INSTITUTE for RESEARCH on POVERTY
UNIVERSITY OF WISCONSIN–MADISON

IRP Discussion Paper

No. 1402-12

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

David E. Frisvold
Department of Economics
Emory University
E-mail: david.frisvold@emory.edu

August 16, 2012

Thanks to Judi Bartfeld, Jane Cooley, Janet Currie, David Deming, Mayu Fujii, Craig Gundersen, Peter Hinrichs, Caroline Hoxby, Alison Jacknowitz, Katherine Magnuson, Diane Schanzenbach, 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), NBER Children's Program, Research Innovation and Development Grants in Economics (RIDGE), and Southern Economic Association (SEA) conferences and IRP-USDA RIDGE workshop, and seminar participants at Georgia Tech University, Lehigh University, and University of Alabama-Birmingham for helpful comments. Thanks to Griffin Edwards, Jennifer Hefner, Hsien-Chang Lin, Josh Robinson, and Maria Vyshnya for research assistance. This research was supported by the Institute for Research on Poverty, Emory Global Health Institute, Robert Wood Johnson Foundation, and Grant Number R03HD067490 from the Eunice Kennedy Shriver National Institute of Child Health & Human Development. The content is solely the responsibility of the author and does not necessarily represent the official views of any of the funding organizations.
Emory University

Abstract

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, including free breakfast for any low-income student, who attends a school that participates in the program. To increase the availability of the SBP, many states mandate that schools participate in the program if the percent of free or reduced-price eligible students in a school exceeds a specific threshold. Using the details of these mandates as a source of identifying variation, I find that the availability of the program increases student achievement.

JEL Classification: I28, H51, I18, H52, H75

Keywords: School Breakfast Program, nutrition, achievement, education

I. Introduction

A large body of research provides evidence that better nourished children perform better in school (e.g., Glewwe, Jacoby, and King, 2001; Winicki and Jemison, 2003; Alderman, Hoddinott, and Kinsey, 2006; Victora et al., 2008). 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 ample 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 regarding whether food assistance programs in the U.S. achieve similar results.

The School Breakfast Program (SBP) was established with the Child Nutrition Act of 1966 to improve the nutritional needs of children "in recognition of the demonstrated relationship between food and good nutrition and the capacity of children to develop and learn" (42 U.S.C. 1771). Upon signing the bill, President Johnson stated that "good nutrition is essential to good learning."[1] Even though the majority of studies conclude that the SBP enhances nutrition, as commonly noted in reviews of the literature, there is very little evidence on the relationship between the SBP and educational outcomes (Fox, Hamilton, and Lin, 2004). This paper fills this gap in the literature and investigates the impact of the availability of the SBP on cognitive achievement.

[1] School Nutrition Association. 2011. Program History & Data. http://www.schoolnutrition.org/Content.aspx?id=1872 (accessed October 10, 2011).

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 guidelines are eligible for free meals. Children from households with income equal to or below 185 percent of the poverty guidelines 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). Although the SBP is similar to the National School Lunch Program (NSLP), the SBP serves a lower income population; approximately half of NSLP participants received a free lunch in 2009, while approximately three quarters of SBP participants received a free breakfast.

In this paper, I focus on the influence of the availability of the SBP in schools, since public policies tend to target the participation of students indirectly through the availability of the program. To increase the availability of the SBP, many states mandate that schools must provide breakfast through the SBP if the percent of free and reduced-price eligible (FRP) students exceeds a set threshold. These thresholds range in value from 10 to 80 percent, and I use these mandates as an identifying source of variation. I first estimate a difference-in-differences specification that compares the achievement among students in schools above and below the threshold values across states with differing levels of SBP thresholds using data from the National Assessment of Educational Progress (NAEP). Second, I use a regression discontinuity design to compare the cognitive achievement of students in schools where the percent of FRP students is just below the mandated threshold to students in schools where the percent of FRP students is just above the threshold. The results suggest that state mandates that schools offer breakfast through the SBP increase math and reading achievement.

The benefits of using NAEP data are the sample size, since NAEP is one of the largest data sets with student achievement measures, and the ability to merge the percent of FRP students in the school from the Common Core of Data. However, NAEP does not include information about the availability of the SBP in the school. Thus, I also utilize data from the Early Childhood Longitudinal Study, Kindergarten Cohort of 1998-99 (ECLS-K), which includes the availability of the SBP in the school and information about consumption, attendance, and behavior that is used to determine the mechanism through which the availability of the SBP influences achievement. The results using the ECLS-K data support the conclusions from the NAEP data and suggest that state mandates that schools offer breakfast through the SBP increase the availability of the SBP in schools, which increases achievement scores. Further, the results suggest that the availability of the SBP improves the nutritional content of what is consumed for breakfast.

II. Why Might the School Breakfast Program Influence Cognitive Achievement?

There are at least three reasons why the availability of the SBP could improve cognitive achievement. First, improved nutrition could enhance cognition (Pollitt and Mathews, 1998).[2] A considerable body of research has examined the impact of eating breakfast through the SBP or universal free breakfast programs on nutrition outcomes.[3] The evidence from the early literature suggests that the SBP does improve the quality of children's diets (Kennedy and Davis, 1998). More recently, Bhattacharya, Currie, and Haider (2006) compare nutrient intakes during the school year and the summer for students in schools that offer the SBP and in schools that do not.

[2] Related to this mechanism, Pollitt and Mathews (1998) also note that breakfast, in particular, could influence cognition by reducing the length of the overnight fast and the associated metabolic changes of fasting.
[3] 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).

They conclude that the availability of the SBP does not increase breakfast consumption but it 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.[4]

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).[5] In particular, the very early stages of iron deficiency can alter dopamine transmission, which influences cognition (Pollitt, 1993). Short-term increases in glucose improve short-term memory and cognitive ability (e.g., Bellisle, 2004); thus, high-fiber foods that provide a more sustained increase in blood glucose could be more effective in boosting cognition (Mahoney et al., 2005).[6] Choline and lecithin, which are found in many foods including eggs, influence the synthesis of the neurotransmitter acetylcholine and may improve memory (Fernstrom, 2000). Additionally, Lieberman (2003) concludes that amino acids, such as tyrosine, and carbohydrate supplementation can improve cognition. Thus, based on the conclusions of the nutrition literature and the findings of Bhattacharya, Currie, and Haider (2006), the availability of the SBP is likely to improve memory and cognition.

---

[4] Further, Crepinsek et al. (2009) demonstrate that, in most elementary schools, school breakfasts offered meet the recommendations of Dietary Guidelines for Americans, except for lower levels of fiber. Millimet, Tchernis, and Husain (2010) document significant non-random selection related to SBP participation, which suggests that the breakfasts that would be consumed at home are likely to be less nutritious than the breakfasts that would be consumed in school.

[5] For a summary of the literature on the relationships between macronutrients and cognition and a discussion of the neurological and biological mechanisms underlying these relationships, see Gibson and Green (2002).

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

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, 1982), reduced social involvement (Barrett, Radke-Yarrow, and Klein, 1982), and reduced attention (Connors and Blouin, 1982). Consistent with both a direct and indirect impact of nutrition, Kleinman et al. (2002) document that the improved nutrition from the introduction of a universal breakfast program in Boston, which provided free breakfast for all students regardless of household income, increased math achievement.[7]

Second, the availability of the SBP could reduce absenteeism or tardiness at school, either because students arrive earlier at school to eat breakfast prior to the beginning of the school day or, indirectly, because improvements in nutrition could reduce illness-related absences. For example, Hinrichs (2010) suggests that the influence of the expansion of the NSLP on educational attainment could be due to an increase in attendance. Kleinman et al. (2002) find that the introduction of a universal breakfast program increased attendance due to improved nutrition.

Third, the availability of the SBP is similar to an increase in household income for households with children receiving subsidized meals (Bhattacharya, Currie, and Haider, 2006).

[7] Related research demonstrates that universal free breakfast programs can improve cognitive and non-cognitive outcomes (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. (e.g., 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, 2011). 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. Further related research addresses the influence of serving breakfast in the classroom instead of the cafeteria and finds that this change increased student achievement (Imberman and Kugler, 2012). There is also a substantial body of research on the relationship between breakfast consumption more generally and cognition (Pollitt and Mathews, 1998). Additional evidence by Dunifon and Kowaleski-Jones (2004) suggests that eating lunch through the National School Lunch Program increases boys' reading scores. While these studies provide important context for understanding the role of breakfast and nutrition, these studies do not directly address the impact of SBP in the U.S.

The reimbursement rate for free breakfasts in 2004 was $1.20 per meal, so the value of the monthly transfer to households below 130 percent of the poverty threshold was approximately $26 per child who consumes breakfast daily.[8] Dahl and Lochner (2012) demonstrate that an increase in family income increases math and reading scores, with larger increases for children from disadvantaged backgrounds, younger children, and boys.

Although there are many reasons to expect that the availability of the SBP will increase achievement, such a result is not obvious a priori. For example, the availability of breakfast could induce low-performing or disruptive students to attend school, which might change the composition of peers in the classroom, and these peer influences could reduce cognitive achievement (Carrell and Hoekstra, 2010; Sacerdote, 2011; Imberman, Kugler, and Sacerdote, 2012). On the other hand, if the availability of breakfast enhances the cognitive or non-cognitive skills of peers, then peer influences could increase achievement.

Further, 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. Carrell, Maghakian, and West (2011) find that starting class earlier in the day decreases student achievement among college freshman; however, Hinrichs (2011) 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, Meyers 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

[8] To put this amount in perspective, $26 per month is approximately 70 percent of the average monthly food costs per person in 2004 of the WIC program.

elementary schools in Massachusetts. This paper builds upon the research of Meyers et al. (1989) and uses state mandates to account for the endogeneity of the availability of the SBP.[9]

III. Estimation Strategies

The primary difficulty in identifying the impact of the SBP on cognitive achievement is that participation in the program is determined by the choices of schools, families, and students and the unobserved determinants of these choices may also be related to the cognitive achievement of students. For example, school administrators may decide to offer breakfast through the SBP to provide assistance to students in disadvantaged families at risk of poor achievement. 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 (NSLP) received free meals in 2009, 72 percent of participants in the SBP received free meals.[10] 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 primarily utilize two distinct estimation strategies that rely on state mandates regarding schools' participation in the SBP as the identifying source of variation. The first approach is a difference-in-differences (DD) specification in which I compare the achievement outcomes among students above and below the different thresholds in states with differing levels of the threshold. The

[9] Bartfeld et al. (2009) also use 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.
[10] 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.

second approach is a regression discontinuity (RD) design that is based on the state mandated thresholds.

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 participated in the NSLP in 2004 (Food Research and Action Center, 2004). To increase participation, many states mandated that schools must offer the SBP if the percent of FRP students is equal to or greater than 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.

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 regions. States in the western half of the country do not commonly require that all or specific schools participate in the SBP. Appendix Table 1 documents these state mandated thresholds for all states during 2004 that apply to elementary schools. Seven states required all elementary schools to participate in the SBP. Sixteen states required select schools to offer breakfast through the SBP based on the percent of FRP students in the school; students in schools in these states are the primary focus of this analysis. Nearly all of these thresholds vary between 10 and 40 percent, except that Connecticut has a threshold of 80 percent.

a. Difference-in- Differences Estimation

In order to use these state mandates as an identifying source of variation, I initially estimate the regression:

$$Y_{ijs} = \delta_1 P_{js} + \delta_2 Z_{js} + \pi X_{ijs} + \tau_s + \nu_{ijs}, \quad (1)$$

where Y_{ijs} is the achievement outcome for student *i* in school *j* in state *s*. P_{js} denotes a set of dummy variables indicating whether the percent of FRP students in the school is greater than or equal to each of the levels used to define the mandated thresholds such that $P_{js,t} = 1\{FRP_{js} \geq t\}, \forall t \in T$, where $1\{\cdot\}$ is an indicator function and *T* denotes the set of thresholds used by states to determine whether the SBP must be available, $T = \{10,20,25,30,33,35,40,80\}$. τ_s represents a vector of state dummy variables, *X* is a vector of individual and school characteristics, and ν is a stochastic error term.[11] State mandates require that school *j* in state *s* provides breakfast through the SBP if the percent of FRP eligible students, FRP_{js}, is greater than or equal to the state-specific threshold, t_s, such that $Z_{js} = 1\{FRP_{js} \geq t_s\}$. δ_1 represents the relationships between different levels of the percentage of FRP students in the school and student achievement, the state dummy variables capture the influence of the differences in state mandates and other state characteristics, and δ_2, which is the coefficient of interest, represents the influence of a binding state mandate on student achievement. Thus, this specification compares students in schools with similar percentages of FRP students, but with different

[11] Although the continuous measure of the percent of FRP students in the school is included in the vector of individual and school characteristics throughout the paper, the results are robust to excluding the continuous measure.

requirements about whether to participate in the SBP based on the state mandates, and students in schools with different percentages of FRP students but with the same state mandate.

b. Regression Discontinuity Design

Additionally, I supplement the DD empirical strategy and examine the robustness of the assumptions of this approach with a RD design that is based on the state mandated thresholds that require schools to offer the SBP. Although these mandates require certain schools to provide breakfast, many schools will participate in the SBP even 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 $FRP_{js} \geq t_s$; accordingly, I implement a "fuzzy" RD design.

