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

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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.

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## 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" (School Nutrition Association, 2011). Consistent with the goal of the program, Bhattacharya, Currie, and Haider (2006) conclude that the availability of the SBP enhances nutrition. However, 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.

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 this has been an important policy lever throughout the history of the program. To increase the availability of the SBP, the federal government provided funding to states for schools serving low-income children to offset the start-up costs of implementing the SBP in the Child Nutrition Act of 1989. In order to receive these funds, 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 primarily from 10 to 40 percent, and I use these mandates as an identifying source of variation. Thus, this paper introduces a new approach for determining the impact of the availability of the SBP.

I first estimate a difference-in-differences specification that compares the achievement among students in schools above to those 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 and attendance 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 provide suggestive evidence 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).[1, 2] Deficiencies in various specific vitamins and minerals, including thiamine, vitamin E, and iron, can lead to a decrease in mental concentration and cognition (Chenoweth, 2007; Greenbaum,

[1] 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.

[2] 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). This area of research is less developed than the relationship between nutrition and cognitive skills, but Bryan et al. (2004) suggest that the micronutrients zinc and omega-3 polyunsaturated fatty acids may be related to attention and Kleinman et al. (1998) find that malnutrition is correlated with behavior problems.

2007a,b).[3] Bryan et al. (2004) notes that brain development occurs through childhood and poor nutrition can influence brain development; in particular, the authors' review of the research on the relationships between nutrients and cognitive development among school-aged children highlights the importance of iodine, iron, and folate and the contribution of zinc, vitamin B12, and omega-3 polyunsaturated fatty acids to long-term cognitive development. The very early stages of iron deficiency can alter dopamine transmission, which influences cognition (Pollitt, 1993). 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. Finally, 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).[4]

A considerable body of research has examined the impact of eating breakfast through the SBP or universal free breakfast programs on nutrition outcomes.[5] For example, 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. 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

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[3] 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).
[4] Figlio and Winicki (2005) find that, in response to accountability pressures, some schools increase glucose loads through school lunches to improve test scores.
[5] 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).

vitamin C, vitamin E, and folate; and reduces the number of calories from fat. 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.

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) utilizes a change in the funding formula to demonstrate an increase in educational attainment from the expansion of the NSLP, which he suggests could be due to an increase in attendance.

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). 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, which is approximately 30 percent of the average monthly SNAP benefits per person and 70 percent of the average monthly food costs per person of the WIC program in 2004 (USDA, 2014).[6] Dahl and Lochner (2012) demonstrate that an increase in family income, based on changes in the Earned Income Tax Credit, 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. 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

[6] The SBP occurs prior to the beginning of school. Thus, there is also an implied income transfer for families with children who would have attended before-school care in the absence of the SBP.

if this reduces the amount of time students sleep. Additionally, 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 skills of peers, then peer influences could increase achievement.

There is a related body of research on the influence of breakfast consumption or other school meal programs, but there is very little research that directly address the impact of the SBP on cognitive achievement in the U.S.[7] Dunifon and Kowaleski-Jones (2004) suggest that eating lunch through the National School Lunch Program increases boys' reading scores based on first-differences between kindergarten and first grade. However, the SBP serves a lower income group of students, is available primarily before the start of the school day, and is available in less schools than the NSLP. Related to breakfast, recent studies have examined universal-free school breakfast programs (UFB), where all students do not pay for breakfast, and breakfast in the classroom programs (BIC) that switch breakfast from being served in the cafeteria before school to the classrooms in the beginning of school. In an experimental evaluation, Bernstein et al. (2004) find that UFB did not influence achievement. Similarly, Leos-Urbel et al. (2013) find that the introduction of UFB in New York City did not influence achievement based on a difference-in-differences strategy. Alternatively, examining the staggered implementation of BIC in different cities, Imberman and Kugler (2013) and Dotter (2013) find that BIC increases

[7] Recent related research outside of the U.S. includes an evaluation of the improvement in the nutritional quality of school meals in the UK, using a difference-in-differences strategy comparing students in schools before and after the reform to neighboring schools, which finds increases in educational achievement and reductions in absences (Belot and James, 2011). On the other hand, McEwan (2013) implements a regression discontinuity design exploiting a change in calorie rations based on a school-level vulnerability index and finds that increases in the number of calories provided in school meals in Chile do not affect students' test scores or attendance.

math achievement by 9 percent and 15 percent of a standard deviation and reading achievement by 6 percent and 10 percent of a standard deviation, respectively. However, changes to the price that subsets of students pay or the location of breakfast are changes that occur in schools that already offer breakfast through the SBP, and changes in the availability of breakfast through the SBP are potentially a more significant change in the school environment. As such, throughout most of the history of the program, efforts to increase the availability of the SBP in schools have been the focus of public policy.

In the paper most related to this, 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 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.[8]

## 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. Consistent with this possibility, Millimet, Tchernis, and Husain (2010) find that there is significant negative selection on unobservables related to SBP participation. Since breakfast is commonly offered prior to the beginning of the school day, the timing could influence which schools and students participate in the SBP. Although 52 percent of participants

[8] 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.

in the National School Lunch Program (NSLP) received free meals in 2009, 72 percent of participants in the SBP received free meals.[9] 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 utilize two 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 of students in schools with higher and lower percentages of FRP students in states with differing levels of the threshold. The second approach is a regression discontinuity design (RD) that compares the achievement of students just above to those just below the 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. School participation increased following the permanent authorization of the SBP in 1975 (Food Research and Action Center (FRAC), 1997). Federal funding was allocated for food and labor costs, but the expansion of the program stagnated in the 1980s. In 1988, only 40 percent of schools that participated in the NSLP offered breakfast through the SBP (FRAC, 1997). To increase the availability of the SBP in schools, Congress authorized funding in the Child Nutrition Act of 1989 to states for schools to cover the start-up costs associated with offering the SBP, provided that schools participate in the program for at least three years (Fox, Hamilton, and Lin, 2004; Public Law No: 101-147). Federal assistance with the start-up costs of establishing the SBP in schools continued until 1996 (Fox, Hamilton, and Lin, 2004). By 1997, 72 percent of schools that participated in the NSLP offered breakfast through the SBP (FRAC, 1997).

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

The grants to cover start-up costs were awarded competitively to states that could ensure that the funds were targeted towards schools with high percentages of FRP students. To attempt to receive funding, many states mandated that schools must offer the SBP if the percent of FRP students in the school is equal to or greater than a specific threshold. For example, Indiana introduce a mandate in 1993 that requires all public schools with 25 percent or more FRP students to offer the SBP. Thus, schools with 26 percent FRP students are required to participate in the program, but schools with 24 percent FRP students 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 FRAC (2004) and the state statutes. Figure 1 displays the geography of these mandates for elementary schools.[10] As seen in this figure, eastern and southern states are likely to impose mandates; however, there is variation in the threshold levels within regions. Western states do not commonly require that all or specific schools participate in the SBP. 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. These thresholds vary between 10 and 40 percent, except that Connecticut has a threshold of 80 percent.

A potential concern with using these mandates as a source of identifying variation is that states could choose to implement a mandate or select the threshold level because of characteristics that are correlated with student achievement. Also, states could have chosen the threshold levels with knowledge of which schools would fall above or below the threshold.

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[10] Appendix Table 1 documents these state mandated thresholds for all states during 2004 that apply to elementary schools. Some states allow exemptions to schools as described in the appendix, so that school-level participation in schools above the threshold may not be 100 percent. For example, in Louisiana, schools may receive a waiver from the mandate if at least 50 percent of the FRP students in the school refuse to eat the offered breakfast.

