Nutrition and Cognitive Achievement: An Evaluation of the School Breakfast Program

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April 19, 2011

Abstract

This paper investigates the impact of eating breakfast through the School Breakfast Program (SBP) on cognitive achievement. Using a regression discontinuity design, I compare the academic achievement of students in schools where the number of free and reduced-price eligible students is just below the mandated threshold to students in schools where the number of free and reduced-price eligible students is just above the threshold. The results show that state mandates increase the availability of the SBP in schools, which increases math, reading, and science achievement in elementary school, particularly for boys.

JEL Classification: I28, I12, H75, J24

Keywords: School Breakfast Program, nutrition, achievement, education

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[†] Thanks to Judi Bartfeld, Mayu Fujii, Craig Gundersen, Alison Jacknowitz, Katherine Magnuson, Hilary Shager, Muzhe Yang, participants at the American Education Finance and Policy Association (AEFP), Association for Public Policy Analysis and Management (APPAM), American Society of Health Economists (ASHE), Research Innovation and Development Grants in Economics (RIDGE), and Southern Economic Association (SEA) conferences and IRP-USDA RIDGE workshop, and seminar participants at Lehigh University for helpful comments. This research was funded, in part, by the Institute for Research on Poverty, Emory Global Health Institute, and Robert Wood Johnson Foundation. Thanks to Griffin Edwards, Jennifer Hefner, Hsien-Chang Lin, and Josh Robinson for research assistance.

1. Introduction

Better nourished children perform better in school (Glewwe, Jacoby, and King, 2001; Winiki and Jemison, 2003; Alderman, Hoddinott, and Kinsey, 2006). Because food insecurity, food insufficiency, and nutrition deficiencies are more prevalent for poor children than non-poor children, low-income children are less likely to acquire the educational benefits from better nutrition (Alaimo et al., 2001; Currie, 2005; Federal Interagency Forum on Child and Family Statistics, 2007). In the United States, food assistance programs have been established to improve the well-being of poor and low-income children. Although there is substantial evidence that nutrition interventions for young children in developing countries have led to increases in cognitive achievement and greater educational attainment (Pollitt et al., 1995; Maluccio et al., 2006), there is limited evidence of the influence of food assistance programs in the U.S. on cognitive achievement (Fox, Hamilton, and Lin, 2004). This paper investigates the impact of the School Breakfast Program (SBP) on cognitive achievement.

The SBP is a federal entitlement program that offers breakfast to any student who attends a school that participates in the program. Children from households with income equal to or below 130 percent of the poverty line are eligible for free meals. Children from households with income equal to or below 185 percent of the poverty line are eligible for reduced-price meals. The SBP provided subsidized breakfast to over 11 million children in 2009 at a cost of nearly $3 billion (United States Department of Agriculture (USDA), 2010).

A considerable body of research has examined the impact of eating breakfast through the SBP or universal free breakfast programs on nutrition outcomes.[1] The evidence from the early

[1] Related research suggests that participation in the SBP reduces childhood obesity, although the National School Lunch Program (NSLP) increases obesity (Schanzenbach, 2009; Millimet, Tchernis, and Husain, 2010). Additionally, Hinrichs (2010a) finds that participation in the NSLP in the mid-1900s increased educational attainment but did not have a lasting impact on health. Further related research shows that the availability of the

literature suggests that the SBP does improve the quality of children's diets (Kennedy and Davis, 1998).[2] More recently, Bhattacharya, Currie, and Haider (2006) use a difference-in-differences strategy to compare nutrient intakes, which are based on dietary recall and blood tests, during the school year and the summer for students in schools that offer the SBP and in schools that do not. They conclude that the availability of the SBP improves the overall nutrition quality of children's diets; increases the likelihood of meeting the Recommended Daily Allowance of fiber, potassium, and iron; decreases the likelihood of having low serum levels of vitamin C, vitamin E, and folate; and reduces the number of calories from fat.

Fewer studies have investigated whether the SBP will lead to improved cognition. There are four primary reasons why the availability of the SBP could influence cognitive achievement. First, improved nutrition could enhance cognition. There could be a direct impact of nutrition as deficiencies in various specific vitamins and minerals can lead to a decrease in mental concentration and cognition, including thiamine, vitamin E, and iron (Chenoweth, 2007; Greenbaum, 2007a,b). Short-term increases in glucose improve short-term memory and cognitive ability (Bellisle, 2004).[3] Additionally, Lieberman (2003) concludes that amino acids, such as tyrosine, and carbohydrate supplementation can improve cognition. There could also be an indirect impact of nutrition through non-cognitive skills, which are important determinants of cognitive achievement (Heckman, Stixrud, and Urzua, 2006). For example, malnutrition is related to behavior problems (Kleinman et al., 1998), anxiety (Barrett, Radke-Yarrow, and Klein,

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SBP increases the likelihood that students eat breakfast (Bartfeld et al., 2009), although this conclusion is not universal (Bhattacharya, Currie, and Haider, 2006).

[2] Methodological concerns limit the usefulness of much of this literature; few studies adequately consider the selection decisions of SBP participation in order to determine a causal effect of the program. For example, Nicklas et al. (1993) simply compare the daily nutrient intakes of children who ate breakfast at school to children who ate breakfast at home or did not eat breakfast. Gordon, Devaney, and Burghardt (1995) use the methodology of instrumental variables, but the use of a weak instrument (the full price of breakfast and school food service characteristics) lessens the value of this approach.

[3] Figlio and Winicki (2005) find that, in response to accountability pressures, some schools increase glucose loads through school lunches to improve test scores.

1982), reduced social involvement (Barrett, Radke-Yarrow, and Klein, 1982), and reduced attention (Connors and Blouin, 1982). Consistent with these findings, Kleinman et al. (2002) document that the improved nutrition from the introduction of a universal breakfast program in Boston increased math achievement.[4]

Second, the availability of the SBP could reduce absenteeism or late attendance at school as students arrive earlier at school to eat breakfast prior to the beginning of the school day.[5] For example, Hinrichs (2010a) suggests that the influence of the expansion of the NSLP on educational attainment could be due to an increase in attendance. Similarly, Kleinman et al. (2002) find that the introduction of a breakfast program increased attendance.

Third, the availability of the SBP is similar to an increase in household income for households with children receiving subsidized meals, since the value of the meal is less than most households' food budget (Bhattacharya, Currie, and Haider, 2006). The reimbursement rate for free breakfasts in 2004 was $1.20, so the value of the monthly transfer to households below 130 percent of the poverty threshold was approximately $26 per child. Dahl and Lochner (2010) demonstrate that an increase in family income increases math and reading scores, with larger increases for children from disadvantaged backgrounds, younger children, and boys.

Fourth, the availability of the SBP could enhance the cognitive and non-cognitive skills of peers.

