

**Comments Welcome
October 2005**

**Reading, Writing, and Raisinets*:
Are School Finances Contributing to Children's Obesity?**

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We thank Sara Christopher, Karenne Eng, AJ Felkey, Katharine Anderson, and Fred Yarger for excellent research assistance. Nancy Brener provided advice in using the SHPPS data. We thank Lisa Barrow, David Card, Kevin Hallock, Helen Levy, Thomas Lemieux, Nina Pavcnik, Doug Staiger, and participants in presentations at UC-Berkeley, the Chicago Fed, the College of William and Mary, Dartmouth College, the NBER Summer Institute and the University of Virginia for helpful discussions. The views expressed here are the authors' and do not necessarily represent those of the Federal Reserve Bank of Chicago or the Federal Reserve System. All errors are our own.

* This is in no way meant to impugn Raisinets, the Nestle Company or any of its other products.

Abstract

The proportion of adolescents in the United States who are obese has nearly tripled over the last two decades. At the same time, schools, often citing financial pressures, have given students greater access to “junk” foods and soda, using proceeds from these sales to fund school programs. We examine whether schools under financial pressure are more likely to adopt potentially unhealthful food policies. Next, we examine whether students’ Body Mass Index (BMI) is higher in counties where a greater proportion of schools are predicted to allow these food policies. Because the financial pressure variables that predict school food policies are unlikely to affect BMI directly, this two step estimation strategy addresses the potential endogeneity of school food policies. We find that a 10 percentage point increase in the proportion of schools in a county that allow students access to junk food leads to about a one percent increase in students’ BMI, on average. However, this average effect is entirely driven by adolescents who have an overweight parent, for whom the effect of such food policies is much larger (2.2%). This suggests that those adolescents who have a genetic or family susceptibility to obesity are most affected by the school food environment. A rough calculation suggests that the increase in availability of junk foods in schools can account for about one-fifth of the increase in average BMI among adolescents over the last decade.

I. Introduction

Over the past three decades, weight problems among children have grown dramatically. After holding fairly steady at around 5% during the 1970s, the percent of 12 to 19 year-olds that were obese doubled by the early nineties and exceeded 15 percent by 2000 (Ogden, et al., 2002).¹ At a basic physiological level, the cause of this increase in overweight status among children is clear: children must be taking in more energy than they expend. What is unclear is what has upset the balance between energy intake and expenditure.

Observers have begun to question the role played by schools, pointing in particular to declines in physical education and increases in the availability of soft drinks and snack foods. New accountability measures, which typically require that students achieve a certain minimum level on standardized tests or the school suffers consequences, may give schools an added incentive to invest resources in core academic curricula and cut back on electives. At the same time, schools may try to raise new money in order to meet the achievement goals while minimizing the need to cut non-core programs. However, the property tax reform movement during the 1970s and 1980s may have limited schools' ability to raise money through traditional means. One way schools can get extra money to maintain optional programs or strengthen core academics is through soft drink and vending contracts, or through other snack food sales. The media is rife with examples of schools cutting deals with soda and snack vending companies in order to increase their discretionary funds. For example, one high school in Beltsville, MD made \$72,438.53 in the 1999-2000 school year through a contract with a soft drink company and another \$26,227.49 through a contract with a snack vending company. The almost \$100,000 obtained was used for a variety of activities, including instructional uses such as purchasing

¹ "Obese" here is defined as a Body Mass Index (BMI) above an age-sex specific cutoff defined by the Centers for Disease control. This cutoff corresponds closely to a BMI above the 95th percentile of age-sex specific BMI

computers, as well as extracurricular uses such as the yearbook, clubs and field trips (Nakamura, 2001). District-level contracts can be even more lucrative – one Colorado Springs district, for example, negotiated a 10-year beverage contract for \$11.1 million dollars (DD Marketing, 2003).²

As school districts nationwide debate the benefits and costs of entering into contracts with soda companies or banning the sales or advertising of snacks and sodas on campus it is important to have solid information on which to base these decisions. For example, high-calorie snack foods and beverages may be so ubiquitous that adolescents will consume them whether or not they are available through the school. If that is the case, policy-makers might prefer schools to sell the foods students crave. In that way, at least students are not leaving school to buy snack food (with all the dangers that may entail) and schools can use the extra funds to students' advantage.

Thus, examining the effect of school food policies on children's weight problems is important, but it is difficult because no one data set contains information on children's height and weight, along with individual and family characteristics that may affect weight problems, and school food policies. Except for the school policies, the National Longitudinal Survey of Youth 1997 (NSLY97) has all of the necessary information for a sample of adolescents. We just need to obtain a proxy for exposure to junk food and/or beverages in school to use these data. We take advantage of the fundraising potential of school food policies to create this proxy via a two-step procedure. In the first step, we examine whether availability and advertising of snack foods and beverages in schools are related to school financial pressures, as captured by tax and

distributions from the late 1960s and early 1970s, prior to the advent of the current weight problems in children.
² While on a per pupil basis these contracts amount to only about 0.5 percent of revenues (authors' calculations based on average revenues in NCES and reports on contracts from DD Marketing), they provide a source of unrestricted funds that may be spent on elective programs.

expenditure limits, school accountability measures, state school financing rules, and relative growth in the school-aged (local) population. In the second step, we use this estimated relationship to predict exposure for adolescents in the NSLY97, and then examine whether availability and advertising of snack foods and beverages in schools can be linked to adolescent Body Mass Index (BMI).³

We find that there is a positive and often significant effect of predicted availability and advertising of snack foods and beverages on adolescent BMI. However, this relationship is driven by those with an overweight parent. We interpret our results to indicate that while for most students school food policies have no effect on their weight, for those with a family susceptibility for weight gain these policies that increase access to snack foods and beverages in school may be a contributing factor.

The paper is organized as follows. Section II provides background on the issues of school food policies and obesity in the United States. Section III describes our empirical approach and discusses our main estimates of the relationship between school food policies and finances and of the effect of school food policies on adolescent obesity. This section also discusses some alternatives to our preferred estimates. Section IV then explores the interaction of school food policy and family susceptibility to weight problems, and Section V concludes.

II. Background on School Food Policies and Obesity in the United States

Public health officials are alarmed at the increase in obesity in the United States. The increase in childhood obesity is particularly worrisome as obesity in childhood has both immediate and long-term health risks, including Type 2 diabetes, hypertension and cardiovascular disease (Ebbeling et. al. 2002), as well as contributing to low quality of life scores

³Body mass index is weight in kilograms divided by height in meters squared.

(Schwimmer et al. 2003). Using data from the National Health and Nutrition Examination Surveys (NHANES), Anderson, Butcher and Levine (2003a) show that for both children and adults, the BMI distributions for 1971-1974 and 1976-1980 are very similar, particularly in the right tail of the distribution. However, beginning with the 1988-1994 NHANES, this right tail gets thicker.⁴ The obesity “epidemic” does not appear to be a matter of a shift to the right of the entire distribution of BMI. Rather, the distributions suggest that whatever changes have taken place to upset the balance between energy in-take and energy expenditure have not affected everyone in the same way. There appears to be some fraction of the population that is particularly susceptible to obesity, and the conditions have become optimal for their disease to flourish.

It is in this setting that school food policies are currently being hotly debated. Policymakers are acting on the intuitive notion that having snacks and sodas readily accessible in schools contributes to children’s obesity.⁵ Despite movements on the legal and policy fronts, there are very few studies that address whether there is a direct relationship between school food policies and obesity.⁶ What is clear, however, is the pervasiveness of snack foods and beverages in U.S. schools. Data from the School Health Policies and Programs Study (SHPPS) from 1994 and 2000 form a nationally representative sample of schools, and include both public and private schools. As shown in Anderson, Butcher and Levine (2003a), these data reveal two clear

⁴ The timing of this change may help focus the investigation of the underlying cause in the increase in childhood obesity. Researchers might fruitfully examine things that changed for children during this period. For example, employment among mothers with young children increased in prevalence and intensity during this period. Anderson, Butcher, and Levine (2003b) examines the role of maternal employment in the probability that a child is obese and finds that increases in mothers’ hours of work can potentially explain between 12 to 35 percent of the increase in childhood obesity among the children of highly educated mothers.