Many of these thresholds were enacted during the 1990s and the specific thresholds have not changed since prior to 1999 (FRAC, 1999), which minimizes policy endogeneity concerns related to states choosing specific thresholds based on the achievement of students in 2003 and 2004. Further, I examine whether the mandates in 2003 are correlated with states' education, income, and demographic characteristics in 1990.[11] The results shown in Table 1 suggest that states with worse economic conditions in 1990, as measured by the unemployment rate, were more likely to adopt a mandate to receive federal funds for schools to implement the SBP. Importantly, no state characteristics are significantly correlated with the threshold level. In particular, the state achievement scores are not correlated with the threshold level. Although it is possible that the mandates are associated with unobserved nutritional deficiencies across states, these results suggest that states did not select these threshold levels based on their economic or demographic conditions or the educational achievement of students in the state. Thus, I focus the analysis on students in schools in states with a partial mandate where the percent of FRP students is an important determinant of the availability of the SBP.[12]

**a. Difference-in- Differences Estimation**

Using these state mandates as an identifying source of variation, I compare students in schools with higher and lower percentages of FRP students in states with higher and lower thresholds. To illustrate this idea, consider two groups of states, one with a threshold of 20 percent and the other with a threshold of 25 percent. I could initially compare the achievement differences of students in schools with 17 percent FRP students to students in schools with 22

[11] State average NAEP elementary school (4th grade) scores were not available as far back as 1990. Instead, I examine the 1990 8th grade mathematics scores and the 1992 4th grade mathematics scores, which also increases the sample size since more states have NAEP scores in 1992 than in 1990.
[12] This sample restriction should minimize policy endogeneity, but trades off internal validity with external validity in that the sample is composed of 1/3 of all states.

percent FRP students in the states with a 20 percent threshold to similar students and schools in the states with a 25 percent threshold. This difference-in-differences strategy could be estimated:

$$Y_{ijs} = \phi_1 Above_{js} + \phi_2 Threshold_s + \phi_3 Threshold \cdot Above_{js} + \mu_{ijs}\,, \tag{1}$$

where $Y_{ijs}$ is the achievement outcome for student *i* in school *j* in state *s*, *Above* denotes that the percent FRP students in the school is above 20 percent such that $Above = 1\{FRP_{js} \geq 20\}$, *Threshold* denotes that the state has a mandate threshold of 20 percent, and $Threshold \cdot Above$ denotes that the school has more than 20 percent FRP students and is located in a state with a threshold of 20 percent so that the state mandate binds, and $\mu$ is an error term. $\phi_3$ is the coefficient of interest in this specification. For this comparison, the sample would be restricted to states with a mandate of 20 or 25 percent and with the percent FRP students less than 25 percent. To control for any state policies or other characteristics associated with achievement that affect all schools in the state, I could add state fixed effects to equation (1). Since the mandates would be subsumed in the state fixed effects, equation (1) would become:

$$Y_{ijs} = \gamma_1 Above_{js} + \tau_s + \gamma_2 z_{js} + \varsigma_{ijs}\,, \tag{2}$$

where $\tau_s$ denotes state fixed effects and I introduce the more general term $z_{js}$ to denote that the mandate for state *s* is binding for school *j* (i.e., the school has more than 20 percent FRP students and is located in a state with a mandate of 20 percent).

Additional comparisons, however, are possible with these groups of states. I could also compare students in schools with 22 percent FRP students to students in schools with 27 percent FRP students in the states with a 20 percent threshold to similar students and schools in the states with a 25 percent threshold. Thus, I could include all students in states with a mandate of 20 or 25 percent and modify equation (2) to estimate:

$$Y_{ijs} = \chi_1 Above20_{js} + \chi_2 Above25_{js} + \chi_3 z_{js} + \tau_s + \upsilon_{ijs}\,, \tag{3}$$

where *Above20* now denotes that the percent FRP students in the school is above 20 percent and *Above25* denotes that the percent FRP students in the school is above 25 percent. $z_{js}$ continues to denote that the mandate for state *s* is binding for school *j* and is equivalent to *Threshold20 · Above20 + Threshold25 · Above25*.

More generally, I estimate the DD specification that allows for similar comparisons across all groups of states with thresholds:

$$Y_{ijs} = \delta_1 P_{js} + \delta_2 Z_{js} + \pi X_{ijs} + \tau_s + \nu_{ijs} \quad (4)$$

Compared to equation (3), $P_{js}$ generalizes *Above20* and *Above25* and $Z_{js}$ generalizes $z_{js}$. $P_{js}$ denotes a set of binary 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 thresholds such that $P_{js,t} = 1\{FRP_{js} \geq t\}, \forall t \in T$ , where *T* denotes the set of thresholds used by states to determine whether the SBP must be available, $T = \{10,20,25,30,33,35,40,80\}$.[13] *X* is a vector of individual and school characteristics and $\nu$ is a stochastic error term.[14]

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 $Z_{js} = 1\{FRP_{js} \geq t_s\}$. $\delta_2$, 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 requirements about whether

[13] Controlling for a set of binary variables for whether a school is above the percent of FRP students at these thresholds allows for the possibility of nonlinear effects of crossing these thresholds instead of simply controlling for the continuous measure of the percent of FRP students in the school.
[14] As described by Todd and Wolpin (2003), achievement is determined by the history of family inputs, school inputs, and the child's endowment. As described below, a binding state mandate and the availability of the SBP are not correlated with the past family and school inputs. Additionally, as also described below, a binding state mandate leads to a persistent increase in the availability of the SBP and reflect the cumulative potential exposure to the SBP.

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.

An important identifying assumption in the DD strategy is that the states with different thresholds have similar trends in achievement as the percent FRP students in schools increases up to the thresholds. Figure 2 displays these trends for states with thresholds of 20 and 25 percent.[15] As shown, the trends for these two groups of states are similar until the percent FRP students reaches 20 percent. Then, the trend for states with a threshold of 25 percent continues, while there is an increase in math achievement for states with a threshold of 20 percent, which suggests that the binding state mandate increases math achievement.

**b. Regression Discontinuity Design**

In addition to the DD strategy comparing students in schools with higher and lower percent FRP students in states with higher and lower thresholds, I implement a RD that compares students in schools just above the threshold to students in schools just below. In contrast to the DD strategy, the RD examines students more narrowly around the threshold to predict the counterfactual achievement scores and relies on the assumption that other determinants of achievement than the availability of the SBP would trend continuously across the thresholds. Thus, the RD requires samples with large numbers of students around the threshold, while the DD utilizes information from a broader set of observations and examines students in states with different thresholds to predict the counterfactual, relying on the assumption that the trends in schools where the threshold is not crossed in other states would be similar.

[15] The trends are similar for all groups of states with similar thresholds, but the figure becomes crowded with the addition of more trend lines. The figure would also look similar if I plotted linear trends.

I implement a "fuzzy" RD design, since many schools will participate in the SBP even in the absence of state mandates. The impact of the availability of the SBP in the school on a student's cognitive achievement is:

$$\theta = \frac{\alpha}{\beta} = \frac{\lim_{FRP_{js}\downarrow t_s} E[Y_{ijs} \mid FRP_{js} = t_s] - \lim_{FRP_{js}\uparrow t_s} E[Y_{ijs} \mid FRP_{js} = t_s]}{\lim_{FRP_{js}\downarrow t_s} E[D_{js} \mid FRP_{js} = t_s] - \lim_{FRP_{js}\uparrow t_s} E[D_{js} \mid FRP_{js} = t_s]}, \quad (5)$$

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

$$D_{js} = \lambda_1 + \beta Z_{js} + f_1(FRP_{js} - t_s) + \varepsilon_{1ijs} \quad (6)$$

$$Y_{ijs} = \lambda_2 + \alpha Z_{js} + f_2(FRP_{js} - t_s) + \varepsilon_{2ijs}, \quad (7)$$

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 $\theta$ is $\hat{\theta} = \hat{\alpha}/\hat{\beta}$. I primarily estimate equations (6) and (7) semiparametrically using local linear regression with a triangle kernel. I examine the robustness of the results to alternate bandwidths and using different polynomial specifications to estimate equations (6) and (7).