[4] Related research demonstrates that universal free breakfast programs can improve cognition (Murphy et al., 1998). The randomized evaluation, the School Breakfast Pilot Project, compared universal free breakfast to the SBP but was not designed to evaluate the impact of the SBP (Bernstein et al., 2004). Other related research is based on school breakfast programs outside of the U.S. (Ask et al., 2006). For example, a recent evaluation of the improvement in the nutritional quality of school meals in the UK finds increases in educational achievement and reductions in absences (Belot and James, 2010). On the other hand, McEwan (2010) finds that increases in the number of calories provided in school meals in Chile does not affect students' test scores or attendance. Additional evidence by Dunifon and Kowaleski-Jones (2004) suggests that eating lunch through the National School Lunch Program increases boys' reading scores.

[5] Additionally, improvements in nutrition could reduce illness-related absences.

On the other hand, to be able to consume breakfast as part of the SBP students must arrive to school earlier, which could have a negative impact on achievement if this reduces the amount of time available for sleep. For example, Carrell, Maghakian, and West (2010) find that starting class earlier in the day decreases student achievement among college freshman; however, Hinrichs (2010b) finds that changes in the starting time of school for high school students has no impact on ACT scores.

In one of the few studies focused specifically on the SBP, Myers et al. (1989) compared the change in achievement of SBP participants to eligible non-participants before and after the introduction of the SBP due to a state mandate in Massachusetts. Their results demonstrate that SBP participation improves cognitive achievement; however, their study is limited to six elementary schools in Massachusetts.

This project builds upon the research of Myers et al. (1989) and uses state mandates to account for the endogeneity of the availability of the SBP.[6] To increase participation in the SBP, many states mandated that schools must provide breakfast through the SBP if the percent of free and reduced-price eligible (FRP) students exceeds a set threshold. Using a regression discontinuity design, I compare the academic achievement of students in schools where the number of free and reduced-price eligible students is just below the mandated threshold to students in schools where the number of free and reduced-price eligible students is just above the threshold.

The results suggest that state mandates that schools offer breakfast through the SBP does increase the availability of the SBP in schools and that reading, math, and science test scores are

[6] Bartfeld et al. (2009) also uses state mandates as a source of identification, where the presence of a state mandate is used as an instrument to identify the impact of the availability of the SBP on food insecurity and breakfast skipping.

influenced by the availability of breakfast in schools, at least for schools and students influenced by state mandates.

2. Data

Data from the Early Childhood Longitudinal Study, Kindergarten Cohort of 1998-99 (ECLS-K) are used to estimate the impact of the SBP. The ECLS-K is a longitudinal study that began in 1998 with a nationally representative sample of kindergarten students and their schools. Information about students, their families, their teachers, and their schools was collected in the fall and spring of kindergarten, fall and spring of first grade, spring of third grade, and spring of fifth grade. Importantly for this paper, the ECLS-K includes information about whether the student eats school breakfast and whether the school provides breakfast in each spring, and direct cognitive assessments of reading and mathematics each wave. Direct cognitive assessments of science are available in the third and fifth grades. The direct cognitive assessments are administered through a two-stage process, where the difficulty of the second-stage of the assessment is based on the student's performance on the first-stage. This process ensures that the assessments were administered at the appropriate level of difficulty and there were no floor or ceiling effects (Pollack et al., 2005). Item Response Theory scale scores of reading, mathematics, and science are used as the measures of cognitive achievement.

Information about whether the school participates in the SBP is provided by the school administrator in third and fifth grade and by parents for each grade. To minimize measurement error, I first use the measure of whether the SBP is available in a school that is reported by the school administrator.[7] If the school administrator did not complete the survey or the response is

[7] Of the 9,860 students with non-missing values for the parent and school administrator reported variables in fifth grade, the responses disagree for 740 students. One possible reason for this discrepancy is that parents are asked

missing, then I use the parent's report of whether breakfast is offered in the school as long as there are at least three students surveyed from the school and all parents' responses for the school are the same.[8,9]

Parents are asked whether the student eats breakfast at school, not specifically about eating breakfast through the SBP. Positive responses from parents could include breakfast consumption through the SBP or competitive foods available in the school, such as vending machines. Thus, students are classified as eating breakfast as part of the SBP only if the SBP is available in the school.

The percent of children eligible for free and reduced price lunch or breakfast in October in the school is provided by school administrators in each survey wave.[10] It is important to note that this variable measures eligibility not actual participation, which can differ due to student and household decisions about participation and direct certification. Students in families receiving benefits from the Supplemental Nutrition Assistance Program or the Temporary Assistance for Needy Families program, according to administrative records, are deemed eligible for FRP meals under direct certification; thus, many students may be certified as eligible without participating in the SBP (Dahl and Scholz, 2011). The percent of FRP students from the ECLS-K data is supplemented with the percent of FRP students reported in the Common Core of Data (CCD),

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whether the school offers breakfast to the school, while school administrators are asked whether the school participates in the USDA's School Breakfast Program.

[8] I also use the modal response of parents in the school in the fifth grade wave as long as the parents' response in the third grade wave was consistent with the school administrators' response in the third grade wave and the student didn't change schools.

[9] To verify the validity of using parents' responses, I examined the similarity of the parents' and school administrators' responses among the set of students with non-missing responses from the school administrator and from parents, as long as there were at least three students surveyed from the school with similar parents' responses to whether the school provides breakfast. The responses are nearly identical for the 5,110 students matching these criteria in the fifth grade wave.

[10] In the fifth grade wave, the ECLS-K includes imputed values of the percent of FRP students, where missing responses are imputed using the values from the previous survey wave; then, if still missing, are imputed using a hot deck procedure based on the school's Title I status, latitude, and longitude; and then, if still missing, are imputed using the Common Core of Data. I use the values from the Common Core of Data instead of the imputed ECLS-K values.

which provides information about the number of students eligible for free and reduced price lunch and the total number of students in the school for the universe of public elementary and secondary schools since 1999.

Information about the state mandates is available from Food Research and Action Center (2004). Figure 1 highlights the geographic distribution of these mandates for elementary schools. As seen in this figure, eastern and southern states are likely to impose mandates; however, there is variation in the threshold levels within region. States in the western half of the country do not commonly require that all or specific schools participate in the SBP. Appendix Table 1 displays these state mandated thresholds for all states during 2004 that apply to elementary schools. These mandates require schools to offer breakfast as part of the SBP if the percent of FRP students is equal to or greater than the threshold. Twenty three states imposed a mandate in 2004, including seven states that required all elementary schools to participate in the SBP.[11] Massachusetts and Washington determine the threshold from the percent of FRP students in the second preceding year, Michigan defines the threshold based on the previous year, and all other states use the percent of FRP students in the fall of the current school year to determine whether the mandate applies.