⁵ For example, New York City public schools recently banned candy, soda and other sugary snacks from school vending machines (Perez-Pena, 2003), similarly the Los Angeles school district has banned the sale of soft drinks during school hours (Fried and Nestle, 2002).

⁶ Studies on related topics include Ludwig, et al. (2001), Cullen et al. (2000), and Kubik et al. (2003) who examine school food and overall nutrition. Additionally, Pateman, et al. (1995) and Weschler et al. (2001) examine the

patterns. First, availability of food and sodas from vending machines increases with grade level. While only 27 percent of elementary schools had vending machines available to students in 2000, that percentage rises to 67 percent for middle schools and to 96 percent for high schools. Second, in the few questions asked consistently across the two years, food availability has increased. For example, while 19 percent of high schools served a brand name fast food in 1994, 26 percent did by 2000.

Before examining the effect of school food policies on children's weight, we first present measures of BMI and obesity from the NHANES for comparison with the NLSY97 data used in our study. BMI for individuals in the NLSY97 is constructed from self-reported height and weight, while the NHANES includes an examination module where height and weight are measured. In table 1 we report mean, median, and 95th percentile BMI for the NLSY97 analysis sample and for the sub-sample of similarly aged (14 to 20 year old) respondents in the NHANES (1999-2000). Since we control for parental BMI in the analysis below, we also report BMI for parents in the NLSY97 and for similarly aged (32-67 year old) adults in the NHANES.

Columns 1 and 2 in Table 1 show measures of BMI for adolescents. Mean and median BMI are both slightly higher in the NHANES, where height and weight are measured by an examiner, than in the NLSY97, where height and weight are self-reported. However, BMI at the 95th percentile is about 35 in the NHANES and only about 32 in the NLSY97. This translates into about 4 percent more of the adolescents in the NHANES categorized as obese than in the NLSY97 sample. The data for adults shows a similar pattern. Both comparisons suggest that very heavy people are under-reporting their weight in the self-reported data, such that the self-

availability of junk food in schools. Finally, Carter (2002) and Fried and Nestle (2002) speculate about the correlation between school policies and adolescent obesity, but do not formally investigate the relationship.

reported data are prone to some measurement error.⁷ Note that this measurement error affects BMI, which we use as a left-hand-side variable in our estimation. Measurement error in the left-hand-side variable will not bias our results unless it is systematically correlated with the first-step variables used to create our exposure proxy. As discussed further below there does not appear to be any correlation.

III. Effect of School Food Policies on Adolescent Obesity

A. Methodology

Much of our empirical strategy is dictated by the realities of the data at our disposal. As mentioned, there are no available data sets that include school policies regarding junk food, measures of school financial pressure, and individual heights, weights and demographics. Thus, we adopt a two-step approach that is similar in spirit to two-sample IV (Angrist and Krueger, 1992, 1995). Ideally, if we had data with all of the elements described above, we could directly investigate the relationship between school policies and student obesity. However, even in this case one might be concerned about bias due to the possible endogeneity of the key food policy variables. Thus, even with access to a richer data set, we would still want to investigate the need for an instrumental variables approach. While data limitations restrict our ability to estimate the simple OLS relationship between obesity and school food policies in the full sample, our two-step methodology is essentially an IV estimator and will address any potential endogeneity.⁸

⁷ Empirical methods for correcting self-reported height and weight are developed in Cawley (1999), but make no substantive difference in this analysis, so are not incorporated here.

⁸ As discussed further below, for a sub-sample of the data, we can directly match the county-level policy data with the individual data. OLS appears to be if anything negatively biased – students exposed to junk food are less likely to be overweight, all else equal. The true IV point-estimates are then very close to those obtained using the two-step method with these data. However, the two-step method sacrifices efficiency, resulting in larger standard errors. See appendix table 2.

We use school food policy information from the SHPPS to create our proxy variable. Specifically, we try three different policies: junk food availability in schools, whether schools have “pouring rights” contracts, and whether soda and snack food advertisements are allowed at schools or school events.⁹ None of these measures is clearly the best *a priori*, they are simply different possible ways to capture exposure to unhealthy food in school. That said, “junk food” is likely the most broad measure, although it does not capture the availability of sugary beverages. The presence of soda vending machines appears almost universal in high schools, though, making it unlikely that we could estimate an effect with this method. Thus, we look only at the more extreme versions of soda availability and advertising.

We aggregate these measures of school food policy to the county level using the SHPPS school weights, where we have 451 public middle and high schools with non-missing information for our measures of school food policy. Our first step, then, estimates the fraction of schools in a county with these policies as a function of county, state, and regional characteristics.¹⁰ The county characteristics we use to predict school food policies include the growth rate of the school age population relative to total population in the county, calculated from the 1990 and 2000 U.S. Censuses.¹¹ Next, we control for the fraction of school finances that come from the state, calculated from the National Center for Education Statistics (NCES) Common Core data. The NCES provides this information at the district level and we use district

⁹ See data appendix for more details. “Junk Food Available” means that students can buy chocolate, candy, cakes, ice cream, or salty snacks (that are not fat free) from a machine or school store. “Pouring Rights” contract means the school has agreed to sell one brand of soft drinks, often in exchange for a percentage of sales or other incentive packages. “Soda or Snack Food Advertisements” means that advertisements are allowed at least at one type of school related activity or in one or more places at the school – for example, on a school bus, at a school sporting event, on school grounds, or school textbooks etc.

¹⁰ In about 10% of the counties in the SHPPS, we have data for only one school, while in another 20%, we have data on just two schools.

¹¹ Specifically, this is defined for the county as the logarithm of the 5 to 17 year old population in 2000 minus the logarithm of the 5 to 17 year old population in 1990, all divided by the logarithm of total population in 2000 minus the logarithm of total population in 1990.

enrollments to aggregate to the county level. The state characteristics include an indicator variable for whether the state has a tax or expenditure limitation and an indicator for whether the state has passed a school accountability measure.¹² We also include a vector of three region dummies, \mathbf{R} (the excluded category is the West).

Specifically, we estimate the following:

$$(1) \quad policy_c = \gamma_0 + \gamma_1 relative\ school\text{-}age\ population\ growth\ rate_c + \gamma_2 fraction\ of\ revenues\ from\ state_c + \gamma_3 tax\ limitation_s + \gamma_4 accountability_s + \gamma_5 \mathbf{R}_s + \omega_c$$

where the c subscript represents county and the s subscript represents state.¹³

The relative growth in the school-age population is meant to capture budgetary pressure on the school system, thus we expect γ_1 to be positive. If the share of children has grown relative to the share of adults, then there may be more financial pressure on schools, and they may be more likely to adopt these food policies that generate discretionary funds. Similarly, we expect γ_4 to be positive, since schools in states with accountability laws may be under pressure to meet certain performance criteria. These criteria generally take the form of standardized tests scores (not measures of students' physical health), and thus schools may divert resources toward core academics and away from other programs. In order to preserve optional programs, schools may then come up with creative ways to raise additional funds, including sales of snack foods and beverages.

The tax and expenditure limit indicator and the fraction of school revenues that come from the state are both meant to capture how difficult it may be for schools to raise additional funds for valued programs. It may be more difficult for schools to raise funds through traditional

¹² We thank David Figlio for the tax and expenditure limit indicators and Margaret Raymond for the accountability indicators. See Data Appendix Table 2 for a list of which states have tax and expenditure limits and which states have accountability measures.