Utilizing this empirical strategy, the impact of the availability of the SBP in the school on a student's cognitive achievement is:

$$\theta = \frac{\alpha}{\beta} = \frac{\lim_{FRP_{js} \downarrow t_s} E\left[Y_{ijs} \mid FRP_{js} = t_s\right] - \lim_{FRP_{js} \uparrow t_s} E\left[Y_{ijs} \mid FRP_{js} = t_s\right]}{\lim_{FRP_{js} \downarrow t_s} E\left[D_{js} \mid FRP_{js} = t_s\right] - \lim_{FRP_{js} \uparrow t_s} E\left[D_{js} \mid FRP_{js} = t_s\right]}, \tag{2}$$

where D_{js} is an indicator variable for whether school j in state s provided breakfast through the SBP, α is the influence of the state mandates on cognitive achievement, β is the influence of the state mandates on the availability of the SBP in schools, and all other variables are defined above. 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). Specifically, to calculate β and α, I estimate the regressions:

$$D_{js} = \lambda_1 + \beta Z_{js} + f_1\left(FRP_{js} - t_s\right) + \varepsilon_{1ijs} \tag{3}$$

$$Y_{ijs} = \lambda_2 + \alpha Z_{js} + f_2\left(FRP_{js} - t_s\right) + \varepsilon_{2ijs}, \tag{4}$$

where $f_1(\cdot)$ and $f_2(\cdot)$ are flexible functions of the difference between the percent of FRP students in the school and the state thresholds. The estimate of θ is $\hat{\theta} = \hat{\alpha} / \hat{\beta}$.

IV. Data

To estimate the impact of the availability of the SBP on achievement, I primarily use two data sources: the National Assessment of Educational Progress (NAEP) and the Early Childhood Longitudinal Study, Kindergarten Cohort of 1998-99 (ECLS-K). The primary advantage of NAEP is the large sample size, and the disadvantage is the lack of information about the availability of the SBP. The advantage of the ECLS-K data is the variety of information including cognitive assessments, the availability of the SBP, the percent of FRP students in each school, and contextual variables to help determine how the SBP might influence achievement; however, the sample size is much smaller than the NAEP data. In order to compare the NAEP estimates to the ECLS-K estimates, I focus on the 2003 4th grade NAEP sample and the 5th grade students in 2004 in the ECLS-K data.

a. National Assessment of Educational Progress

The NAEP is the largest nationally representative assessment of the academic achievement of elementary and secondary school students in the U.S. Since 1969, national and state samples of students were assessed in math, reading, and other subjects periodically for students in grades 4, 8, and 12. Since 2003, students in grades 4 and 8 have been assessed in math and reading at least once every two years. Limited demographic information is available for each student. This analysis utilizes the 2003 combined national and state NAEP sample for 4th grade students for math and reading.

Students do not complete the entire assessment. Instead, students complete blocks of questions for each subject and five plausible values of math and reading achievement are drawn at random from a distribution of Item Response Theory scale scores conditional on student's demographics and responses to specific assessment questions.[12] Individual estimates based on these five plausible values are calculated by estimating regression specifications for each plausible value separately and appropriately combining the estimates.[13]

b. Early Childhood Longitudinal Study, Kindergarten Cohort of 1998-99

The second primary data source is the ECLS-K, which 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.

Direct cognitive assessments are available in each wave for reading and mathematics and in the third and fifth grade waves for science. 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; these measures do not reflect student test scores on state-required exams and, instead, are designed to measure cognitive development.

[12] See Rogers and Stoeckel (2004) for further details about the assessment.

[13] Specifically, the combined point estimate is the average of the individual point estimates. The standard error is equal to the square root of the sum of the average of the squared standard deviations and 1.2 multiplied by the sampling variance of the individual point estimates.

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.[14] If the school administrator did not complete the survey or the response is 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. I also use the modal response of parents in the school in the fifth grade wave as long as the parents' modal 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.[15]

Parents are asked whether the student received a breakfast provided by the school. Unfortunately, the survey does not specifically ask about eating breakfast through the SBP; thus, positive responses from parents could include breakfast consumption through the SBP or competitive foods available in the school, such as vending machines. To reduce measurement error, students are classified as eating breakfast as part of the SBP only if the SBP is available in the school.[16]

c. Determining Whether a State Mandate is Binding

[14] Of the 9,860 students with non-missing values for the parent and school administrator reported variables in the fifth grade wave, the responses disagree for 740 students. One possible reason for this discrepancy is that parents are asked whether the school offers breakfast to the school, while school administrators are asked whether the school participates in the USDA's School Breakfast Program.

[15] 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.

[16] In comparison to administrative records, Jacobson, Briefel, Gleason, and Sullivan (2001) note that parents over-report school breakfast consumption, at least in the Continuing Survey of Food Intakes by Individuals (CSFII).

In the ECLS-K data, 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, and this information is used to determine whether schools are required to offer the SBP based on state mandates.[17] 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), 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 in October for each year since 1999. For the analysis with NAEP data, the percent of FRP students reported in the CCD data is the only source of information used to determine whether schools are required to offer the SBP based on state mandates.

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 and the negative attention from removing previously-provided benefits for low-income students, schools that previously participated in the SBP are unlikely to stop offering breakfast if the percent of FRP students temporarily falls below the threshold.[18] Thus, 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 in the ECLS-K because of the history of data about the percent of FRP students in

[17] 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). Concerns about underreporting of eligibility are mitigated because I focus on the maximum percent of FRP students in the preceding 5 years. Additionally, if the administrators' report of the percent of children eligible for free and reduced-price meals do not fully capture all eligible children but these are the values reported to the state, then these values would be appropriate for the identification strategies in this paper.

[18] Another issue is related to the timing of the mandates. For some states, schools calculate the percent of FRP students in the fall (commonly October 1) 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.

the school and whether the school offers breakfast through the SBP is reported by the school administrator. 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. To allow comparisons between data sets, I focus on the 2003 NAEP wave and compare the maximum percent of FRP students in the school between 1999 and 2003 in the CCD data to the state threshold in 2003. All state thresholds in 2003 are the same as in 2004, with the exception that Vermont instituted a mandate in 2004 that applied to all schools.

d. Descriptive Statistics

I restrict both samples to students in public schools with non-missing values for math and reading achievement. Further, in the ECLS-K sample, I exclude students with missing values for the availability of the SBP in school and science achievement and exclude the ten students in middle school in 2004. I focus the analysis on students in states with a partial mandate and exclude students in states without a mandate or with a mandate that requires all schools to offer the SBP to avoid policy endogeneity related to the adoption of state mandates. These restrictions yield a sample size of 53,430 students in the NAEP math sample, 51,640 students in the NAEP reading sample, and 3,040 students in the ECLS-K sample.[19]

Table 1 describes the characteristics of students and schools in the NAEP and ECLS-K samples. For the math NAEP sample, 35,900 students attend a school that is required to participate in the SBP and 17,520 students attend a school that is not required to participate in the SBP. The average math and reading scores of students in schools that are required to participate in the SBP are lower than the average scores of students in schools that are not required to

[19] To comply with the security requirements related to the use of the restricted-access NAEP and ECLS-K data, all sample sizes throughout the paper are rounded to the nearest 10. Additional descriptive statistics for students in states without a mandate and with a full mandate are shown in Appendix Tables 2 and 3.

participate. However, students in schools required to participate are more disadvantaged according to their family characteristics. By design, the student body in schools required to participate in the SBP is poorer; nearly five times as many students in these schools are eligible for free school meals.

In the ECLS-K sample, 2,560 students attend a school that participates in the SBP and 480 students attend a school that does not participate in the SBP. 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, as also shown in the NAEP data, students in schools that offer breakfast are more disadvantaged according to their family characteristics. 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 eight percent of schools that exceed the state threshold participate in the SBP compared to 45 percent of schools below the threshold.

V. Results

I first present DD and RD results using NAEP data before turning to the analogous results using ECLS-K data. Then, I present results describing the mechanisms through which the availability of the SBP can influence achievement using ECLS-K data.

Table 2 displays the estimates of equation (1) using NAEP data. Since the NAEP data do not contain information about whether the SBP is available in each school, these estimates reflect the reduced-form impact of a binding state mandate as opposed to the impact of the availability of the SBP as a result of a binding state mandate. As shown in the first column for both math and reading, a binding state mandate increases math achievement by 2.2 points, which is 7.7 percent of a standard deviation and 0.9 percent of the mean, and reading achievement by 2.0 points, which is 5.4 percent of a standard deviation and 0.9 percent of the mean. The second column displays the estimates for a restricted sample of students in schools within 20 percentage points of the state thresholds, which would be less influenced by observations in which the state mandates are unlikely to change whether the SBP is available in the school. The estimates are fairly similar to those in the first column; a binding state mandate increases math achievement by 2.6 points or 9.3 percent of a standard deviation and reading achievement by 1.9 points or 5.2 percent of a standard deviation.

Table 3 also displays the estimates using a RD design with NAEP data. These estimates are calculated using a local linear regression with a triangle kernel and a bandwidth of 5, which is the optimal bandwidth derived from Imbens and Kalyanaraman (2009). As shown in Table 3, exceeding the state threshold increases math achievement by 2.6 points or 9.1 percent of a standard deviation and reading achievement by 4.4 points or 12.2 percent of a standard deviation. For math achievement, these results are very similar to the DD estimates, while, for reading achievement, these results are more than double the DD estimates.

The results from the RD design are shown graphically in Figure 2. To reduce the noise in the graphs, students are grouped in bins with a width of two percentage points and the points on the graph represent the average value for each bin. These graphs highlight the discontinuity at the state thresholds in schools participating in the SBP. The downward sloping trend in achievement that is shown throughout most of the range of the x-axis 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.

There are a variety of specification checks that are important to validate the RD design, and the results from these specification checks are reported in the appendix. Estimates of the discontinuity in individual and family characteristics at the state thresholds are shown in Appendix Table 4. There is no statistically significant discontinuity in race, sex, and family background in the fifth grade wave, but students are more likely to live in a suburban area in schools above state thresholds and to attend large schools with a high percent minority. 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 or using a polynomial function as shown in Appendix Table 5.

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 known 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 in Appendix Figure 1, there is no evidence of strategic manipulation of the assignment variable. The state thresholds used to define the SBP mandates are also different than the funding thresholds for the Title I program, which provides federal funding to schools with high percentages of FRP students.[20] Given that the amount of funding to schools through the Title I program is much larger than the funding through the SBP program, any precise manipulation of the percent of FRP students is more likely to occur around the Title I thresholds than the SBP thresholds. Further, the results are robust to excluding schools in Massachusetts from the sample, which is the only state that uses a threshold similar to the severe need threshold that changes the federal reimbursement rate to schools for breakfasts served.

Overall, the estimates using NAEP data suggest that a binding state mandate increases math by 9 percent of a standard deviation and reading achievement by 5 to 12 percent of a standard deviation. However, NAEP data are unable to demonstrate whether exceeding the state mandated threshold influences whether schools provide breakfast through the SBP or why the availability of the SBP might influence achievement. Fortunately, ECLS-K data are helpful for these aspects.