An important threat to identification is that, particularly since the state thresholds are known, administrators could influence whether the school is above or below the threshold and thus required to offer breakfast. The use of direct certification, which was introduced in 1989, minimizes concerns about measurement error and schools strategically manipulating the percent of FRP students. Eligibility for free or reduced-price school meals has historically been determined by households completing an application and self-reporting income. Using direct certification, school districts or state agencies examine administrative records and determine that students in families receiving benefits from the Supplemental Nutrition Assistance Program (SNAP), the Temporary Assistance for Needy Families (TANF) program, or Food Distribution Program on Indian Reservations are eligible for free meals (Dahl and Scholz, 2011). By 2002, nearly two-thirds of school districts utilized direct certification to determine eligibility (Dahl and Scholz, 2011). Any additional applications for eligibility are subject to state and federal verification with penalties for false reporting that include restricting funding to schools.

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.[16] 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.

Direct certification, state verification and the threat of reduced funding, and the relatively smaller funding compared to Title I reduce, but do not necessarily eliminate, concerns related to the strategic manipulation of schools above and below the threshold. Thus, I examine a variety of specification checks to validate the RD design below, including examining whether there are discontinuities in other determinants of achievement at the thresholds.

## 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

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

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 4$^{th}$ grade NAEP sample and the 5$^{th}$ grade students in 2004 in the ECLS-K data.[17]

**a. National Assessment of Educational Progress**

NAEP is the largest nationally representative assessment of the achievement of 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 4$^{th}$ 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 students' demographics and responses to specific assessment questions (Rogers and Stoeckel, 2004). I estimate separate regressions for each plausible value and appropriately combine the estimates.[18]

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

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[17] Because of the time difference in the samples, I do not formally implement a two-sample two-stage least squares estimator (e.g., Inoue and Solon, 2010). Instead, I informally scale up the estimates of the impact of the mandates on achievement by the estimate of the impact of the mandates on the availability of the SBP from the ECLS-K data.
[18] 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 errors and 1.2 multiplied by the sampling variance of the individual point estimates.

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. I focus the analysis on the fifth grade survey wave in 2004 because information about whether the school offers breakfast through the SBP is reported by the school administrator instead of parents, food consumption is available, and I am able to merge the previous five years of data about the percent of FRP students in the school to this wave.

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 primarily use the measure reported by the school administrator. Only parents are asked whether the student received a breakfast provided by the school. Students are classified as eating breakfast as part of the SBP only if the SBP is available in the school. Although I examine breakfast consumption in school as a mechanism for the availability of the SBP to influence achievement, I view the results as merely suggestive due to measurement error concerns and focus attention on the availability of the SBP, which is an important policy lever that has been used throughout the history of the program to influence breakfast consumption.[19]

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. The fifth grade

[19] Parents may provide information about other breakfast sources instead of the SBP, may be unaware of whether their child eats breakfast at school, may be unwilling to truthfully respond due to perceived stigma, and may respond about current instead of annual consumption. In contrast, the availability of the SBP should be measured with less error because the response is provided by a school administrator, the question specifically asks about the USDA's School Breakfast Program, and the SBP is provided throughout the school year so that current reports would not differ from annual reports.

wave also contains administrative attendance records that distinguish between excused and unexcused absences and tardies and food consumption measures. Students in fifth grade are asked to report the number of servings consumed during the prior 7 days of milk; 100 percent fruit juice; soda, sports drinks, or less than 100 percent fruit juice; fruit; green salad; potatoes excluding french fries and potato chips; carrots; and other vegetables.

### c. Determining Whether a State Mandate is Binding

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. 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 available to determine whether schools are required to offer the SBP based on state mandates.[20]

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

[20] The ECLS-K and CCD variables measures eligibility, not actual participation, which can differ due to student and household decisions about participation and direct certification. 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 values of the CCD data that are reported by states to NCES and the values in the ECLS-K are the same values that schools report to the states to determine whether schools are required to offer breakfast through the SBP, then these would be the appropriate values for the identification strategies used in the paper. However, there is a possibility of measurement error in the percent FRP values, particularly in states that determine whether the mandates bind in days besides October 1. Also, the number of free and reduced-price eligible students in the CCD is top censored at the total number of students in the school minus three to avoid identifying any student as eligible for free lunch.

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. In fact, no schools in the ECLS-K sample stop offering breakfast through the SBP once the school exceeds the threshold. Thus, I examine whether the school exceeds the state threshold in any of the previous years since 1999. 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 for partial mandates in 2003 are the same as in 2004.

### d. Descriptive Statistics

I restrict both samples to students in public schools with non-missing values for all achievement measures.[21] Further, in the ECLS-K sample, I exclude students with missing values for the availability of the SBP in school and 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.[22]

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[21] RD and DD estimates suggest that a binding state mandate and thus, the availability of the SBP, is not related to having a missing achievement score.

[22] 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. Additional details about the data and the construction of the analysis samples are included in the data appendix.

Table 2 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 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, 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 difficultly 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 2 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 of the impact of a binding state mandate. Then, I describe DD and RD results using ECLS-K data of the impact of a binding state mandate and the availability of the SBP. Finally, using ECLS-K data, I examine heterogeneity and the potential mechanisms.

**a. Results from NAEP Data**

Table 3 displays the estimates of equation (4) 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 (with a standard error of 0.902), which is 7.7 percent of a standard deviation and 0.9 percent of the mean, and reading achievement by 2.0 points (with a standard error of 1.124), 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 reasonably similar to those in the first column; a binding state mandate increases math achievement by 2.6 points (with a standard error of 1.137) or 9.3 percent of a standard deviation and reading achievement by 1.9 points (with a standard error of 1.432) or 5.2 percent of a standard deviation.

As shown in Table 4, a binding state mandate is not correlated with any of the school or individual characteristics used as control variables in the primary specifications, based on DD regressions with each school and individual characteristic as the dependent variable.[23] These

[23] The primary results shown in the first columns for math and reading achievement in Table 3 are robust to including a set of dummy variables denoting that a state has a mandate at a specific threshold instead of state fixed

results suggest that having a binding state mandate, and being required to provide breakfast through the SBP, does not reflect the characteristics of the students, parents, or schools.

Table 3 also displays the RD estimates using 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 (with a standard error of 1.242) or 9.1 percent of a standard deviation and reading achievement by 4.4 points (with a standard error of 1.820) 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 results from the RD design are shown graphically in the top panel of Figure 3.[24] To reduce the noise in the graphs, students are grouped in bins with a width of three percentage points and the points on the graph represent the average value for each bin. 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 often larger.[25]

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effects, as shown in Appendix Table 4; thus, the results are robust to not controlling for time-invariant state attributes. The results are also similar, but slightly increase in magnitude, when excluding school and individual characteristics.

[24] To visually highlight observations closest to the threshold, the figures display observations within 30 percentage points of the threshold. For the entire sample, the range of math achievement is 210 to 265 and movements along the x-axis to the right do not necessarily increase the percent of FRP students in the school in the range of the graph more than 10 percentage points below the state threshold.

