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The Gap within the Gap: Using Longitudinal Data to Understand Income Differences in Student Achievement

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ABSTRACT

Gaps in educational achievement between high- and low-income children are growing. Administrative datasets maintained by states and districts lack information about income but do indicate whether a student is eligible for subsidized school meals. We leverage the longitudinal structure of these datasets to develop a new measure of persistent economic disadvantage. Half of 8th graders in Michigan are eligible for a subsidized meal, but just 14 percent have been eligible for subsidized meals in every grade since kindergarten. These children score 0.94 standard deviations below those never eligible for subsidies and 0.23 below those occasionally eligible. There is a negative, linear relationship between grades spent in economic disadvantage and 8th grade test scores. This is not an exposure effect: the relationship is almost identical in 3rd grade, before children have been differentially exposed to five more years of economic disadvantage. Survey data show that the number of years that a child will spend eligible for subsidized lunch is negatively correlated with her current household income. Years eligible for subsidized meals can therefore be used as a reasonable proxy for income. Our proposed measure can be used in evaluations to estimate heterogeneous effects, to improve value-added calculations, and to better target resources.

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Gaps in educational achievement between high- and low-income children are growing. The poverty gap in standardized test scores is 40 percent larger today than it was 25 years ago and is twice as large as the black-white gap (Reardon 2011). Test scores are an early predictor of 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).

A long literature studies the link between family resources in childhood and educational outcomes.[1] Studies that exploit longitudinal data show that deficits are particularly large for children who are persistently disadvantaged.[2] But the household surveys that these studies rely upon are infrequent and suffer from non-response and attrition.[3] The administrative datasets increasingly analyzed by education researchers (Dynarski and Berends, 2015) do not have these weaknesses, but typically contain a single, crude proxy for income: an indicator of a students' eligibility for federally-subsidized school meals.

Children in households with income below 185 percent of the federal poverty line are eligible for subsidized meals in school. Subsidized-meal eligibility is widely used by researchers as a proxy for poverty. But nearly half of students nationwide are eligible for subsidized meals, while only a quarter of US children live in poverty. These two statistics make clear that eligibility for subsidized meals is a blunt measure of economic disadvantage. It is, for now, the only measure available to the many researchers and practitioners who work with administrative

[1] See Duncan and Brooks-Gunn 1997; Duncan, Magnuson, Kalil, and Ziol-Guest 2012; Duncan and Murnane 2011; or Mayer 1997 for a review of this literature.
[2] See, for example, Duncan, Brooks-Gunn and Klebanov 1994; Haveman, Wolfe, Spaulding 1991; Ku and Plotnick 2003; NICHD 2005; Rothstein and Wozny 2013; and Wolfe et al. 1996.
[3] Meyer, Mok, and Sullivan 2015 and Meyer Nittag 2015 show that non-response and attrition are increasingly common in household surveys.

data to evaluate the effects of educational programs, measure gaps in student achievement, and steer resources toward the most needy children.

We use administrative data from Michigan to develop a more detailed measure of economic disadvantage. Our data contain information on the entire population of students in the Michigan public schools. We leverage the longitudinal nature of these data to document systematic variation in outcomes and disadvantage *within* the population of children who are eligible for subsidized meals. Children who spend all of their school years eligible for subsidized meals have the lowest scores, while those who are never eligible have the highest. In 8th grade, the score gap between these two groups is nearly a standard deviation. The scores of children who spend a few of their school years eligible for subsidized meals fall between these two extremes.

There is a negative, nearly linear relationship between the number of grades spent in economic disadvantage and 8th grade test scores. This relationship holds after controlling for student demographics and school fixed effects. The lower scores do not appear to be caused by more years in disadvantage: this linear relationship is similar in 3rd grade, *before* children have been differentially exposed to five more years of economic disadvantage. Rather, we show that family income in a given year is negatively correlated with the number of years that a child *will* spend eligible for subsidized meals.[4]

Our results imply that the *number of years* that a child spends eligible for subsidized meals is a reasonable proxy for household income. While still crude, this proposed measure captures greater variation in economic resources and educational outcomes than does the variable

[4] We use a household survey, the Early Childhood Longitudinal Study (ECLS) in this supplementary analysis. Our findings are consistent with income following a random walk, with drift: families with very low permanent incomes are unlikely to randomly cross the eligibility threshold for subsidized meals, while those with slightly higher incomes will randomly do so in some years.

currently used by researchers, which captures only a child's *current* eligibility for subsidized meals. In Michigan, roughly half of 8th graders are eligible for a subsidized meal; they score about 0.69 standard deviations below those who are not eligible. But just 14 percent of 8th graders had been eligible for subsidized meals in every year since kindergarten, and these children score 0.94 standard deviations below those who were never eligible (and 0.23 standard deviations below those who were occasionally eligible). In future work, we will examine how well our new measure predicts educational attainment, including college attendance and graduation. We will also examine its performance in states other than Michigan.

Our proposed measure of economic disadvantage will improve estimates of the value added by teachers and schools. Two classrooms may have identical numbers of *currently* disadvantaged children but different numbers of *persistently* disadvantaged children. A value-added measure that does not account for these differences will be biased against teachers of persistently disadvantaged children. Our measure of persistence can also be used in evaluations, in order to estimate heterogeneity in causal effects or as a control to reduce omitted-variables bias.

Finally, our proposed measure can be used to better target resources toward the most disadvantaged children. Many federal, state and local programs distribute money based on the share of a school's or district's students eligible for subsidized meals. In Michigan, schools that have identical shares of students who are currently eligible for subsidized meals vary considerably in the share of students who are persistently eligible (see Figure 5). By taking these differences into account, practitioners and policy-makers can better target resources intended to support the most disadvantaged children and their schools.

II. Prior Literature: Family Resources and Child Outcomes

Most research examining the correlation between income and child outcomes relies on contemporaneous, rather than longitudinal, measures of income. 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 score gap between students with family incomes in the 90th and 10th percentiles is around one standard deviation.

An extensive literature documents the chronic nature of poverty in the United States.[5] It is plausible that children who are chronically poor face more severe challenges than children who experience poverty intermittently. Researchers who exploit longitudinal data show that racial and socioeconomic gaps emerge by the time children enter kindergarten and persist into adulthood.[6,7] Persistently disadvantaged children have worse test scores, more behavioral problems, and lower schooling and wages as adults.[8]

This research rely on surveys such as the Panel Study of Income Dynamics (PSID) and the National Longitudinal Survey of Youth (NLSY), which include longitudinal measures of income as well as detailed demographics. But these surveys suffer from response bias and sample attrition, which are plausibly correlated with depth of disadvantage. Recent work shows a decline in the quality of household survey data compared to administrative data (Meyer, Mok, and Sullivan 2015; Meyer and Nittag 2015).

[5] See Ashworth, Hill, Walker 1994; Bane and Ellwood 1986; and Cellini, McKernan, Ratcliffe 2008. 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.
[6] See Duncan and Magnuson 2011; Fryer and Levitt 2004; Magnuson and Duncan 2006; and Heckman et al., 2010.
[7] See 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; Rothstein and Wozny 2013; Smith, Brooks-Gunn, Klebanov 1997; Wolfe et al. 1996.
[8] Duncan and coauthors (1994) conclude that the IQ deficit associated with persistent poverty is 80 percent higher than the deficit associated with transitory poverty.