For these state mandates to be an effective source of identification, crossing the state mandated threshold must influence whether the school participates in the SBP. One issue that arises is, given the costs associated with establishing the SBP in a school, whether a school that previously participated in the SBP will stop offering breakfast if the percent of FRP students temporarily falls below the threshold. Another issue is related to the timing of the mandates. For most states, schools calculate the percent of FRP students in the fall (commonly October 1)

[11] California and New Hampshire require schools to provide at least one meal to FRP students but do not specify whether breakfast must be offered. These states are defined as not mandating that breakfast must be available.

and compare this percentage to the state threshold, but schools offer breakfast at the beginning of the school year. Schools may imperfectly predict whether they will be required to participate in the SBP. To alleviate these concerns, I examine whether the school exceeds the state threshold in any of the previous years since 1999. I focus the analysis on the fifth grade survey wave because of the history of data about the percent of FRP students in the school and whether the school offers breakfast through the SBP is reported by the school administrator. Thus, I compare the maximum percent of FRP students in the school between 1999 and 2004 in the ECLS-K and CCD data to the state threshold in 2004.

I restrict the sample to students in public school in the 2004 survey wave with non-missing values for school participation in the SBP and math, reading, and science achievement.[12] I further exclude the ten students in middle school in 2004 from the sample. These sample restrictions yield a sample size of 8,700 students.[13] Table 1 describes the characteristics of these students and schools. In this sample, 4,720 students attend a school in a state without a mandate, 1,000 students attend a school in a state that requires the SBP to be available, and 2,990 students attend a school in a state that requires schools to participate in the SBP if the percent of FRP students exceeds a threshold. In states without a mandate, 80 percent of students attend a school that offers the SBP, while 87 percent of students in states with a mandate attend a school that offers the SBP. The achievement scores of students in states with and without mandates are similar.

Among students in states with a partial mandate, 2,530 students attend a school that participates in the SBP and 460 students attend a school that does not participate in the SBP.

[12] Some charter schools are likely not bound by the state mandates. Thus, I also exclude charter schools that are also not coded as regular schools.

[13] To comply with the security requirements related to the use of the restricted-access ECLS-K data, all sample sizes throughout the paper are rounded to the nearest 10.

The average reading, math, and science scores of students in schools that participate in the SBP are lower than the average scores of students in schools that do not participate. However, students in schools that offer breakfast are more disadvantaged according to their family characteristics. As would be expected, the student body in schools that participate in the SBP is poorer. The average family income of students in schools that participate in the SBP is approximately half of the average family income of their peers in schools that do not offer breakfast. Additionally, parents of students in schools that participate have 2 less years of schooling. These descriptive statistics highlight the difficult in inferring the impact of participating in the SBP by comparing students in schools that do and do not offer breakfast.

The final two columns in Table 1 compare the descriptive statistics of students in schools where the percent of FRP students exceeds the state threshold to students in schools below the threshold. Ninety nine percent of schools that exceed the state threshold participate in the SBP compared to 45 percent of schools below the threshold.

3. Methodology and Results

The primary difficulty in determining the impact of the SBP on cognitive achievement is that participation in the program is determined primarily by the choices of schools and families, and the unobserved determinants of these choices may also be related to the cognitive achievement of students. For example, school administrators may decide to participate in the SBP to provide meals for students in disadvantaged families; these students may be at risk for poor achievement as a result of their family background. Consistent with this possibility, Millimet, Tchernis, and Husain (2010) find that there is significant selection on unobservables related to SBP participation, where SBP participants are more likely to be obese based on their

unobservable characteristics. Further, although 52 percent of participants in the National School Lunch Program received free meals in 2009, 72 percent of participants in the SBP received free meals.[14] Thus, the SBP is a program that targets and serves disadvantaged students, even more so than other school meals programs.

In order to estimate the effect of the availability of the SBP on cognitive achievement, I use a regression discontinuity design that is based on state mandates regarding schools' participation in the SBP. I focus primarily on the influence of the availability of the SBP in schools because state policies, such as mandates, specifically target the availability of the program as opposed to directly targeting participation.

Although the SBP is an entitlement program, the student's school must participate in the program in order for the student to be able to receive breakfast. While the SBP has expanded significantly over the past 20 years, the program was available in approximately only 80 percent of schools that participate in the National School Lunch Program during the 2003-4 school year (Food Research and Action Center, 2004). To increase participation, many states mandated that schools must offer the SBP if the percent of FRP students exceeds a specific threshold. For example, Ohio requires all K-8 schools with 33 percent or more FRP students to offer the SBP. Thus, elementary schools in which 34 percent of the students are FRP are required to participate in the program, but elementary schools in which 32 percent of the students are FRP are not required to do so. A small difference in the percent of FRP students around these state mandated thresholds may lead to a large change in the likelihood that a school offers breakfast through the SBP.

[14] Author's calculations based on program administrative data from http://www.fns.usda.gov/pd/sbsummar.htm and http://www.fns.usda.gov/pd/slsummar.htm.

The relationship between cognitive achievement and a school's SBP participation is specified as:

$$Y_{ijs} = \lambda + \theta D_{js} + \varepsilon_{ijs}, \quad (1)$$

where Y_{ijs} is a measure of the cognitive achievement of student *i* is school *j* in state *s*, D_{js} is an indicator variable for whether school *j* in state *s* provided breakfast through the SBP, θ is the effect of the school's participation in the SBP, and ε represents all other determinants of achievement. State mandates require that school *j* in state *s* provides the SBP if the percent of FRP eligible students, P_{js}, exceeds the state mandated threshold $\overline{P}_s$, such that $Z_{js} = 1\{P_{js} \geq \overline{P}_s\}$.

Many schools will participate in the SBP in the absence of state mandates. Thus, these mandated thresholds are likely to increase the probability of offering the SBP from a positive probability to a probability near one when $\{P_{js} \geq \overline{P}_s\}$. Because the state mandated thresholds do not change the probability of a school's participation from zero to one, a "fuzzy" regression discontinuity is implemented.

The impact of the availability of the SBP in the school on a student's cognitive achievement is:

$$\theta = \frac{\alpha}{\beta} = \frac{\lim_{P_{js} \downarrow \overline{P}_s} E[Y_{ijs} \mid P_{js} = \overline{P}_s] - \lim_{P_{js} \uparrow \overline{P}_s} E[Y_{ijs} \mid P_{js} = \overline{P}_s]}{\lim_{P_{js} \downarrow \overline{P}_s} E[D_{js} \mid P_{js} = \overline{P}_s] - \lim_{P_{js} \uparrow \overline{P}_{s_s}} E[D_{js} \mid P_{js} = \overline{P}_s]}, \quad (2)$$

where α is the influence of the state mandates on cognitive achievement and β is the influence of the state mandates on the availability of the SBP in schools. This empirical strategy is analogous to using an instrumental variables approach, where the state mandated threshold is an instrument for the availability of the SBP (Hahn, Todd, and Van der Klaauw, 2001).

