaged (omitted group)					
R-squared	0.120	0.174	0.262	0.263	0.696
Panel B. Current poverty: Free vs. reduced-price lunch					
Currently disadvantaged (free lunch)	-0.739	-0.587	-0.422	-0.418	-0.101
	(0.020)	(0.015)	(0.004)	(0.004)	(0.002)
Currently disadvantaged (reduced-price lunch)	-0.412	-0.357	-0.251	-0.248	-0.064
	(0.020)	(0.017)	(0.007)	(0.007)	(0.004)
Not currently disadvantaged (omitted group)					
R-squared	0.126	0.177	0.264	0.264	0.696
Panel C. Persistent poverty					
Persistently disadvantaged	-0.939	-0.759	-0.550	-0.545	-0.132
	(0.023)	(0.018)	(0.006)	(0.006)	(0.004)
Transitorily disadvantaged	-0.703	-0.580	-0.433	-0.429	-0.107
	(0.021)	(0.016)	(0.004)	(0.004)	(0.002)
Never disadvantaged (omitted group)					
R-squared	0.146	0.192	0.270	0.271	0.697
Demographic controls		X	X	X	X
School FE			X	X	X
Zip code controls				X	X
Number of Observations	313,078	313,078	313,078	313,078	313,078

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 with valid school identifier in 8th grade and with valid 7th grade math standardized test scores.

Notes: Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Each PanelXcolumn represents separate regressions. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, and whether the student was missing at least one year of data between kindergarten and 8th grade. Zip code controls include median household income from American Community Survey 5-year estimates from 2010-2014. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

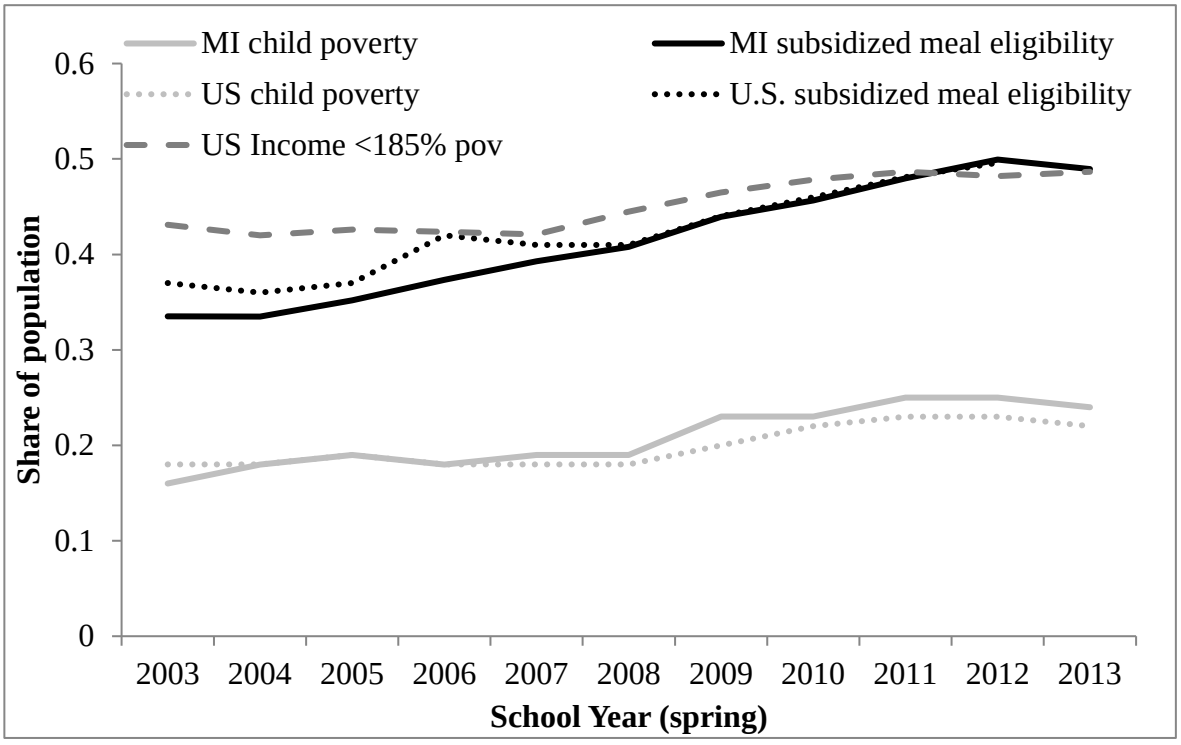
Table 4. Does lifetime disadvantage add explanatory value in the presence of current disadvantaged and prior test scores?

	No Controls	Demographic controls + prior test scores	+Demographic controls, prior tests, and prior disadvantage
Currently disadvantaged	-0.694	-0.095	-0.033
	(0.019)	(0.002)	(0.003)
Transitorily disadvantaged			-0.084
			(0.003)
Persistently disadvantaged			-0.101
			(0.005)
Never disadvantaged (omitted group)			
School FE		X	X
Zip code controls		X	X
R-squared	0.120	0.696	0.697
Number of Observations	313,078	313,078	313,078

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 with valid school identifier in 8th grade and with valid 7th grade math standardized test scores.