¹³ Later in the section we'll investigate alternatives, such as including state fixed effects or a measure of

means in a state with strict tax and expenditure limits, thus we expect γ_3 to be positive. We also expect it to be difficult to raise local funds if it is typical for larger amounts of school funding to come from the state. Thus, we expect γ_2 to be positive. Each state has a funding formula that specifies how much of a school district's funds will come from the state.¹⁴ For this reason, we prefer to rely mainly on the variation at the state level.¹⁵ That is, we are comparing different systems, rather than focusing on different treatments within a system. Within a state this fraction tends to be negatively related to fiscal capacity, and thus potentially to individual socioeconomic status. Across states, more school funding coming from the state may reflect more difficulty for local school districts to unilaterally decide to raise funds. This difficulty may simply be political – that is the district relies more on the state because it is difficult to pass higher local property tax rates. Alternatively, the difficulty may stem from characteristics of the local tax base. For example, localities with a large commercial base may be in a better position to raise funds because the businesses pay local taxes, but do not increase the number of children requiring education. Finally, we control for region of the country (R) in both the first and second stage to control for additional factors that may influence school food policy decisions and children's obesity.

Having obtained estimates of $\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4$ and γ_5 using the SHPSS/NCES/Census county-level data, we then use these estimates to predict food policies in individual-level data from the NLSY97. Because the independent variables in the first stage vary only at the county and state level, and since we know the county of residence for the NLSY97, we can append the

socioeconomic status.

¹⁴ The most common approach is the foundation program, but other methods include a flat grant, percentage equalizing, guaranteed tax base or guaranteed equal yield programs (Sielke and Holmes).

¹⁵ In our SHPPS data, the average ranges from 32 percent in South Carolina to 75 percent in New Mexico, while in the NLSY97 data, New Hampshire has the minimum at 11 percent, and Hawaii the maximum at 88 percent. Almost 70 percent of the variation comes from across state differences. We describe the effects of using state fixed effects

appropriate fiscal, legal, and population change variables to the individual data and create predicted food policies based on the first–step estimates. This prediction can then serve as our proxy for exposure to unhealthy food in school, and we can then estimate the effect of food policy on individual weight status, controlling for additional covariates.

To do so, we use a model of the following form:

$$(2) \quad \ln(bmi)_i = \alpha + \beta_1 \text{predicted policy}_c + \beta_2 \mathbf{X}_i + \beta_3 \mathbf{F}_i + \beta_4 \mathbf{R}_i + \varepsilon_i$$

where $\ln(bmi)$ is the log of the individual’s Body Mass Index; \mathbf{X} is a set of individual-level covariates, including age, race, sex and cigarette use; \mathbf{F} is a set of family background covariates, including family income, mother’s and father’s education and the log of the responding parent’s BMI; and \mathbf{R} is a set of region dummies. Finally, we adjust the standard errors for arbitrary forms of heteroskedasticity and within county correlation. In addition, in order to adjust for the fact that the food policy is estimated, we adjust the standard errors following Murphy and Topel (1985).

B. The Relationship between School Food Policies and Finances

The results from the first step, in which we estimate equation (1) above are shown in Table 2. The first column gives the means of the independent variables while the first row gives the means for the dependent variables across the 180 counties represented in the SHPPS. First, note that all of the estimated effects for the instruments are of the predicted sign. Since higher values for each independent variable represents a higher level of local budgetary pressure, our hypothesis predicts a positive coefficient. For both junk food and pouring rights, the fraction of total revenues that come from the state is significantly positive. For both junk food and school advertising, the tax and expenditure limit indicator is significant. Thus, at least one of the

below.

variables is significant in each case. The F-statistics reported at the bottom of the table indicate that the excluded instruments combined are significant at better than the 1-percent level for both junk food and pouring rights, but are not significant at conventional levels for school advertising. Note that the standard errors are corrected for arbitrary forms of heteroskedasticity and within state correlation.¹⁶

C. The Effect of Predicted School Policies on Obesity

The results from estimating equation (2) described above are reported in Table 3. Columns (1) – (2) use junk food availability as the predicted policy, columns (3) – (4) use pouring rights, and columns (5) – (6) use soda or snack food ads. Recall that while each is a potential proxy for exposure to unhealthy food and beverages in school, junk food is likely to be the broadest measure. For each policy, the first model includes no covariates other than region dummies, while the second estimates equation (2) in full. The first thing to note is that the additional covariates have very little impact on the key policy coefficient. This result is not really unexpected, given that the policy variable is predicted based on exogenous fiscal policy measures that are unlikely to be highly correlated with the individual’s demographic background.¹⁷

Focusing on the results that include the full set of controls, the column (2) estimates imply that a 10 percentage point increase in the proportion of schools in a county that make junk food available to their students is correlated with a nearly 1 percent (0.90%) increase in students’ BMI. The results are smaller for the fraction of schools with pouring rights contracts, and

¹⁶ In this stage, the data are already at the county level, but we allow for within state correlation. In the second stage, the data is at the individual level, but we allow for within-county correlations, since the predicted policy will only vary at the county level.

¹⁷ The fact that the results do not change a great deal when we include individual measures of socio-economic status suggests that variation in our measures of school food policies is not driven by unmeasured differences in socio-economic status. Below we investigate the role of socioeconomic status more fully.

marginally significant. The results for the fraction of schools that allow advertising are smaller still and are insignificant. This result suggests that it is the actual availability of potentially unhealthy foods that affects adolescents' weight, as opposed to the type of contract the schools sign with soda purveyors or the advertising they allow.

Turning to the estimates for the other variables, in all cases the point estimates imply that females and those from richer families have lower BMIs, while blacks and Hispanics have higher BMIs.¹⁸ Perhaps the most interesting control variable is the parental BMI, which implies an elasticity of 0.22 between child and parent.¹⁹ This strong correlation provides evidence on the importance of shared genetics, shared environment or both. Finally, note that because we have more than one excluded instrument, we can construct overidentification tests for the null hypothesis that our instruments are exogenous. In all cases, we fail to reject the null hypothesis (although we come somewhat close in the case of advertisements).

D. Alternative Specifications

The evidence to this point is strongly suggestive of a role in adolescent weight problems for the availability of junk food through schools. It is important to realize, though, that budgetary pressures are likely to result in a range of school actions beyond increased food and beverage sales. To the extent that these sales are highly correlated with other things affecting student health, such as cutting physical education, we cannot separately identify the effects.²⁰ Given the lack of ideal data, the models estimated here can never be definitive. However, we

¹⁸ Note that in the NHANES females are not less likely to be obese, so our finding may be a reflection of sex-specific errors in the NLSY97 self-reported height and weight

¹⁹ Note that 83 percent of the time this parent is the biological mother, while 11% of the time it is the biological father. Another 3% are a related female guardians and the rest are mainly step-mothers. If we limit the sample to only those for whom the responding parent is the biological mother, we get nearly identical results.

²⁰ Cutting staff may be a response to budgetary pressure that we do not expect to have an effect on student health. However, to the extent the cuts are correlated with actions that are, we may still find an effect. When we replace our food policy variable in the first step with a staffing measure such as librarians or administrators per student, the instruments are all of the expected sign, but are not jointly significant. Thus, there is no significant effect in the

can explore several potential areas of concern in hopes of adding weight to the validity of our results.

First, one might be concerned that there are characteristics of individuals or places that affect BMI that are correlated with our predicted school food policy variables. For example, one might be concerned that socioeconomic status (SES), which research shows is correlated with obesity, is also correlated with our predicted food policy. While we include a rich set of individual-level controls for SES it is possible to add an aggregate measure of SES in both steps. We investigate three such measures computed at the county level: per capita income, percent black and percent college graduate. Only per capita income is significant (and then only at the 9 percent level) in predicting junk food availability. Interestingly, this significant effect on junk food availability is positive. Thus, contrary to what one might have assumed, higher SES communities are more likely to make junk food available in schools. In the second step estimation, per capita income is negative and insignificant, while the effect of junk food drops slightly to 0.062. With a standard error of 0.038, this point estimate is neither significantly different from our preferred estimate in Table 3 or from zero.