I implement two approaches to estimate β and α. First, I estimate the regressions:

$$D_{js} = \lambda_1 + \beta Z_{js} + m_1\left(P_{js} - \overline{P}_s\right) + \varepsilon_{1ijs} \quad (3)$$

and

$$Y_{ijs} = \lambda_2 + \alpha Z_{js} + m_2\left(P_{js} - \overline{P}_s\right) + \varepsilon_{2ijs}, \quad (4)$$

where $m_1(\cdot)$ and $m_2(\cdot)$ are flexible parametric functions. I focus the analysis on a trimmed sample that includes only students in schools where the percent of FRP students is within 20 percentage points of the state threshold. Second, I estimate a local linear regression using a triangle kernel and the same bandwidth. The estimate of θ is $\hat{\theta} = \hat{\alpha}/\hat{\beta}$.

a. Mean Differences

The descriptive statistics shown in the last two columns of Table 1 contain means for students in schools with $\left(P_{js} \geq \overline{P}\right)$ and $\left(P_{js} < \overline{P}\right)$. As described above, the regression discontinuity design relies on the mean values of student achievement as the percent of FRP students in the school nears the state threshold, both from above and from below. Before turning to estimates of α and β, I present simple Wald estimates that are based on means for students in schools within five percentage points, both above and below, the state thresholds. There are 130 students in schools with the percent of FRP students within five percentage points above the state thresholds and 100 students in schools with the percent of FRP students within five percentage points below the state thresholds. As shown in Table 2, among schools with the percent of FRP students just above the state threshold, 100 percent of students attend a school that participates in the SBP. Among schools with the percent of FRP students just below the state threshold, only 55 percent of students attend a school that participates in the SBP. Thus, there is a 46 percentage point difference between schools just above and just below the state mandated thresholds.

Although the achievement scores of students in all schools above the state thresholds were substantially below the achievement scores of students in all schools below the state thresholds, as shown in Table 1, when the sample is restricted to schools within five percentage points of the state thresholds, this relationship is reversed. The mean reading, math, and science achievement scores of students in schools above the state thresholds are higher than the achievements scores of students in schools below the thresholds. Students in schools slightly above the state threshold score 4.4 points, or 3 percent, higher on reading, 5.8 points, or 5 percent, higher on math, and 4.8 points, or 8 percent, higher on science than students in schools slightly below the state threshold. Thus, the resulting Wald estimate on the impact of the availability of the SBP in school is 9.7 points for reading achievement, 12.8 points for math achievement, and 10.5 points for science achievement.

b. Regression Discontinuity Estimates

The estimates of β and α are shown in Table 3. The first row shows the estimate of β, which is the impact of the state mandates on schools' participation in the SBP. The additional rows show the estimates of α, which is the influence of the state mandates on cognitive achievement, for reading, math, and science. The first column displays the OLS estimates without any covariates, while the second column includes additional covariates to reduce small sample biases and improve the precision of the estimates. The third column displays the estimates of θ, which are equivalent to the estimates for achievement in the second column divided by the estimate for schools' participation in the SBP in the second column and are calculated using instrumental variables. For all regressions, $m_1(\cdot)$ and $m_2(\cdot)$ are specified as a linear polynomial in $\left(P_{js} - \overline{P}_s\right)$ and includes an interaction term between R_{js} and $\left(P_{js} - \overline{P}_s\right)$. The

linear specification was chosen based on the Schwarz criterion and joint hypothesis tests of higher order polynomial terms. The fourth column displays the local linear estimates of β and α, while the fifth column displays the local linear estimates of θ.

As shown in Table 3, exceeding the state threshold increases the probability that a school participates in the SBP by 54 percentage points and this estimate is robust to the inclusion of additional covariates. There is also a large, positive increase at the state thresholds for reading, math, and science. Reading achievement increases by 7.0 points, which is 5 percent of the mean of students just below the state threshold as shown in Table 2. Math achievement increases by 6.8 points, which is 6 percent of the mean of students just below the state threshold as shown in Table 2. Science achievement increases by 4.9 points, which is 8 percent of the mean of students just below the state threshold as shown in Table 2. Controlling for individual and family characteristics slightly decreases the estimates. The estimated impact of the availability of breakfast through the SBP is an 8 percent increase in reading achievement, 10 percent increase in math achievement, and 14 percent increase in science achievement.

These results are shown graphically in Figures 2 through 5. To reduce the noise in the graphs, students are grouped in bins with a width of three percentage points and the points on the graph represent the average value for each bin. The lines on the graphs on the left of the figures are fitted values from the regressions shown in Table 3, while the graphs on the right of the figures are local linear estimates. These graphs highlight the discontinuity at the state thresholds in schools participating in the SBP. The downward sloping trend in achievement is the result of the relationship between poverty and test scores; moving to the right on the x-axis, the percent of FRP students in the school is larger.

Table 4 examines the differential impact of the availability of the SBP on achievement by gender. Exceeding the state threshold has a similar impact on the availability of the SBP in the schools attended by male and female students in this sample, but has a larger impact on the reading, math, and science achievement of male students.

Tables 5, 6, and 7 examine the mechanisms through which state mandates and the availability of the SBP could influence achievement. In Table 5, the OLS results show that exceeding the state threshold increases the probability that a student eats breakfast in school by 9 percentage points; however, this result is not robust to alternative specifications as there is no impact on breakfast consumption in school from the local linear regression estimates.[15] Table 6 displays the estimates of the relationship between attending a school that is required to offer the SBP and five measures of non-cognitive skills. The results show that there is no impact on the non-cognitive skills of females, but that there is a decrease in the self-control and interpersonal skills of males, which could result from additional time in a cafeteria with relatively less supervision. Table 7 displays the estimates of the relationship between attending a school that is required to offer the SBP and school attendance. The results are suggestive that the availability of the SBP decreases unexcused absences, but not excused absences. The magnitudes of the point estimates suggest that this impact is larger for male than female students.

c. Specification Checks

Overall, these results suggest that there are discontinuities in the availability of the SBP in schools and students' eating breakfast as part of the SBP, and that the SBP does influence

[15] Further, there is no impact of the availability of the SBP on the total days per week that a student eats breakfast. However, additional results of a decrease in food insecurity and body mass index suggest that the availability of the SBP does not change whether a student eats breakfast but influences what a student eats for breakfast, which is consistent with the conclusions of Bhattacharya, Currie, and Haider (2006).

achievement scores, particularly for boys. There are a variety of specification checks, however, that are important to validate the regression discontinuity design and increase the confidence in these results. One specification test is to examine whether individual and family characteristics exhibit discontinuities around the state thresholds, where the lack of a discontinuity would support the validity of the regression discontinuity design. Table 8 displays the results of this specification test. There is no statistically significant discontinuity in race, sex, and family background in the fifth grade wave, with the exception that students are less likely to live in a rural area in schools above state thresholds.

Another concern related to a regression discontinuity design is whether there is the possibility of precise sorting around the threshold. In this context, the concern relates to whether school administrators are able to strategically reduce the number of FRP students below the state threshold so that the mandate does not bind. This type of manipulation could potentially occur if administrators discourage eligible students from submitting the school meals application. However, from examining the distribution of the percent of FRP students in the school centered at the state threshold, there is no evidence of strategic manipulation of the assignment variable. In contrast, the density is higher above the state threshold, which is due to the construction of the assignment variable as the maximum percent of FRP students in the school since 1999.