A large and rapidly expanding literature makes use of administrative data held by states and school districts to conduct educational research (Dynarski and Berends, 2015). These datasets lack the detailed data on income and demographics of the PSID and NLSY. But they are large, covering the universe of public school students, and contain comprehensive information on students' test scores and educational attainment. These datasets track students longitudinally, with each child assigned a unique identifier that in many states (including Michigan) stays with a student through college.

In these administrative data, eligibility for subsidized school meals is the only measure of economic status. Local education agencies use this variable to allocate Title I funds, which subsidize the schooling of low-income children (U.S. Department of Education 2012). This variable, discussed in detail below, is used widely by education researchers as a proxy for poverty (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 educational outcomes.

III. The National School Lunch Program

The National School Lunch Program (NSLP) is an $11 billion federal program, established by the 1946 National School Lunch Act. The NLSP provides subsidies that allow 31 million students to receive free or reduced-price lunch (Food and Nutrition Services 2012). Schools receive federal reimbursement for each student eligible for subsidized lunches (Food and Nutrition Services 2015).

In recent years, nearly half of all school children received subsidized meals (see Figure 1). The growth in the population of children receiving subsidized meals has outpaced the growth in children living below the poverty line (again, Figure 1). This is in part due to the faster growth in the share of children living in households with income between the poverty line and 185 percent of the federal poverty line.

A student can qualify for free or reduced-price meals in two ways: by providing paperwork to their school or through "direct certification," which is triggered by a child's receipt of other federal, means-tested benefits. Once a student has gained eligibility for NSLP through either methods, she is eligible for the entire school year and up to 30 days of the next school year (USDA 2015).

Under the first method, families showing monthly, household income below 185 percent of the federal poverty guideline gain eligibility for a reduced-price meal, and families below 130 percent get a free meal.[9] As of 2015, a family of four must have annual earnings below $31,525 in order to qualify for free meals and below $44,863 to qualify for reduced-price meals.[10]

Under the second method, children automatically gain eligibility if their families receive means-tested benefits such as food stamps (SNAP), food subsidies for women, infants and children (WIC), welfare (TANF), or have foster children. In these cases, families do not have to fill out paperwork: eligibility is proactively established (in Michigan's case, by the state) using administrative data from these other programs. Students who are directly certified for subsidized

[9] NSLP uses the federal poverty guideline which differs slightly from the federal poverty threshold. 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.
[10] These are the income cutoffs in the 48 contiguous states. Separate guidelines are established for Alaska and Hawaii. See http://aspe.hhs.gov/poverty-guidelines for details. Take-up in social welfare programs is correlated with attributes that determine social outcomes (Currie 2004). Research shows that some students receiving subsidized meals have income above the program cutoff (Newman and Ralston 2006; Harwell and LeBeau 2010; Hauser 1994; Kurki, Boyle, and Aladjem 2004; Randolph and Prejean-Harris 2014). This finding is in part due to the eligibility rules: eligibility is determined by a single month's income. Once a student is certified, she maintains her eligibility for the entire calendar year, even if her household income rises over the course of the year.

meals tend to have lower incomes than those who become eligible by filling out an application, as the income cutoffs for many of these programs are below 185 percent of the poverty threshold.[11]

Entire schools can now be deemed eligible for subsidized meals through the "community eligibility" provision. As of 2010, schools are allowed to provide free lunches to all students if at least 40 percent are directly certified. States and districts vary in the speed with which they have taken up this option. Some states have stopped collecting student-level income data in schools that are community-eligible. Michigan has not, since the student-level information is used to distribute other state-controlled funds.

For backward-looking evaluations using administrative data, the subsidized-meals indicator is still the only available proxy for income. Our proposed measure, based on the persistence of eligibility for school meals, is therefore relevant for researchers using the many years of historical data that have been compiled by states and districts. Any researcher working with administrative, education data from 2010 forward should ask the relevant agency when and how it made the shift toward community eligibility, and whether individual student eligibility is still recorded. We discuss this point further in the conclusion.

IV. Data and Method

Our data are drawn from from the Michigan Center for Educational Performance and Information (CEPI) and contain longitudinal information on all students in the Michigan public school systems since the 2002-2003 school year. We focus on students who were in 8th grade

[11] The income cutoff for food stamps is 130 percent of poverty (U.S. Department of Education 2012) and for WIC it is 185 percent of poverty (http://www.fns.usda.gov/wic/wic-income-eligibility-guidelines). The income thresholds for TANF vary by state, in more than half of states it is $9,540 a year 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 income requirements for foster care.

during the 2010-2011 through 2012-2013 school years. We can track these cohorts from kindergarten through 8th grade and therefore observe their subsidized meal eligibility throughout elementary school.[12]

We restrict the sample to 8th graders who were in the Michigan public school system in 7th grade. This allows us to control for lagged achievement in some specifications. We make no further restrictions on how many years students must be present in the Michigan public school system.[13] Within our sample, 76 percent of 8th graders are in Michigan public schools for the full nine years since kindergarten. In all analyses, we include an indicator for whether a student was missing in at least one year.[14]

The outcome of interest is standardized test scores in math in 8th grade.[15] Test scores are standardized by grade and year for all students in Michigan public schools. Scores are therefore interpreted as standard deviations and capture a student's performance relative to other students in Michigan public schools in that year and grade.

We create several measures of economic disadvantage using the longitudinal data. We define *persistently disadvantaged* children as those eligible for subsidized meals in every grade since kindergarten.[16] Those who were never eligible for subsidized meals during those grades

[12] 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.
[13] See Data Appendix for detailed explanation of restrictions.
[14] Students who were missing in at least one year typically scored about 0.06 standard deviation below students present for all nine years. Results are quite similar if we restrict the sample to children present for all nine years between kindergarten and 8th grade (see Appendix Table 3).
[15] Patterns are quite similar for other subject areas.
[16] In order to be considered "persistently disadvantaged," 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 are automatically considered "transitorily disadvantaged." Our results are not sensitive to this decision, changing little when we restrict the sample to students observed for the full nine years (see Appendix Table 3).

are defined as *never disadvantaged*. The remaining children spent some years eligible for subsidized meals; we define them as *transitorily disadvantaged*.[17]

We use the term *currently disadvantaged* to refer to a child's eligibility for subsidized meals in her tested grade (in our case, 8th grade). This is the variable that typically would be used by researchers calculating income-based gaps in achievement.[18]

V. Sample Characteristics

Nearly 60 percent of Michigan 8th graders in the 2011-2013 school years were eligible for subsidized meals at least once between kindergarten and 8th grade (see Table 1). These children spend, on average, six years eligible for subsidizes. Of this group, about a quarter (14 percent of the full sample) were persistently disadvantaged, in that they were eligible in every grade since kindergarten. Another forty percent of children were never disadvantaged.

Demographics differ starkly by these measures of economic disadvantage. Ninety percent of the never disadvantaged are white, compared to 60 percent of those who are ever disadvantaged. Students ever 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. The persistently disadvantaged are more concentrated in urban areas, while the transitorily disadvantaged are more concentrated in suburban areas. The persistently disadvantaged attend schools with a higher concentration of students eligible for subsidized meals than those who are transitorily disadvantaged.

[17] 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.