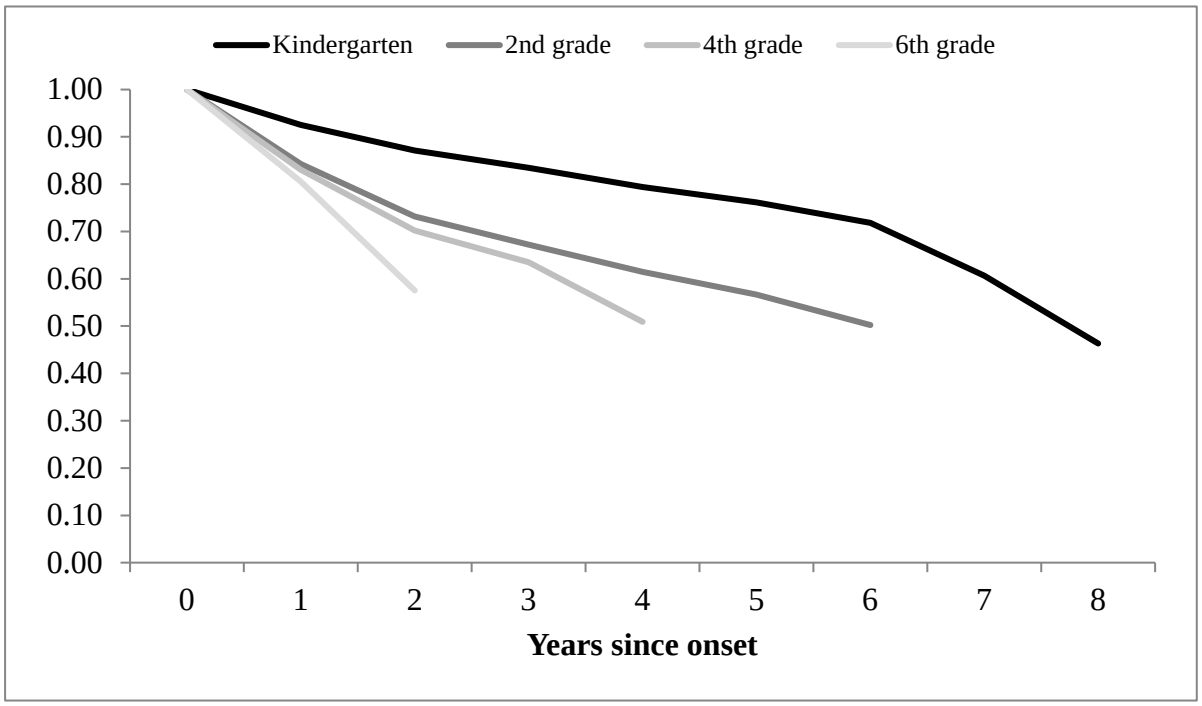
Notes: Regressions of standardized math test scores on indicators for subsidized meal eligibility. Currently disadvantaged students include those who received subsidized meals in 8th grade, regardless of past eligibility. Transitorily disadvantaged students consist of those who received subsidized meals at least once between kindergarten and 8th grade but not every year. Persistently disadvantaged students consist of those who received subsidized meals in every year between kindergarten and 8th grade. These three groups are not mutually exclusive: all persistently disadvantaged students are also included in the currently disadvantaged category. Some transitorily disadvantaged students are in the currently disadvantaged category, while those who were disadvantaged in a prior year but not in 8th grade are considered transitorily disadvantaged but not currently disadvantaged. Controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade, school fixed effects, and prior math test scores. Prior test scores measured in 7th grade. Zip code controls include median household income from American Community Survey 5-year estimates from 2010-2014. Standard errors clustered at the school level.

Figure 1. Share of K-12 students experiencing economic disadvantage by year



Source: Michigan subsidized meal eligibility calculated from Single Record Student Database/Michigan Student Data System files from the Michigan Department of Education. Child poverty rates from http://datacenter.kidscount.org/data/tables/43-children-in-poverty-100-percent-poverty.#detailed/2/24/false/868,867,133,38,35/any/321,322. U.S. subsidized lunch from the Common Core of Data: https://nces.ed.gov/ccd/tables/2000_schoollunch_01.asp. U.S. Income < 185% indicates share of national population with income below 185% of the federal poverty threshold for given household size. From the Survey of Income and Program Participation waves 2001 through 2008, estimates weighted by monthly person weights. Income measured in monthly increments.

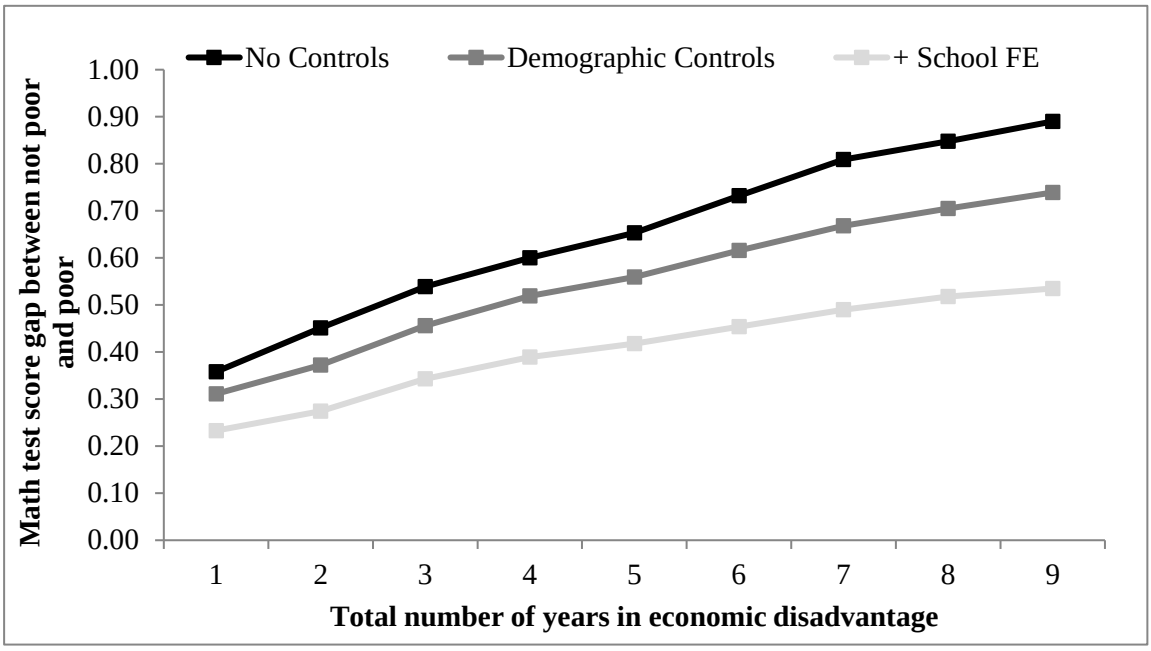
Figure 2. Early onset predicts persistent disadvantage
Survival rate in subsidized meal eligibility by grade of onset



Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Note: Survival rate in subsidized meal eligibility by grade of onset. Sample restricted to students who first became eligible for subsidized meals in 2006.

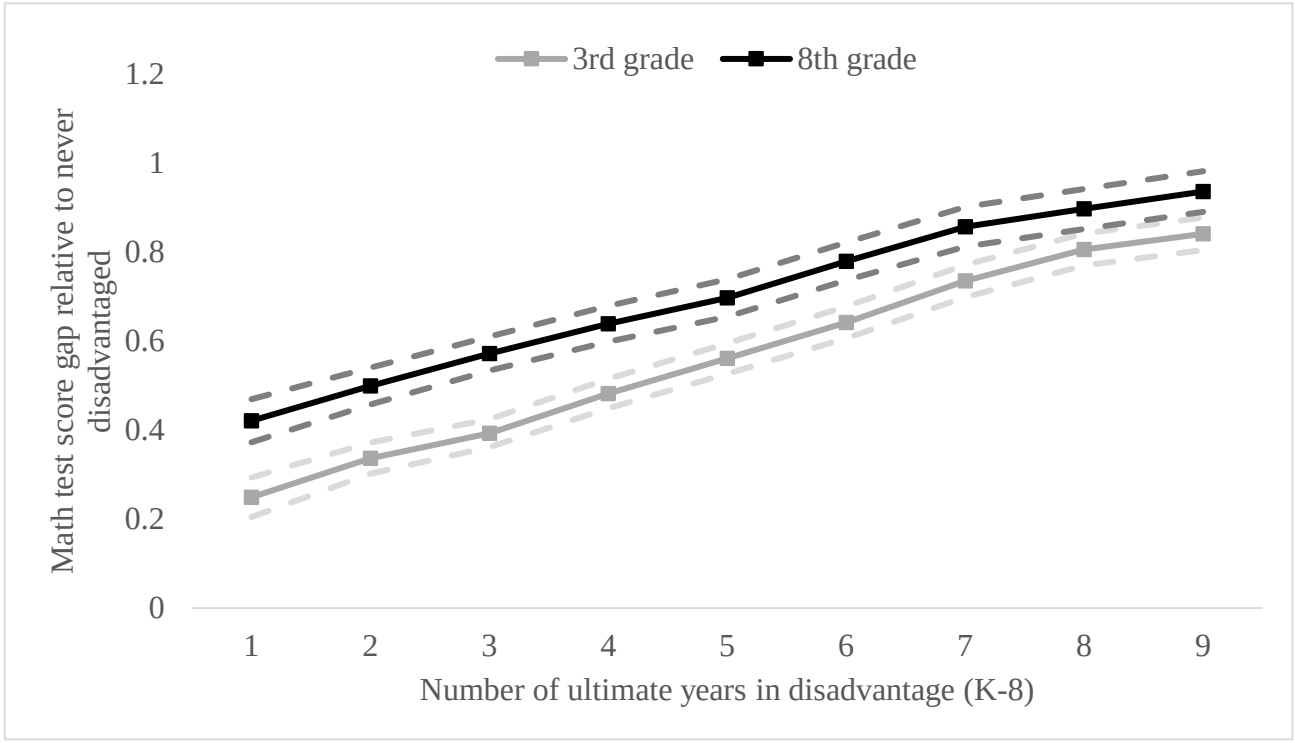
Figure 3. How do test score gaps vary by number of years of disadvantage?



Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 with valid school identifier in 8th grade and with valid 7th grade math standardized test scores.

Notes : From regressions of standardized 8th grade math test scores on a set of indicators for number of total years eligible for subsidized meals between kindergarten and 8th grade. Students who are never observed to be economically disadvantaged serve as the comparison group. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Standard errors clustered at the school level.