One may still be concerned that unobserved variables resulting in spurious correlation are driving our results. Presumably, any such spurious correlation would apply to both student's BMI and their parent's BMI. However, any true impact of food policies in school should affect only the students, not their parents. Thus, as a falsification exercise we use the parental BMI as the dependent variable in the second step.²¹ The coefficient (standard error) on junk food in this specification is -0.018 (0.045), which is significantly different from the result for students, and

second step.

²¹ We drop the student-specific covariates of age, sex and smoking behavior, but add student BMI to provide for the role of genetics.

not significantly different from zero.²² Thus, it does not appear that our main results are being driven by some simple form of spurious correlation due to unobservables.

Another concern is that our state-level variables are really only capturing fixed state effects. In order to see whether our state variables are merely picking up across state differences, we estimated a set of “placebo” results where we estimated the first stage with only a full set of state dummies, but excluded these from the second stage. If this had given us similar results to those reported in Table 3, we would have been concerned that our instruments were working through unobserved state differences, as opposed to through the budgetary pressures posited above. However, we find no effect of the food policy variables when predicted from state fixed effects.

One might also worry, though, that state fixed effects belong in both the first and second stage (i.e. that there are unobserved characteristics at the state level that drive both food policies and adolescent BMI). Because much of the variation in our policy variables is at the state level via differences in accountability and tax and expenditure limitations, we allow only for region, rather than state fixed effects. Nonetheless, if we replace our region dummies with state dummies (and thus drop the two state-level instruments) the effect of junk drops slightly (in this case to 0.074), but again is not significantly different from our preferred estimate. Precision is lost, however, as the two remaining instruments are only significant at the 6 percent level in the first stage.

Finally, for a nonrandom subset of the data, we can match the county-level policy from the SHPPS data to the individual-level data from the NLSY97.²³ There are 1007 individuals,

²² The result with no control variables is also significantly different from the parallel model for students and not significantly different from zero.

²³ Data Appendix Table 1 shows summary statistics for all the variables in the overall and matched samples of the NLSY97. The means are very similar for the 2 samples, especially for BMI. The main differences seem to be that

living in 78 different counties for whom we can perform this match. As a check on our two-step procedure, we estimate several models with these matched data. First, we estimate equation (2) using OLS, where “predicted policy” is no longer predicted, but is the actual fraction of sampled SHPPS schools in the county reporting the policy. We then estimate the same model by IV, using the state and county legal, finance, and population change variables from equation (1) as the excluded instruments. Finally, we estimate the two-step procedure on the smaller matched sample and compare these results with the actual IV results. The first stage results are reported in Appendix Table 1. The second stage results are reported in Appendix Table 2.

The point estimates from the two-step and IV models are very similar to each other, and to those in Table 3. However, the smaller sample size results in relatively large standard errors, such that none are significant at conventional levels.²⁴ For junk food, recall that in Table 3 the estimated effect was 0.090, with a standard error of 0.045. The IV model in the matched sample produces an estimated effect of 0.140, but with a standard error of 0.084. Standard errors are even larger with the two-step method. The matched sample two-step procedure yields a slightly larger estimate of 0.160, with a standard error of 0.117. Based on the matched sample, we conclude that our two-step method is producing estimates similar to what would be obtained from a more standard IV model, but that we pay a price with slightly larger standard errors.

A perhaps more interesting comparison is that between the OLS and IV estimates for the matched sample. The OLS point estimates are uniformly smaller (between 0.019 and 0.034) than the IV or two-step estimates, and not significantly different from zero. The implication, then, is that the OLS estimates are biased downward. One possibility is that the types of areas with more junk food, pouring rights contracts and snack food ads are the types of areas for which

there are more respondents in the West and fewer in the South in the matched sample.

²⁴ Recall there are only 78 counties represented in these matched data, greatly reducing the variation used to estimate

other unobservables would tend to produce leaner adolescents.²⁵ For example, suppose that parental demand for better academic achievement, more extracurricular activities (or both) is behind schools raising additional funds through food policies. These same demanding parents may provide more healthful foods and exercise opportunities in their homes than less involved parents, resulting in a negative bias in the OLS estimates. This possibility is supported by the earlier finding that junk food availability seems to be positively correlated with SES. Alternatively, simple attenuation bias due to measurement error in the policy variable may explain the larger IV estimates.

Overall, then, it appears that while our two-step procedure can only ever be suggestive of the positive effect on adolescent BMI of the availability of junk food through schools, many potential problems can be ruled out. Additionally, the value of the two-step procedure as an IV estimator is apparent, but perhaps not in the manner expected. It appears that schools in better off communities are more likely to offer junk food to their students. Thus, even though food and beverage availability can be predicted by budgetary pressures, it is not the low SES areas that turn to food and beverage sales to raise money.

IV. The Interaction of School Food Policy and Genetics (or Family Susceptibility)

The overall results can be summarized as implying that a 10 percentage point increase in the proportion of schools with junk food is correlated with about a 1 percent higher BMI for the average student. There are smaller and often insignificant effects for the other food policies examined here. One should not read the estimates in Table 3, however, as implying that every student exposed to such food policies will increase their BMI by 1 percent. A fairly large

the policies.

²⁵ Hausman tests for whether the policies are exogenous reject exogeneity in the cases of junk food availability and

literature exists documenting a strong genetic component to weight (e.g. Grilo and Pogue-Geile, 1991). At the same time, the increases in obesity seen over the past 20 years clearly cannot be attributed to changes in the gene pool. Thus, it seems reasonable to expect that some portion of the population has a genetic susceptibility for weight gain, and under certain conditions will, in fact, be more likely to gain weight. The idea of a genetic predisposition for weight gain is at the heart of the theory of the “thrifty gene” by pioneering geneticist James Neel (Neel, 1962). In studying the Pima Indians, he theorized that in difficult times, when many Pima died of starvation, the survivors had a genetic advantage in storing energy as fat. This “thrifty gene” was then passed on to future generations. In modern times, when the Pima live in an environment of relative caloric abundance, this genetic predisposition toward more efficient fat storage results in high rates of obesity.

It is with this idea of the interaction between nature and nurture in mind that we estimate equation (2) separately by parental weight status. Table 4 shows results separately for those whose responding parent is normal weight ($BMI < 25$), overweight ($25 \leq BMI < 30$), and obese ($BMI \geq 30$). For completeness we show the results for all the policies, although only those for junk food availability are significantly different from zero. While it is difficult to get precise estimates for these smaller subgroups (especially the obese parent group), the effect of junk food on adolescents whose parents are overweight is statistically significantly different from those whose parents are normal weight.²⁶ For the students with a normal weight parent, there is essentially no effect of junk food (or any of the other policies) on their BMI. However, for those whose parent is overweight, a 10 percentage point increase in the proportion of schools with junk food availability increases their BMI by over 2 percent (2.21%). The estimates for the other

snack food and beverage advertising, suggesting that instrumenting for these policies is appropriate.

²⁶ We reject that the estimates are the same with a p-value of 0.047.

school food policies are less precise. However, in each case, the point estimates for those with overweight parents are much larger. Thus, there is evidence that for those who are genetically susceptible to weight gain, the school environment may play an important role. At the same time, for the 44 percent of students with normal weight parents, the school food policy makes no difference at all.

V. Summary and Avenues for Future Research

Researchers and public health officials are currently at a loss to explain the rapid rise in weight problems among children and adolescents. While it is clear that weight gain is attributable to taking in more energy than one expends, it is unclear what has upset the balance between energy intake and expenditure in recent decades. Thus, it is important to consider the environmental factors that may affect either the intake or expenditure of energy. In looking at adult obesity, Cutler, Glaeser and Shapiro (2003) point to technological innovations over recent decades that have lowered the time cost of food consumption. The result of these lower time costs is increased caloric intake. In the adolescent context, the increasing number of schools that allow students access to junk food or provide vending machines for student use might be considered examples of this type of technological innovation.

Perhaps not surprisingly, then, policy makers have begun to point to school food policies as potentially important contributors to student weight problems. Although no solid evidence currently exists on this link, several large school districts have banned or severely restricted the availability of sodas and snack foods in schools. This paper takes a first step at assessing the effect of school food policies on adolescent weight.