[18] Some administrative datasets include a variable that distinguishes between eligibility for free vs. reduced-price meals. Since not all researchers have this variable, we don't focus on it in our analysis. In Michigan, almost all children (85 percent) eligible for a subsidized meal are eligible for a free meal; our results therefore change little if we focus on the free-meal children (see Appendix Table 4).

Our administrative data lack information on income, parental education, and family structure. We show median income from the American Community Survey (ACS) in the zip code in which students live. Students who are never disadvantaged live in a zip code where the median household income is $63,000 (2014$), while those who were ever disadvantaged live in neighborhoods with a median household income of about $46,000. For the persistently disadvantaged, neighborhood income is $41,000.

We turn to nationally-representative survey data to shed more light on demographic differences between children who are persistently disadvantaged, transitorily disadvantaged and never disadvantaged. The Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 (ECLS-K) includes information on household income and subsidized-meal eligibility. About half of 8th graders in 2006-2007 were ever eligible for subsidized meals (similar to Michigan) and about 10 percent were eligible in each survey wave of the ECLS-K (again, similar to Michigan; see Appendix Table 5).[19]

As in Michigan, persistently disadvantaged students in the ECLS-K are much more likely to be a racial or ethnic minority (73 percent compared to 46 percent among transitorily disadvantaged and 11 percent among the never disadvantaged). They were also much less likely to live with both parents at the start of the survey (51 percent compared to 65 percent among the transitorily disadvantaged and 91 percent among the never disadvantaged) and much less likely to have a parent with a college degree (two percent compared to 244 percent among the transitorily disadvantaged and 57 percent among the never disadvantaged). Family income also varies substantially by the persistence of disadvantage; we discuss this in detail later in the paper.

[19] The ECLS-K does not collect annual information on subsidized meal eligibility; we can observe whether a student is eligible in each of the five waves of data collection. We define the persistently disadvantaged as those who were eligible in each of the five waves. The transitorily disadvantaged were eligible in at least one wave but not all five waves.

As these statistics make clear, the persistently disadvantaged are a distinct minority within the larger population of students who are eligible for subsidized meals. They are poorer, more likely to live in single-parent families, and have parents with lower educational attainment. As we now show, these students have far lower test scores than their peers who are only temporarily (or never) eligible for subsidized school meals.

VI. Achievement Gaps by Economic Disadvantage

We first estimate a conventional measure of the income gap in academic achievement, by comparing the math scores of children who are, at the time of testing, eligible and ineligible for subsidized meals. Measured this way, the gap in 8th grade math score gap is 0.69 standard deviations (see Table 2).

If our goal is to capture the effect of persistent disadvantage, this measure is biased downward by classification error. This error goes both ways: some of those currently eligible for subsidized meals were not eligible in previous years, while some of those currently ineligible were eligible at some point. Among Michigan students *ineligible* for subsidized meals in 8th grade, 22 percent were eligible in a previous grade (Table 1, final column). And those who were *eligible* for subsidized meals in 8th grade spent an average of 2.25 grades *not* eligible for the subsidies.

When we compare children who are persistently disadvantaged to those who are never disadvantaged, the achievement gap widens considerably. The score difference between the never disadvantaged and the persistently disadvantaged is nearly a standard deviation (0.94), 35 percent wider than the conventional measure (Table 2). Persistently disadvantaged students score a quarter of a standard deviation below transitorily disadvantaged students.

The standard indicator for economic disadvantage is often included as a control in a regression that includes other variables, such as race, ethnicity, sex, and school characteristics. For quantitative researchers, a key question is therefore whether these other observables "explain" the larger achievement deficit among persistently disadvantaged students. If observables explain the differences, then the analyst need only include these observables in the regression in order to eliminate biases that may otherwise be induced by unobserved heterogeneity within the population of currently disadvantaged students.

We explore this by estimating test-score gaps that control for student characteristics, school fixed effects, and neighborhood characteristics. Table 3 presents results. In Panel A, we measure disadvantage the conventional way, based on current eligibility for subsidized lunch. In Panel B, we use our measures of persistent 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, column 3 adds school fixed effects, Column 4 adds controls for median household income in a household's zip code, Column 5 includes controls for prior-year test scores,.

With no controls in the model, we replicate the gaps shown in Table 2: a score gap of 0.69 standard deviations between those currently eligible for a subsidized meal and those not eligible, 0.70 standard deviations between the never disadvantaged and the transitorily

disadvantaged, and 0.94 standard deviations between the persistently disadvantaged and the never disadvantaged.

We next add controls for race, ethnicity and gender, as well as their interactions. We also add a dummy that indicates a student is a Michigan native and one that indicates immigrant status. Controlling for these variables moderately reduces the all of the test score gaps (column 2). But the gap between the never disadvantaged and the persistently disadvantaged (0.76 standard deviations) is still nearly 40 percent larger than the gap based on the conventional measure of contemporaneous eligibility (0.55 standard deviations).

Controlling for school fixed effects further reduces gaps (column 3). Still, the within-school gap between the never disadvantaged and the persistently disadvantaged (0.55) is 41 percent larger than the gap based on standard measure of contemporaneous eligibility (0.39).[20] The difference between these estimates is statistically significant.

These last results indicate that persistent disadvantage is not solely a geographic phenomenon. Even within schools, there is substantial variation in the performance of children who are persistently vs. transitorily disadvantaged. This could be because schools draw on neighborhoods with widely varying household incomes and levels of persistent poverty. However, controlling for household income in the child's home zip code (column 4) does very little to change these within-school results.[21]

Researchers estimating causal effects of programs on achievement often include lagged test scores (e.g., Angrist et al., 2016). Does our proposed measure of persistent disadvantage

[20] Table 3 shows a substantial gap *within* schools between disadvantaged and non-disadvantaged children. This contrasts with the black-white gap which, as shown by Fryer and Levitt (2004), is largely eliminated by school fixed effects.

[21] Median household income data come from a five-year sample of the American Community Survey from 2010-2014. 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.

explain additional variation in scores, once lagged scores are included? In column 5 of Table 3, we add 7th grade math scores to the regression. All of the gaps shrink considerably, but our measure of persistent disadvantage (Panel B) still generates a larger gap than the conventional measure (Panel B). The conventional gap, conditional on lagged test scores, is 0.095 standard deviations; the gap by persistent disadvantage is 0.132 standard deviations. The gap based on our persistent disadvantage is 40 percent larger than that based on the conventional measure of disadvantage, even after including demographics, school effects, and lagged test scores.

These results have implications for practitioners. Practitioners cannot identify the most disadvantaged students using only measures of current disadvantage, even if they *also* have access to information on prior test scores and neighborhood income. Our.

The implication of these results for researchers depends upon the specific context. The bias induced by an omitted variable rises with the conditional correlations of the omitted variable (persistent disadvantage, in this case) with i) the variable of interest (e.g., an indicator for a treatment) and ii) the outcome of interest (in this case, test scores). We have shown that the second condition for omitted-variables bias is met when the outcome of interest is test scores and persistent disadvantage is excluded from the regression. Whether this omission will bias coefficients on other variables interest depends on how strongly correlated these variables are with persistent disadvantage.

VII. Do Achievement Gaps Widen with Each Year of Disadvantage?

We have shown that children who are persistently disadvantaged perform worse than those who are disadvantaged in only some grades. We next examine how the size of this gap varies with the number of grades spent in disadvantage.