Additionally, the results of the estimates of the impact of exceeding the state thresholds on achievement are generally robust to alternative bandwidth choices in the local linear regression estimates. Smaller bandwidths and higher order polynomials increase the estimates, so that the reported results are conservative estimates of the impact of the availability of the SBP.

4. Conclusion

The School Breakfast Program has been shown to improve the nutritional quality of children's diets. This paper examines whether the SBP improves cognitive achievement. To increase the availability of the SBP, approximately half of all states mandate that schools participate in the SBP if the percent of FRP students exceeds a specific threshold. Using a regression discontinuity design, I compare the outcomes of students in schools above the threshold to students in schools below the threshold. The results suggest that these state mandates have been effective in increasing the participation of schools in the SBP and that these mandates increase reading, math, and science achievement.

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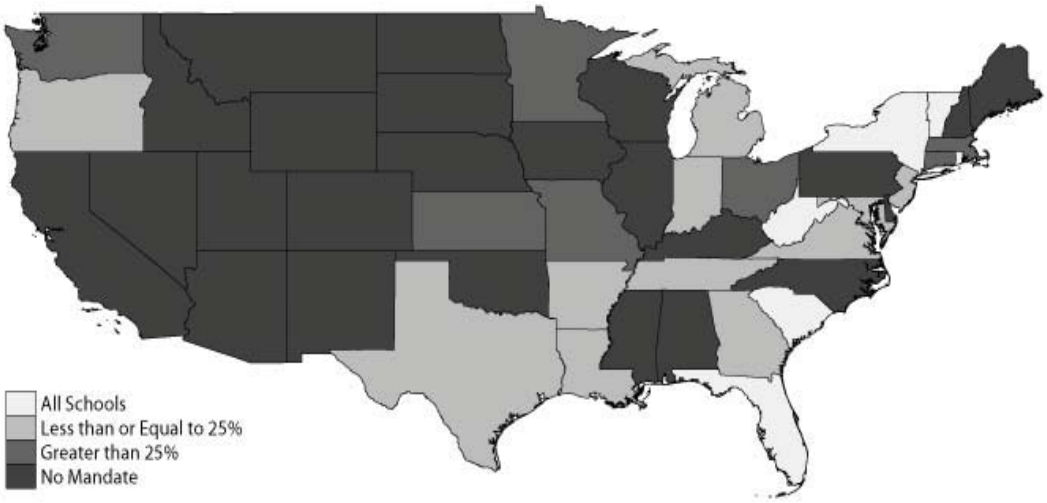
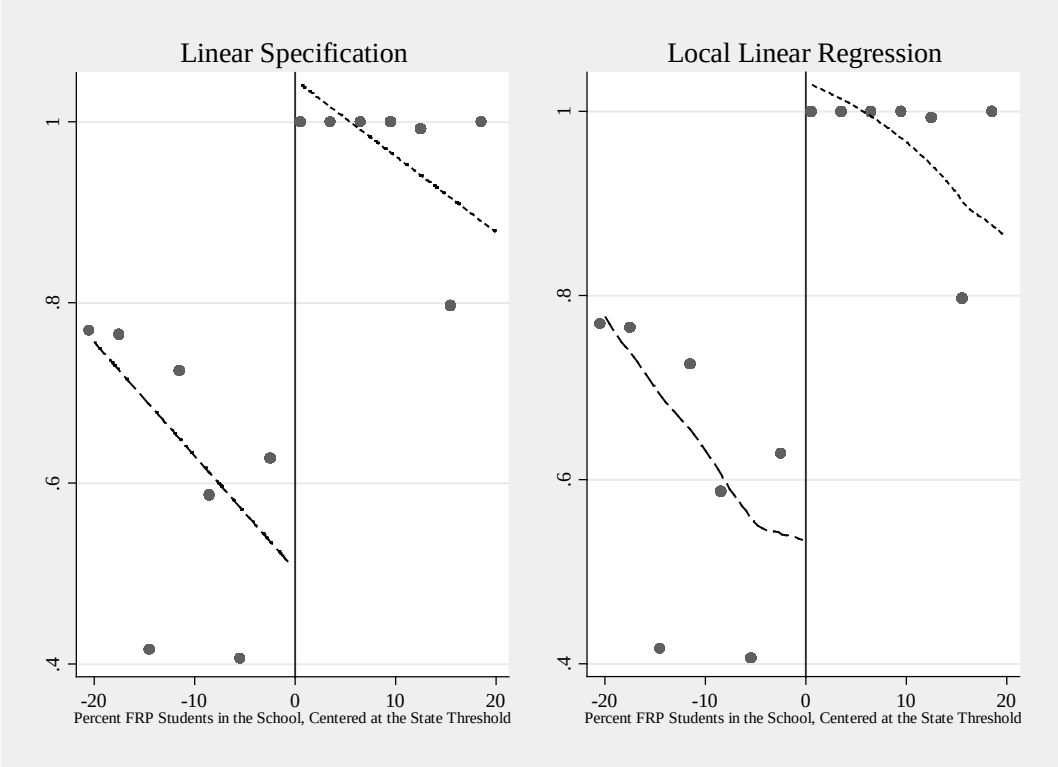
Figure 1: State Mandated Thresholds



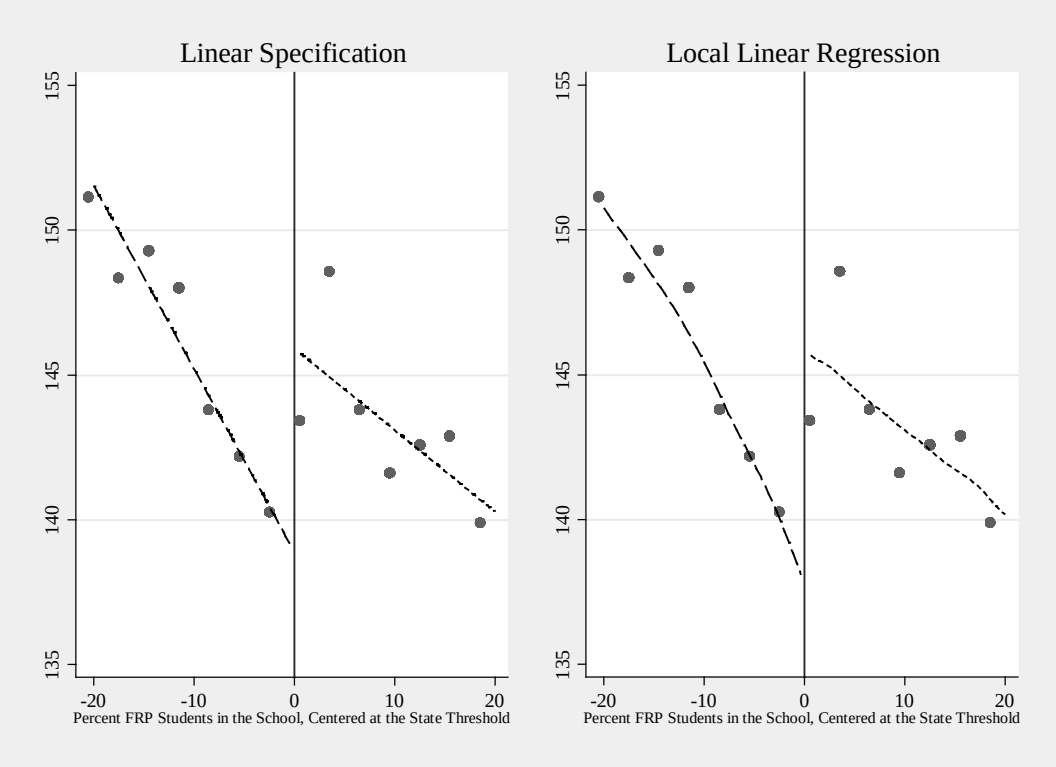
Notes: If the percent of free and reduced-price eligible students in the school exceeds the state mandated threshold, then the school is required to participate in the School Breakfast Program. These thresholds are based on state laws in 2004.
Source: Food Research and Action Center (2004)