We find that schools that are under financial pressure (as captured by our available data) are more likely to make junk food available to their students, have pouring rights contracts, and allow food and beverage advertising to students. We use measures that capture financial pressure to predict the fraction of schools in a county with these particular food policies, and then estimate the effect of the fraction of schools in a county with these food policies on adolescent BMI. First, this two-step method is the only way to examine this question since there are no data with information on students' BMI and their schools' food policies. Second, however, this method is meant to give us variation in school food policies that is correlated with schools' fiscal capacity, but not directly correlated with unobservable factors linked to the prevalence of unhealthy weights among the students.

We find fairly robust evidence that an increase in the proportion of schools making junk food available to students is linked to an increase in students' BMI. Our results for the other school policies, pouring rights contracts and food and beverage advertisements, are smaller and less precise. The results suggest that a 10 point increase in the percentage of schools in a county that allow their students access to junk food leads to a 1 percent increase in students' BMI. Since average weight for adolescents in this sample is about 148 pounds, this translates into about 1.5 extra pounds per 10 percentage point increase in availability.

This result, however, masks large differences between those who we would think have a family or genetic susceptibility to obesity and those who do not. For those students with normal weight parents, there is no effect of school food policies on their BMI. However, for students with overweight parents, the effect of a 10 percentage point increase in schools making junk food available to students is a greater than 2 percent increase in students' BMI. Since the average weight among adolescents with an overweight parent is 166 pounds, this translates into 3.3 extra

pounds per 10 percentage point increase in junk food availability. This is consistent with the facts of the obesity epidemic: people in the right hand tail of the BMI distribution have been putting on weight more rapidly than those in the rest of the distribution. As mentioned earlier, there appears to be a portion of the population that is susceptible to obesity, and the current environment is one that promotes their condition. For students with this susceptibility, these school food policies appear to be part of the environment that encourages their propensity to gain weight.

Currently, policy makers are acting to reduce access to junk food and soda in a number of school districts around the country, with the express purpose of curbing adolescent obesity. We can do a rough “back of the envelope calculation” to bound how much of the recent increase in adolescent BMI may be attributed to the increased availability of such foods in schools over the last decade.²⁷ Data from the 1994 and 2000 waves of the SHPPS show that the percentage of high schools giving their students access to vending machines increased from 88 percent to 96 percent, or by 8 percentage points. Unfortunately, the 1994 SHPPS data do not allow us to calculate the fraction of schools giving access to junk food, and “junk food availability” and “access to a vending machine” are not the same thing.²⁸ Junk food may be available through cafeterias and school stores, for example, and vending machines may stock healthful snacks. Thus, for this rough calculation, we assume that the *increase* in access to junk food is the same as the increase in access to vending machines. Our estimates for the impact of junk food availability on adolescent BMI imply that an 8 percentage point increase in the number of schools allowing students access to junk food would translate into about a 0.8 percent increase in

²⁷ This calculation uses the authors’ calculations from the NHANES and SHPPS data reported in Anderson, Butcher, and Levine (2003a) tables 1 and 6.

²⁸ In particular, only about 75 percent of schools give students access to foods we have defined as “junk food” in 2000, while 96 percent give students access to a vending machine.

BMI on average. Data from the NHANES show that BMI among 12-19 year olds increased by about 3.5 percent between the 1988-1994 and the 1999-2000 interviews. Roughly then, about a fifth (22%) of the average increase in adolescent BMI could be attributed to the increase in availability of junk food in schools.²⁹

Thus, policy makers may be disappointed if they are expecting reductions in junk food availability in schools, for example, to be a “magic bullet” in the fight against adolescent obesity. Future research might fruitfully examine the impact of these changes on the ground in New York and Los Angeles and other school districts where they have banned certain “junk foods.” Evaluations of the impact will need to consider which products are allowed to substitute for soda and “junk” foods (for example, fruit juices, which are allowed under most of these revised school policies, often have just as many calories as non-diet soda). In addition, evaluators should take into account the benefits of existing school food policies. If it is the case that existing food policies help generate funds for valuable programs, then the benefit (potentially to all students) needs to be weighed against the health costs borne by the fraction of students with a susceptibility to obesity.

²⁹ One should not assume that just because we estimate a larger impact of junk food availability on BMI for adolescents with an overweight parent that increases in junk food availability in school are responsible for a larger proportion of the increase in BMI among this group. The percentage increase in BMI (the denominator in this calculation) is likely larger for this group as well.

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Table 1: Comparison of BMI and Obesity Across Data Sets

	NHANES 1999-2000	NLSY97 1999 Panel	NHANES 1999-2000	Parent's of NLSY97 1999 Panel
Age	14-20	14-20	Women 32-67	32-67
BMI Mean	24.07 (5.47)	22.99 (4.63)	28.52 (7.25)	26.53 (5.87)
BMI Median	22.77	21.95	27.55	25.10
BMI 95 th Percentile	34.8	31.93	41.93	37.76
Fraction Obese	0.152 (0.359)	0.109 (0.312)	0.373 (0.484)	0.228 (0.419)
No. of Obs.	1742	3482	1293	3482

Notes: Summary statistics and standard deviations (in parentheses) from authors' calculations from the 1999-2000 National Health and Nutrition Examination Survey (NHANES) and the 1999 panel of the National Longitudinal Survey of Youth 1997 cohort. In the NLSY97 data on parent's BMI is for the responding parent: 83% are the biological mothers, 10% are the biological fathers, 3% are related female guardians, 2% are stepmothers. To come close to matching this, the NHANES data are for women in the relevant age range. The data are weighted using sample weights.

Table 2: First Stage Predictions of Food Policies

	Mean of Independent Variable (Std. Dev.)	Fraction of Schools in County in which can Purchase Junk Food	Fraction of Schools in County with “Pouring Rights” Contracts	Fraction of Schools in County that allow Food Ads. at School
Mean of Dep. Var. (Std. Dev.)		0.748 (0.352)	0.671 (0.405)	0.441 (0.406)
Share of Total Rev. from State Sources	0.495 (0.142)	0.350 (0.157)	0.502 (0.239)	0.371 (0.241)
State has Tax and Expenditure Limits	0.472 (0.501)	0.113 (0.061)	0.077 (0.059)	0.119 (0.061)
1990 to 2000 Relative Growth Rate in County Pop. Aged 5-17	0.939 (10.18)	0.0003 (0.0016)	-0.0004 (0.0025)	0.0020 (0.0020)
State has School Accountability Rules	0.856 (0.353)	0.070 (0.100)	0.113 (0.073)	-0.042 (0.102)
Northeast	0.156 (0.363)	0.102 (0.089)	-0.061 (0.139)	-0.102 (0.122)
Midwest	0.261 (0.440)	-0.156 (0.068)	0.212 (0.071)	0.130 (0.095)
South	0.372 (0.485)	0.047 (0.071)	0.140 (0.075)	0.233 (0.077)
Constant		0.469 (0.121)	0.193 (0.151)	0.131 (0.167)
No. of Observations	180	180	179	180
R-squared		0.1334	0.1058	0.1344
F-statistic for excluded instruments		3.88	4.91	2.04
p-value for excluded instruments		0.0094	0.0026	0.1069

Notes: Dependent variables come from public middle and high schools sampled in the 2000 wave of the School Health Policy and Programs Study (SHPPS). SHPPS school weights are used to aggregate the data to the county level. Revenues come from the NCES Common Core Data for each district. District enrollment is used to aggregate the data to the county level. Growth in county population of children aged 5-17 relative to total county population growth from 1990 to 2000 comes from the U.S. Census. See data appendix for more details. See data appendix table 2 for information on which states have property tax revenue limits and which have accountability laws. “Junk Food Available” means that the students can buy chocolate, candy, cakes, ice cream or salty snacks (that are not fat free) from a machine or school store. “Pouring Rights” contracts means the school has agreed to sell one brand of soft drinks. “Soda or Snack Food Advertisements” means that advertisements are allowed at least at one type of school related activity or in one or more places at the school – for example, on a school bus, at a school sporting event, on school grounds, or school textbooks etc. Standard errors (in parentheses) are adjusted for arbitrary correlation within the state.