Figure 2 plots the score gap in 8th grade against the number of grades spent in economic disadvantage since kindergarten.[22] The top line plots unconditional gaps. Note that no functional form is imposed upon this line; it connects unconditional score differences. We obtain these differences by regressing 8th grade scores against a set of nine dummies that indicate the number of grades that a child has spent in economic disadvantage since kindergarten. The reference group is children who spent no grades in economic disadvantage.[23]

Children who spend one year in economic disadvantage score about a third of a standard deviation below children who are never disadvantaged. This gap widens by about 0.08 standard deviations for each additional year of disadvantage; the relationship is nearly linear after the first year of disadvantage. The intercept drops slightly, and the slope is reduced, when demographic controls are included in the regression (middle line). The relationship is further attenuated, but the overall pattern remains, when school fixed effects are added (bottom line).

Figure 2 reveals that the score gap widens steadily with each additional year of disadvantage. The obvious interpretation is that this is a dosage effect, with each year of disadvantage placing children yet further behind. But this interpretation is wrong, as we demonstrate with Figure 3. Here, we replicate the unconditional, 8th grade gaps of Figure 2 (top line). We add to the graph unconditional differences in scores in 3rd grade. While the intercept is lower, the slope is almost identical. Figure 4 shows the same plots for scores for grades three through eight. The lines shift up monotonically with each grade, tracing out the growth during

[22] We also examined how the timing of disadvantage is related to the achievement gap by estimating coefficients on time-lagged indicators of disadvantage (see Appendix Figure 2 and Appendix Table 8). Eligibility for subsidized meals in kindergarten and in the current grade have the largest coefficients.

[23] As in all previous regressions, we include a dummy that indicates whether a children was not observed in Michigan public schools during one or more grades. Results are similar when the sample is limited to a balanced panel of children enrolled in every grade from kindergarten through 8th grade.

elementary school of the achievement gap. It is this upward drift in the gap that captures the widening of the achievement gap over a child's lifetime.

The slope of each line, by contrast, appears to capture fixed differences between children who spend more or fewer years in disadvantage. In 3rd grade, children who *will* spend nine years in economic disadvantage (and have already spent four years in disadvantage) during grade school score 0.84 standard deviations lower than children who will never be disadvantaged. By 8th grade, *after* they have spent nine grades in economic disadvantage, the gap is 0.94 standard deviations. Ninety percent of the gap is already in place as of 3rd grade, when the linearity of the relationship between the gap and ultimate years spent in disadvantage is also already established.

These graphs clearly show that the linear relationship between years of disadvantage and test scores *do not* reflect a "dosage effect," where dosage is measured by years spent in disadvantage. Rather, as we now show, years spent in disadvantage is correlated with the *depth* of a child's economic disadvantage.

In kindergarten, children who *will* spend nine grades in economic disadvantage by 8th grade are *already* poorer than children who will spend just a few grades in economic disadvantage. We see this in the ECLS-K, where mean income falls with each additional year spent eligible for subsidized meals (see Figure 5).[24] Among children who will never be eligible for subsidized meals, family income is an average of $85,000 in 3rd grade. Among children who will be eligible for one grade, income is an average of about $47,000 (this is close to median household income in the US). Among children who will be eligible for five grades, income is an average of about $20,000. The relationship is similar in 8th grade.[25]

[24] Since the ECLS-K does not collect data every year, we are only able to observe whether a student is eligible for each of the five waves collected between kindergarten and 8th grade, rather than the full nine years.
[25]Family income is measured in 13 income categories, ranging from less than $5,000 to more than $200,000. We assigned the midpoint of each category for this analysis.

These results indicate that the number of grades spent in economic disadvantage is a proxy for the level of income. This is consistent with family income moving in a random walk, drifting upward with each year. The poorest families have little chance of randomly moving above the cutoff for subsidized meals, so will typically spend every grade eligible for subsidized meals. Families with slightly higher incomes might randomly move above the cutoff for one year. The closer a family's permanent income is to the eligibility cutoff, the more likely it is to drift over in a given year.

VIII. Changes in the Determination of Eligibility for Subsidized Meals

Eligibility standards for subsidized, school meals are in motion. Federal "community eligibility" rules established in 2010 allow a school to provide free meals to all of its students if at least 40 percent are found to be individually eligible.[26] States and districts vary in the speed with which they have taken up this option. Some have stopped collecting information on student-level eligibility in schools that are community-eligible (Michigan has not).

How does this affect the relevance of our analysis? For backward-looking evaluations using administrative data, the subsidized-meals indicator is still the only proxy for income. Our proposed measure is therefore relevant for researchers using such historical data. In any research that relies on data gathered since 2010, analysts should learn how eligibility for subsidized meals is determined in their sample schools and how the student-level variable for eligibility in their data is coded.

Going forward, states will increasingly use eligibility for federal, means-tested programs (TANF, WIC and food stamps) to automatically qualify students for subsidized meals. Adding indicators for eligibility for these programs to administrative datasets will keep these datasets

[26] See Chingos (2016) for a further description of the changes to the subsidized meal program and its implications for education policy researchers.

relevant. Without student-level proxies for family income, researchers cannot calculate gaps in student outcomes, understand how program impacts differ by income, or reliably calculate value-added measures of teacher and school quality.

Once states and districts shift toward this new indicator of economic disadvantage, the insights of this paper will still be relevant. Educational outcomes will certainly be correlated with *persistence* in receipt of TANF, WIC and food stamps, just as they are correlated with persistence in eligibility for subsidized meals. In future work, we will examine these correlations.

IX. Discussion and Conclusion

Our findings have implications for researchers, policymakers and practitioners. We have uncovered considerable heterogeneity within the population of children eligible for subsidized meals. Sixty percent of Michigan's 8th graders were eligible for subsidized lunch at least once during their time in the public schools. But just a quarter of these children (14 percent of all 8th graders) were economically disadvantaged in *every year* between kindergarten and 8th grade.

These persistently disadvantaged children score nearly one standard deviation below students who were never disadvantaged. The conventional method of estimating this gap, which relies only on current eligibility for subsidized meals, yields a gap of 0.69 standard deviations. The gap as defined by persistent disadvantage is comparable to that between children in the 90th and 10th percentiles of the family income distribution (Reardon 2011). The gap as defined conventionally is comparable to that between children at the midpoint and top (or bottom) of the family income distribution (Reardon 2011).

We find a negative, nearly linear relationship between scores and the number of grades spent in economic disadvantage. This relationship holds even after controlling for student demographics and school fixed effects. The lower scores do not appear to be caused by more

years spent in disadvantage: this relationship is almost identical in 3rd grade, *before* children have been differentially exposed to five more years of economic disadvantage. Rather, as we show in a supplementary analysis with survey data, family income in a given year is negatively correlated with the number of years that a child *will* spend eligible for subsidized meals. Years eligible for subsidized meals is therefore a reasonable proxy for income.

Researchers can use our proposed measure to better estimate value-added and to estimate causal effects. A value-added measure that does not account for differences between current disadvantage and persistent disadvantage will be systematically biased against the teachers and schools of persistently disadvantaged children. In calculating measures of teacher and school effectiveness, controlling for persistent disadvantage will better capture variation in students' baseline characteristics.