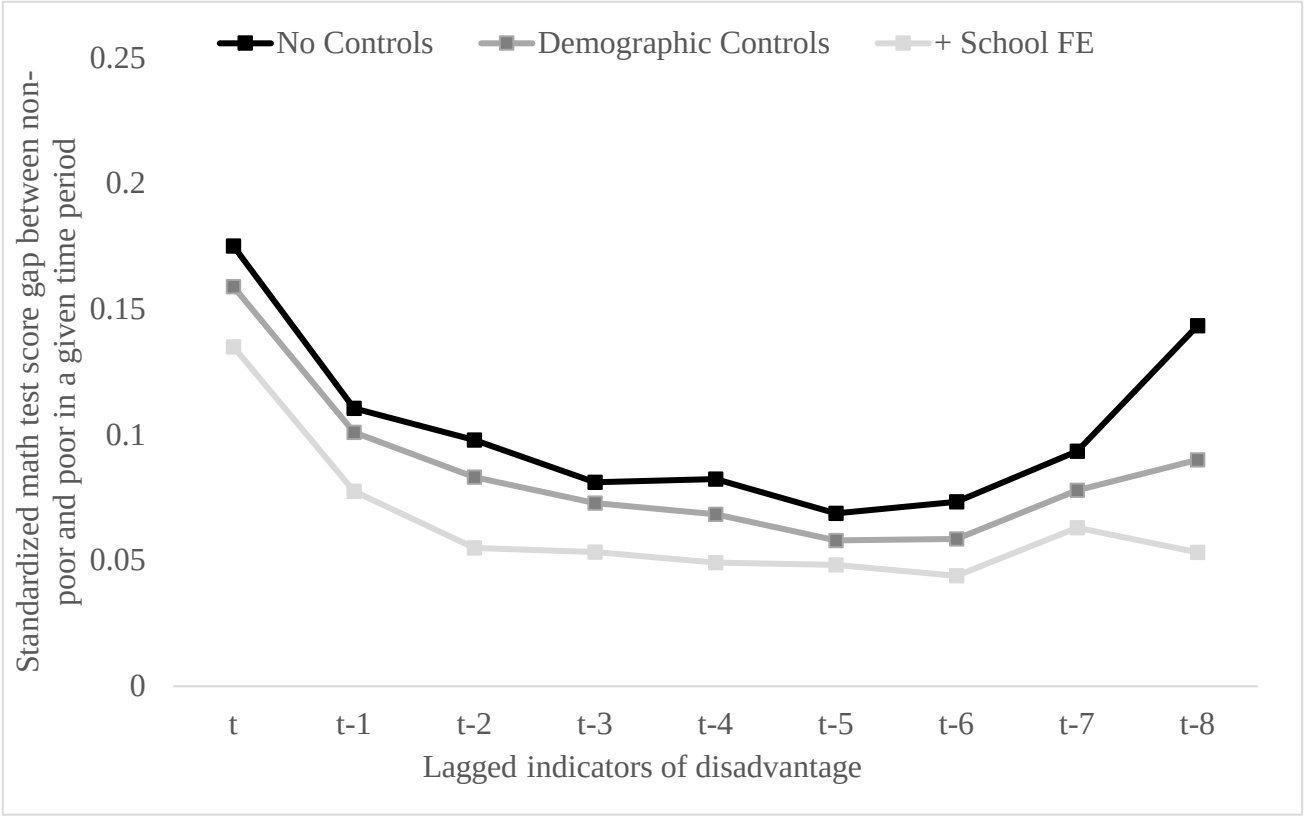
Figure 4. Did the persistently disadvantaged have lower achievement in 3rd grade than the transitorily disadvantaged? 3rd and 8th grade math test score gaps by number of ultimate years in disadvantage between kindergarten and 8th grade



Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 with valid school identifier in 8th grade and with valid 7th grade math standardized test scores.

Notes: From regressions of standardized 3rd and 8th grade math test scores on set of indicators for number of ultimate years eligible for subsidized meals between kindergarten and 8th grade. Students who were never eligible serve as the comparison group. Test scores measured for same cohort of students--8th graders in 2011-2013--in different grades. Number of ultimate years of disadvantage evaluated between kindergarten and 8th grade; 3rd graders will not necessarily have experienced all years of disadvantage as of 3rd grade. Each line represents a separate regression. No other controls included. Standard errors clustered at the school level. Dashed grey lines represent 95% confidence intervals.

Figure 5. How do test score gaps vary by timing of disadvantage? OLS regression of 8th grade math test scores on lagged indicators of subsidized meal eligibility



Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 with valid school identifier in 8th grade and with valid 7th grade math standardized test scores.

Notes: From regressions of standardized 8th grade math test scores on set of lagged indicators for subsidized meal eligibility from the current year up to eight years prior. Students who are not economically disadvantaged in a given time period serve as the comparison group. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, and whether the student was missing at least one year between kindergarten and 8th grade. Standard errors clustered at the school level.

Appendix Table 1. Do math test score gaps persist after controlling for observable characteristics? OLS regressions using different measures of disadvantage, 8th graders in 2010

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current poverty				
Currently disadvantaged	-0.687	-0.543	-0.381	-0.112
	(0.02)	(0.015)	(0.006)	(0.004)
Not currently disadvantaged (omitted group)				
R-squared	0.116	0.175	0.269	0.667
Panel B. Persistent poverty				
Persistently disadvantaged	-0.908	-0.738	-0.537	-0.155
	(0.024)	(0.019)	(0.008)	(0.006)
Transitorily disadvantaged	-0.647	-0.534	-0.395	-0.126
	(0.02)	(0.016)	(0.006)	(0.004)
Never disadvantaged (omitted group)				
R-squared	0.145	0.193	0.278	0.668
Panel C. Current and persistent poverty in same model				
Currently disadvantaged	-0.138	-0.118	-0.088	-0.024
	(0.013)	(0.012)	(0.01)	(0.007)
Transitorily disadvantaged	-0.550	-0.452	-0.334	-0.110
	(0.022)	(0.017)	(0.009)	(0.006)
Persistently disadvantaged	-0.769	-0.621	-0.451	-0.132
	(0.026)	(0.021)	(0.012)	(0.009)
Never disadvantaged (omitted group)				
R-squared	0.147	0.194	0.278	0.668
Demographic controls		X	X	X
School FE			X	X
Number of Observations	108,360	108,360	108,360	108,360

Source : Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade in the 2009-2010 school year.