[25] Figure 3 suggests that observations just below the threshold may be driving much of the results, particularly for math achievement, which could suggest that there is strategic manipulation of the percent of FRP students in the school near the threshold. To address this possibility, I examine the robustness of the results to excluding observations nearest to the threshold where any manipulation would most likely occur. For the math sample, I exclude the 170 observations within 0.1 percentage points, 950 observations within 0.5 percentage points, and 1450 observations within 1 percentage point of the threshold. The corresponding sample sizes for the reading sample are 200, 900, and 1410. The estimates never decrease towards zero, which suggests that strategic manipulation around the threshold is not causing the estimates to be positive.

There are a variety of specification checks that are important to validate the RD design.[26] Estimates of the discontinuity in individual and family characteristics at the state thresholds along with the mean for students in schools where the percent of FRP students is below the threshold are shown in Table 4. There is no statistically significant discontinuity in race, sex, and family background, but students are less likely to live in a rural area in schools above state thresholds and more likely to attend schools with a higher percent minority. There are also no statistically significant discontinuities in predicted math and reading scores, where these scores are predicted based on all observable characteristics. The magnitudes of the point estimates for the predicted achievement scores are also much smaller than the magnitudes for the estimates of the discontinuity of the actual achievement scores. Figure 3 also visually displays the lack of a discontinuity in predicted math achievement and race, which is a determinant of achievement. Further, from examining the distribution of the percent of FRP students in the school centered at the state threshold, there is no evidence of strategic manipulation of the assignment variable, which is an important threat to identification as discussed above.[27]

[26] The results of additional specification checks are shown in the appendix. Appendix Table 5 displays regression discontinuity design estimates at false thresholds five and ten percentage points above and below the actual threshold. None of the estimates are statistically significant at the five percent level and only one out of eight of the estimates are significant at the ten percent level. Additionally, the estimates of the impact of exceeding the state thresholds on achievement are largely robust to alternative bandwidth choices in the local linear regression estimates or using a polynomial function as shown in Appendix Table 6. The reading estimates are slightly smaller for both larger and smaller bandwidths and the estimates using a quadratic polynomial are larger. The math estimates generally increase as the bandwidth increases, but are essentially constant above a bandwidth of 7.5, and the estimates using a quadratic polynomial are larger. 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.

[27] The assignment variable is the maximum of the percent FRP students in the school since 1999, which takes into account that schools do not stop offering breakfast once they are required to do so and begin to offer breakfast through the SBP as described in the previous section. Appendix Figure 1 displays the distribution of the percent of FRP students in the school centered at the state threshold. Because of the construction of the assignment variable, the density is thick throughout the right half of the distribution. As shown in Appendix Figure 2, the un-centered distribution of the percent of FRP students in the school contains more mass near 100 percent.

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.

**b. Results from ECLS-K Data**

The first row of Table 5 displays the estimates of equation (4) 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 (with a standard error of 0.141) more likely to offer breakfast through the SBP than schools without a binding mandate. A binding state mandate increases math achievement by 2.0 points (with a standard error of 1.739), which is 9.6 percent of a standard deviation and 1.8 percent of the mean, reading achievement by 2.7 points (with a standard error of 1.923), which is 11.9 percent of a standard deviation and 2.0 percent of the mean, and science achievement by 2.2 points (with a standard error of 1.328), which is 15.9 percent of a standard deviation and 3.8 percent of the mean.[28] 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 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 as shown in italics in Table 5.

[28] As shown in Appendix Table 7, the estimates for offering breakfast through the SBP, math, reading, and science are 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.

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 set of rows of Table 5. 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 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 similar to the unadjusted differences in means for students in schools within five percentage points of the state thresholds, as shown in the third set of rows of Table 5. Students in schools with a binding state mandate are 40.4 percentage points (with a standard error of 0.147) 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 percentage points 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 set of rows of Table 5. Exceeding the state threshold increases the probability that a school participates in the SBP by 46.8 percentage points (with a standard error of 0.059). There is also a large increase at the state thresholds for math, reading, and science; math achievement increases by 7.6 points (with a standard error of 3.432), reading achievement increases by 6.6 points (with a standard error of 3.014), and science achievement increases by 5.5 points (with a standard error of 0.393).[29] These results are shown graphically in Figure 4 and these graphs highlight the discontinuity at the state thresholds in schools participating in the SBP. These estimates are large in magnitude and larger than the unadjusted differences in means.[30] Although the magnitudes are not precisely estimated so that the 95 percent confidence intervals would include the DD estimates for the entire sample, these RD estimates provide further evidence of an increase in achievement as a result of a binding state mandate.

With the ECLS-K data, it is possible to implement a variety of falsification tests by examining outcomes that should not be affected by the availability of the SBP. As shown in Table 6, 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.[31] Thus, these results suggest that 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.

Another benefit of the ECLS-K data is the ability to examine important sources of heterogeneity in the impact of a binding state mandate and the availability of the SBP. Using

[29] Appendix Tables 8 through 10 display the specification checks for the RD using ECLS-K data. As shown in Appendix Table 8, there is no statistically significant discontinuity in race, sex, family background, and predicted test scores based on all observable characteristics 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 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 9, so that the reported results are conservative estimates of the impact of the availability of the SBP. Finally, RD 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 10.
[30] The magnitude is driven by the skewness of the distribution of achievement near the state thresholds, as shown in Appendix Figure 3 for math achievement, and the large increase in math achievement for the left tail of the distribution.
[31] As shown in Appendix Table 8, RD estimates for these outcomes are also not statistically significant.

administrative records to examine the determinants of participation, Moore et al. (2009) find that students who qualify for a free or reduced-price breakfast, males, and students with larger family sizes are more likely to consume breakfast through the SBP. The first three sets of rows in Table 7 displays the DD estimates of the impact of a binding state mandate for these three groups of students. Low-income students with a family income of less than $40,000, which is approximately equal to 185 percent of the poverty guidelines in 2004, benefit more than their higher income peers. A binding state mandate increases math achievement by 8.079 points (with a standard error of 2.869) or 37.2 percent of a standard deviation, reading achievement by 9.679 points (with a standard error of 3.827) or 40.9 percent of a standard deviation, and science achievement by 7.148 points (with a standard error of 2.175) or 52.5 percent of a standard deviation and each of these estimates are larger than the corresponding estimate for all students in Table 5. The increases for males and students with a large family size, defined as greater than five, are also larger than the estimates for all students in Table 5. These results suggest that the influence of being required to offer breakfast through the SBP is greater for students who are more likely to consume the breakfast.

Another potential source of heterogeneity is the levels of the state thresholds since the thresholds range primarily from 10 to 40 percent. Higher thresholds could induce higher poverty schools to offer breakfast and the resulting impacts on achievement could be different than lower thresholds influence on lower poverty schools. To examine this source of heterogeneity, I include an interaction term combining the binary variable denoting that the school is above the state threshold with the mean-centered threshold value. As shown in Table 7, none of these interaction terms are statistically significant, which suggests that the influence of a binding mandate is constant for threshold values ranging from 10 to 40 percent.

The final source of heterogeneity to examine is the years of potential availability of the SBP. Since schools do not stop offering breakfast through the SBP once a state mandate is binding, students may be exposed to the SBP for multiple years and the proper interpretation of the estimates above may be the cumulative availability of the SBP throughout elementary school instead of the annual impact. Of the set of students who attended a school required to offer breakfast in the fifth grade, 52 percent attended a school for all six years (grades K-5) that is required to offer breakfast through the SBP, another 14 percent attended such a school for at least three years, 34 percent attended such a school for one or two years, and the mean is 4.17 years. The final set of rows in Table 7 displays the DD estimates where the primary variable of interest is the number of years above the state threshold instead of a binary variable indicating that the school is currently above the threshold. Each year of attending a school with a binding state mandate increases math achievement by 0.572 points (with a standard error of 0.204) or 2.7 percent of a standard deviation, reading achievement by 0.470 points (with a standard error of 0.270) or 2.0 percent of a standard deviation, and science achievement by 0.130 points (with a standard error of 0.132) or 0.9 percent of a standard deviation.