The first row of Table 3 displays the estimates of equation (1) using ECLS-K data for the availability of the SBP and math, reading, and science achievement. Schools where the percent of FRP students exceeds the state threshold, so that the state mandate binds, are 33 percentage points more likely to offer breakfast through the SBP than schools without a binding mandate. This estimate is not sensitive to whether a set of dummy variables for each of the threshold values of the mandates are included instead of state fixed effects and whether covariates are included (results not shown), which supports the experimental nature of the research design. A binding state mandate increases math achievement by 2.0 points, which is 9.6 percent of a standard deviation and 1.8 percent of the mean, reading achievement by 2.7 points, which is 11.9 percent of a standard deviation and 2.0 percent of the mean, and science achievement by 2.2

[20] For examples of regression discontinuity estimates of the impact of Title 1 funding using the FRP thresholds, see van der Klaauw (2008) and Weinstein, Stiefel, Schwartz, and Chalico (2009).

points, which is 15.9 percent of a standard deviation and 3.8 percent of the mean. Although these estimates are not precisely estimated, possibly due to the smaller sample, the estimates are very similar to the DD and RD estimates for math and the RD estimates for reading using NAEP data. After dividing the achievement estimates by 0.329, the results shown in the first row suggest that the availability of the SBP increases math achievement by 29.2 percent of a standard deviation, reading achievement by 36.2 percent of a standard deviation, and science achievement by 48.3 percent of a standard deviation.

Restricting the sample to students in schools within 20 percentage points of the state thresholds reduces the sample by nearly one-third, as shown in the second row of Table 3. Although the estimate for reading achievement is similar for this restricted sample, the estimates for the availability of the SBP, math achievement, and science achievement increase. The estimates for math and science achievement are statistically significant from zero at the 5 percent level and are within the 95 percent confidence intervals of the estimates for the entire sample.

The DD estimates from the restricted sample are fairly similar to the unadjusted differences in means for students in schools within five percentage points of the state thresholds, as shown in the third row of Table 3. Students in schools with a binding state mandate are 40.4 percentage points more likely to attend a school that offers breakfast through the SBP even though the difference in the percent of FRP students in the school is only 6.6 percentage points. These students score 27.1 percent of a standard deviation higher in math, 13.8 percent of a standard deviation higher in reading, and 31.9 percent of a standard deviation higher in science. These differences in means are essentially RD estimates for the sample within 5 percent of the state thresholds in which each observation is weighted equally.

The RD estimates based on local linear regression estimates using a triangle kernel and a bandwidth of 20 are shown in the fourth row of Table 3. Exceeding the state threshold increases the probability that a school participates in the SBP by 46.8 percentage points. There is also a large, positive increase at the state thresholds for math, reading, and science; math achievement increases by 7.6 points, reading achievement increases by 6.6 points, and science achievement increases by 5.5 points. These results are shown graphically in Figures 3 and these graphs highlight the discontinuity at the state thresholds in schools participating in the SBP.[21] These estimates are large in magnitude and larger than the unadjusted differences in means. The magnitude is driven by the skewness of the distribution of achievement near the state thresholds, as shown in Appendix Figure 2 for math achievement, and the large increase in math achievement for the left tail of the distribution. Although the magnitudes are not precisely estimated and the 95 percent confidence intervals would include the DD estimates for the entire sample, these RD estimates provide further evidence of a positive increase in achievement as a result of a binding state mandate.

As an additional assessment of the impact of the availability of the SBP using alternate assumptions, I estimate a difference-in-differences-in-differences (DDD) specification with the entire ECLS-K sample that compares the achievement outcomes among students with and without state mandates, in schools above and below the threshold levels, and in schools that do and do not offer the SBP. Specifically, I estimate the specification:

---

[21] Appendix Tables 6 through 8 display the specification checks for the regression discontinuity design using ECLS-K data. As shown in Appendix Table 6, there is no statistically significant discontinuity in race, sex, and family background in the fifth grade wave or initial achievement upon school entry, with the exception that students are less likely to live in a rural area in schools above state thresholds. 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 increase the estimates as shown in Appendix Table 7, so that the reported results are conservative estimates of the impact of the availability of the SBP. Finally, regression discontinuity estimates do not reveal a statistically significant change in cognitive achievement at false thresholds of 5 and 10 percentage points greater than and less than the true state thresholds, as shown in Appendix Table 8.

$$Y_{ijs} = \gamma_1 P_{js} + \gamma_2 Z_{js} + \gamma_3 D_{js} + \gamma_4 P_{js} \times D_{js} + \gamma_5 \phi_s \times D_{js} + \gamma_6 Z_{js} \times D_{js} + \rho X_{ijs} + \phi_s + \upsilon_{ijs}, \qquad (5)$$

where the variables are defined as above. γ_6 is the coefficient of interest. Estimates of equation (5) for reading, math, and science achievement are shown in the fifth row of Table 3. The availability of the SBP as the result of a binding state mandate increases math achievement by 5.2 points or 23.7 percent of the standard deviation of math achievement for all students in the ECLS-K, reading achievement by 3.4 points or 14.2 percent of a standard deviation, and science achievement by 1.2 points or 8.3 percent of a standard deviation; however, the estimates for reading and science are not statistically significant. In comparison to the DD estimates scaled by the impact on offering breakfast through the SBP, these magnitudes are uniformly smaller, although the magnitude of the estimate for math is similar (23.7 percent to 29.2 percent).

Overall, the body of evidence across multiple data sets and different estimation strategies suggests that a binding state mandate increases the availability of the SBP, which, in turn, increases achievement. Schools in which the percent of FRP students exceeds the state threshold are at least 33 percentage points more likely to offer breakfast through the SBP. The results for math achievement are the most consistent, with a binding state mandate increasing math achievement by at least 9 percent of a standard deviation. A binding state mandate generally increases reading achievement by at least 5 percent of a standard deviation, and the results for science achievement are less robust, but consistently positive. These positive results stand in stark contrast to the differences in means shown in Tables 1 and highlight the significant selection on unobservable characteristics associated with the availability of the SBP that is consistent with previous literature.

With the ECLS-K data, it is possible to implement a variety of falsification tests by examining the relationship between a binding state mandate and outcomes that should not be affected by the availability of the SBP. As shown in Table 4, a binding state mandate is not related to math or reading achievement upon school entry in the fall of kindergarten, whether the school receives Title I funding, the years of experience of the principal, and the frequency of vigorous exercise. Although not shown in the table, RD and DDD estimates for these outcomes are also not statistically significant. Thus, the increase in the availability of the SBP in response to a binding state mandate does not reflect pre-existing trends in achievement, other funding received by the school, the characteristics of the school administration, or other health-related characteristics of the student body.

A further benefit of the ECLS-K data is the ability to examine the mechanisms through which the availability of the SBP could influence achievement. Consistent with the potential mechanisms identified in section II, I examine the impact of a binding state mandate, and thus the availability of the SBP, on food consumption, non-cognitive skills, and attendance. As shown in Table 5, a binding state mandate increases the probability that a student eats breakfast in school by 5.6 percentage points, which implies that the availability of the SBP increases breakfast consumption at school by 17 percentage points, but this increase is not statistically significant. The impact on the total days per week that a student eats breakfast, which includes breakfast consumed at home, is small in magnitude and not statistically significant. However, consistent with the results of Bhattacharya, Currie, and Haider (2006), the availability of the SBP influences what a student eats for breakfast even though it does not change whether a student eats breakfast. As shown in panels A and B, a binding state mandate increases milk consumption by 2.7 servings per week, or 26 percent of the mean, and fruit consumption by 1.2 servings per week, or 16 percent of the mean, and decreases soda consumption by 0.8 servings per week, or 13 percent of the mean. Although the nutrition data in the ECLS-K are limited in that they are self-reported and do not measure nutrients, nevertheless, the results suggest that the availability of the SBP improves nutrition. The results in this table also suggest that the availability of the SBP does not influence achievement due to changes in non-cognitive skills or school attendance. Overall, these results suggest that the availability of the SBP improves nutrition and that the improvement in nutrition contributes to the increase in achievement.

VI. Conclusion

Despite that one of the motivating factors for the establishment of the School Breakfast Program was to improve cognitive outcomes for students by improving nutrition, there are few previous studies that have examined whether the SBP improves cognitive achievement. This paper adds to the literature by estimating the impact of the availability of the SBP in schools on cognitive achievement. Using multiple data sources and different identification strategies, I find that state mandates that require schools to provide breakfast through the SBP substantially increase the availability of the SBP in schools and, in turn, improve math achievement by at least 9 percent of a standard deviation and reading achievement by at least 5 percent of a standard deviation. Achievement upon school entry, whether the school receives Title I funding, the experience of the principal, and health-related behaviors of the student body are not related to whether schools are required to provide breakfast through the SBP, which supports the conclusion that the results estimate the effect of the availability of the SBP. Investigating the mechanisms through which the availability of the SBP influences achievement, I find that a binding state mandate increases the consumption of nutritious foods, decreases the consumption of unhealthy beverages, and does not influence attendance or non-cognitive skills. Overall, the results suggest that state mandates have been effective in increasing the availability of the SBP in schools and that these mandates increase student achievement by improving nutrition.

In addition to providing evidence on the impact of state mandates and the availability of the SBP, this paper contributes to the understanding of the influence of childhood health and nutrition on cognitive achievement, which is an important determinant of human capital. Further, these results suggest that food assistance programs and nutrition interventions can influence cognitive achievement, not just in developing countries, but also in higher income countries, such as the U.S.

References

Alaimo, Katherine, Christine M. Olson, Edward A. Frongillo Jr, and Ronette R. Briefel (2001) "Food Insufficiency, Family Income, and Health in US Preschool and School-Aged Children," *American Journal of Public Health*, 91(5), 781-786.

Alderman, Harold, John Hoddinott, and Bill Kinsey (2006) "Long Term Consequences of Early Childhood Malnutrition," *Oxford Economic Papers*, 58, 450-474.

Ask, Anne S., Sigrunn Hernes, Ingebjorg Aarek, Gaute Johannessen, and Margaretha Haugen (2006) "Changes in Dietary Pattern in 15 Year Old Adolescents Following a 4 Month Dietary Intervention with School Breakfast – A Pilot Study," *Nutrition Journal*, 5(33), 1-6.

Barrett, David E., Marian Radke-Yarrow, Robert E. Klein (1982) "Chronic Malnutrition and Child Behavior: Effects of Early Caloric Supplementation on Social and Emotional Functioning at School Age," *Developmental Psychology*, 18(4), 541-556.

Bartfeld, Judi, Myoung Kim, Jeong Hee Ryu, and Hong-Min Ahn (2009) "The School Breakfast Program: Participation and Impacts," United States Department of Agriculture Contractor and Cooperator Report No. 54.

Bellisle, France (2004) "Effects of Diet on Behavior and Cognition in Children," *British Journal of Nutrition* 92(Suppl. 2): S227-S232.

Belot, Michele and Jonathan James (2011) "Healthy School Meals and Educational Outcomes," *Journal of Health Economics*, 30(3), 489-504.

Bernstein, L.S., J.E. McLaughlin, M.K. Crepinsek, and L.M. Daft (2004) *Evaluation of the School Breakfast Program Pilot Project: Final Report*, Nutrition Assistance Program Report Series, Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition, and Evaluation.

Bhattacharya, Jayanta, Janet Currie, and Steven J. Haider (2006) "Breakfast of Champions? The School Breakfast Program and the Nutrition of Children and Families," *Journal of Human Resources*, 41(3), 445-466.

Carrell, Scott E. and Mark L. Hoekstra (2010) "Externalities in the Classroom: How Children Exposed to Domestic Violence Affect Everyone's Kids," *American Economic Journal: Applied Economics*, 2(1), 211-228.

Carrell, Scott E., Teny Maghakian, and James E. West (2011) "A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents," *American Economic Journal: Economic Policy*, 3(3), 62-81.

Chenoweth, Wanda L. (2007) "Vitamin B Complex Deficiency and Excess," in Robert M. Kliegman, Hal B. Jenson, Richard Behrman, and Bonita F. Stanton (eds.) Nelson Textbook of Pediatrics, 18th edition, Philadelphia: Saunders.