Notes : Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Each PanelXcolumn represent separate regressions. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

Appendix Table 2. Do math test score gaps persist after controlling for observable characteristics? OLS regressions using different measures of disadvantage, 5th graders in 2011-2013

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current poverty				
Currently disadvantaged	-0.699	-0.550	-0.392	-0.114
	(0.015)	(0.012)	(0.004)	(0.002)
Not currently disadvantaged (omitted group)				
R-squared	0.123	0.173	0.274	0.671
Panel B. Persistent poverty				
Persistently disadvantaged	-0.886	-0.703	-0.511	-0.144
	(0.018)	(0.014)	(0.005)	(0.003)
Transitorily disadvantaged	-0.638	-0.529	-0.393	-0.120
	(0.016)	(0.013)	(0.004)	(0.003)
Never disadvantaged (omitted group)				
R-squared	0.144	0.185	0.280	0.672
Panel C. Current and persistent poverty in same model				
Currently disadvantaged	-0.175	-0.153	-0.133	-0.041
	(0.009)	(0.008)	(0.006)	(0.004)
Transitorily disadvantaged	-0.507	-0.416	-0.297	-0.091
	(0.017)	(0.013)	(0.006)	(0.004)
Persistently disadvantaged	-0.711	-0.549	-0.380	-0.105
	(0.019)	(0.015)	(0.008)	(0.005)
Never disadvantaged (omitted group)				
R-squared	0.146	0.187	0.281	0.672
Demographic controls		X	X	X
School FE			X	X
Number of Observations	314,092	307,359	307,359	307,359

Source : Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 5th grade in the 2010-2011 through 2012-2013 school years.

Notes : Regressions of standardized 5th grade math test scores on indicators for subsidized meal eligibility. Each PanelXcolumn represent separate regressions. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 5th grade. Prior test scores measured in 4th grade. Standard errors clustered at the school level.

Appendix Table 3. Do math test score gaps persist after controlling for observable characteristics? OLS regressions using different measures of disadvantage, 8th graders in 2011-2013 who were present for all nine years.

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current poverty				
Currently disadvantaged	-0.664	-0.535	-0.389	-0.093
	(0.018)	(0.014)	(0.004)	(0.003)
Not currently disadvantaged (omitted group)				
R-squared	0.113	0.160	0.248	0.692
Panel B. Persistent poverty				
Persistently disadvantaged	-0.922	-0.747	-0.552	-0.131
	(0.022)	(0.018)	(0.006)	(0.004)
Transitorily disadvantaged	-0.638	-0.547	-0.418	-0.102
	(0.019)	(0.016)	(0.004)	(0.003)
Never disadvantaged (omitted group)				
R-squared	0.142	0.179	0.257	0.694
Panel C. Current and persistent poverty in same model				
Currently disadvantaged	-0.173	-0.151	-0.130	-0.031
	(0.009)	(0.008)	(0.006)	(0.004)
Transitorily disadvantaged	-0.517	-0.441	-0.328	-0.081
	(0.019)	(0.016)	(0.006)	(0.004)
Persistently disadvantaged	-0.749	-0.598	-0.425	-0.101
	(0.022)	(0.018)	(0.008)	(0.005)
Never disadvantaged (omitted group)				
R-squared	0.145	0.181	0.258	0.694
Demographic controls		X	X	X
School FE			X	X
Number of Observations	255,463	255,426	255,426	253,077

Source : Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013 and present for all nine years between kindergarten and 8th grade.

Notes : Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Each PanelXcolumn represent separate regressions. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

Appendix Table 4. Descriptive statistics from ECLS-K sample, by persistence of disadvantage

	Never disadvantaged	Transitorily disadvantaged	Persistently disadvantaged
Child Characteristics			
Male	0.53	0.52	0.51
White	0.77	0.35	0.19
Black	0.04	0.23	0.38
Hispanic	0.07	0.22	0.35
Family Characteristics			
Mother's age at wave 1	35.03	31.80	31.83
Number of siblings at wave 1	1.22	1.55	1.94
Single mom at wave 1	0.06	0.22	0.34
Single mom at wave 7	0.09	0.24	0.39
Family type at wave 1			
Two parents, w/siblings	0.78	0.57	0.47
Two parents, no siblings	0.13	0.08	0.04
One parent, w/siblings	0.04	0.23	0.37
One parent, no siblings	0.04	0.09	0.07
Other	0.01	0.03	0.06
Mom works full time at wave 1	0.41	0.35	0.34
Mom works part time at wave 1	0.23	0.13	0.14
Mom unemployed at wave 1	0.01	0.04	0.05
Mom out of labor force at wave 1	0.21	0.22	0.29
Parent's highest education			
LTHS	0.00	0.15	0.29
HS degree	0.12	0.29	0.41
Some College	0.31	0.32	0.27
College Degree	0.57	0.24	0.02
Family Income Measures			
Wave 1 income as % of poverty	1.99	1.66	1.41
Wave 2 family income	71,208	31,416	18,459
Number of Observations	4741	3212	871

Source: Early Childhood Longitudinal Survey Kindergarten class of 1998-1999.

Descriptive statistics by subdized meal eligibility category. Weighted by 8th grade person weights

Appendix Table 5. OLS regressions of math test scores on measures of economic disadvantage, 8th graders 2011-2013 (exclude reduced price lunch students*)

	No Controls	Demographic Controls	Demog+ School FE	+ 3rd grade test scores
Panel A. Current poverty				
Currently disadvantaged	-0.838	-0.653	-0.468	-0.106
	(0.021)	(0.016)	(0.005)	(0.004)
Not currently disadvantaged (omitted group)				
R-squared	0.154	0.206	0.294	0.548
Panel B. Persistent poverty				
Persistently disadvantaged	-1.014	-0.804	-0.579	-0.130
	(0.01)	(0.009)	(0.006)	(0.005)
Transitorily disadvantaged	-0.754	-0.625	-0.469	-0.111
	(0.02)	(0.016)	(0.005)	(0.004)
Never disadvantaged (omitted group)				
R-squared	0.177	0.220	0.301	0.550
Panel C. Current and persistent poverty in same model				
Currently disadvantaged	-0.202	-0.172	-0.141	-0.029
	(0.013)	(0.011)	(0.008)	(0.007)
Transitorily disadvantaged	-0.604	-0.498	-0.366	-0.090
	(0.021)	(0.016)	(0.008)	(0.006)
Persistently disadvantaged	-0.812	-0.634	-0.443	-0.103
	(0.01)	(0.008)	(0.006)	(0.005)
Never disadvantaged (omitted group)				
R-squared	0.179	0.221	0.302	0.550
Demographic controls		X	X	X
School FE			X	X
Number of Observations	218,866	218,831	218,831	218,831

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Notes: Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Each PanelXcolumn represent separate regressions. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Standard errors clustered at the school level.