### c. Evidence on the Mechanisms

A further benefit of the ECLS-K data is the ability to examine the mechanisms through which the availability of the SBP influences 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 and attendance.[32] As shown in Table 8, a binding state mandate increases the probability that a student eats breakfast in school by 5.6

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[32] In results not shown, I also examine the influence on non-cognitive skills and find no relationship between a binding state mandate and teachers' reports of approaches to learning, self-control, interpersonal skills, externalizing problem behaviors, or internalizing problem behaviors.

percentage points (with a standard error of 0.045), but this increase is not statistically significant. Estimates of the relationship between having a binding state mandate and breakfast consumption in the school that is free or reduced-price, as reported by the parent, show that a binding state mandate increases the probability that a student eats a subsidized breakfast by 5.6 percentage points (with a standard error of 0.028) or 22 percent of the mean, which implies that the availability of the SBP increases breakfast consumption at school by 17 percentage points.[33]

The impacts on the number of days eating breakfast with a family member and the total days per week that a student eats breakfast, which includes breakfast consumed at home, are small in magnitude and not statistically significant. These estimates are consistent with the results of Bhattacharya, Currie, and Haider (2006), which concludes that the availability does not change whether a student eat breakfast but does influence what a student eats for breakfast.

Further evidence that the availability of the SBP influences what a student eats for breakfast is shown in panels B and C of Table 8. 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.

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[33] The impact of SBP participation could be calculated by dividing the previous estimates by 0.17, which would suggest large impacts of participation, if breakfast consumption at school was the only mechanism through which the availability of the SBP influences achievement. However, measurement error in the parents' reports of breakfast consumption is likely to bias these estimates, unlike the school administrators' reports of the availability of the SBP as discussed above. Gundersen, Pepper, and Kreider (2012) document the significant influence of misclassification error on the estimated effects of consuming lunch through the NSLP and Paxton-Aiken et al. (2002) and Moore et al. (2009) document that misclassification error from parental reports is more severe for SBP participation than NSLP participation. Thus, these estimates are merely suggestive of the influence of a binding state mandate on breakfast consumption at school and I refer to the impact of the availability of the SBP on achievement as the primary estimates in the paper.

The results in panel D of Table 8 suggest that the availability of the SBP does reduce unexcused absences and tardiness by a large amount relative to the mean, but these estimates are not estimated precisely and the estimates relative to the mean for excused absences and tardiness are similarly large but in the opposite direction. Thus, it is difficult to conclude that the availability of the SBP increases achievement because of an increase in attendance. Overall, these results from Table 8 suggest that the availability of the SBP improves nutrition and that the improvement in nutrition contributes to the increase in achievement.

## VI. Discussion and 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. To increase the availability of the SBP in schools, approximately one-third of states require some schools to offer breakfast through the SBP if the percent of FRP students exceeds a specific threshold. This paper adds to the literature by estimating the impact of the availability of the SBP in schools on cognitive achievement using multiple data sets and different estimation strategies based on these state requirements.

Using ECLS-K data, I find that 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. A binding state mandate increases math achievement by approximately 8 or 9 percent of a standard deviation in the NAEP data based on the different estimation strategies and by at least 9 percent in the ECLS-K data. Thus, the availability of the SBP increases math achievement by at least 23 percent of a standard deviation in the NAEP data and at least 29 percent of a standard deviation in the ECLS-K data, which is a significant improvement. Since students who attend a school required to offer the SBP have done so for approximately four years based on the ECLS-K, these magnitudes reflect the cumulative availability of the SBP throughout much of elementary school. Attending a school that offers breakfast through the SBP for one year increases math achievement by 8 percent of a standard deviation. These positive results stand in stark contrast to the differences in means based on school-level participation in the SBP and highlight the significant selection on observed and unobserved characteristics associated with the availability of the SBP that is consistent with previous literature.

In support of the conclusion that the results estimate the effect of the availability of the SBP, 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. 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 and decreases the consumption of unhealthy beverages, but does not influence attendance. 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.

Overall, these results suggest that the persistent exposure to the relatively more nutritious breakfast offered through the SBP throughout elementary school can yield important gains in achievement. 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.

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.

Bryan, Janet, Saskia Osendarp, Donna Hughes, Eva Calvaresi, Katrine Baghurst, and Jan-Willem van Klinken (2004) "Nutrients for Cognitive Development in School-aged Children," *Nutrition Reviews*, 62(8), 295-306.

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.

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 (1997) *School Breakfast Scorecard 1997*, Washington, DC: Food Research and Action Center.
Food Research and Action Center (1999) *School Breakfast Scorecard 1999*, Washington, DC: Food Research and Action Center.
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.
Gundersen, Craig, Brent Kreider, and John Pepper (2002) "The Impact of the National School Lunch Program on Child Health: A Nonparametric Bounds Analysis," *Journal of Econometrics*, 166, 79-91.
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.
Imberman, Scott A. and Adriana D. Kugler (2012) "The Effect of Providing Breakfast in Class on Student Performance," Journal of Policy Analysis and Management, 33(3), 669-699.
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.

Leos-Urbel, Jacob, Amy Ellen Schwartz, Meryle Weinstein, Sean Corcoran (2013) "Not Just for Poor Kids: The Impact of Universal Free School Breakfast on Meal Participation and Student Outcomes," *Economics of Education Review*, 36, 88-107.

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. (2013) "The Impact of Chile's School Feeding Program on Education Outcomes," *Economics of Education Review*, 32, 122-139.

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.

Moore, Quinn, Lara Hulsey, and Michael Ponza (2009). "Factors Associated with School Meal Participation and the Relationship between Different Participation Measures," Mathematica Policy Research, Inc. Contractor and Cooperator Report No. 53.

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.

Paxton-Aiken, Amy E., Suzanne Domel Baxter, Joshua M. Tebbs, Christopher J. Finney, Caroline H. Guinn, and Julie A. Royer (2012) "How Accurate are Parental Responses Concerning Their Fourth-Grade Children's School-Meal Participation, and What is the Relationship Between Children's Body Mass Index and School-Meal Participation Based on Parental Responses?" *International Journal of Behavioral Nutrition and Physical Activity*, 9(30), 1-9.

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.

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

Todd, Petra E. and Kenneth I. Wolpin (2003) "On the Specification and Estimation of the Production Function for Cognitive Achievement," *Economic Journal*, 113: F3-F33.