Table 3: Estimated Effect of Predicted School Food Policies on Ln(BMI)
Public School Students in the NLSY 1997

	Dep Var: Ln(BMI) Policy: Junk Food Available	Dep Var: Ln(BMI) Policy: Junk Food Available	Dep Var: Ln(BMI) Policy: Pouring Rights	Dep Var: Ln(BMI) Policy: Pouring Rights	Dep Var: Ln(BMI) Policy: Beverage or Snack Food Ads.	Dep Var: Ln(BMI) Policy: Beverage or Snack Food Ads.
	(1)	(2)	(3)	(4)	(5)	(6)
Predicted Policy	0.106 (0.052)	0.090 (0.045)	0.099 (0.052)	0.075 (0.042)	0.041 (0.041)	0.038 (0.033)
African American		0.034 (0.012)		0.035 (0.012)		0.034 (0.012)
Hispanic		0.016 (0.011)		0.017 (0.011)		0.016 (0.011)
Female		-0.027 (0.007)		-0.027 (0.007)		-0.027 (0.007)
Age		0.019 (0.003)		0.019 (0.003)		0.019 (0.003)
Family Inc. (in 100Ks)		-0.015 (0.009)		-0.014 (0.009)		-0.014 (0.009)
Ln(Parent's BMI)		0.221 (0.018)		0.221 (0.018)		0.221 (0.018)
No. of Obs	3482	3482	3482	3482	3482	3482
R-squared	0.0037	0.1078	0.0040	0.1074	0.0022	0.1065
p-value for Overid. test ($\chi^2 \sim 3$ d.f.)		0.554		0.425		0.116
Mean (SD) of Pred. Policy	0.758 (0.119)	0.759 (0.119)	0.684 (0.137)	0.684 (0.137)	0.438 (0.168)	0.438 (0.168)
Mean (SD) of Dep. Var.	3.117 (0.183)	3.117 (0.183)	3.117 (0.183)	3.117 (0.183)	3.117 (0.183)	3.117 (0.183)

Notes: Data are from the 1999 panel of the NLSY97. The sample includes individuals who attended public schools during the 1999-2000 school year. In both sets of models we include dummies for region (Northeast, Midwest, and South), and a constant. In the second set of models we control for whether the individual reports smoking since the last interview, years of education of the biological mother and father, and dummy variables indicating if this information is missing. Log of Parent's BMI is for the responding parent (see notes to table 1). Table 2 shows the model used to create the predicted policy. The results here are from two sample estimation. The standard errors (in parentheses) are corrected both for arbitrary correlation within county, and for the fact that the policy variable is estimated. The regressions are weighted with NLSY sample weights. The overidentification test is for the null hypothesis that the excluded instruments are exogenous. In all cases, we fail to reject exogeneity.

Table 4: Estimated Effect of Predicted School Food Policies on Ln(BMI)
Public School Students in the NLSY 1997,
by Responding Parent's Weight Status

Policy Variable	Under to Normal Weight	Overweight (Not Obese)	Obese
Junk Food Avail.	0.014 (0.052)	0.221 (0.090)	0.079 (0.110)
R-Squared	0.0645	0.0769	0.0360
Pouring Rights	0.024 (0.045)	0.157 (0.081)	0.076 (0.098)
R-Squared	0.0646	0.0737	0.0361
Any Ads	-0.009 (0.053)	0.092 (0.065)	0.0004 (0.049)
R-Squared	0.0644	0.0718	0.0351
No. of Obs.	1533	1043	906
Mean (SD) of	3.075	3.128	3.194
Dependent Var.	(0.154)	(0.180)	(0.212)

Notes: Data are from the 1999 panel of the NLSY97. The sample includes individuals who attended public schools during the 1999-2000 school year. All models include the same set of controls variables as columns 2, 4, and 6 in table 3. Table 2 shows the model used to create the predicted policy. The results here are from two sample estimation. The standard errors (in parentheses) are corrected both for arbitrary correlation within county, and for the fact that the policy variable is estimated. The regressions are weighted with NLSY sample weights. Under to normal weight is defined as a BMI<25, overweight (not obese) is defined as a 25<=BMI<30 and obese is defined as a BMI>=30. The responding parent is the biological mother 83% of the time, and the biological father 10% of the time, while 3% are related female guardians and 2% are stepmothers.

Appendix Table 1: First Stage Results for the “Matched” Sample.
Percent of Schools in the County with given Food Policy

	(1) Junk Food Available	(2) Pouring Rights	(3) Any Beverage or Snack Food Ads
Mean of Dependent Variable (Std. Dev.)	0.816 (0.277)	0.649 (0.385)	0.427 (0.376)
Share of Total Revenues	-0.188	0.570	0.311
From State Sources	(0.214)	(0.415)	(0.377)
State has Tax and Expenditure Limits	0.093 (0.077)	0.023 (0.118)	-0.045 (0.094)
1990 to 2000 Relative Growth Rate in County Pop. Age 5-17	-0.0007 (0.0015)	-0.002 (0.003)	0.002 (0.001)
State has School Accountability Rules	0.334 (0.099)	0.097 (0.208)	0.381 (0.138)
Northeast	0.006 (0.077)	-0.402 (0.126)	-0.460 (0.120)
Midwest	-0.125 (0.084)	-0.037 (0.147)	0.063 (0.160)
South	-0.066 (0.053)	0.127 (0.072)	0.159 (0.074)
African American	-0.077 (0.051)	0.132 (0.084)	0.015 (0.049)
Hispanic	-0.045 (0.059)	-0.011 (0.070)	-0.153 (0.049)
Smoked since last interview	-0.0001 (0.0153)	0.010 (0.017)	0.017 (0.021)
Female	0.032 (0.016)	0.031 (0.026)	0.022 (0.023)
Age	-0.001 (0.008)	-0.007 (0.012)	0.014 (0.011)
Family Income (in 100Ks)	0.017 (0.024)	0.021 (0.028)	-0.051 (0.031)
Mother’s Education	-0.003 (0.004)	-0.007 (0.007)	-0.007 (0.004)
Father’s Education	-0.002 (0.003)	-0.007 (0.006)	-0.002 (0.005)
Ln(Parent’s BMI)	0.001 (0.034)	-0.001 (0.060)	0.023 (0.047)
No. of Observations	1007	1007	1007
R-squared	0.2921	0.3029	0.4013
F-statistic for excluded instruments	10.87	1.74	6.14
p-value for excluded instruments	0.0000	0.1709	0.0012

Notes: Data are for those individuals in the 1999 panel of the NLSY97 whose counties overlap with the SHPPS 2000 sample. The 1007 individuals live in 78 counties. The regressions also include dummy variables for whether mother’s education and father’s education is missing and a constant. See notes to tables 2 and 3 for additional information. Standard errors (in parentheses) are adjusted for arbitrary correlation within the state.

Appendix Table 2: Estimated Effect of Food Policy on Ln(BMI)
 OLS, IV and Two-Sample Estimation with the “Matched” Sample

Policy Variable & Est. Method	Coefficient (Std Err)	R-Square	Mean (SD) of Policy Var.	Mean (SD) of Predicted Var.
Junk Food				
OLS	0.034 (0.028)	0.16	0.816 (0.277)	
IV	0.140 (0.084)	0.14		
Two-Sample	0.160 (0.117)	0.16		0.758 (0.128)
Pouring Rights				
OLS	0.019 (0.017)	0.16	0.649 (0.385)	
IV	0.084 (0.092)	0.15		
Two-Sample	0.125 (0.103)	0.16		0.650 (0.124)
Snack Food Ads				
OLS	0.034 (0.026)	0.16	0.427 (0.376)	
IV	0.146 (0.070)	0.13		
Two-Sample	0.139 (0.135)	0.16		0.410 (0.146)

Notes: Models also include age, family income, ln(parent’s BMI), dummies for race, sex, region (Northeast, Midwest, and South), whether the individual reports smoking since the last interview, years of education for the biological mother and father, and dummy variables indicating if this information is missing, and a constant. Standard errors (in parentheses) are adjusted for arbitrary correlation within county. For the two-sample models, they are also adjusted for the fact that the policy variable is estimated based on the model shown in appendix table 1. All models have 1007 observations and a dependent mean (SD) of 3.126 (0.190).