*Anyone who was ever reduced-price lunch between kindergarten and 8th grade.

Appendix Table 6. Black/white test score gap, 8th graders 2011-2013

Black/White test score gap				
	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Black	-0.686	-0.386	-0.276	-0.048
	(0.021)	(0.032)	(0.023)	(0.015)
R-squared	0.071	0.107	0.233	0.694
Demographic controls		X	X	X
School controls				X
School FE			X	X
Number of Observations	318,622	313,078	313,078	313,078

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Notes: Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

Appendix Table 7. OLS regressions of 8th grade math test scores on disadvantage in each grade, 8th graders 2011-2013

	No Controls	Demographic Controls	Demog+ School FE
Eligibility for subsidized meals in time:			
t	-0.175	-0.159	-0.135
	(0.011)	(0.01)	(0.007)
t-1	-0.111	-0.101	-0.078
	(0.012)	(0.011)	(0.008)
t-2	-0.098	-0.083	-0.055
	(0.01)	(0.009)	(0.008)
t-3	-0.081	-0.073	-0.053
	(0.009)	(0.009)	(0.008)
t-4	-0.082	-0.068	-0.049
	(0.009)	(0.008)	(0.008)
t-5	-0.069	-0.058	-0.048
	(0.009)	(0.008)	(0.008)
t-6	-0.073	-0.059	-0.044
	(0.008)	(0.008)	(0.008)
t-7	-0.094	-0.078	-0.063
	(0.008)	(0.007)	(0.007)
t-8	-0.143	-0.090	-0.053
	(0.008)	(0.007)	(0.006)
R-squared	0.155	0.188	0.258
Demographic controls		X	X
School FE			X
Number of Observations	230,803	230,803	230,803

Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Notes: Regressions of standardized 8th grade math test scores on set of lagged indicators for subsidized meal eligibility from the current year up to eight years prior. Students who are not economically disadvantaged in a given time period serve as the comparison group. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Standard errors clustered at the school level.

Appendix Table 8. Sample selection: Share of 8th graders present for each number of years, 8th graders in 2011-2013 school years

Number of years in the data (at least)	All	Currently poor	Not Currently poor
1	1.00	1.00	1.00
2	0.99	0.99	0.98
3	0.97	0.97	0.97
4	0.95	0.96	0.95
5	0.94	0.94	0.93
6	0.92	0.92	0.91
7	0.89	0.90	0.89
8	0.86	0.86	0.86
9	0.76	0.74	0.78
Number of Observations	357,457	172,818	184,639

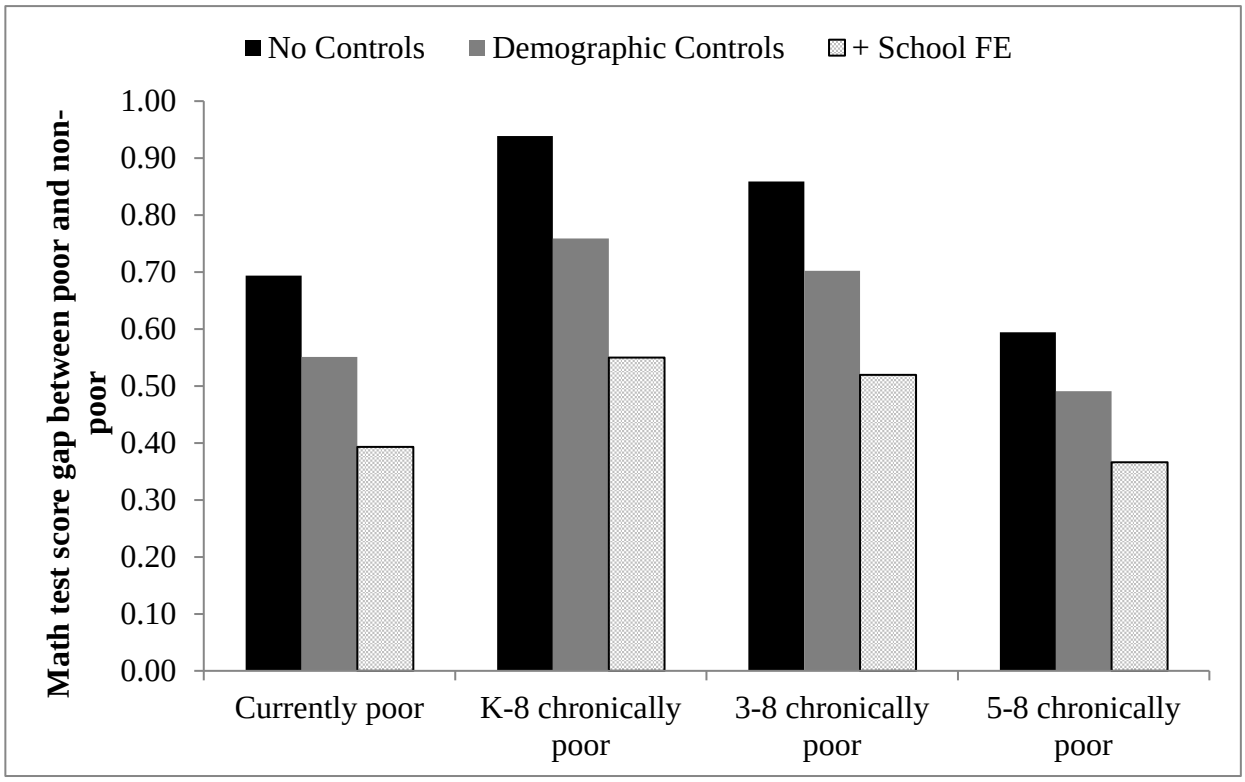
Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Appendix Table 9. What factors predict likelihood of being present all nine years?