Currie, Janet (2005) "Health Disparities and Gaps in School Readiness," *Future of Children*, 15(1), 117-138.

Dahl, Gordon B. and Lance Lochner (2012) "The Impact of Family Income on Child Achievement: Evidence from the Earned Income Tax Credit," *American Economic Review*, 102(5), 1927-1956.

Dahl, Molly W. and John Karl Scholz (2011) "The National School Lunch Program and School Breakfast Program: Evidence on Participation and Noncompliance," working paper.

Dunifon, Rachel E. and Lori Kowaleski-Jones (2004) “Exploring the Influence of the National School Lunch Program on Children” Institute for Research on Poverty Discussion Paper 1277-04.
Federal Interagency Forum on Child and Family Statistics (2007) *America’s Children: Key National Indicators of Well-Being, 2007*, Washington, DC: U.S. Government Printing Office.
Fernstrom, John D. (2000) “Can Nutrient Supplements Modify Brain Function?” *American Journal of Clinical Nutrition*, 71(suppl), 1669S-1673S.
Figlio, David N. and Joshua Winicki (2005) “Food for Thought: The Effects of School Accountability Plans on School Nutrition,” *Journal of Public Economics* 89:381-394.
Food Research and Action Center (2004) *School Breakfast Scorecard 2004*, Washington, DC: Food Research and Action Center.
Fox, Mary Kay, William Hamilton, and Biing-Hwan Lin, eds. (2004) *Effects of Food Assistance and Nutrition Programs on Nutrition and Health: Volume 3, Literature Review*, Food Assistance and Nutrition Research Report No. 19-3, Washington, DC: U.S. Department of Agriculture.
Gibson, E. Leigh and Michael W. Green (2002) “Nutritional Influences on Cognitive Function: Mechanisms of Susceptibility,” *Nutrition Research Reviews*, 15, 169-206.
Glewwe, Paul, Hanan G. Jacoby, and Elizabeth M. King (2001) “Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis,” *Journal of Public Economics*, 81, 345-368.
Greenbaum, Larry A. (2007a) “Vitamin E Deficiency,” in Robert M. Kliegman, Hal B. Jenson, Richard Behrman, and Bonita F. Stanton (eds.) Nelson Textbook of Pediatrics, 18th edition, Philadelphia: Saunders.
Greenbaum, Larry A. (2007b) “Micronutrient Mineral Deficiencies,” in Robert M. Kliegman, Hal B. Jenson, Richard Behrman, and Bonita F. Stanton (eds.) Nelson Textbook of Pediatrics, 18th edition, Philadelphia: Saunders.
Hahn, Jinyong, Petra Todd, and Wilbert Van der Klaauw (2001) “Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design,” *Econometrica*, 69(1), 201-209.
Heckman, James J., Jora Stixrud, Sergio Urzua (2006) “The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior,” *Journal of Labor Economics*, 24(3), 411-482.
Hinrichs, Peter (2010) “The Effects of the National School Lunch Program on Education and Health,” *Journal of Policy Analysis and Management*, 29(3), 479-505.
Hinrichs, Peter (2011) “When the Bell Tolls: The Effects of School Starting Times on Academic Achievement,” *Education Finance and Policy*, 6(4), 486-507.
Imberman, Scott A. and Adriana D. Kugler (2012) “The Effect of Providing Breakfast on Student Performance: Evidence from an In-Class Breakfast Program,” National Bureau of Economic Research working paper 17720.
Imberman, Scott A., Adriana D. Kugler, and Bruce I. Sacerdote (2012) “Katrina’s Children: Evidence on the Structure of Peer Effects from Hurricane Evacuees,” *American Economic Review*, 102(5), 2048-2082.
Kennedy, Eileen and Carole Davis (1998) “US Department of Agriculture School Breakfast Program,” *American Journal of Clinical Nutrition*, 67(suppl.), 798S-803S.

Kleinman, RE, JM Murphy, M Little, M Pagano, CA Wehler, K Regal, and MS Jellinek (1998) "Hunger in Children in the United States: Potential Behavioral and Emotional Correlates," *Pediatrics*, 101(1), e3.

Kleinman, R.E., S. Hall, H. Green, D. Korzec-Ramirez, K. Patton, M.E. Pagano, and J.M. Murphy (2002) "Diet, Breakfast, and Academic Performance in Children," *Annals of Nutrition and Metabolism* 46(suppl 1): 24-30.

Lieberman, Harris R. (2003) "Nutrition, Brain Function, and Cognitive Performance," *Appetite* 40: 245-254.

Mahoney, Caroline R., Holly A. Taylor, Robin B. Kanarek, and Priscilla Samuel (2005) "Effect of Breakfast Composition on Cognitive Processes in Elementary School Children," *Physiology & Behavior*, 85, 635-645.

Maluccio, John A., John Hoddinott, Jere R. Behrman, Reynaldo Martorell, Agnes R. Quisumbing, and Aryeh D. Stein (2006) "The Impact of an Experimental Nutritional Intervention in Childhood on Education among Guatemalan Adults," International Food Policy Research Institute, Food Consumption and Nutrition Division Discussion Paper 207.

McEwan, Patrick J. (2010) "The Impact of School Meals on Education Outcomes: Discontinuity Evidence from Chile," working paper.

Millimet, Daniel L., Rusty Tchernis, and Muna Husain. 2010. "School Nutrition Programs and the Incidence of Childhood Obesity." *Journal of Human Resources* 45(3): 640-654.

Murphy, J. Michael, Maria E. Pagano, Joan Nachmani, Peter Sperling, Shirley Kane, and Ronald E. Kleinman (1998) "The Relationship of School Breakfast to Psychosocial and Academic Functioning," *Archives of Pediatrics and Adolescent Medicine*, 152, 899-907.

Meyers, Alan F., Amy E. Sampson, Michael Weitzman, Beatrice L. Rogers, and Herb Kayne (1989) "School Breakfast Program and School Performance," *AJDC*, 143, 1234-1239.

Pollack, J.M., S. Atkins-Burnett, M. Najarian, and D.A. Rock (2005) *Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), Psychometric Report for the Fifth Grade* (NCES 2006-036), Washington, DC: National Center for Education Statistics.

Pollitt, Ernesto (1993) "Iron Deficiency and Cognitive Function," *Annual Review of Nutrition*, 13, 521-537.

Pollitt, Ernesto, Kathleen S. Gorman, Patrice L. Engle, Juan A. Rivera, and Reynaldo Martorell (1995) "Nutrition in Early Life and the Fulfillment of Intellectual Potential," *Journal of Nutrition*, 125(4), 1111S-1118S.

Pollitt, Ernesto and Rebecca Mathews (1998) "Breakfast and Cognition: An Integrative Summary," *American Journal of Clinical Nutrition*, 67(suppl), 804S-813S.

Rogers, A.M and J.J. Stoeckel (2004) *NAEP 2003 Mathematics and Reading Secondary-Use Data Files Data Companion*, Washington, DC: National Center for Education Statistics.

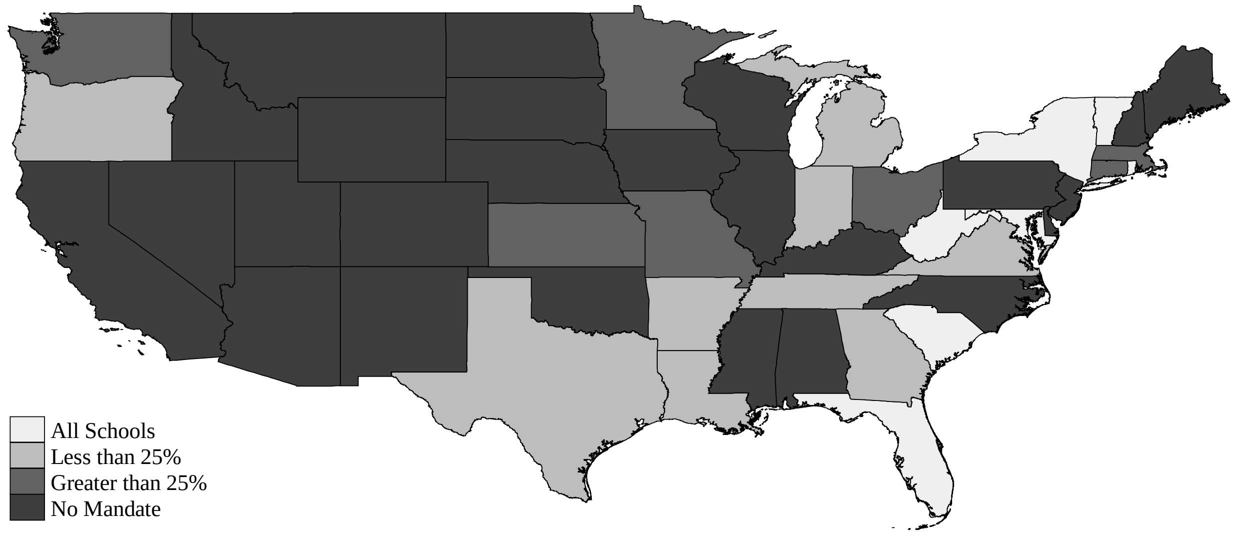
Sacerdote, Bruce (2011) "Peer Effects in Education: How Might They Work, How Big Are They and How Much Do We Know Thus Far?" in Eric A. Hanushek, Stephen Machin, and Ludger Woessmann (eds.) *Handbook of the Economics of Education*, Volume 3, Amsterdam: Elsevier B.V., 249-277.

Schanzenbach, Diane Whitmore. 2009. "Do School Lunches Contribute to Childhood Obesity?" *Journal of Human Resources* 44(3):684-709.

United States Department of Agriculture (2010) *The School Breakfast Program Fact Sheet*, http://www.fns.usda.gov/cnd/Breakfast/AboutBFast/SBPFactSheet.pdf

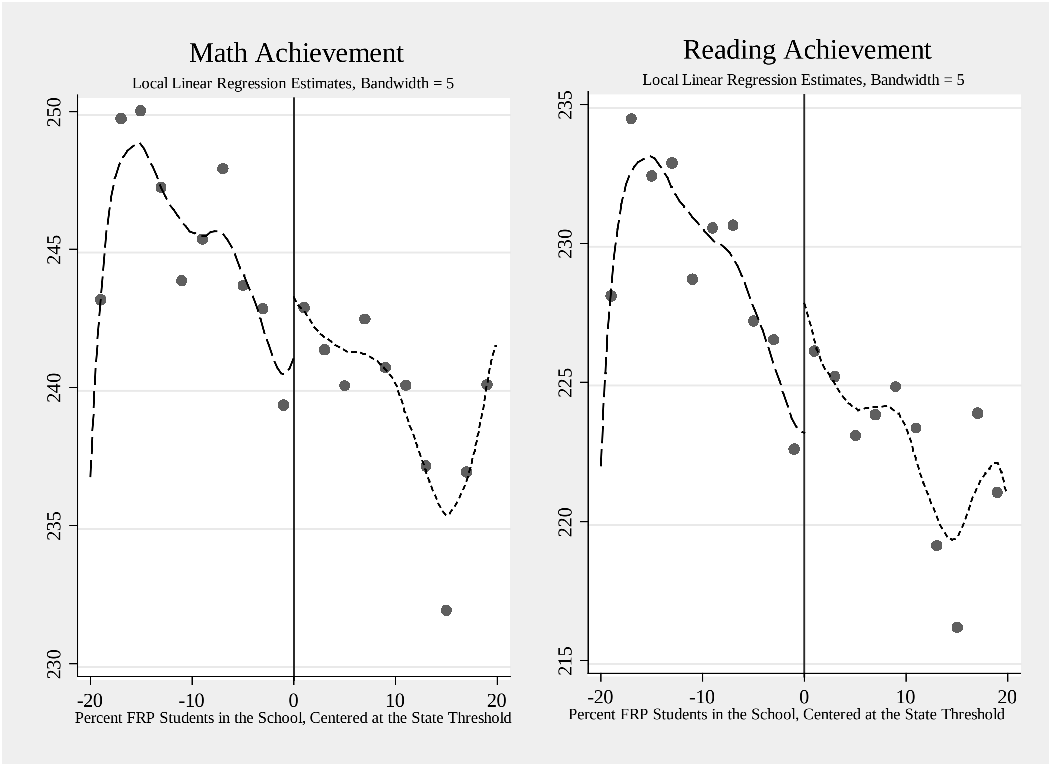
van der Klaauw, Wilbert (2008) "Breaking the Link between Poverty and Low Student Achievement: An Evaluation of Title I," Journal of Econometrics, 142, 731-756.
Victora, Cesar G., Caroline Fall, Pedro C. Hallal, Reynaldo Martorell, Linda Richter, Harshpal Singh Sachdev, for the Maternal and Child Undernutrion Study Group (2008) "Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital," *Lancet*, 371, 340-357.
Weinstein, Meryle G., Leanna Stiefel, Amy Ellen Schwartz, and Luis Chalico (2009) "Does Title I Increase Spending and Improve Performance? Evidence from New York City," New York University working paper #09-09.
Winicki, Joshua and Kyle Jemison (2003) "Food Insecurity and Hunger in the Kindergarten Classroom: Its Effect on Learning and Growth," *Contemporary Economic Policy*, 21(2), 145-157.