DATA APPENDIX

Because no one data set contains all of the variables necessary for our analysis, we must build our data from several different sources. These include the School Health Policies and Programs Study (SHPPS), the Common Core of Data for school districts from the National Center for Education Statistics (NCES), county population data from the 1990 and 2000 Census, and individual-level data on public school students from the National Longitudinal Survey of Youth 1997 (NLSY97). We describe our use of each of these in turn.

The SHPPS is a national study conducted in 1994 and 2000 for the Center for Disease Controls (CDC).³⁰ While the study covers a broad range of school health policies and procedures at the state, district, school and classroom level, we focus on the 2000 school environment survey. This questionnaire asks about the school's policies regarding such things as the availability of snack foods through vending machines, school stores and snack bars; the details of an exclusive contract with a soft drink manufacturer (if any); and the types of advertising for sodas and snack foods allowed. Unfortunately, the majority of these questions were not asked in 1994. While unlike the 1994 study, the 2000 study also includes elementary schools, we do not include them in our main analysis, since we will be focusing on youths age 14 and older who are enrolled in public schools.

We choose three food policies from the SHPPS for the bulk of our analysis. First is an indicator of student access to junk foods, defined as the availability through vending machines or school stores of chocolate candy; other candy; cookies, crackers, cakes, pastries or other baked goods that are not low in fat; or salty snacks that are not low in fat. Second is an indicator for having an exclusive "pouring rights" contract with a soft drink manufacturer. Third is an

³⁰ For more information on SHPPS, see <http://www.cdc.gov/nccdphp/dash/shpps/>.

indicator that advertisements promoting student consumption of candy, meals from fast food restaurants or soft drinks are permitted in any number of ways, such as in the school building, on textbook covers or food service menus, on buses, or at athletic fields.

Since we are focusing on public school financing issues, we limit ourselves to the public schools in the SHPPS. We use data on the 451 public middle and high schools for which all the variables we need have non-missing information. For these schools we can identify their school district and merge on district-level information about school finances from the NCES Common Core of Data.³¹ The SHPPS data give the QED (Quality Education Data) district codes. We purchased the cross-walk between the QED and NCES district codes from QED. We use the NCES district codes to merge data on district finance information from the NCES. While detailed financial data is available, we want a simple summary measure of local fiscal capacity. Thus, we choose to use the fraction of total district revenues that come from the state, since even state funding formulas that are not explicitly equalization schemes, such as the most common foundation grant formula, result in there being a negative correlation between local fiscal capacity and the state share of funding.³²

The lowest geographic level of detail available in our individual-level data sets is the county. We therefore aggregate the SHPPS and NCES data up to the county level.³³ Using the school weights in the SHPPS, then, we calculate the probability that a school in the county has each of these policies. There are 180 counties in 41 states covered in our SHPPS sample. The NCES fiscal data is averaged across all districts in the county using district enrollment levels as

³¹ More information about the NCES Common Core of Data can be found at <http://nces.ed.gov/ccd/>. The latest fiscal data available at the time the project began was for the 1998-1999 school year. Thus, the fiscal data lags the policy data by one year.

³² See, for example, the summary discussion of *Public School Finance Programs in the United States and Canada* by Sielke and Holmes at <http://www.ed.sc.edu/aefa/reports/ch1.pdf>.

³³ The NCES identifies the county in which the district headquarters is located.

weights. Finally, we merge on two state-level indicators and the county-level relative growth in the school-age population. The first indicator is for whether the state has tax and expenditure limitations in place.³⁴ These types of local limits were commonly passed beginning in the late 1970s and into the 1980s, with some states tightening their laws in the early 1990s. The second indicator is for whether a state has passed a school accountability measure. These types of laws are mainly of a much more recent vintage, with many not implemented until the mid-1990s. Data appendix table 1 provides a complete list of states with each of these types of laws and the dates they were implemented. Finally, we compute the relative growth rate for the school-age population based on county-level population figures for those age 5-17 and the total population from the 1990 and 2000 Census. The growth rate is then calculated as:

$$\frac{\ln(\text{age 5-17 population in 2000}) - \ln(\text{age 5-17 population in 1990})}{\ln(\text{total population in 2000}) - \ln(\text{total population in 1990})}$$

Table 2 includes the sample means of each of these predictor variables.

The second major component of the project uses individual level data on adolescents that includes height and weight, along with individual and family background demographics. The National Longitudinal Survey of Youth, 1997 panel (NLSY97) is a survey of 8984 youths who were age 12-16 as of December 31, 1996. The first round of the survey took place between February of 1997 and May of 1998. Additional waves have been carried out annually during the school year. We use data from wave 3, which was collected in the 1999-2000 school year, to be in accord with the SHPPS data.

Wave 3 of the data contains information on 7958 individuals. We limit that to those who are enrolled in public school, which reduces the sample to 4653 individuals. By the time we eliminate those with missing information for variables used in our analysis, we are left with a

³⁴ These laws are from Downes and Figlio (1999), updated to reflect the 2000 status.

working sample of 3482 individuals. In order to use our two step estimation, we append the data on state tax limitations and state accountability laws to the NLSY97 data using state identifiers provided in the confidential geocode data. Similarly, we append county level data on the share of total school revenue from state sources, and the 1990 to 2000 relative growth rate in the county population aged 5-17 using the county identifiers in the geocode data. The individuals in our NLSY97 sample live in 426 counties.

We measure the adolescents' weight status using the log of their body mass index (BMI). BMI is defined as weight in kilograms divided by height in meters squared (kg/m^2) and is a commonly used measure to define obesity and overweight in adults. For example, according to guidelines in National Institutes of Health (1998), adults are considered underweight if their BMI is less than 18.5, overweight if their BMI is 25 or more, and obese if their BMI is 30 or more. Use of the BMI to assess children and adolescents has been slightly more controversial, although its use is fairly widespread.³⁵ The Centers for Disease Control (CDC) has recently endorsed the use of BMI to assess overweight status in children and adolescents, and has produced sex-specific BMI distributions for children aged 2 to 20 for just this purpose. While results are similar using probability of overweight, we choose to use the continuous BMI measure.

Before calculating BMI, however, we make a few corrections for obvious typographical problems with the recorded height and weight data. As a first step in cleaning the weight data, we replace any weight value in a given year with the average from the years surrounding it if the

³⁵ Ideally, one would prefer to measure overweight using a measure that reflects adiposity. Since it is impractical to do so in large scale surveys, researchers have employed the BMI, which only requires the measurement of height and weight. It is somewhat controversial when used to assess overweight among children because children experience growth spurts at individual-dependent ages and this can weaken the relationship between height and weight-based measures to adiposity. See Freeman, et al. (1995) and Whitaker, et al. (1997) for a discussion of the use of BMI in children. Recently, Dietz and Bellizzi (1999) reporting on a conference convened by the International Obesity Task Force, noted that the BMI "offered a reasonable measure with which to assess fatness in children and adolescents." Additionally, they conclude that a BMI above the 85th percentile for a child's age and sex group is likely to accord with the adult definition of overweight, and above the 95th percentile with the adult definition of

given value is less than half or more than double the average of those surrounding it. So for example, for a wave 3 weight observation, we replace it with the average of the wave 2 and wave 4 weight values if it is less than half or more than double the average of the wave 2 and 4 values.