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

United States Department of Agriculture (2014) Supplemental Nutrition Assistance Program Participation and Costs, http://www.fns.usda.gov/sites/default/files/pd/SNAPsummary.pdf

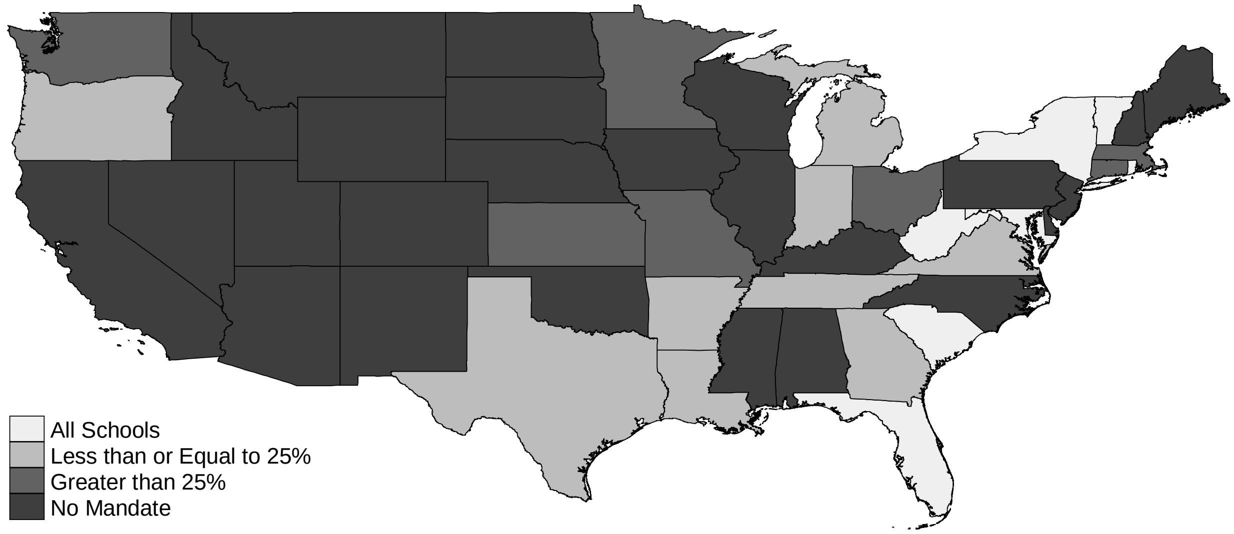
van der Klaauw, Wilbert (2008) "Breaking the Link between Poverty and Low Student Achievement: An Evaluation of Title I," Journal of Econometrics, 142, 731-756.

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.

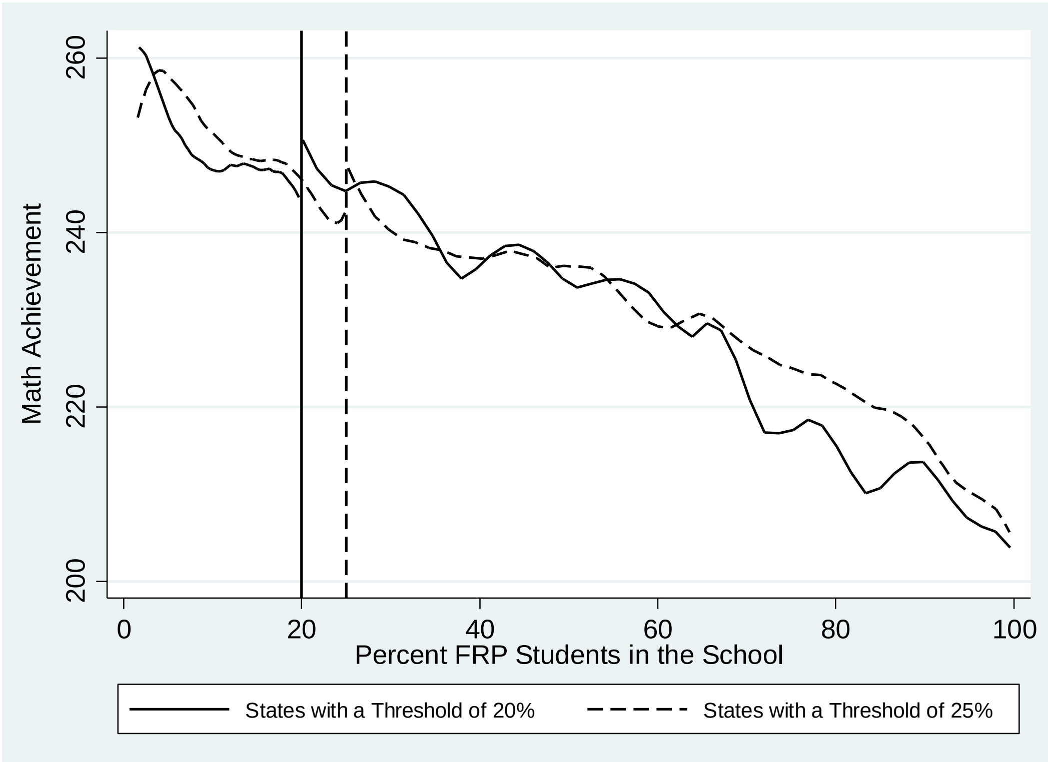
Winicki, Joshua and Kyle Jemison (2003) "Food Insecurity and Hunger in the Kindergarten Classroom: Its Effect on Learning and Growth," *Contemporary Economic Policy*, 21(2), 145-157.

**Figure 1: State Mandated Thresholds**



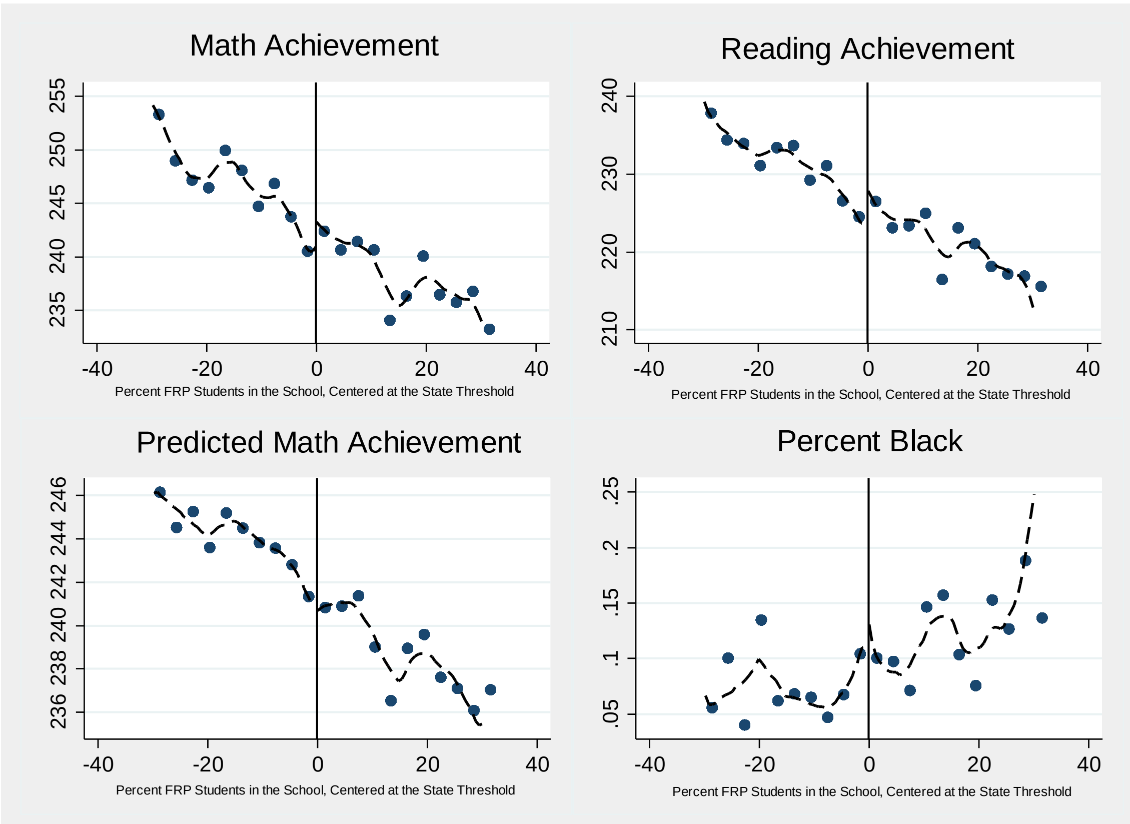

Notes: If the percent of free and reduced-price eligible students in the school exceeds the state mandated threshold, then the school is required to provide breakfast through the School Breakfast Program. These thresholds are based on state laws in 2004.
Source: See Appendix Table 1.