Figure 2: Participation of Schools in the School Breakfast Program by the Percent of Free and Reduced-Price Eligible Students in the School



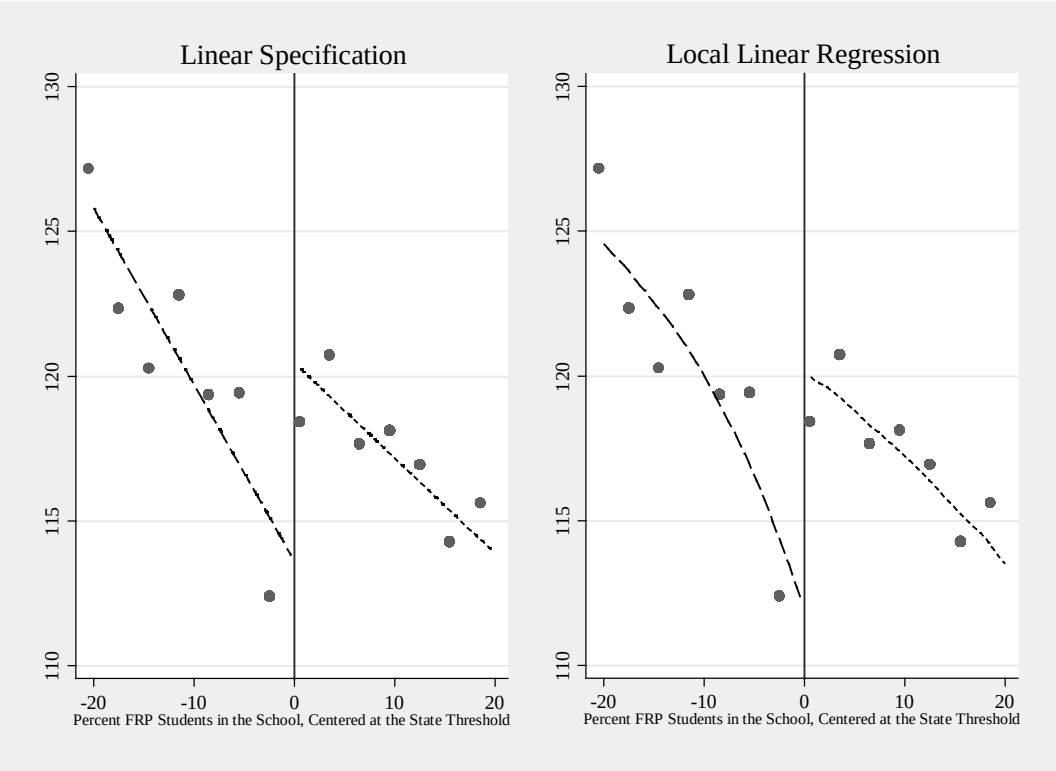
Notes: The points on the graph represent averages for students grouped in bins with a width of three percentage points. In the left panel, the lines are fitted values from a regression with a linear polynomial fully interacted with an indicator denoting that the percent of free and reduced-price eligible students exceed the state threshold. In the bottom panel, the dash line is the estimates from a local linear regression.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Figure 3: Reading Scores by the Percent of Free and Reduced-Price Eligible Students in the School



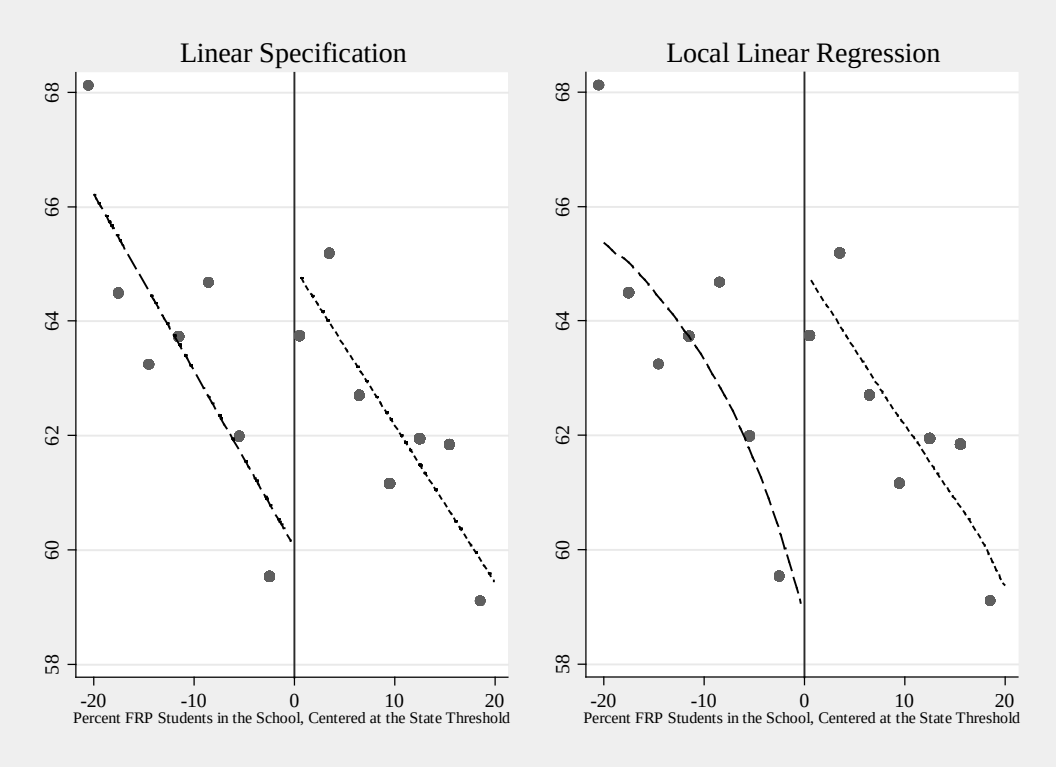
Notes: See Figure 2.