Policymakers and practitioners can use our proposed measure to better target resources intended to support the most disadvantaged children. Schools with identical shares of *currently* disadvantaged children may have widely differing shares of *persistently* disadvantaged children. In Michigan, as in many states, there are many schools in which all children are eligible for subsidized meals. In Michigan schools where 100 percent of 8th graders are *currently* disadvantaged, the concentration of *persistent* disadvantage varies from 18 to 86 percent (see Figure 6). The conventional measure of economic disadvantage (current eligibility for subsidized meals) provides no traction in differentiating between these schools, or between classrooms within these schools. Our proposed measure of persistent disadvantage allows for finer distinctions between schools and classrooms, allowing for better targeting of scarce resources.

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Data Appendix

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 the Michigan Department of Education (MDE) and the Michigan Center for Educational Performance and Information (CEPI). Results, information and opinions are the authors' and do not reflect the views or positions of MDE or CEPI.

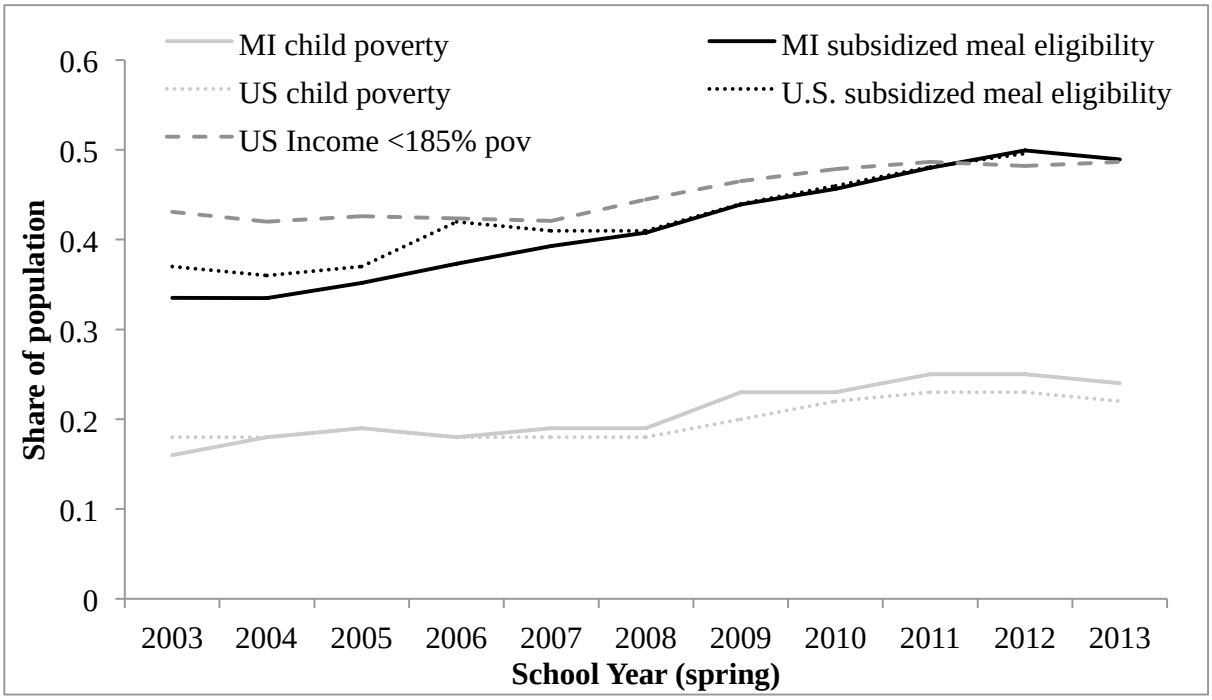
Data are drawn from the Single Record Student Database (SRSD), the Michigan Student Data System (MSDS), which replaced the SRSD in 2010, and the Michigan Educational Assessment Program (MEAP) database. The SRSD and MSDS provide annual information on student demographics such as race, gender, subsidized meal eligibility, special education status, limited English proficiency (LEP) status, and migrant status. It also contains information on the grade level and schools a student attended each year since the 2002-2003 school year. The MEAP provides information on standardized test scores in a variety of subject-grade combinations. Students in Michigan are tested in 3rd through 8th grade and again in 11th grade.

We limit the sample to students who were in 8th grade between the 2010-2011 and 2012-2013 school years and had valid 8th grade math test scores (341,133 observations). We do not restrict the sample to first-time 8th graders, so some students may have repeated a grade in a prior year. We exclude students who did not have a 7th grade math test score (12,974 observations), which we use to control for prior achievement in some analyses. We also exclude students without a valid school identifier in 8th grade (9,537 observations). To maximize our sample size, we make no further restrictions on whether the student was present in the Michigan public school system for the nine years between kindergarten and 8th grade (Appendix Table 7 shows a frequency table for the share of 8th graders present in the data for the full nine years, separately

by subsidized meal status in 8th grade). Among all 8th graders in our analysis, 76% were present in all nine years, and 86% were present for at least eight years. Students eligible for subsidized meals in 8th grade were slightly less likely to be in the Michigan public school system for nine years (74% compared to 78% of non-eligible 8th graders).

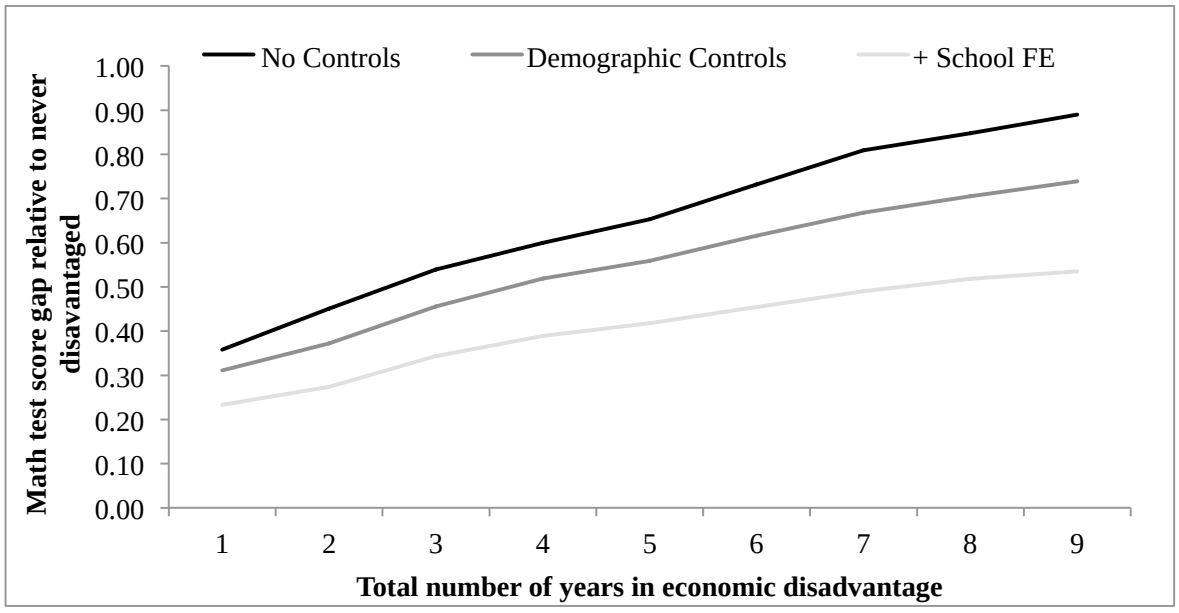
In regressions, we include an indicator for whether a student was not in the Michigan public school system for all nine years. These students typically had lower math test scores, on the order of 0.01 to 0.06 of a standard deviation. Results are nearly identical if we instead limit the sample to students present in Michigan public schools in all graded from kindergarten through 8th grade.