**Figure 2: Trends in Math Achievement**



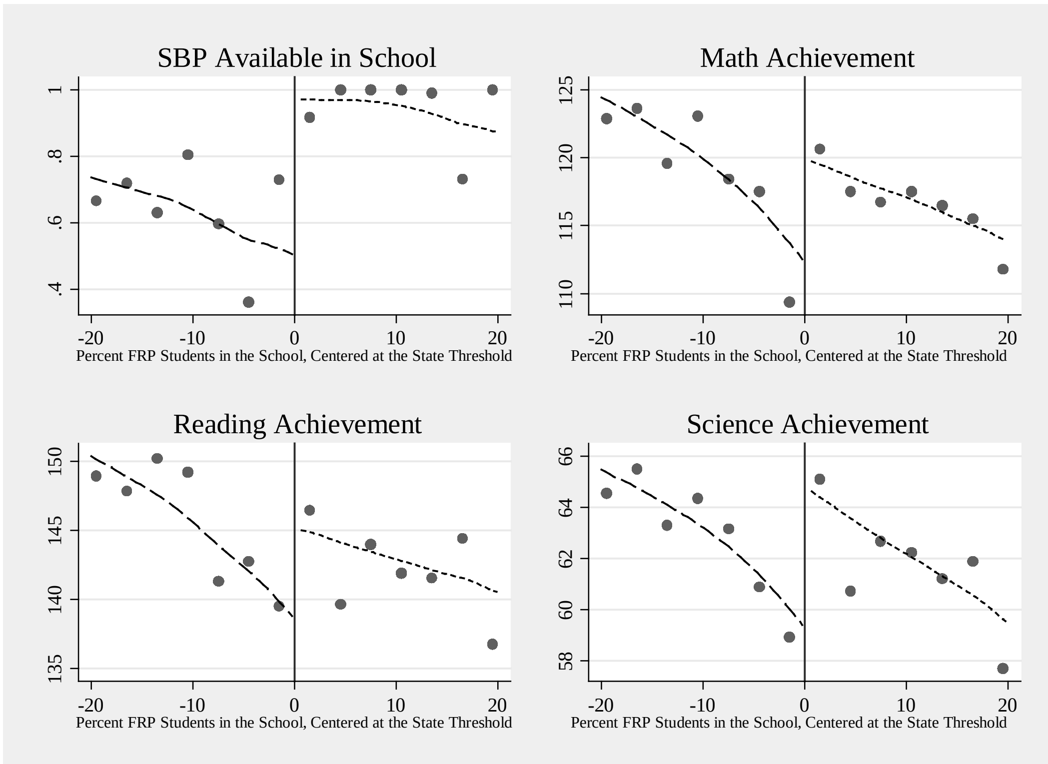

Notes: The dashed lines are the estimates from local linear regressions with a triangle kernel and a bandwidth of 5. These graphs are estimates for the first plausible value for math achievement. The solid line shows the mean achievement scores for all states with a threshold of 20 percent and the dashed line shows the mean achievement scores for all states with a threshold of 25 percent. The corresponding vertical lines highlight the threshold values.
Source: National Assessment of Education Progress (NAEP) 2003 Grade 4 Math Assessment

**Figure 3: 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 three percentage points. The dashed lines are the estimates from local linear regressions with a triangle kernel and a bandwidth of 5. The top panel displays estimates for the first plausible value for math and reading achievement. Predicted math achievement is constructed using the observable characteristics included in Table 2.
Source: National Assessment of Education Progress (NAEP) 2003 Grade 4

**Figure 4: 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: Determinants of State Thresholds Requiring Schools to Offer Breakfast through the School Breakfast Program**

| | Mandate | Mandate | Threshold | Threshold |
|---|---|---|---|---|
| NAEP 8th Grade Math 1990 | 0.0049 | | 0.0325 | |
| | (0.0178) | | (0.0311) | |
| NAEP 4th Grade Math 1992 | | 0.0190 | | -0.0104 |
| | | (0.0223) | | (0.0252) |
| Percent HS Graduates | -0.0187 | -0.0329 | -0.0798 | -0.0129 |
| | (0.0262) | (0.0231) | (0.0581) | (0.0244) |
| Unemployment Rate | 15.3728 | 17.3593 | -0.9367 | -0.5571 |
| | (7.3469) | (6.8972) | (5.7252) | (5.5255) |
| Poverty Rate | -0.0283 | -0.0221 | 0.0119 | -0.0309 |
| | (0.0246) | (0.0271) | (0.0271) | (0.0385) |
| Percent White | 1.5391 | 1.1070 | -10.3779 | -2.4401 |
| | (1.8482) | (1.9152) | (7.9914) | (2.6246) |
| Percent Black | 2.0377 | 1.4876 | -10.9203 | -2.7907 |
| | (1.3574) | (1.3730) | (8.3373) | (2.8854) |
| Percent in Rural Area | -0.0158 | -0.6079 | -2.8514 | -0.9127 |
| | (0.6331) | (0.7019) | (1.8903) | (0.6600) |
| Observations | 38 | 42 | 11 | 13 |

Notes: The first two columns display average partial effects from probit regressions examining the determinants, using state characteristics in 1990 or 1992, of whether a state adopted a mandate requiring schools to offer breakfast through the SBP by 2003. The last two columns display OLS coefficients examining the determinants of the value of the thresholds that are adopted. Heteroskedasticity-robust standard errors are shown in parentheses.
Sources: U.S. Census Bureau; National Assessment of Education Progress (NAEP)

## Table 2: 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) |
| Observations (math / reading sample) | 53430 / 51640 | 35900 / 34260 | 17520 / 17380 | 3040 | 2560 | 480 | 2240 | 800 |

Notes: Standard deviations in parentheses.  Sample sizes rounded to the nearest 10 to comply with NCES 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 3: 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) | (1.242) | (1.124) | (1.432) | (1.820) |
| | [0.077] | [0.093] | [0.091] | [0.054] | [0.052] | [0.122] |
| Observations | 53430 | 20110 | 53430 | 51640 | 19690 | 51640 |
| Sample | All | Within 20 pp. | All | All | Within 20 pp. | All |

Notes: Standard errors are shown in parentheses. For the difference-in-differences specifications, standard errors 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 to comply with NCES nondisclosure requirements.
Source: NAEP 2003 Grade 4

**Table 4: Estimates of the Influence of a Binding State Mandate on Other Characteristics, NAEP Data**

| | Mean | DD Estimate | RD Estimate |
|---|---|---|---|
| Age (months) | 120.085 | 0.005 | 0.153 |
| | (5.011) | (0.212) | (0.302) |
| Female | 0.489 | -0.012 | 0.012 |
| | (0.500) | (0.011) | (0.025) |
| Black | 0.070 | 0.042 | 0.020 |
| | (0.255) | (0.044) | (0.017) |
| Hispanic | 0.043 | -0.040 | 0.005 |
| | (0.201) | (0.049) | (0.014) |
| Other Race/Ethnicity | 0.042 | 0.022 | 0.017 |
| | (0.201) | (0.013) | (0.014) |
| Eligible for Free School Meals | 0.118 | -0.014 | 0.027 |
| | (0.310) | (0.016) | (0.016) |
| Eligible for Reduced-Price School Meals | 0.049 | -0.009 | 0.016 |
| | (0.208) | (0.012) | (0.011) |
| Urban Residence | 0.127 | 0.044 | -0.022 |
| | (0.333) | (0.075) | (0.023) |
| Rural Residence | 0.296 | 0.081 | -0.239 |
| | (0.456) | (0.074) | (0.022) |
| Percent Minority | 13.74 | -4.813 | 8.196 |
| | (16.50) | (3.226) | (1.269) |
| School Size | 524.50 | 8.896 | 7.633 |
| | (186.47) | (20.301) | (9.687) |
| Predicted Math | 244.270 | 1.242 | -0.502 |
| | (9.009) | (0.942) | (0.542) |
| Predicted Reading | 228.438 | 1.939 | -1.292 |
| | (11.269) | (1.066) | (0.720) |
| Observations | | 53430 | 53430 |