Figure 4: Math Scores by the Percent of Free and Reduced-Price Eligible Students in the School



Notes: See Figure 2.

Figure 5: Science Scores by the Percent of Free and Reduced-Price Eligible Students in the School



Notes: See Figure 2.

Table 1: Means (and Standard Deviations)

		Students in States:							
					With a Partial Mandate:				
	All Students	Without a Mandate	With a Mandate	With a Full Mandate	All	In Schools That Offer SBP	In Schools That Do Not Offer SBP	In Schools with Pct. FRP Above Threshold	In Schools with Pct. FRP Below Threshold
School Offers SBP	0.833	0.801	0.872	0.946	0.847	1.000	0.000	0.986	0.45
	(0.373)	(0.399)	(0.335)	(0.226)	(0.360)	(0.000)	(0.000)	(0.116)	(0.498)
Reading Score	137.130	135.809	138.692	139.261	138.502	136.841	147.671	135.382	147.29
	(23.485)	(23.959)	(22.815)	(21.976)	(23.090)	(23.403)	(18.826)	(23.284)	(20.092)
Math Score	112.680	111.048	114.611	115.467	114.324	112.794	122.772	111.503	122.28
	(21.860)	(22.433)	(21.001)	(21.547)	(20.811)	(20.900)	(18.141)	(21.040)	(17.912)
Science Score	56.560	55.388	57.948	56.521	58.426	57.334	64.454	56.488	63.89
	(14.618)	(14.895)	(14.160)	(14.385)	(14.055)	(14.113)	(12.076)	(14.087)	(12.442)
Distance to Threshold	30.524	--	30.524	51.245	23.585	32.464	-25.428	39.742	-21.95
	(37.923)		(37.923)	(34.032)	(36.610)	(31.115)	(23.612)	(26.464)	(18.278)
Above Threshold	0.368	0.000	0.804	1.000	0.738	0.860	0.066	1.000	0.00
	(0.482)	(0.000)	(0.397)	(0.000)	(0.440)	(0.347)	(0.248)	(0.000)	(0.000)
Percent FRP eligible	54.994	58.813	50.476	51.245	50.219	56.960	13.011	63.138	13.81
	(31.859)	(31.878)	(31.243)	(34.032)	(30.253)	(27.457)	(13.064)	(23.980)	(8.809)
Age (months)	134.627	134.476	134.807	133.430	135.268	135.394	134.570	135.384	134.94
	(4.500)	(4.414)	(4.594)	(4.372)	(4.575)	(4.611)	(4.310)	(4.630)	(4.406)
Female	0.495	0.498	0.491	0.490	0.491	0.498	0.454	0.494	0.48
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.498)	(0.500)	(0.500)
Black	0.131	0.118	0.145	0.162	0.140	0.159	0.030	0.182	0.02
	(0.337)	(0.323)	(0.352)	(0.369)	(0.346)	(0.366)	(0.172)	(0.385)	(0.142)
Hispanic	0.198	0.216	0.177	0.252	0.152	0.172	0.043	0.186	0.06
	(0.399)	(0.412)	(0.382)	(0.434)	(0.359)	(0.377)	(0.205)	(0.389)	(0.228)
Other Race/Ethnicity	0.127	0.163	0.085	0.086	0.085	0.084	0.090	0.079	0.10
	(0.333)	(0.370)	(0.279)	(0.280)	(0.278)	(0.277)	(0.286)	(0.269)	(0.301)
White	0.544	0.502	0.593	0.499	0.624	0.586	0.837	0.554	0.82
	(0.498)	(0.500)	(0.491)	(0.500)	(0.484)	(0.492)	(0.371)	(0.497)	(0.382)
Family Income (000s)	58.439	54.489	63.113	65.522	62.306	54.543	105.159	49.217	99.20
	(49.751)	(46.384)	(53.089)	(56.470)	(51.892)	(45.212)	(64.125)	(40.805)	(61.230)
Poverty	0.227	0.202	0.249	0.191	0.205	0.235	0.040	0.265	0.040
	(0.402)	(0.383)	(0.416)	(0.368)	(0.388)	(0.408)	(0.185)	(0.424)	(0.176)
Family Size	4.611	4.677	4.532	4.480	4.550	4.553	4.531	4.555	4.53
	(1.357)	(1.431)	(1.260)	(1.239)	(1.267)	(1.302)	(1.051)	(1.317)	(1.112)
Parents' Highest Education	14.101	13.927	14.307	14.638	14.196	13.890	15.887	13.655	15.72
	(2.568)	(2.549)	(2.575)	(2.571)	(2.568)	(2.485)	(2.354)	(2.442)	(2.284)
Birth Weight	117.950	117.626	118.333	118.018	118.438	117.785	122.047	117.243	121.81
	(18.411)	(18.280)	(18.560)	(19.331)	(18.297)	(18.133)	(18.793)	(18.239)	(18.048)
Grade	4.888	4.894	4.880	4.894	4.875	4.862	4.945	4.853	4.94
	(0.332)	(0.323)	(0.342)	(0.333)	(0.345)	(0.360)	(0.227)	(0.372)	(0.243)
Observations	8700	4720	3990	1000	2990	2530	460	2200	780

Notes: Standard deviations in parentheses. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 2: Means within Five Percentage Points Above and Below the State Thresholds

	School Participates in SBP	Reading Score	Math Score	Science Score	Percent FRP
Above State Threshold	1.000	145.924	119.648	64.567	27.889
	(0.000)	(1.908)	(1.601)	(1.015)	(0.544)
Below State Threshold	0.545	141.504	113.810	59.808	22.260
	(0.050)	(2.268)	(2.076)	(1.402)	(0.643)
Difference	0.455	4.420	5.838	4.759	5.629
(Above – Below)	(0.044)	(2.944)	(2.579)	(1.691)	(0.837)
Difference in Achievement / Difference in School Participation		9.714	12.831	10.459	

Notes: Standard errors in parentheses. The number of observations within five percentage points and above the state thresholds is 130 and the number of observations within five percentage points and below the state thresholds is 100.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 3: Regression Discontinuity Estimates