Figure 1
Share of school-aged children experiencing economic disadvantage



Sources: 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, based on monthly income increments, weighted by monthly person weights.

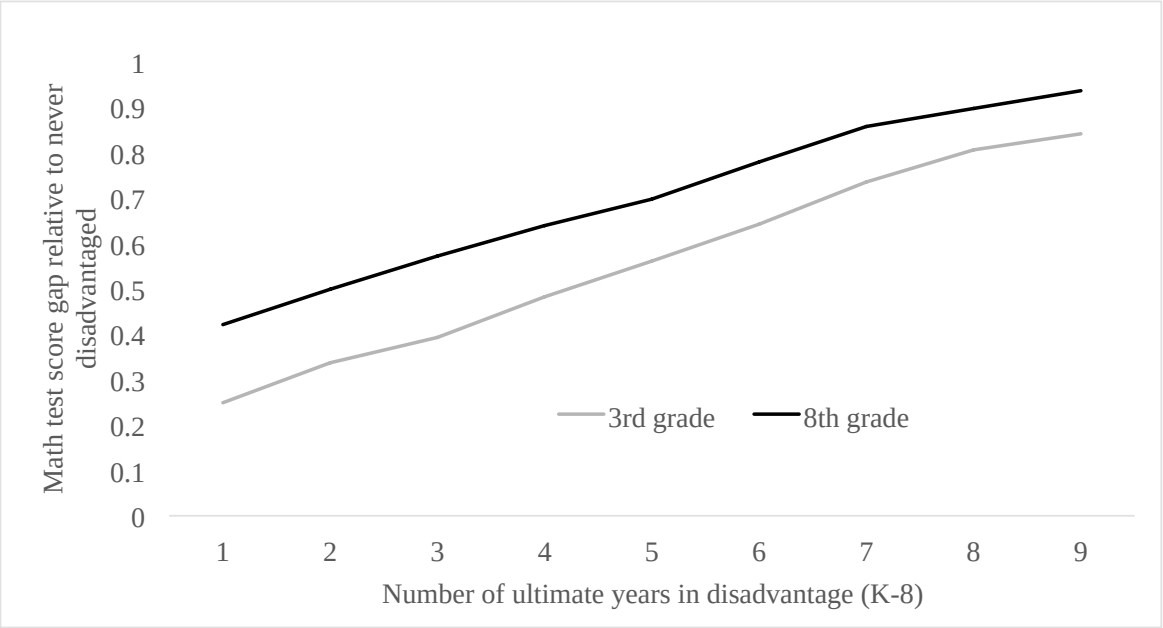
Figure 2
How do test score gaps vary by number of years of disadvantage?



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.

Notes: Plots coefficients from regressions of standardized 3rd and 8th grade math test scores on set of indicators for number of years eligible for subsidized meals between kindergarten and 8th grade.Demographic controls consist of 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.

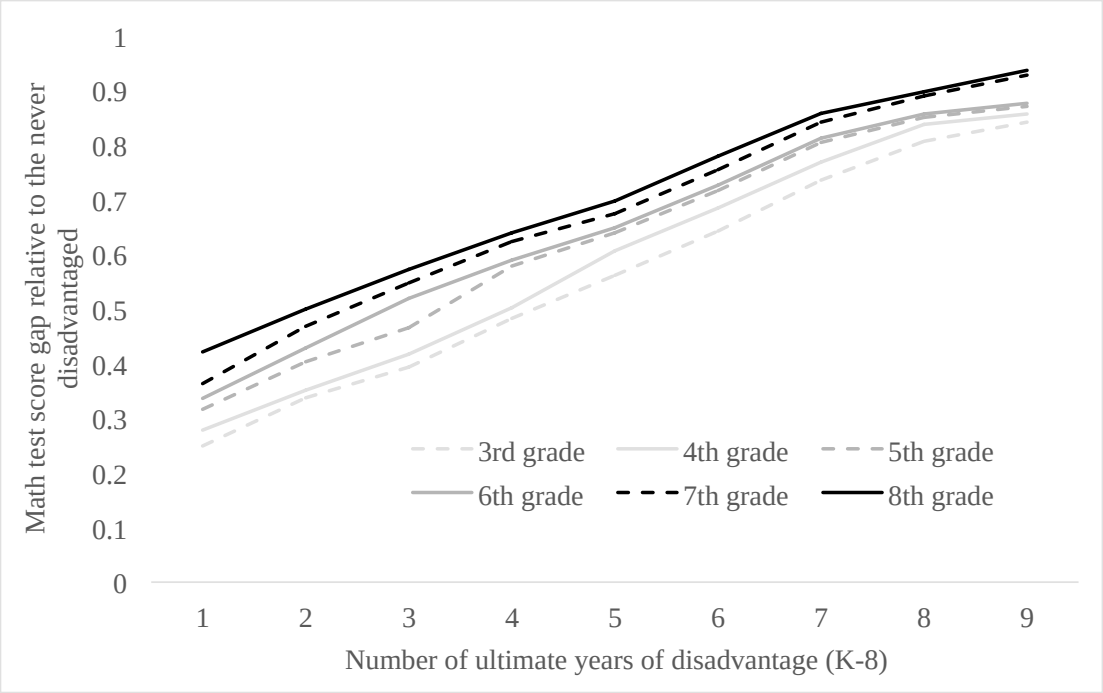
Figure 3
Gaps emerge by third grade



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.

Notes: Plots unconditional gaps in standardized 3rd and 8th grade math test scores by number of years eligible for subsidized meals between kindergarten and 8th grade.

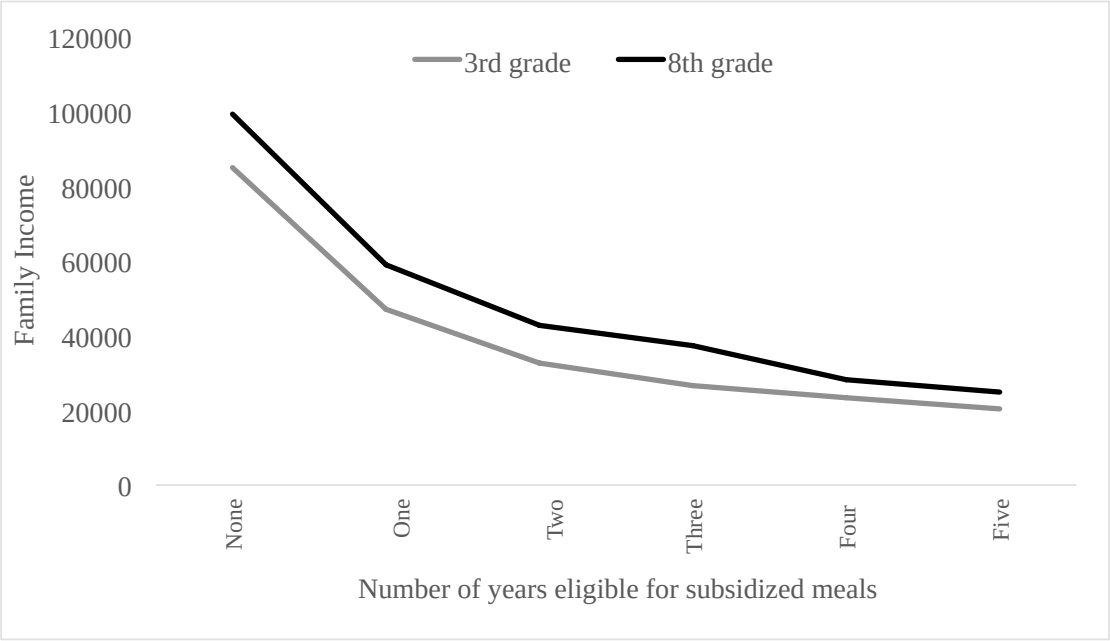
Figure 4
Gaps by grade and years spent in disadvantage



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

Notes: Plots unconditional gaps in standardized math test scores by number of years eligible for subsidized meals between kindergarten and 8th grade.