Because several individuals are missing weight data for one or more years, this presents a problem in comparing a given weight value to the values surrounding it. So, we employ an additional screening method. We flag weight values less than 60 or greater than 300 and then examine them by hand to distinguish between those individuals who have consistently high or consistently low weights and those individuals who have a single weight value which is very different from all other available weight data for that individual. For those individuals who have an outlier weight value, we replace it with the average of the weight values from the closest waves.

After creating the BMI values, we then flag any value which is less than 10 or greater than 40. We chose 10 and 40 as our cutoff values because the 3rd percentile for a 12 year-old is around 15 and the 97th percentile for a 20 year-old is 35. For those individuals with a flagged BMI, we then examine the height values by hand in order to identify those height values which clearly stand out from the rest. In all cases, only the feet value of height is altered since it is virtually impossible to determine if the inches values are inaccurate. The outlier height values are replaced with the nearest height value that makes sense. For example an individual who has the height values 5'10", 8'11", 5'11", 5'11", 6'0" will have the 8' replaced with 5'. An individual who has the height values 4'11", 7'2", 5'2", 5'3", 5'3" will have the 7' replaced with 5'. Finally, the BMI values are recomputed using the altered weights and altered heights.

obese.

Ultimately, only 5 sample BMI values are different from those computed from the recorded values.

We also use parental BMI in the analysis. This information was collected in the initial wave from the responding parent (88% are biological mothers, 10% are biological fathers, 3% are related female guardians, and 2% are stepmothers). There are outliers in these data as well, but with only 1 year of information, we cannot follow the procedure described above for identifying incorrect information. Bad data leading to the misidentification of students as having “obese” parents may explain why our results for that subgroup are relatively imprecise. Without other information, our options for dealing with misreported data are limited. We re-estimated the results in table 3 dropping those with parents with BMIs above 40, above 50, and above 60. These three sets of results are very similar to those in table 3.

One other key explanatory variable needs some re-coding. We want to control for an individual’s socioeconomic background, so we construct a variable that will capture each individual’s permanent household income. Because the youth in our sample are all enrolled in public schools, in most cases this variable is the average of the gross household income values of a youth’s parents over the period 1996-2000 (collected in 1997-2001). For 1996, we use a gross household income variable which was constructed using information collected during the initial parent interview.³⁶ For 1997 through 2000, we use gross household income variables constructed using information from household income update questionnaires. The household income update questionnaires were administered each survey year to the parents of individuals who still lived at home. They collected the following information:

- whether or not the parent had an income

³⁶ In a few cases (2% of the full sample), youth who were considered independent answered these income questions instead of the parent.

- the amount of the parent's income if it existed
- whether or not the parent's spouse/partner had an income
- whether or not the parent and spouse/partner had any other forms of income
- the amount of the other income if it existed

The gross household income variables we use for 1997 through 2000 are created so that income from a particular source is zero if the parent responding reports that they did not have that type of income, is the amount of that type of income if the amount is available and the parent reports that they do have that type of income, and is missing otherwise. The income amounts from each of the three distinct sources are then summed to get a gross household income variable for 1997-2000. For these years, if the gross household income value is still missing after using the household income update information, we replace it with a household income value which was collected from each youth age 14 and older in the 1998-2001 surveys.³⁷ We then convert each of these final gross household income variables to 2000 dollars. Finally, in order to get a variable representative of “permanent” household income, we average gross household income across all years, 1997-2001. We replace this permanent household income value with a missing value if we do not have at least two years of valid household income data to calculate the average.

³⁷ The survey requested income information for parents if the youth was considered dependent. However, if the youth was considered independent, the survey requested income information for all individuals age 14 and older in the household.

Data Appendix Table 1: Summary Statistics

	Full Sample	Matched Sample
White	0.686 (0.464)	0.587 (0.493)
Black	0.151 (0.358)	0.162 (0.369)
Hispanic	0.117 (0.322)	0.204 (0.403)
Smoked since last interview	0.348 (0.476)	0.302 (0.460)
Female	0.471 (0.499)	0.458 (0.499)
Age	16.2 (1.10)	16.26 (1.08)
Family Income (in \$100Ks)	0.556 (0.429)	0.605 (0.482)
Biological Mother's Education	12.3 (3.84)	12.1 (4.16)
Biological Father's Education	11.2 (5.25)	10.8 (5.70)
Bio. Mom's Education Missing	0.051 (0.220)	0.064 (0.245)
Bio. Dad's Education Missing	0.137 (0.344)	0.172 (0.378)
Northeast	0.163 (0.370)	0.162 (0.369)
Midwest	0.278 (0.448)	0.224 (0.417)
South	0.331 (0.471)	0.253 (0.435)
West	0.228 (0.419)	0.361 (0.481)
BMI	22.99 (4.63)	23.23 (4.95)
Ln(BMI)	3.12 (0.018)	3.13 (0.190)
Obese	0.109 (0.312)	0.116 (0.321)
Overweight	0.242 (0.428)	0.247 (0.432)
Parent's BMI	26.53 (5.87)	26.38 (5.50)
Ln(Parent's BMI)	3.26 (0.204)	3.25 (0.198)
Parents Obese	0.228 (0.419)	0.230 (0.421)
Parents Overweight	0.518 (0.500)	0.533 (0.499)
Sample Size	3482	1007

Notes: Mean and (standard deviation) shown. The data are from the 1999 panel of the NLSY97. The “full” sample is for all individuals who attend public school and for whom we have information for the full set of variables listed here. The “matched” sample is for only those individuals who live in counties that overlap with those sampled in the School Health Policies and Programs survey. See text for additional information about the samples.

Data Appendix Table 2: Tax and Expenditure Limits and School Accountability By State

State	Tax and Expenditure Limits	Year of Enactment, Tightening	School Accountability	Year System Implemented
Alabama	No		Yes	1997
Alaska	No		No	
Arizona	Yes	1975, 1990	Yes	2000
Arkansas	Yes	1982	Yes	1999
California	Yes	1978	Yes	1999
Colorado	Yes	1974, 1990	Yes	1999
Connecticut	No		Yes	1984
Delaware	No		Yes	1998
District of Columbia	No		Yes	1997
Florida	No		Yes	1999
Georgia	No		Yes	2000
Hawaii	No		No	
Idaho	No		No	
Illinois	No		No	
Indiana	Yes	1974	Yes	1995
Iowa	Yes	1972, 1992	No	
Kansas	Yes	1974	Yes	1995
Kentucky	Yes	1980	Yes	1995
Louisiana	Yes	1979	Yes	1999
Maine	No		Yes	1999
Maryland	No		Yes	1999
Massachusetts	Yes	1981	Yes	1998
Michigan	Yes	1979	Yes	1998
Minnesota	Yes	1972	Yes	1996
Mississippi	Yes	1984	Yes	1994
Missouri	Yes	1981	Yes	1997
Montana	Yes		Yes	1998
Nebraska	No		No	
Nevada	No		Yes	1996
New Hampshire	No		Yes	1993
New Jersey	Yes	1977	Yes	1995
New Mexico	Yes	1980	No	
New York	No		Yes	1998
North Carolina	No		Yes	1993
North Dakota	No		No	
Ohio	Yes	1977	Yes	1998
Oklahoma	No		Yes	1996
Oregon	Yes	1991	Yes	2000
Pennsylvania	No		Yes	1997
Rhode Island	No		Yes	1997
South Carolina	Yes	1981	Yes	1999
South Dakota	No		No	
Tennessee	No		Yes	1996
Texas	Yes	1983	Yes	1994
Utah	No		No	
Vermont	No		Yes	1999
Virginia	No		Yes	1998
Washington	Yes	1980	Yes	1998
West Virginia	No		Yes	1997
Wisconsin	No		Yes	1993
Wyoming	No		Yes	1999

Source: Tax and Expenditure Limit information is from David Figlio for 2000, from data used in “Do tax and expenditure limits provide a free lunch? Evidence on the links between limits and public sector service quality” (Downes and Figlio, 1999). School Accountability Information is from Mackie Raymond for 2000, from data used in “Improving Educational Quality: How Best to Evaluate Our Schools” (Hanushek and Raymond, 2002).