Figure 1: State Mandated Thresholds



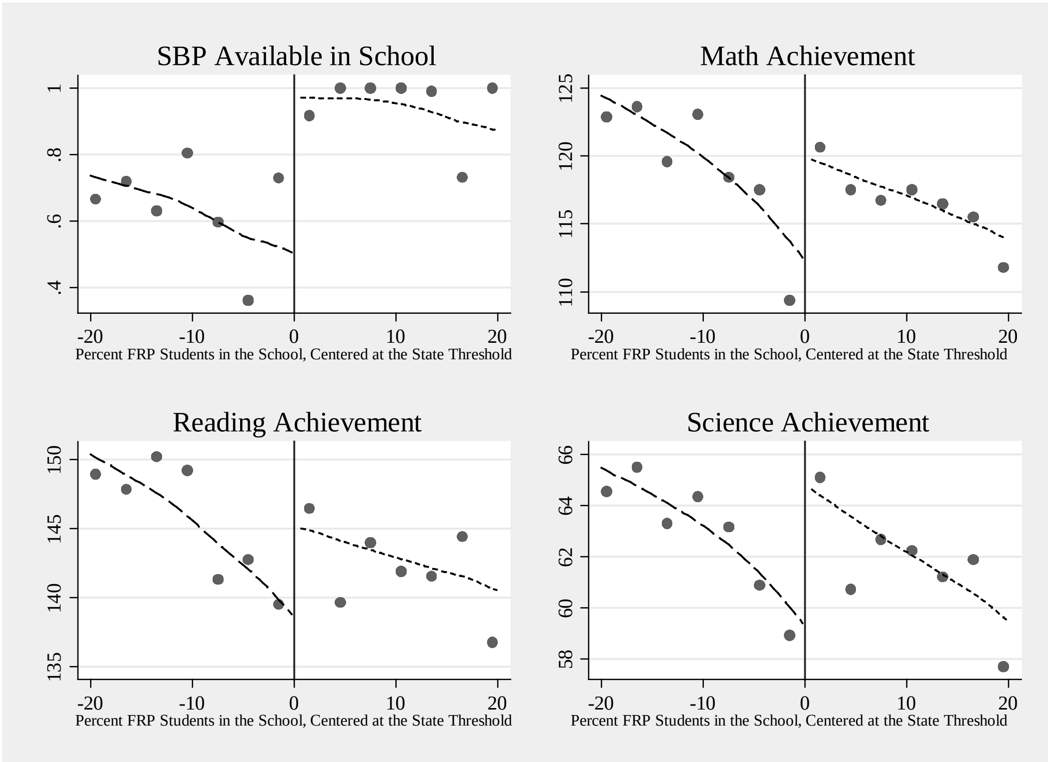
Notes: If the percent of free and reduced-price eligible students in the school exceeds the state mandated threshold, then the school is required to provide breakfast through the School Breakfast Program. These thresholds are based on state laws in 2004.
Source: See Appendix Table 1.

Figure 2: Math and Reading Scores by the Percent of Free and Reduced-Price Eligible Students in the School, NAEP data



Notes: The points on the graph represent averages for students grouped in bins with a width of two percentage points. These graphs are estimates for the first plausible value for math and reading. The dashed lines are the estimates from local linear regressions with a triangle kernel and a bandwidth of 5.
Source: National Assessment of Education Progress (NAEP) 2003 Grade 4

Figure 3: Participation of Schools in the School Breakfast Program, Math Achievement, Reading Achievement, and Science Achievement by the Percent of Free and Reduced-Price Eligible Students in the School, ECLS-K Data



Notes: The points on the graph represent averages for students grouped in bins with a width of three percentage points. The dashed lines are the estimates from local linear regressions with a triangle kernel and a bandwidth of 20.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 1: Means (and Standard Deviations)

	NAEP			ECSL-K				
	All	In Schools with Pct. FRP Above Threshold	In Schools with Pct. FRP Below Threshold	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
Math Score	234.628	228.464	247.258	114.196	112.688	122.233	111.324	122.231
	(28.166)	(27.425)	(25.305)	(20.846)	(20.941)	(18.363)	(21.086)	(17.865)
Reading Score	217.427	209.801	232.464	138.390	136.716	147.311	135.172	147.391
	(36.770)	(36.292)	(32.866)	(23.131)	(23.438)	(19.108)	(23.300)	(20.090)
Science Score	--	--	--	58.370	57.254	64.315	56.403	63.872
				(14.075)	(14.132)	(12.157)	(14.110)	(12.428)
School Offers SBP	--	--	--	0.842	1.000	0.000	0.979	0.459
				(0.365)	(0.000)	(0.000)	(0.143)	(0.499)
Distance to Threshold	19.440	39.848	-22.378	23.562	32.452	-23.814	39.796	-21.853
	(37.199)	(24.309)	(20.154)	(36.559)	(31.158)	(24.905)	(26.382)	(18.118)
Above Threshold	0.672	1.000	0.000	0.737	0.857	0.098	1.000	0.000
	(0.469)	(0.000)	(0.000)	(0.441)	(0.351)	(0.298)	(0.000)	(0.000)
Percent FRP eligible	49.248	65.448	16.051	50.103	56.864	14.071	63.083	13.790
	(30.822)	(23.192)	(12.437)	(30.158)	(27.404)	(14.578)	(23.813)	(8.782)
Age (months)	121.273	121.853	120.085	135.258	135.386	134.577	135.363	134.966
	(6.099)	(6.486)	(5.011)	(4.572)	(4.610)	(4.305)	(4.624)	(4.413)
Female	0.491	0.492	0.489	0.492	0.499	0.458	0.496	0.483
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.499)	(0.500)	(0.500)
Black	0.243	0.326	0.070	0.140	0.161	0.033	0.183	0.020
	(0.428)	(0.469)	(0.255)	(0.347)	(0.367)	(0.180)	(0.387)	(0.140)
Hispanic	0.116	0.152	0.043	0.154	0.173	0.048	0.188	0.057
	(0.320)	(0.359)	(0.201)	(0.360)	(0.378)	(0.214)	(0.391)	(0.231)
Other Race/Ethnicity	0.039	0.038	0.042	0.086	0.085	0.090	0.079	0.105
	(0.194)	(0.191)	(0.201)	(0.280)	(0.279)	(0.286)	(0.270)	(0.307)
White	0.602	0.483	0.845	0.620	0.581	0.830	0.549	0.817
	(0.489)	(0.499)	(0.361)	(0.485)	(0.493)	(0.377)	(0.498)	(0.386)
Eligible for Free School Meals	0.390	0.523	0.118	--	--	--	--	--
	(0.482)	(0.495)	(0.310)					
Eligible for Reduced-Price School Meals	0.078	0.092	0.049	--	--	--	--	--
	(0.263)	(0.285)	(0.208)					
Family Income (000s)	--	--	--	61.997	54.247	103.299	48.812	98.881
				(51.766)	(45.082)	(64.116)	(40.473)	(61.240)
Poverty	--	--	--	0.207	0.237	0.046	0.267	0.038
				(0.389)	(0.409)	(0.197)	(0.425)	(0.178)
Family Size	--	--	--	4.549	4.554	4.523	4.555	4.531
				(1.265)	(1.300)	(1.060)	(1.317)	(1.110)
Parents' Highest Education	--	--	--	14.189	13.882	15.824	13.644	15.714
				(2.562)	(2.482)	(2.354)	(2.434)	(2.280)
Birth Weight	--	--	--	118.425	117.772	121.904	117.209	121.827
				(18.261)	(18.054)	(18.972)	(18.162)	(18.119)
Grade	4.000	4.000	4.000	4.875	4.862	4.946	4.853	4.938
	(0.000)	(0.000)	(0.000)	(0.345)	(0.362)	(0.227)	(0.373)	(0.242)
Urban Residence	0.344	0.450	0.127	0.348	0.387	0.141	0.419	0.150
	(0.475)	(0.498)	(0.333)	(0.467)	(0.478)	(0.334)	(0.483)	(0.346)
Rural Residence	0.318	0.329	0.296	0.222	0.231	0.172	0.234	0.187

	(0.466)	(0.470)	(0.456)	(0.406)	(0.413)	(0.365)	(0.414)	(0.381)
Percent Minority	37.59	49.23	13.74	--	--	--	--	--
	(35.61)	(36.62)	(16.50)					
School with ≥ 80 Pct. Minority	--	--	--	0.204	0.240	0.017	0.276	0.004
				(0.403)	(0.427)	(0.128)	(0.447)	(0.061)
School Size	510.20	503.22	524.50	--	--	--	--	--
	(188.32)	(188.82)	(186.47)					
School with ≥ 750 Students	--	--	--	0.142	0.157	0.065	0.146	0.133
				(0.349)	(0.364)	(0.246)	(0.353)	(0.339)
School with < 300 Students	--	--	--	0.115	0.118	0.096	0.131	0.068
				(0.319)	(0.323)	(0.295)	(0.338)	(0.251)
Eat School Breakfast	--	--	--	0.335	0.407	0.000	0.438	0.066
				(0.472)	(0.491)	(0.000)	(0.496)	(0.249)
Observations (math sample)	53430	35900	17520					
Observations (reading sample)	51640	34260	17380					
Observations				3040	2560	480	2240	800

Notes: Standard deviations in parentheses. Sample sizes rounded to the nearest 10 to comply with nondisclosure requirements. The means and standard deviations for all NAEP variables except the reading score are based on the math sample.
Source: National Assessment of Education Progress (NAEP) 2003 Grade 4; Early Childhood Longitudinal Study, Kindergarten Cohort 5th grade wave in 2004

Table 2: Estimates of the Influence of a Binding State Mandate on Math and Reading Achievement, NAEP Data

	Math			Reading		
	Difference-in-Differences		Regression Discontinuity	Difference-in-Differences		Regression Discontinuity
Above State Threshold	2.174	2.622	2.554	2.001	1.927	4.413
	(0.902)	(1.137)	(1.370)	(1.124)	(1.432)	(1.813)
	[0.077]	[0.093]	[0.091]	[0.054]	[0.052]	[0.122]
Observations	53430	20110	20110	51640	19690	19690
Sample	All	Within 20%	Within 20%	All	Within 20%	Within 20%

Notes: Standard errors are shown in parentheses. For the difference-in-differences specifications, standard errors are robust to heteroskedasticity and allow for clustering within states. The figures in brackets represent the marginal effect expressed in units of a standard deviation, where the estimate is divided by the standard deviation of the achievement score for all students in states with partial mandates. The estimates shown represent the combined estimates of the five plausible values for each achievement score. The variable denoting that the school is above the state threshold is defined as 1 if the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold mandating the availability of the SBP and 0 if the percent of FRP students in the school is below the state threshold. For the difference-in-differences specifications, additional variables include state fixed effects, dummy variables denoting whether the percent of FRP students in the school exceeds each of the levels used to define the state mandates (10, 20, 25, 30, 33, 35, 40, and 80 percent), age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), poverty status, urban/rural, the percent of the student body who are nonwhite, the number of students in the school, and a continuous measure of the percent of FRP students in the school. The regression discontinuity estimates are calculated using local linear regression with a triangle kernel and a bandwidth of 5. Sample sizes rounded to the nearest 10.
Source: NAEP 2003 Grade 4