Figure 5
Annual Income by years of disadvantage

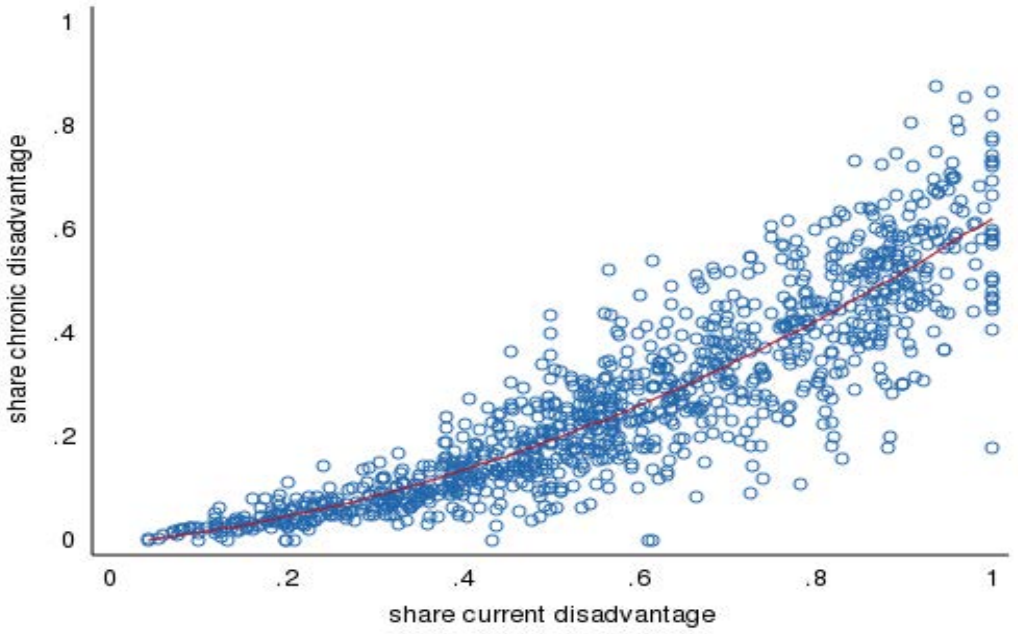


Source: Early Childhood Longitudinal Study-Kindergarten, class of 1998-99.

Notes: Income measured by assigning the mid-value within each income category in the ECLS-K.

Figure 6

Shares of 8th graders currently disadvantaged vs. persistently disadvantaged



Source: Single Record Student Database/Michigan Student Data System from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013. Sample limited to schools with at least 10 8th graders.

Table 1

Characteristics of Michigan 8th graders by economic disadvantage

			Persistence measures			Contemporaneous measures		
	All 8th graders	Never disadvantaged	Ever	Persistently	Transitorily	Free or Reduced	Free only	Neither
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%	0.28	0.18	0.35	0.38	0.34	0.36	0.29	0.21
75-90%	0.10	0.01	0.16	0.23	0.13	0.17	0.19	0.03
over 90%	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

Score gaps vary by definition of disadvantage

Michigan 8th graders in 2011-2013

	Math Score Difference
Contemporaneous measures	
Currently disadvantaged vs. not currently disadvantaged	0.69
Free vs. not currently disadvantaged	0.74
Free vs. reduced	0.33
Persistence 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.

Notes: Math test scores standardized by grade and year.

Table 3

OLS regressions of score gaps, 8th graders in 2011-2013

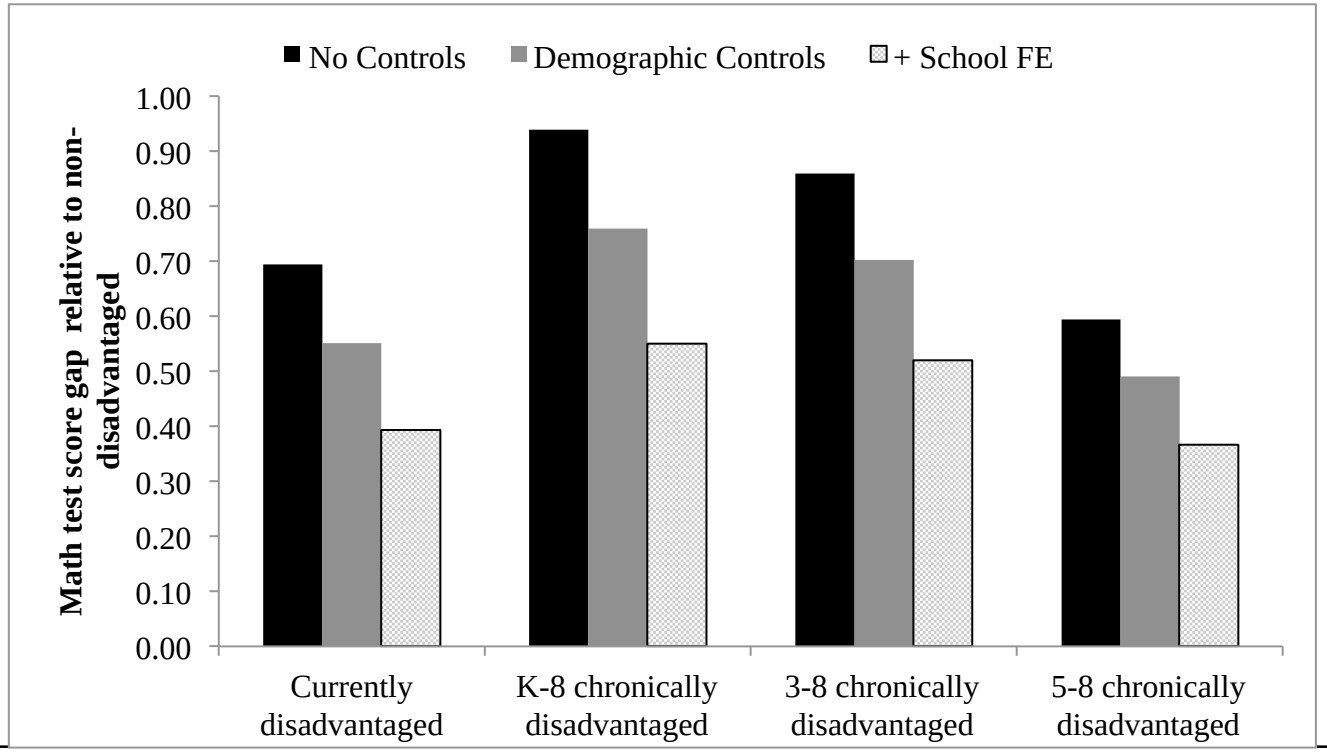
	No controls	+ Demographic controls	+ School FE	+ Zip code income	+ Prior test scores
Panel A. Current disadvantage					
Currently disadvantaged	-0.694	-0.551	-0.393	-0.389	-0.095
	(0.019)	(0.015)	(0.004)	(0.004)	(0.002)
Transitorily disadvantaged					
Persistently disadvantaged					
Not disadvantaged (omitted group)					
R-squared	0.120	0.174	0.262	0.263	0.696
Panel B. Persistent disadvantage					
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.