	OLS	OLS	IV	LLR	LLR (Wald)
Panel A: School Participates in SBP					
Above Threshold	0.542	0.556		0.498	
	(0.050)	(0.051)		(0.062)	
R^2	0.214	0.226			
Panel B: Reading Score					
Above Threshold	7.041	6.446	11.591	8.048	16.167
	(2.807)	(2.413)	(4.395)	(2.883)	(6.159)
R^2	0.015	0.251	0.225		
Panel C: Math Score					
Above Threshold	6.834	6.297	11.323	8.252	16.575
	(2.456)	(2.150)	(3.996)	(3.212)	(6.915)
R^2	0.021	0.250	0.221		
Panel D: Science Score					
Above Threshold	4.890	4.702	8.454	6.041	12.134
	(1.666)	(1.473)	(2.768)	(2.148)	(4.774)
R^2	0.017	0.244	0.188		
Observations	1160	1160	1160	1160	1160
Covariates	No	Yes	Yes	No	No
Polynomial	Linear	Linear	Linear		

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. Covariates include age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, and parent's education, birth weight, grade, urban/rural, and poverty status. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 4: Results for Males and Females

	School Participates in SBP	Reading Score	Math Score	Science Score
Females				
OLS	0.524	4.501	4.107	4.087
	(0.070)	(3.233)	(2.981)	(2.015)
LLR	0.459	6.800	6.689	4.871
	(0.062)	(3.973)	(3.783)	(2.417)
Observations	570	570	570	570
Males				
OLS	0.583	8.439	8.342	5.288
	(0.075)	(3.636)	(3.046)	(2.125)
LLR	0.547	10.427	9.485	7.096
	(0.086)	(5.132)	(3.598)	(2.290)
Observations	600	600	600	600

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. Covariates include age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, and parent's education, birth weight, grade, urban/rural, and poverty status. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 5: Eats Breakfast at School

	All Students	Females	Males
OLS	0.092	0.119	0.099
	(0.047)	(0.061)	(0.071)
LLR	0.005	0.025	-0.021
	(0.053)	(0.074)	(0.069)
Observations	1060	510	550

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. Covariates include age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, and parent's education, birth weight, grade, urban/rural, and poverty status. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 6: Non-cognitive skills: Social Rating Scales

	Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problem Behaviors	Internalizing Problem Behaviors
All Students					
OLS	0.005	-0.116	-0.136	-0.003	-0.136
	(0.076)	(0.068)	(0.076)	(0.065)	(0.076)
LLR	0.043	-0.096	-0.127	0.010	-0.172
	(0.091)	(0.068)	(0.085)	(0.072)	(0.083)
Observations	1140	1130	1120	1140	1130
Female Students					
OLS	0.168	-0.002	-0.022	-0.104	-0.120
	(0.104)	(0.087)	(0.101)	(0.076)	(0.094)
LLR	0.263	0.047	0.056	-0.064	-0.153
	(0.115)	(0.098)	(0.115)	(0.082)	(0.101)
Observations	550	550	550	550	550
Male Students					
OLS	-0.175	-0.237	-0.255	0.104	-0.170
	(0.113)	(0.109)	(0.116)	(0.110)	(0.122)
LLR	-0.144	-0.243	-0.286	0.052	-0.220
	(0.107)	(0.123)	(0.110)	(0.155)	(0.170)
Observations	590	580	570	580	580

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. Covariates include age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, and parent's education, birth weight, grade, urban/rural, and poverty status. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 7: School Attendance

	% Excused Absences	% Unexcused Absences	% Excused Tardies	% Unexcused Tardies
All Students				
OLS	0.499	-0.640	0.576	-0.344
	(0.619)	(0.223)	(0.259)	(0.206)
LLR	-0.107	-0.595	0.288	0.125
	(0.742)	(0.289)	(0.221)	(0.246)
Observations	1030	1020	990	990
Females				
OLS	-0.322	-0.556	1.034	-0.515
	(0.572)	(0.271)	(0.407)	(0.301)
LLR	-0.907	-0.444	0.690	0.255
	(0.690)	(0.272)	(0.398)	(0.322)
Observations	500	490	490	490
Males				
OLS	1.234	-0.677	0.014	-0.121
	(1.127)	(0.362)	(0.319)	(0.276)
LLR	0.432	-0.845	-0.187	0.013
	(1.018)	(0.405)	(0.361)	(0.293)
Observations	530	530	500	500

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. Covariates include age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, and parent's education, birth weight, grade, urban/rural, and poverty status. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 8: Discontinuities in Other Characteristics

	OLS	LLR
Age	-0.529	-0.358
	(0.570)	(0.739)
Female	-0.076	-0.103
	(0.064)	(0.064)
Black	-0.004	0.007
	(0.025)	(0.032)
Hispanic	0.007	-0.007
	(0.031)	(0.036)
Other Race	-0.002	0.002
	(0.037)	(0.046)
Family Income	7.245	6.012
	(7.147)	(7.342)
Poverty	0.033	0.000
	(0.036)	(0.040)
Family Size	-0.274	-0.360
	(0.150)	(0.161)
Parents' Highest Education	0.192	0.281
	(0.298)	(0.369)
Urban	-0.025	-0.007
	(0.056)	(0.062)
Rural	-0.276	-0.132
	(0.053)	(0.054)
Birth weight	-1.638	-1.632
	(2.224)	(2.279)
Grade	0.002	-0.020
	(0.037)	(0.039)
Observations	1160	1160

Notes: Heteroskedasticity-robust standard errors in parentheses. OLS regressions include an indicator variable denoting that the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold, the percent of FRP students in the school centered at the state threshold, and the interaction of the centered percent of FRP students in the school and the indicator variable denoting that the percent of FRP students in the school exceeds the state threshold. The sample includes only students in schools where the percent of free and reduced-price eligible students is within 20 percentage points of the state threshold. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Appendix Table 1: State Mandated Thresholds of the Percent of Free and Reduced Price Eligible Students above Which States Must Provide School Breakfast for Elementary School Students

State	2004
Alabama	.
Alaska	.
Arizona	.
Arkansas	0.2
California	.
Colorado	.
Connecticut	0.8
Delaware	.
District of Columbia	.
Florida	0
Georgia	0.25
Hawaii	.
Idaho	.
Illinois	.
Indiana	0.25
Iowa	.
Kansas	0.35
Kentucky	.
Louisiana	0.25
Maine	.
Maryland	0
Massachusetts	0.4
Michigan	0.2
Minnesota	0.33
Mississippi	.
Missouri	0.35
Montana	.
Nebraska	.
Nevada	.
New Hampshire	.
New Jersey	.
New Mexico	.
New York	0
North Carolina	.
North Dakota	.
Ohio	0.33
Oklahoma	.
Oregon	0.25
Pennsylvania	.
Rhode Island	0
South Carolina	0
South Dakota	.
Tennessee	0.25
Texas	0.1
Utah	.
Vermont	0
Virginia	0.25
Washington	0.4
West Virginia	0
Wisconsin	.
Wyoming	.

Notes: The figures in this table represent the thresholds such that a school must provide the School Breakfast Program if the number of free and reduced price eligible students is equal to or greater than this threshold. Zero means that the all schools must provide the SBP. California and New Hampshire mandate that schools must provide at least one meal; these states are coded as not having a mandate since schools are likely to provide lunch instead of breakfast.
Source: Food Research and Action Center (2004)