Notes: The first column includes the means (and standard deviations) of the 17,520 observations in schools where the percent of FRP students is below the state threshold. The second column includes estimates from difference-in-differences specifications predicting each of the characteristics listed in the row heading. Each estimate is from a separate specification. In this column, standard errors that allow for clustering within states are shown in parentheses. The third column displays regression discontinuity design estimates of the discontinuity in each of the characteristics listed in the row heading. The regression discontinuity design estimates are calculated using local linear regression with a triangle kernel and a bandwidth of 5. In this column, standard errors are shown in parentheses. Sample sizes rounded to the nearest 10 to comply with NCES nondisclosure requirements.
Source: NAEP 2003 Grade 4 Math Assessment

**Table 5: 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: Impact of the SBP* | | *6.088* | *8.356* | *6.802* | |
| | | *[0.292]* | *[0.362]* | *[0.483]* | |
| | | | | | |
| DD, Sample within 20 pp. | 0.446 | 5.140 | 2.688 | 5.017 | 1180 |
| | (0.147) | (2.589) | (2.182) | (1.522) | |
| | | [0.247] | [0.116] | [0.356] | |
| *DD: Impact of the SBP* | | *11.525* | *6.027* | *11.249* | |
| | | *[0.554]* | *[0.260]* | *[0.798]* | |
| | | | | | |
| Difference in Means, Sample within 5 pp. | 0.404 | 5.653 | 3.199 | 4.482 | 240 |
| | (0.050) | (2.544) | (2.876) | (1.648) | |
| | | [0.271] | [0.138] | [0.319] | |
| *Diff. in Means: Impact of the SBP* | | *13.993* | *7.918* | *11.094* | |
| | | *[0.671]* | *[0.342]* | *[0.790]* | |
| | | | | | |
| Regression Discontinuity (RD) | 0.468 | 7.647 | 6.599 | 5.538 | 3040 |
| | (0.059) | (3.432) | (3.014) | (2.079) | |
| | | [0.367] | [0.285] | [0.393] | |
| *RD: Impact of the SBP* | | *16.334* | *14.094* | *11.828* | |
| | | *(7.538)* | *(7.186)* | *(5.079)* | |
| | | *[0.784]* | *[0.609]* | *[0.840]* | |

Notes: For the DD estimates, standard errors that allow for clustering within states are shown in parentheses. For the RD estimates, bootstrapped standard errors are shown in parentheses. The figures in brackets represent the marginal effect expressed in units of the standard deviation of the achievement score for all students in states with partial mandates. Estimates in italics represent the impact of school-level participation in the SBP where the estimates are divided by the corresponding estimates in the first column. The differences in means are estimated using a sample of students in schools within five percentage points of the threshold. The DD and RD estimates correspond 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. Additional variables for the DD specifications 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 to comply with NCES nondisclosure requirements.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

**Table 6: 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: Standard errors that allow for clustering within states are shown 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 to comply with NCES nondisclosure requirements.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

**Table 7: Heterogeneity in the Influence of a Binding State Mandate, ECLS-K Data**

| | Math | Reading | Science |
|---|---|---|---|
| Low-Income Students | 8.079 | 9.679 | 7.148 |
| | (2.869) | (3.827) | (2.175) |
| | [0.372] | [0.409] | [0.525] |
| | 1230 | 1230 | 1230 |
| Males | 4.623 | 3.801 | 3.119 |
| | (2.495) | (3.753) | (1.742) |
| | [0.222] | [0.159] | [0.225] |
| | 1540 | 1540 | 1540 |
| Large Family Size | 8.440 | 9.155 | 5.477 |
| | (3.471) | (3.337) | (2.838) |
| | [0.376] | [0.374] | [0.367] |
| | 490 | 490 | 490 |
| Interactions with Threshold Values | 0.077 | 0.107 | -0.056 |
| | (0.125) | (0.133) | (0.138) |
| | [0.037] | [0.046] | [-0.040] |
| | 3040 | 3040 | 3040 |
| Years Above State Threshold | 0.572 | 0.470 | 0.130 |
| | (0.204) | (0.270) | (0.132) |
| | [0.027] | [0.020] | [0.009] |
| | 2600 | 2600 | 2600 |

Notes: The first three panels show estimates of the impact of a binding state mandate for three groups of students who are identified in the literature as most likely to eat breakfast offered through the SBP. Low-income is defined as having family income less than $40,000, which approximately corresponds to 185 percent of the poverty guidelines for the mean family size in the sample of 4.5 in 2004 of $37,814. A large family size is defined as greater than 5, which is the top quintile of the family size distribution. Years above the state threshold measures the cumulative potential years of exposure to the SBP and is defined as the number of years that the school the student attended was required to offer breakfast based on the state mandates. Standard errors that allow for clustering within states 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 that subsample in states with partial mandates. However, the figure in brackets for the interaction with the threshold values represents the marginal effect in standard deviation units of an increase in the threshold value of 10 percentage points relative to the mean. The figure in brackets for the years above the state threshold represents the marginal effect in standard deviation units of one additional year of attending a school that is required to offer the SBP. The final numbers are the number of observations. Additional variables included are shown in Table 6. Sample sizes rounded to the nearest 10 to comply with NCES nondisclosure requirements.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort

**Table 8: Difference-in-Differences Estimates of the Mechanisms through which the Availability of the School Breakfast Program Influences Student Achievement**

| Panel A: Breakfast Consumption | | | |
|---|---|---|---|
| Eats Breakfast at School | Eats FRP Breakfast at School | Days Eating Breakfast with Family | Days Eating Breakfast |
| 0.056 | 0.056 | -0.216 | 0.165 |
| (0.045) | (0.028) | (0.207) | (0.142) |
| 2730 | 2730 | 2800 | 2800 |
| {0.335} | {0.259} | {5.537} | {5.641} |

| Panel B: Food Consumption | | | |
|---|---|---|---|
| Servings of Milk | Servings of Juice | Servings of Soda | Servings of Fruit |
| 2.719 | 1.051 | -0.830 | 1.159 |
| (1.206) | (0.795) | (0.468) | (0.563) |
| 3040 | 3040 | 3040 | 3040 |
| {10.412} | {5.020} | {6.469} | {7.435} |

| Panel C: Additional Food Consumption | | | |
|---|---|---|---|
| Servings of Salad | Servings of Potatoes | Servings of Carrots | Servings of Other Vegetables |
| -0.139 | 0.042 | 0.539 | -0.334 |
| (0.358) | (0.247) | (0.395) | (0.732) |
| 3040 | 3040 | 3040 | 3040 |
| {2.139} | {1.829} | {2.687} | {4.852} |

| 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 |
| {2.741} | {0.974} | {0.742} | {0.626} |

Notes: Standard errors that allow for clustering within states are shown in parentheses. The number below the standard errors is the number of observations. The mean of the dependent variable is listed in curly brackets. For additional notes, see Table 7.
Source: Early Childhood Longitudinal Study, Kindergarten Cohort