	Outcome: Present in all nine years
8th grade math test score	0.010
	(0.001)
Free or reduced price lunch eligible	-0.013
	(0.002)
Female	0.007
	(0.002)
Race/Ethnic Background	
White (reference)	
American Indian	-0.007
	(0.01)
Asian American	-0.080
	(0.006)
Black	-0.094
	(0.003)
Hawaiian	-0.109
	(0.032)
Hispanic	-0.030
	(0.005)
Race/Gender interactions	
Female*American Indian	0.015
	(0.014)
Female*Asian American	0.010
	(0.009)
Female*Black	0.028
	(0.004)
Female*Hawaiian	0.068
	(0.044)
Female*Hispanic	0.002
	(0.006)
Migrant	-0.092
	(0.023)
Born in Michigan	0.227
	(0.002)
Constant	0.627
R-squared	0.07
Number of Observations	321,179

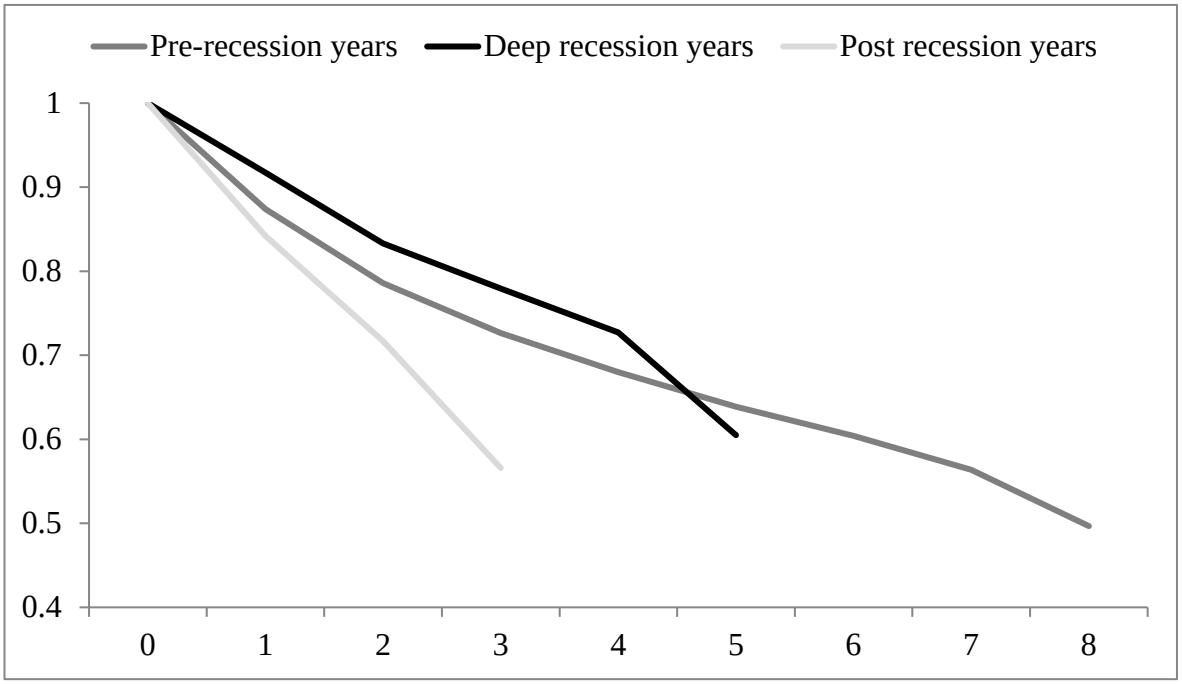
Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

Appendix Figure 1. Variation in test score gaps using different number of years to calculate chronic poverty



Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.
Notes: From OLS regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Demographic controls include race and gender indicators, interactions of race and gender indicators, whether the student was an immigrant, whether the student was a Michigan native, whether the student was missing at least one year between kindergarten and 8th grade. Standard errors clustered at the school level.