Table 3: Estimates of the Influence of a Binding State Mandate on Math and Reading Achievement, ECLS-K Data

	School Offers SBP	Math	Reading	Science	Observations
Difference-in-Differences (DD)	0.329	2.003	2.749	2.238	3040
	(0.141)	(1.739)	(1.923)	(1.328)	
		[0.096]	[0.119]	[0.159]	
DD, Sample within 20%	0.446	5.140	2.688	5.017	1180
	(0.147)	(2.589)	(2.182)	(1.522)	
		[0.247]	[0.116]	[0.356]	
Difference in Means	0.404	5.653	3.199	4.482	240
	(0.050)	(2.544)	(2.876)	(1.648)	
		[0.271]	[0.138]	[0.319]	
Regression Discontinuity (RD)	0.468	7.647	6.599	5.538	1180
	(0.050)	(3.037)	(3.741)	(1.756)	
		[0.367]	[0.285]	[0.393]	
Diff-in-Diff-in-Diff (DDD)		5.186	3.352	1.206	8830
		(2.246)	(2.249)	(1.618)	
		[0.237]	[0.142]	[0.083]	

Notes: For the DD and DDD estimates, heteroskedasticity-robust standard errors that allow for clustering within states are shown in parentheses. For the RD estimates, heteroskedasticity-robust standard errors are shown in parentheses. For the differences in means, standard errors are shown in parentheses. The figures in brackets represent the marginal effect expressed in units of a standard deviation, where the estimate is divided by the standard deviation of the achievement score for all students in states with partial mandates. The DD and RD estimates corresponds to the coefficients of the variable denoting that the school is above the state threshold, which is defined as 1 if the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold mandating the availability of the SBP and 0 if the percent of FRP students in the school is below the state threshold or if the state does not have a mandate. The DDD estimates corresponds to the coefficients of the variable denoting that the school is above the state threshold multiplied by whether the SBP is provided in the school. Additional variables for the DD and DDD include state fixed effects, dummy variables denoting whether the percent of FRP students in the school exceeds each of the levels used to define the state mandates (10, 20, 25, 30, 33, 35, 40, and 80 percent), age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, parent's education, birth weight, grade, urban/rural, poverty status, the percent of the student body who are nonwhite, the number of students in the school, and the percent of FRP students in the school. The RD estimates are calculated using local linear regression with a triangle kernel and a bandwidth of 20. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 4: Falsification Tests, ECLS-K Data

	Fall Kindergarten Math	Fall Kindergarten Reading	School Receives Title I Funding	Years of Experience of Principal	Days per Week of Vigorous Exercise
Above State Threshold	0.211	-0.033	-0.149	-0.301	-0.005
	(0.575)	(0.808)	(0.216)	(1.647)	(0.281)
Observations	2710	2580	2920	2900	2760

Notes: Heteroskedasticity-robust standard errors that allow for clustering within states in parentheses. The variable denoting that the school is above the state threshold is defined as 1 if the percent of free and reduced-price eligible (FRP) students in the school exceeds the state threshold mandating the availability of the SBP and 0 if the percent of FRP students in the school is below the state threshold or if the state does not have a mandate. Additional variables include state fixed effects, dummy variables denoting whether the percent of FRP students in the school exceeds each of the levels used to define the state mandates (10, 20, 25, 30, 33, 35, 40, and 80 percent), age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, parent's education, birth weight, grade, urban/rural, poverty status, the percent of the student body who are nonwhite, the number of students in the school, and the percent of FRP students in the school. Sample sizes rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Table 5: Difference-in-Differences Estimates of the Mechanisms through which the Availability of the School Breakfast Program Influences Student Achievement

Panel A: Breakfast and Food Consumption

Eats Breakfast at School	Days Eating Breakfast	Servings of Milk	Servings of Juice	Servings of Soda
0.056	-0.019	2.719	1.051	-0.83
(0.045)	(0.130)	(1.206)	(0.795)	(0.468)
2730	2740	3040	3040	3040

Panel B: Additional Food Consumption

Servings of Fruit	Servings of Salad	Servings of Potatoes	Servings of Carrots	Servings of Other Vegetables
1.159	-0.139	0.042	0.539	-0.334
(0.563)	(0.358)	(0.247)	(0.395)	(0.732)
3040	3040	3040	3040	3040

Panel C: Non-Cognitive Skills

Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problem Behaviors	Internalizing Problem Behaviors
-0.042	-0.027	-0.005	-0.037	-0.057
(0.035)	(0.047)	(0.045)	(0.042)	(0.058)
2940	2910	2870	2930	2900

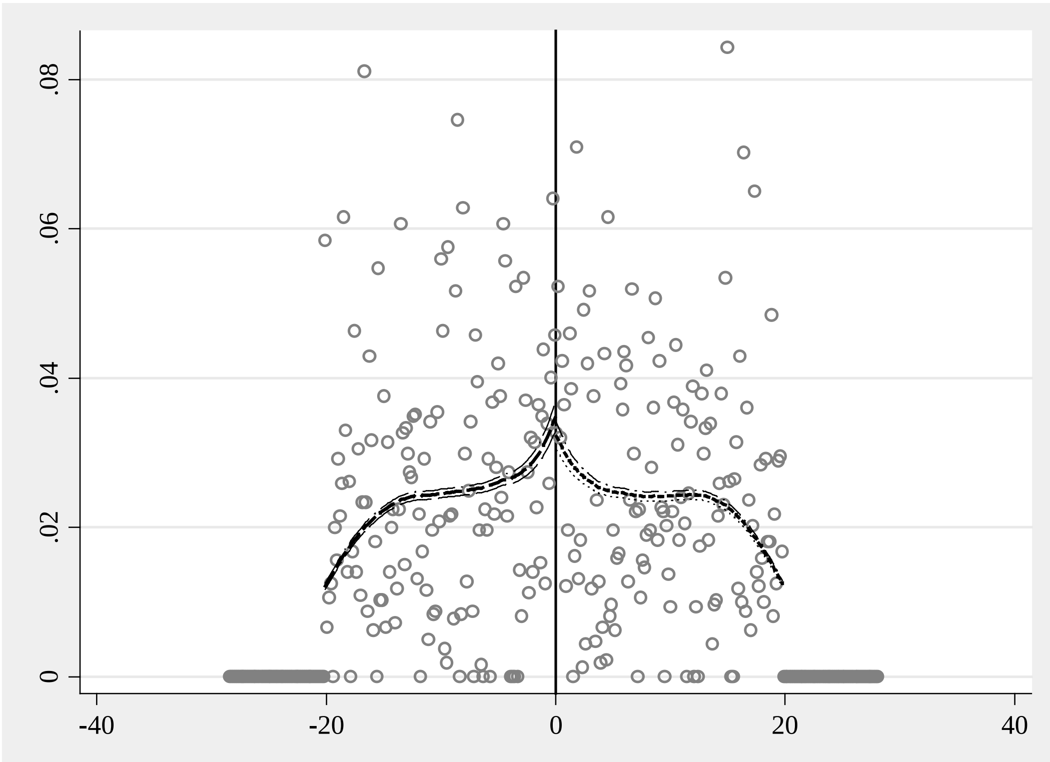
Panel D: Attendance

% Excused Absences	% Unexcused Absences	% Excused Tardies	% Unexcused Tardies
0.210	-0.097	0.333	-0.430
(0.414)	(0.374)	(0.201)	(0.289)
2470	2470	2310	2310

Notes: See Table 4.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

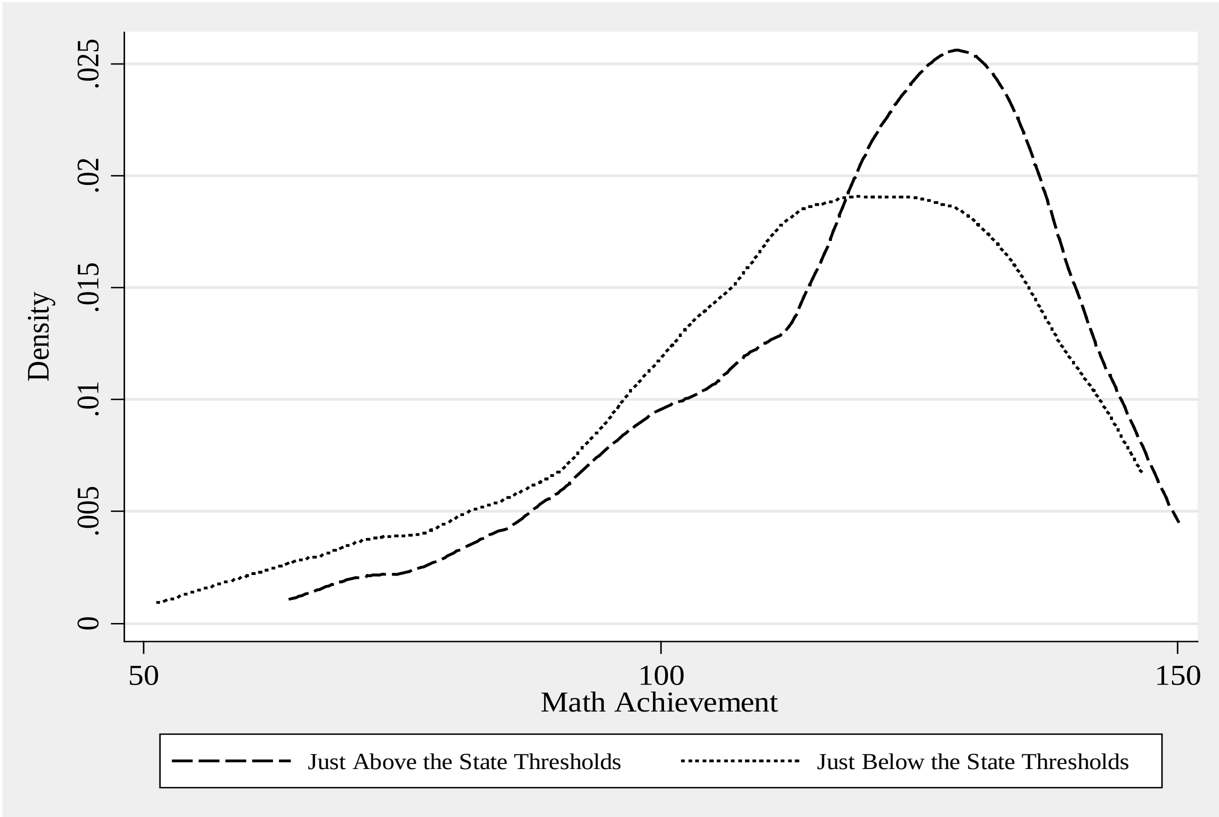
Appendix

Appendix Figure 1: Density of the Percent of FRP Students Centered at the State Threshold, NAEP Data



Notes: This figure demonstrates the lack of a discontinuity in the density of the percent of FRP students at the state thresholds requiring participation in the SBP program, which is consistent with a lack of selective sorting around the thresholds
Sources: The data source is National Assessment of Education Progress (NAEP) 2003 Grade 4. The source for the code to generate the figure is McCrary (2008).