Notes: Regressions of standardized 8th grade math test scores on indicators for subsidized meal eligibility. Each column in each panel represents a separate regression. Demographic controls consist of 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. School FE are for 8th grade school. Zip code income is median household incomein 8th grade zip code from American Community Survey 5-year estimates, 2010-2014. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

Appendix Figure 1

Variation in test score gaps using different number of years to calculate persistent disadvantage



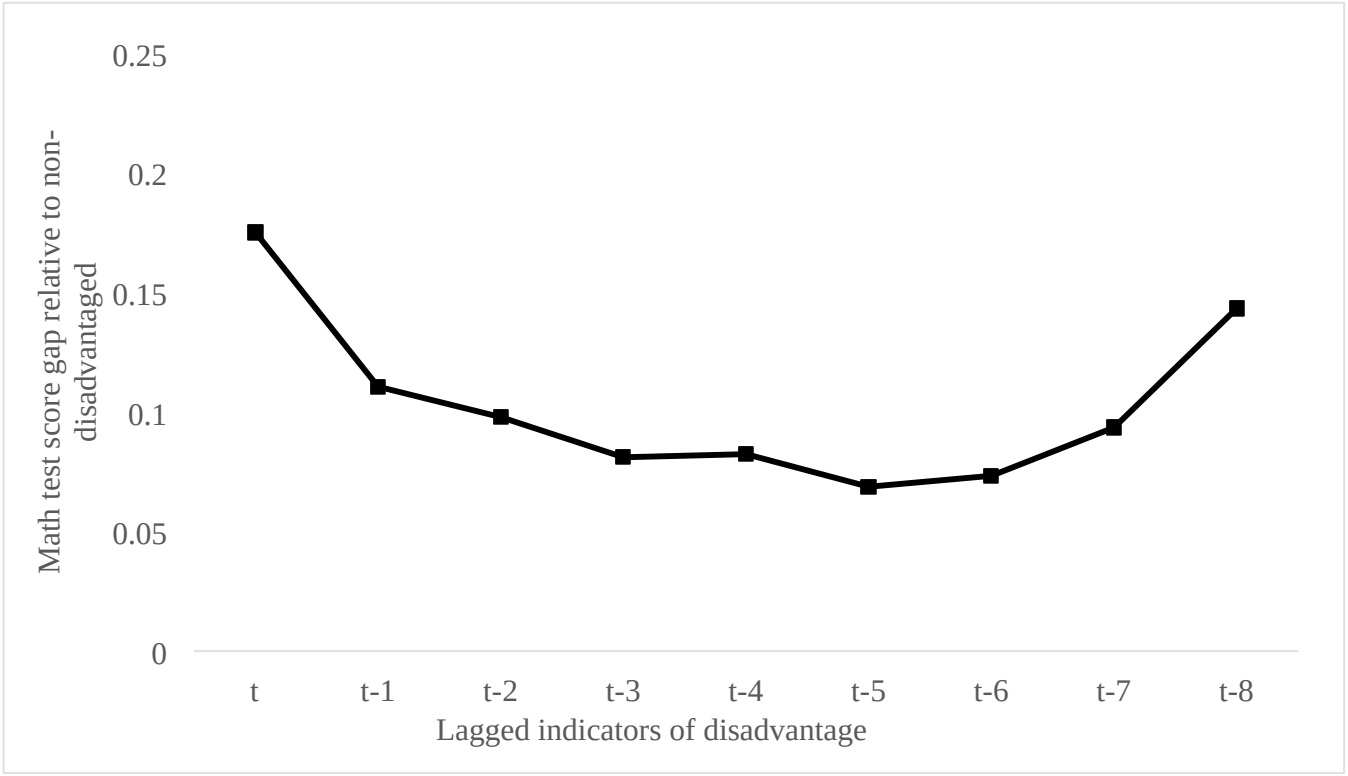
Source: Single Record Student Database/Michigan Student Data System and Assessment files from the Michigan Department of Education. Students who were in 8th grade between 2010-2011 and 2012-2013.

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.

Appendix Figure 2

Score gaps by timing of disadvantage

OLS regression of 8th grade math test scores on lagged indicators 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: Plots coefficients on lagged indicators of subsidize meal eligibility Students who are not economically disadvantaged in a given time period serve as the comparison group.

Appendix Table 1

OLS regressions of score gaps, 8th graders in 2009-2010

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current disadvantage				
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 disadvantage				
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
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 column in each panel represents a separate regression. Demographic controls consist of 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. School FE are for 8th grade school. Zip code income is median household incomein 8th grade zip code from American Community Survey. Prior test scores measured in 7th grade. Standard errors clustered at the school level.

Appendix Table 2

OLS regressions of score gaps, 5th graders in 2011-2013

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current disadvantage				
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 disadvantage				
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
Demographic controls		X	X	X
School FE			X	X
Number of Observations	314,092	307,359	307,359	307,359

Notes: See notes to Appendix Table 1.

Appendix Table 3

OLS regressions of score gaps, 8th graders in 2011-2013

Students in Michigan public schools during every grade, K-8

	No Controls	Demographic Controls	+ School FE	+ Prior test scores
Panel A. Current disadvantage				
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 disadvantage				
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
Demographic controls		X	X	X
School FE			X	X
Number of Observations	255,463	255,426	255,426	253,077

Notes: See notes to Appendix Table 1. Sample limited to students observed in Michigan public schools in every grade from kindergarten through 8th grade.

Appendix Table 4

OLS regressions of score gaps, 8th graders in 2011-2013

Free vs. reduced-price lunch

	No controls	+ Demographic controls	+ School FE	+ Zip code controls	+ Prior test scores
Panel A. Current disadvantage					
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 disadvantage: 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
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

Notes: See notes to Appendix Table 1.

Appendix Table 5

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 Structure (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
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			
Wave 2 family income	71,208	31,416	18,459
Number of Observations	4741	3212	871

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

Notes: Weighted by 8th grade person weights

Appendix Table 6
OLS regressions of score gaps by disadvantage in lagged grade
8th graders in 2011-2013

	No Controls	Demographic Controls	Demog+ School FE
Disadvantage in grade:			
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

Notes: See notes to Appendix Table 1. Coefficients are on indicators for subsidized-meal eligibility in listed grade.

Appendix Table 7

8th graders by number of years present in Michigan public schools

Number of years in the data (at least)	All	Currently disadvantaged	Not currently disadvantaged
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.