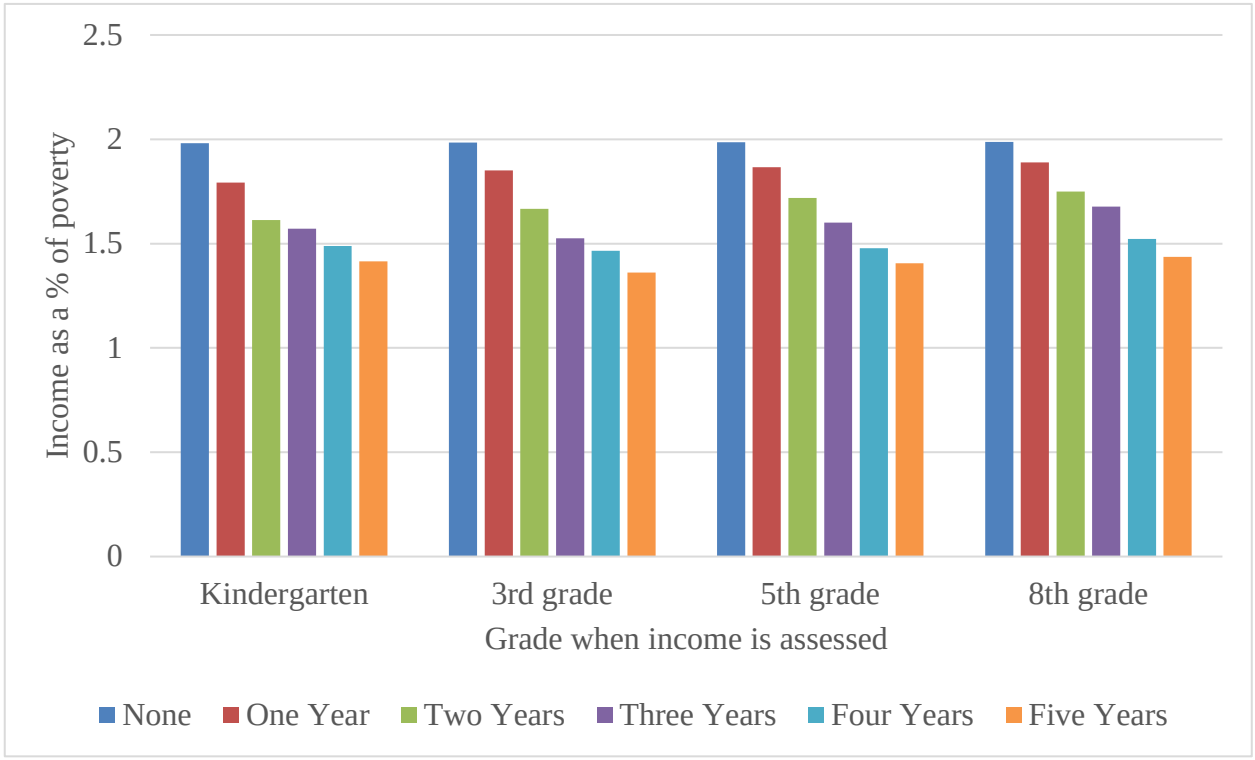
Appendix Figure 2. Share of students remaining disadvantaged years after initial spell began, by school year of initial spell



Source: Single Record Student Database/Michigan Student Data System files from the Michigan Department of Education.

Notes: Pre-recession years include 2003-2005, deep recession includes spells starting in 2008, post recession years include 2010-2013.

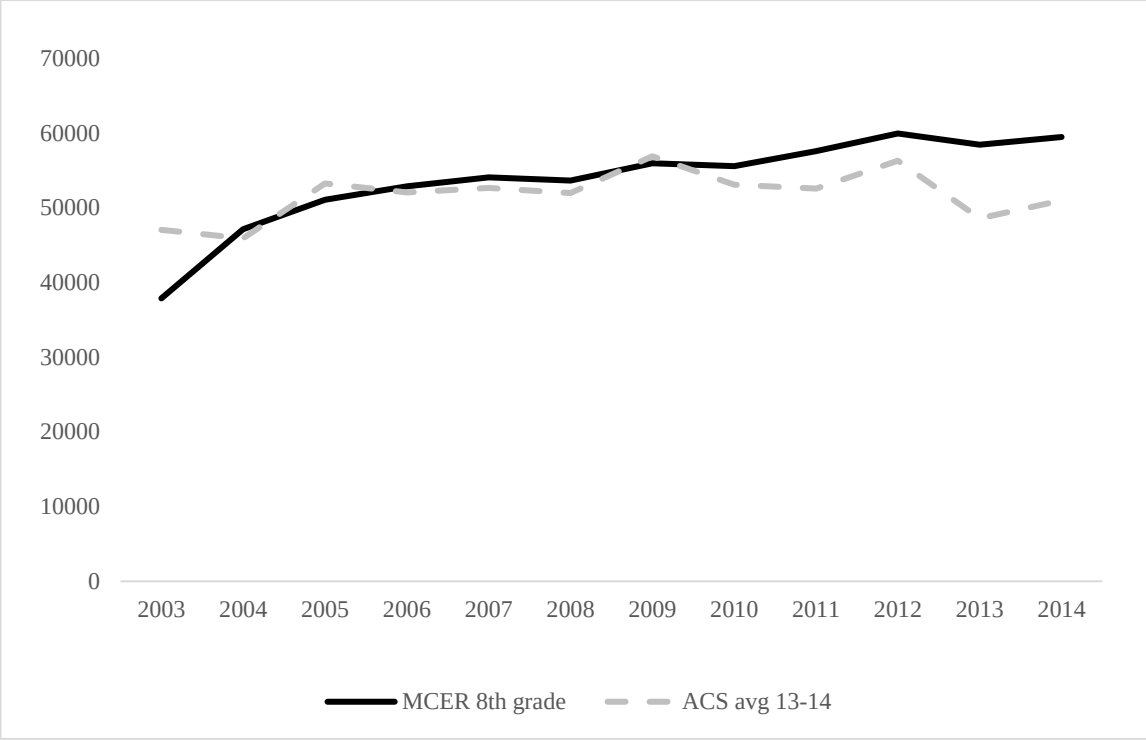
Appendix Figure 3. How does income vary over time by number of years eligible for subsidized meals?



Source: Early Childhood Longitudinal Survey- Kindergarten class of 1998-99.

Notes: Income measured as a percent of the federal poverty line in each grade, by number of years eligible for subsidized meals.

Appendix Figure 4. How many 8th graders are eligible for subsidized meals using the ACS vs. Michigan administrative data?



Note: For the ACS counts, sample restricted to 13 year olds in each year who lived in Michigan and whose family income was less than 185 percent of poverty, weighted by person weights. The MCER data uses the free or reduced price lunch flag for 8th graders between 2003 and 2013, and the poverty flag for 2014.