Appendix Figure 2: The Distribution of Mathematics Achievement within Five Percent of the State Thresholds, ECLS- Data



Notes: This figure shows the skewness of the distributions of math achievement among students in schools within five percent below and above the state thresholds, as well as the shift in achievement throughout the distribution and the left tail in particular.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Appendix Table 1: State Mandated Thresholds in 2004 of the Percent of Free and Reduced Price Eligible Students above Which States Must Provide School Breakfast for Elementary School Students

State	Mandate Threshold	Notes
Alabama	.	
Alaska	.	
Arizona	.	
Arkansas	0.20	Schools may apply for a one-year waiver from the mandate if implementing a breakfast program will create a financial hardship due to lack of equipment or facilities. ARK. CODE ANN. § 6-18-705.
California	.	Requires schools to provide at least one meal to FRP students but does not specify whether breakfast must be offered, so that schools may opt to provide lunch only. CAL. EDUC. CODE § 49558.
Colorado	.	
Connecticut	0.80	CONN. GEN. STAT. ANN. § 10-266w.
Delaware	.	
District of Columbia	.	
Florida	0	FLA. STAT. § 1006.06.
Georgia	0.25	GA. CODE ANN. § 20-2-66.
Hawaii	.	
Idaho	.	
Illinois	.	
Indiana	0.25	IND. CODE ANN. § 20-5-13.5-4
Iowa	.	
Kansas	0.35	Schools with less than 35 percent FRP students may apply for a waiver requesting to not participate in the SBP program. The state determines the threshold from the percent of FRP students in March of the preceding year. KAN. STAT. ANN. § 72-5125
Kentucky	.	
Louisiana	0.25	A school may receive a waiver if at least 50 percent of FRP students in the school refuse to participate. LA. REV. STAT. ANN. §17:192.
Maine	.	
Maryland	0	Schools with less than 15 percent FRP students or with at least 25 percent of FRP students in the school refusing to participate may receive a waiver from this mandate. MD. CODE. ANN. EDUC. § 7-701 and §7-702.
Massachusetts	0.40	Determines the threshold from the percent of FRP students in the second preceding October. Schools must also have received at least 50 applications from FRP students in the preceding year. MASS. GEN. LAWS ch.69 §1C.
Michigan	0.20	Determines the threshold from the percent of FRP students in the preceding October. MICH. COMP. LAWS § 380.1272a.
Minnesota	0.33	Mandate applies to schools with at least 25 FRP students. MINN. STAT. ANN. § 124D.117.
Mississippi	.	
Missouri	0.35	Schools may receive a waiver for 3 years through a majority vote of the school board. MO. REV. STAT. § 191.803.
Montana	.	
Nebraska	.	
Nevada	.	

New Hampshire	.	Requires schools to provide at least one meal to FRP students but does not specify whether breakfast must be offered, so that schools may opt to provide lunch only. § 189:11-a.
New Jersey	.	The mandate enacted in 2003 was not effective until the 2005 school year. N. J. STAT. § 18A:33-10.
New Mexico	.	
New York	0	A school may receive a one-year waiver if at least 95 percent of FRP students or at least 90 percent of all students in the school refuse to participate or if the program will result in an increase in real property taxes. N.Y. COMP. CODES R. & REGS. tit. 8, § 114.2.
North Carolina	.	
North Dakota	.	
Ohio	0.33	Schools are also required to provide breakfast if at least 50 percent of the students' parents request the program. OHIO REV. CODE ANN. § 3313.81.3.
Oklahoma	.	
Oregon	0.25	Schools are also required to provide breakfast if the school qualifies for assistance from Title I funds. Schools may apply for a two year waiver from the mandate if the school is financially unable to implement a breakfast program. OR. REV. STAT. §327.535.
Pennsylvania	.	
Rhode Island	0	R.I. GEN. LAWS § 16-8-10.1.
South Carolina	0	Schools may apply for a waiver from the mandate if implementing a breakfast program will create a financial hardship due to lack of equipment or facilities or if it will create scheduling difficulties. SC CODE ANN. §59-63-790.
South Dakota	.	
Tennessee	0.25	TENN. CODE ANN. § 49-6-2302.
Texas	0.10	TEX. EDUC. CODE ANN. § 33.901.
Utah	.	
Vermont	0	Schools may receive a waiver for one year through a majority vote of the local citizens. VT. STAT. ANN. § 1264.
Virginia	0.25	VA. CODE ANN. § 22.1-207.3.
Washington	0.40	Determines the threshold from the percent of FRP students in the second preceding year. Schools may be exempt from the mandate under compelling circumstances. WASH. REV. CODE § 28A.235.140(3)(a).
West Virginia	0	Schools may receive a two-year waiver from the mandate under compelling circumstances. W. VA. CODE § 18-5-37.
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.
Source: Thresholds and state statues are from Food Research and Action Center (2004). Additional information is taken directly from the state statues.

Appendix Table 2: Means (and Standard Deviations), NAEP Data

		Students in States:					
					With a Partial Mandate		
	All Students	Without a Mandate	With a Mandate	With a Full Mandate	All	In Schools with Pct. FRP Above Threshold	In Schools with Pct. FRP Below Threshold
Math Score	233.225	232.494	234.198	233.093	234.628	228.464	247.258
	(28.333)	(28.407)	(28.204)	(28.273)	(28.166)	(27.425)	(25.305)
Reading Score	216.626	215.962	217.512	217.727	217.427	209.801	232.464
	(36.730)	(36.893)	(36.494)	(35.783)	(36.770)	(36.292)	(32.866)
Distance to Threshold	28.864	--	28.864	53.107	19.440	39.848	-22.378
	(38.225)		(38.225)	(29.054)	(37.199)	(24.309)	(20.154)
Above Threshold	0.328	0.000	0.764	1.000	0.672	1.000	0.000
	(0.469)	(0.000)	(0.425)	(0.000)	(0.469)	(0.000)	(0.000)
Percent FRP eligible	49.200	48.352	50.329	53.107	49.248	65.448	16.051
	(29.626)	(29.013)	(30.387)	(29.054)	(30.822)	(23.192)	(12.437)
Age (months)	120.640	120.475	120.861	119.801	121.273	121.853	120.085
	(5.840)	(5.572)	(6.171)	(6.229)	(6.099)	(6.486)	(5.011)
Female	0.491	0.491	0.492	0.494	0.491	0.492	0.489
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)
Black	0.187	0.145	0.242	0.241	0.243	0.326	0.070
	(0.389)	(0.351)	(0.428)	(0.427)	(0.428)	(0.469)	(0.255)
Hispanic	0.130	0.138	0.118	0.121	0.116	0.152	0.043
	(0.335)	(0.345)	(0.322)	(0.326)	(0.320)	(0.359)	(0.201)
Other Race/Ethnicity	0.071	0.093	0.042	0.047	0.039	0.038	0.042
	(0.256)	(0.289)	(0.199)	(0.211)	(0.194)	(0.191)	(0.201)
White	0.613	0.624	0.599	0.590	0.602	0.483	0.845
	(0.486)	(0.484)	(0.489)	(0.490)	(0.489)	(0.499)	(0.361)
Eligible for Free School Meals	0.374	0.355	0.399	0.422	0.390	0.523	0.118
	(0.477)	(0.470)	(0.483)	(0.487)	(0.482)	(0.495)	(0.310)
Eligible for Reduced-Price School Meals	0.089	0.095	0.080	0.086	0.078	0.092	0.049
	(0.279)	(0.287)	(0.266)	(0.275)	(0.263)	(0.285)	(0.208)
Urban Residence	0.322	0.318	0.327	0.281	0.344	0.450	0.127
	(0.467)	(0.466)	(0.469)	(0.450)	(0.475)	(0.498)	(0.333)
Rural Residence	0.360	0.395	0.315	0.305	0.318	0.329	0.296
	(0.480)	(0.489)	(0.464)	(0.460)	(0.466)	(0.470)	(0.456)
Percent Minority	36.82	35.91	38.04	39.22	37.59	49.23	13.74
	(34.75)	(34.20)	(35.44)	(34.96)	(35.61)	(36.62)	(16.50)
School Size	527.33	524.76	530.74	583.60	510.20	503.22	524.50
	(241.54)	(253.58)	(224.47)	(291.39)	(188.32)	(188.82)	(186.47)
Observations (math sample)	172980	98790	74190	20770	53430	35900	17520
Observations (reading sample)	168070	96060	72010	20370	51640	34260	17380

Notes: Standard deviations in parentheses. Sample sizes rounded to the nearest 10 to comply with nondisclosure requirements. The means and standard deviations for all variables except the reading score are based on the math sample.
Source: National Assessment of Education Progress (NAEP) 2003 Grade 4

Appendix Table 3: Means (and Standard Deviations), ECLS-K Data

		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
Reading Score	137.157	135.842	138.697	139.605	138.390	136.716	147.311	135.172	147.391
	(23.467)	(23.917)	(22.835)	(21.925)	(23.131)	(23.438)	(19.108)	(23.300)	(20.090)
Math Score	112.642	110.999	114.567	115.661	114.196	112.688	122.233	111.324	122.231
	(21.857)	(22.433)	(21.002)	(21.428)	(20.846)	(20.941)	(18.363)	(21.086)	(17.865)
Science Score	56.561	55.367	57.958	56.745	58.370	57.254	64.315	56.403	63.872
	(14.612)	(14.883)	(14.162)	(14.353)	(14.075)	(14.132)	(12.157)	(14.110)	(12.428)
School Offers SBP	0.829	0.799	0.865	0.931	0.842	1.000	0.000	0.979	0.459
	(0.376)	(0.401)	(0.342)	(0.253)	(0.365)	(0.000)	(0.000)	(0.143)	(0.499)
Distance to Threshold	30.350	--	30.350	50.372	23.562	32.452	-23.814	39.796	-21.853
	(37.814)		(37.814)	(34.200)	(36.559)	(31.158)	(24.905)	(26.382)	(18.118)
Above Threshold	0.370	0.000	0.803	1.000	0.737	0.857	0.098	1.000	0.000
	(0.483)	(0.000)	(0.398)	(0.000)	(0.441)	(0.351)	(0.298)	(0.000)	(0.000)
Percent FRP eligible	54.924	58.981	50.171	50.372	50.103	56.864	14.071	63.083	13.790
	(31.834)	(31.790)	(31.226)	(34.200)	(30.158)	(27.404)	(14.578)	(23.813)	(8.782)
Age (months)	134.615	134.455	134.801	133.454	135.258	135.386	134.577	135.363	134.966
	(4.499)	(4.415)	(4.588)	(4.368)	(4.572)	(4.610)	(4.305)	(4.624)	(4.413)
Female	0.497	0.500	0.493	0.496	0.492	0.499	0.458	0.496	0.483
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.499)	(0.500)	(0.500)
Black	0.130	0.117	0.145	0.160	0.140	0.161	0.033	0.183	0.020
	(0.336)	(0.321)	(0.352)	(0.366)	(0.347)	(0.367)	(0.180)	(0.387)	(0.140)
Hispanic	0.200	0.219	0.177	0.246	0.154	0.173	0.048	0.188	0.057
	(0.400)	(0.414)	(0.381)	(0.431)	(0.360)	(0.378)	(0.214)	(0.391)	(0.231)
Other Race/Ethnicity	0.128	0.164	0.086	0.088	0.086	0.085	0.090	0.079	0.105
	(0.334)	(0.370)	(0.281)	(0.283)	(0.280)	(0.279)	(0.286)	(0.270)	(0.307)
White	0.542	0.500	0.591	0.507	0.620	0.581	0.830	0.549	0.817
	(0.498)	(0.500)	(0.491)	(0.500)	(0.485)	(0.493)	(0.377)	(0.498)	(0.386)
Family Income (000s)	58.493	54.471	63.203	66.759	61.997	54.247	103.299	48.812	98.881
	(49.848)	(46.277)	(53.351)	(57.654)	(51.766)	(45.082)	(64.116)	(40.473)	(61.240)
Poverty	0.227	0.249	0.202	0.187	0.207	0.237	0.046	0.267	0.038
	(0.402)	(0.416)	(0.383)	(0.365)	(0.389)	(0.409)	(0.197)	(0.425)	(0.178)
Family Size	4.612	4.680	4.534	4.489	4.549	4.554	4.523	4.555	4.531
	(1.354)	(1.428)	(1.257)	(1.233)	(1.265)	(1.300)	(1.060)	(1.317)	(1.110)
Parents' Highest Education	14.103	13.924	14.313	14.677	14.189	13.882	15.824	13.644	15.714
	(2.571)	(2.552)	(2.577)	(2.588)	(2.562)	(2.482)	(2.354)	(2.434)	(2.280)
Birth Weight	117.932	117.577	118.348	118.121	118.425	117.772	121.904	117.209	121.827
	(18.370)	(18.240)	(18.514)	(19.250)	(18.261)	(18.054)	(18.972)	(18.162)	(18.119)
Grade	4.888	4.895	4.880	4.894	4.875	4.862	4.946	4.853	4.938
	(0.331)	(0.322)	(0.342)	(0.332)	(0.345)	(0.362)	(0.227)	(0.373)	(0.242)
Urban Residence	0.337	0.309	0.371	0.437	0.348	0.387	0.141	0.419	0.150
	(0.465)	(0.455)	(0.474)	(0.488)	(0.467)	(0.478)	(0.334)	(0.483)	(0.346)
Rural Residence	0.259	0.324	0.184	0.072	0.222	0.231	0.172	0.234	0.187
	(0.431)	(0.462)	(0.379)	(0.252)	(0.406)	(0.413)	(0.365)	(0.414)	(0.381)
School with ≥ 80 Pct. Minority	0.275	0.318	0.224	0.283	0.204	0.240	0.017	0.276	0.004
	(0.447)	(0.466)	(0.417)	(0.451)	(0.403)	(0.427)	(0.128)	(0.447)	(0.061)
School with ≥ 750 Students	0.185	0.180	0.191	0.335	0.142	0.157	0.065	0.146	0.133
	(0.388)	(0.384)	(0.393)	(0.472)	(0.349)	(0.364)	(0.246)	(0.353)	(0.339)
School with < 300 Students	0.136	0.163	0.104	0.075	0.115	0.118	0.096	0.131	0.068
	(0.343)	(0.369)	(0.306)	(0.263)	(0.319)	(0.323)	(0.295)	(0.338)	(0.251)
Eat School Breakfast	0.329	0.334	0.323	0.287	0.335	0.407	0.000	0.438	0.066
	(0.470)	(0.472)	(0.468)	(0.453)	(0.472)	(0.491)	(0.000)	(0.496)	(0.249)
Days Eating Breakfast	5.678	5.701	5.651	5.682	5.641	5.686	5.414	5.705	5.472
	(1.361)	(1.372)	(1.348)	(1.338)	(1.351)	(1.358)	(1.291)	(1.364)	(1.301)

% Excused Absences	2.650	2.687	2.607	2.183	2.741	2.678	3.069	2.624	3.064
	(3.230)	(3.050)	(3.429)	(2.721)	(3.613)	(3.673)	(3.272)	(3.844)	(2.861)
% Unexcused Absences	0.980	0.902	1.071	1.379	0.974	1.056	0.544	1.184	0.395
	(2.191)	(2.136)	(2.249)	(2.806)	(2.033)	(2.109)	(1.503)	(2.193)	(1.346)
% Excused Tardies	0.690	0.641	0.747	0.765	0.742	0.651	1.171	0.684	0.889
	(1.994)	(1.706)	(2.289)	(2.255)	(2.300)	(1.942)	(3.509)	(2.231)	(2.463)
% Unexcused Tardies	0.765	0.752	0.781	1.302	0.626	0.697	0.286	0.687	0.470
	(2.867)	(2.738)	(3.014)	(4.639)	(2.296)	(2.460)	(1.201)	(2.419)	(1.942)
Approaches to Learning	3.049	3.043	3.057	3.085	3.048	3.023	3.180	3.003	3.175
	(0.680)	(0.683)	(0.677)	(0.691)	(0.672)	(0.680)	(0.614)	(0.686)	(0.615)
Self-Control	3.227	3.211	3.244	3.281	3.232	3.209	3.353	3.191	3.348
	(0.599)	(0.598)	(0.599)	(0.613)	(0.594)	(0.598)	(0.557)	(0.606)	(0.545)
Interpersonal Skills	3.064	3.052	3.078	3.131	3.060	3.038	3.174	3.024	3.158
	(0.637)	(0.635)	(0.640)	(0.638)	(0.640)	(0.642)	(0.616)	(0.648)	(0.607)
Externalizing Prob. Behaviors	1.651	1.658	1.643	1.614	1.653	1.673	1.553	1.689	1.556
	(0.587)	(0.580)	(0.595)	(0.611)	(0.589)	(0.598)	(0.533)	(0.607)	(0.527)
Internalizing Prob. Behaviors	1.646	1.650	1.641	1.620	1.648	1.660	1.588	1.664	1.606
	(0.545)	(0.535)	(0.557)	(0.551)	(0.559)	(0.565)	(0.521)	(0.562)	(0.548)
Fall Kindergarten Math	22.488	21.823	23.245	22.714	23.432	22.733	26.837	22.167	26.802
	(8.475)	(8.242)	(8.673)	(8.707)	(8.655)	(8.454)	(8.821)	(8.234)	(8.851)
Fall Kindergarten Reading	29.057	28.603	29.553	29.713	29.497	28.943	32.053	28.460	32.092
	(9.320)	(9.400)	(9.208)	(9.793)	(8.998)	(8.832)	(9.319)	(8.537)	(9.584)
School Receives Title I	0.695	0.736	0.646	0.543	0.682	0.736	0.396	0.801	0.353
	(0.460)	(0.441)	(0.478)	(0.498)	(0.466)	(0.441)	(0.490)	(0.399)	(0.478)
Years of Experience, Principal	9.478	9.446	9.516	8.222	9.956	9.749	10.998	9.077	12.338
	(7.420)	(7.357)	(7.493)	(7.334)	(7.497)	(7.296)	(8.372)	(7.045)	(8.146)
Days/Wk. Vigorous Exercise	3.719	3.669	3.776	3.682	3.807	3.809	3.797	3.809	3.804
	(1.905)	(1.910)	(1.897)	(1.949)	(1.879)	(1.914)	(1.693)	(1.921)	(1.764)
Servings of Milk	10.446	10.535	10.342	10.136	10.412	10.162	11.748	9.846	11.995
	(9.366)	(9.398)	(9.329)	(9.305)	(9.337)	(9.359)	(9.111)	(9.269)	(9.351)
Servings of Juice	5.499	5.693	5.273	6.017	5.020	5.037	4.931	5.110	4.770
	(7.294)	(7.422)	(7.136)	(7.557)	(6.971)	(7.106)	(6.211)	(7.246)	(6.136)
Servings of Soda	6.324	6.278	6.377	6.107	6.469	6.666	5.419	6.760	5.655
	(7.732)	(7.759)	(7.702)	(7.451)	(7.784)	(7.969)	(6.623)	(8.065)	(6.878)
Servings of Salad	2.322	2.340	2.300	2.775	2.139	2.124	2.217	2.082	2.298
	(4.390)	(4.406)	(4.371)	(5.038)	(4.109)	(4.180)	(3.710)	(4.208)	(3.816)
Servings of Potatoes	2.029	2.170	1.864	1.966	1.829	1.874	1.592	1.864	1.733
	(3.830)	(4.028)	(3.578)	(3.912)	(3.458)	(3.589)	(2.640)	(3.679)	(2.745)
Servings of Carrots	2.985	3.208	2.725	2.840	2.687	2.558	3.369	2.525	3.139
	(5.601)	(5.818)	(5.326)	(5.339)	(5.321)	(5.253)	(5.625)	(5.229)	(5.549)
Servings of Other Vegetables	5.204	5.495	4.863	4.893	4.852	4.831	4.965	4.793	5.018
	(6.524)	(6.789)	(6.183)	(5.968)	(6.255)	(6.337)	(5.807)	(6.450)	(5.675)
Servings of Fruit	7.916	8.324	7.439	7.450	7.435	7.505	7.060	7.555	7.099
	(8.338)	(8.569)	(8.034)	(7.946)	(8.065)	(8.262)	(6.919)	(8.351)	(7.199)
Observations	8830	4770	4070	1030	3040	2560	480	2240	800

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

Appendix Table 4: Discontinuities in Other Characteristics, NAEP Data

Characteristic	Estimated Discontinuity
Age (months)	0.271
	(0.193)
Female	0.021
	(0.020)
Black	-0.003
	(0.011)
Hispanic	0.004
	(0.010)
Other Race/Ethnicity	0.018
	(0.009)
Eligible for Free School Meals	0.009
	(0.018)
Eligible for Reduced-Price School Meals	0.002
	(0.010)
Urban Residence	-0.051
	(0.016)
Rural Residence	-0.086
	(0.019)
Percent Minority	3.671
	(0.629)
School Size	24.143
	(7.549)
Observations	20110

Notes: Standard errors are shown in parentheses. The regression discontinuity estimates are calculated using local linear regression with a triangle kernel and a bandwidth of 5. 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: NAEP 2003 Grade 4 Math Assessment

Appendix Table 5: Estimates from a Regression Discontinuity Design with Alternate Bandwidths and Functional Form, NAEP Data

	LLR				OLS	
	5	7.5	10	20	Quadratic	Quadratic
Reading	4.413	4.011	3.766	2.946	5.709	5.487
	(1.813)	(1.633)	(1.450)	(1.088)	(1.529)	(1.467)
Math	2.554	3.548	3.482	3.035	5.598	4.651
	(1.370)	(1.165)	(1.098)	(0.784)	(1.047)	(0.990)
Covariates					No	Yes

Notes: Standard errors are shown in parentheses. Local linear regressions use a triangle kernel and the bandwidth is specified in the table. 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), poverty status, urban/rural, the percent of the student body who are nonwhite, the number of students in the school, and a continuous measure of the percent of FRP students in the school. The quadratic specification was chosen based on the Schwarz criterion and joint hypothesis tests of higher order polynomial terms. 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. The sample size for reading is 19,690 and the sample size for math is 20,110. Sample sizes rounded to the nearest 10.
Source: NAEP 2003 Grade 4 Assessment

Appendix Table 6: Discontinuities in Other Characteristics, ECLS-K Data

Characteristic	Estimated Discontinuity
Age	-0.678
	(0.635)
Female	-0.101
	(0.066)
Black	0.005
	(0.027)
Hispanic	0.000
	(0.036)
Other Race	-0.013
	(0.042)
Family Income	4.162
	(7.267)
Poverty	0.030
	(0.047)
Family Size	-0.314
	(0.153)
Parents' Highest Education	0.218
	(0.373)
Urban	-0.051
	(0.072)
Rural	-0.153
	(0.058)
Birth weight	-2.069
	(2.361)
Grade	-0.016
	(0.049)
Fall Kindergarten Reading Score	1.313
	(1.436)
Fall Kindergarten Math Score	0.543
	(1.066)
School Receives Title I Funds	0.020
	(0.073)
Days of Vigorous Exercise	0.305
	(0.242)
Observations	1180

Notes: Heteroskedasticity-robust standard errors in parentheses. The regression discontinuity estimates are calculated using local linear regression with a triangle kernel and a bandwidth of 20. 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 size rounded to the nearest 10.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

Appendix Table 7: Estimates from a Regression Discontinuity Design with Alternate Bandwidths and Functional Form, ECLS-K Data

	LLR				OLS	
	10	15	20	25	Linear	Linear
Math	11.681	9.383	7.647	7.004	6.234	6.842
	(5.001)	(3.729)	(3.037)	(2.734)	(2.438)	(2.153)
Reading	5.866	7.430	6.599	6.120	5.538	5.950
	(6.438)	(4.493)	(3.741)	(3.447)	(2.793)	(2.434)
Science	8.353	6.763	5.538	5.177	4.738	4.948
	(3.106)	(2.121)	(1.756)	(1.663)	(1.646)	(1.488)
Covariates					No	Yes
Observations	1180	1180	1180	1180	1180	1180

Notes: Local linear regression estimates using a triangle kernel and bandwidth as shown in the table. 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. age in months, gender, race/ethnicity (black, Hispanic, and other race, with white excluded), family income, family size, parent's education, birth weight, grade, urban/rural, poverty status, the percent of the student body who are nonwhite, the number of students in the school, and the percent of FRP students in the school. The linear specification was chosen based on the Schwarz criterion and joint hypothesis tests of higher order polynomial terms. 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 8: Regression Discontinuity Estimates at False Thresholds, ECLS-K Data

	0	-10	-5	+5	+10
Reading	6.599	-5.064	2.308	-1.316	0.184
	(3.741)	(2.931)	(3.466)	(3.317)	(2.097)
Math	7.647	-2.271	-2.877	-0.489	0.013
	(3.037)	(2.508)	(2.966)	(2.845)	(2.114)
Science	5.538	-0.520	-1.327	-0.876	1.309
	(1.756)	(1.926)	(1.811)	(1.582)	(1.19)
Observations	1180	1180	1180	1180	1180

Notes: Local linear regression estimates using a triangle kernel and bandwidth of 20. 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